INTER-AMERICAN TROPICAL TUNA COMMISSION

EXTERNAL REVIEW OF IATTC BIGEYE TUNA ASSESSMENT

La Jolla, California (USA)
3-7 May 2010

FINAL REPORT

1. BACKGROUND

The assessment of bigeye tuna in the eastern Pacific Ocean (EPO), defined for the purposes of this review as the area east of 150°W between 40°N and 40°S (Figure 1), is based on fitting an age- and length-structured population dynamics model to data on catches, catch rates, length-frequency data, and data on length-at-age. The fisheries in the EPO were divided into four longline fisheries (Fleets 1-4) and 11 surface fisheries (Fleets 5-15). The assessment uses the Stock Synthesis 3 software (Methot 2009). The IATTC staff identified a set of assumptions which are reflected in the base-case model (Aires-da-Silva and Maunder 2009). This model suggests that the spawning biomass of bigeye tuna in the EPO was near the historic low level at the beginning of 2009. At that time, the spawning biomass ratio (SBR; the ratio of the spawning biomass at that time to that of the unfished stock) was about 0.17, which is about 11% less than the level corresponding to the maximum sustainable yield (MSY). The assessment includes a number of sensitivity tests which explore the impacts of changes on some of the assumptions of the base-case model*.

IATTC staff requested that the review panel consider the following general questions related to the assessment of bigeye tuna stocks in the EPO:

1. What is an appropriate stock structure for assessment of bigeye tuna in the EPO?
2. How can variability in size at age be accommodated in the stock assessment?

* Unless otherwise modified, the word "model" means stock assessment model.

3. Has a major change in recruitment occurred over the history of the fishery?
4. What is causing the patterns in the length-composition residuals?
5. How should indices of abundance be computed and used in the assessment?
6. How should the tagging data be used in the assessment model?

Staff members provided the Panel with several documents (Appendix A) prior to the meeting and introduced each agenda item (Appendix B) with a series of presentations. The staff identified two key undesirable features of the current base-case model, related to questions 3 and 4 above:

a. the fit of the base-case model to the length-frequency data for the southern longline fishery (Fleet 9) exhibits a systematic residual pattern. Specifically, there is a higher proportion of smaller fish in the catch than is predicted by the model for the years before 1990, while there is a higher proportion of large fish in the catch than is predicted by the model after 1990 (Figure 2).
b. one of the most striking features of the base-case assessment is the estimated increase in recruitment. Recruitment increases dramatically during the mid-1990s to a level approximately double that estimated for the period back to 1975. This trend has been questioned for several years. This increase coincided with the expansion of catches from the purse-seine fishery on fish-aggregating devices (FADs) and an increase in the mean size of fish taken in the southern longline fishery.

These two features, as well as a pattern in the residuals for Fleets 3 and 9, in which negative residuals in Fleet 9 correspond with positive residuals for Fleet 3 (Figure 3) from 1997 to 2007, were a focus for discussion. The Panel made numerous requests of the staff for additional model runs to further understand the behavior of the model and to identify sets of hypotheses regarding biological and fishery processes which could reduce these undesirable features of the base-case model. The focus of these runs was on the case in which the entire EPO is assumed to contain a single homogeneous stock of bigeye tuna. However, a subset of the runs focused on the "central" area (the areas enclosing Fleets 3 and 11 in Figure 1).

The Panel identified a series of issues, divided into general topics based on the material provided before the meeting, the information in a series of background documents, and the results of the requested model runs. Drs. Alain Fonteneau and Eleutorio Yáñez also made presentations and comments. This report reflects the Panel's view on the work of the staff. Progress in regards to improving the assessment will require additional modeling and data. The Panel has summarized its key findings and **makes specific recommendations to the staff** on each issue.

Based on the results of the requested model runs, the Panel concludes that there is considerable uncertainty regarding the absolute abundance of bigeye tuna in the EPO using a stock assessment which treats all bigeye west of 150°W as a single homogeneous population. Specifically:

1. If the expected size of a 40-quarter-old bigeye is "large" (~190-200cm) and the selectivity pattern for the southern longline fishery is asymptotic, the assessment estimates a relatively small stock.
2. If the expected size of a 40-quarter-old bigeye is "small" (< 170cm) or the selectivity pattern for the southern longline fishery is dome-shaped, the assessment estimates a relatively large stock with dynamics dominated by changes in recruitment over time.

The Panel thanks the staff of the IATTC, in particular Mark Maunder and Alexandre Aires-da-Silva, for their hard work and willingness to respond to Panel requests, for their exceptional support, provisions, and general hospitality during the review.

2. GENERAL TOPICS

2.1. Data issues

2.1.1. CPUE data

In the absence of survey indices of abundance, catch per unit effort (CPUE) data currently provide the model with the best available information on changes in relative abundance over time, particularly the indices of abundance for the southern longline fishery.

Operational level catch and effort data are available for the purse-seine fishery, and an algorithm is used to estimate effort in days fished by the three set types (unassociated, floating-object-associated, and dolphin-associated) based on the number of sets by set type and total days fished. Operational level data are not available for the longline fisheries, and the staff depends on data aggregated to 5x5-degree area and month. Only the Japanese fleet has had a continuous presence in the fishery, but information on targeting practices by the Japanese fleet, as informed by hooks per basket, are only available from 1975.

Allowance is made within the base-case model for process and observation errors when fitting CPUE data. The extent of such errors is estimated as part of the fitting procedure. Based on the estimated errors, the CPUE series for the surface fisheries have little influence on the final model estimates.

2.1.2. Findings

The purse-seine data are unlikely to reflect changes in abundance, particularly due to developments in the FAD fishery and are consequently given lower weight in the model (*i.e.* higher observation-error coefficient of variation (CV)). Developing reliable indices of abundance for purse-seine fisheries is difficult, but any information on fishing practices is likely to lead to an improved understanding of the relationship between abundance and catch rates, and hence possibly changes in the component of the population available to this fishery. Further understanding of the dynamics of the purse-seine fishery, in particular the use of FADs, may lead to more informative data from this fishery. Therefore, the Panel strongly supports the development of collaborative scientific research programmes into FAD use, as described in IATTC Resolution C-09-01.

Standardization of the longline indices currently does not account for factors found to be important in CPUE standardizations for other longline fisheries, *e.g.* target depth, vessel effects, line type, and fine-scale location. There have been changes in fleet composition and line type in the longline fishery over the time period considered in the assessment.

Patterns in the length-frequency data from the purse-seine and longline fisheries that are attributed to changes in fishing practices or selectivity have major implications for the interpretation of CPUE data.

2.1.3. Recommendations

The Panel recommends that plots of predicted versus observed CPUE should be used as a diagnostic for evaluating the fit to the various indices.

The Panel notes that there is considerable value in having the staff collaborate with national scientists to examine the potential effects on CPUE of changes in fishing practices (such as line type) and fleet composition and efficiency. The Panel is encouraged that collaboration is currently occurring between scientists from Japan and the Secretariat of the Pacific Community (SPC) on an analysis of Western and Central Pacific Ocean (WCPO) longline CPUE, using operational level catch and effort data.

Any assumed temporal changes in the longline fishery within the assessment model, *e.g.* estimation of temporal changes in selectivity or catchability, including time splits, represent changes in the interpretation of the longline CPUE series. The Panel therefore recommends that the explanatory variables used to standardise CPUE should be investigated to see if they can explain changes over time in length-frequency data, *e.g.* summarized by the median and/or some other percentile.

2.2. Length-frequency data

Age data for tropical tunas are typically unavailable or are limited, so length-frequency data are important for estimating growth, selectivity, and recruitment. A comprehensive port sampling program collects species composition and length-frequency samples from the purse-seine fisheries in the EPO. Length-frequency data are currently available from two longline fleets (Japan and Chinese Taipei). The Japanese data are collected on the vessels and the data supplied is fish length aggregated at either 5x10 degree or 10 x 20 degree monthly resolution. There is currently uncertainty regarding the quality of the Chinese Taipei data, and until this is resolved, these data are not being used in the assessment.

2.2.1. Findings

Studies in the WCPO have found a potential bias in length-frequency distributions caused by sampling bias. Specifically, there is an apparent selection bias whereby the small and extremely large fish are under-represented in the samples and the 'medium' sized fish are over-represented when on-board samplers are required to take small random samples from purse-seine catches (Lawson 2009). There is insufficient information to determine if a similar bias exists in the data collected in the IATTC port sampling programme.

The fits to some of the purse-seine and longline length-frequency samples are poor, and this likely represents model mis-specification which could be related to various assumptions, *e.g.* time-invariant selectivity, spatial homogeneity, constant growth, *etc*. One of the key patterns in the length-frequency data is the increase in median length since 1990. Some of the residual patterns for the southern longline fishery could be improved by assuming a temporal change in selectivity, but there was no simple explanation why such a change may have occurred. Many of the approaches for improving the fit to the length-frequency data examined during the review resulted in major changes to the results of the assessment.

2.2.2. Recommendations

The effect of a potential sampling bias on estimated length frequencies, and hence the total catch, should be evaluated. The Panel recommends that experimental work will need to be conducted to correct the sampling procedures if the stock assessment results are sensitive to adjusting the data to account for possible different levels of this bias.

Given that the longline length-frequency data can affect assessment results, further detailed examination of these data is strongly recommended. Such work could provide insights into potential spatially-defined fisheries.

2.3. Spatial considerations

The IATTC bigeye tuna management area (Figure 1) includes tropical as well as temperate habitat in both the northern and southern hemispheres, and extends to the west to 150°W longitude. Purse-seine fleets and longline fleets from IATTC member countries operate in different parts of the management area. This area is not oceanographically homogeneous, and fishing methods vary throughout the region. The size and age composition of the bigeye catch varies with location as well as with gear type as a result of these inhomogeneities. The base-case assessment attempts to account for spatial heterogeneity by estimating separate selectivity and catchability schedules for each fleet. Tagging data from both "conventional" dart tags and electronic tags are widely applied to better understand spatial issues. Practical considerations constrain the assessment to the boundaries of the IATTC management area, but the effects of excluding large areas of the Pacific bigeye tuna range are not clear.

There is no single analytical framework for assessing poorly-mixed stocks residing in a heterogeneous environment. The options range from a fully-resolved spatially-explicit model to a framework of independent stock assessments applied to arbitrarily delineated regions.

2.3.1. Findings

Tagging data show clearly that bigeye tuna tagged in the "central" area (the area in which fleets 3 and 11 operate; Figure 1) are generally recaptured inside or very near this area. The estimated diffusivity is low, approximately 500 nm^2/day (corresponding to a daily linear displacement of about 22 nm/day; Schaefer and Fuller, 2006). Exchange rates appear to be very low between the central area and either the northern or southern areas, and the assumption that the stock is uniformly mixed is violated. However, few tagged bigeye have been released outside the central region and, as a result, very few data are available on exchange rates with the other regions. The tagging data are not sufficiently extensive to use in selecting an appropriate spatial assessment framework. The area-specific assessment models showed a high degree of synchrony for recruitment. Depletion levels varied among regions, but the putative stock in the central area was most depleted. The sum of the independent assessments was about 50% higher than the single, region-wide assessment.

The regression tree analyses of the length-frequency data (aggregated in 5° latitude by 10° longitude by month) suggest spatial strata that are different from the spatial boundaries that define fleets within the base-case model (Document BET-01-02a).

Sensitivity analyses that included data from the WCPO showed some inconsistency with expectations. Namely, the biomass estimates increased as expected when WCPO catch is included in the model without fitting to the WCPO data. However, the biomass estimates were lower than the EPO base-case model when the WCPO data were used when fitting the model. .

2.3.2. Recommendations

The Panel recommends that:

1. The Commission's tagging program be substantially extended to include all regions in the bigeye tuna area (particularly in the area round 120°E-10°S), large fish, and multiple years;
2. The staff develop a joint proposal with the WCPFC to begin long-term tagging operations for tropical tunas in the Pacific Ocean, with emphasis on bigeye tuna;
3. Longline fishery definitions be re-evaluated to ensure that the length-frequency distributions are homogeneous within fisheries, particularly in the southern area. This may lead to more longline fleets defined in this area;
4. The staff begin to consider assessment methods appropriate to a spatially-inhomogeneous stock and fisheries that can be applied as new tagging data become available.
5. The staff continue collaboration with WCPFC scientists on Pacific-wide bigeye assessments.

3. ASSESSMENT METHODS

3.1. Stock assessment modelling platform

A-SCALA, a custom-built integrated assessment model developed by the IATTC staff, was used for the EPO bigeye assessment from 2000 to 2006. A-SCALA has the advantage of having been developed with tropical tuna assessments in mind. However, it lacks several key features that are likely to be important in future assessments; in particular, it cannot use tagging data and implement spatially-structured models. A-SCALA was compared with other currently available assessment packages (Maunder 2006), and it was decided to adopt Stock Synthesis (SS) as the stock assessment platform. Stock Synthesis is used widely within the United States for assessments, including for some tuna stocks. It is currently developed and maintained by Dr. Richard Methot (US National Marine Fisheries Service, NMFS). The staff has worked closely with Dr. Methot to modify SS for IATTC assessments.

3.1.1. Findings

The transition to an alternative stock assessment modelling framework that can use tagging data and consider multiple regions was important, and will allow a greater range of model scenarios to be examined. Although the IATTC staff has no direct control over the development of SS, to date this has caused no problems for the Commission's assessments after the Richards growth model was incorporated into SS. More changes to SS will likely be necessary as steps are taken towards spatially-structured models.

3.1.2. Recommendation

It is possible that the current voluntary arrangement for SS developments may restrict development of the assessment. The Panel therefore recommends that the staff seek ways to formalise the collaboration with NMFS to reduce the potential risk that the development of the bigeye assessment is hampered by the lack of direct control of software development.

3.2. Data weighting

3.2.1. Findings

The effective sample sizes in the base-case model are the same for all fisheries, which equalizes the "importance" of all fisheries. Increasing the effective sample size for the length-frequency data from the southern longline fishery (Fleet 9) led to a marked change to the outcomes of the assessment. In particular, the recruitment and residual patterns improved when the effective sample sizes for the southern longline fishery were increased.

Model runs in which the input CVs on CPUE data for the southern longline fishery were fixed at 0.1 or 0.2 provided similar root mean squared errors (about 0.15).

3.2.2. Recommendations

The Panel recommends that effective samples sizes assigned to the longline length-frequency data in the SS input file be re-evaluated, taking into account the model-estimated effective sample sizes; *i.e.*, care should be taken not to set the pre-specified effective sample sizes to values that are inconsistent with the fit of the model to the length-frequency data.

The Panel recommends that the observation error CVs for the CPUE data be pre-specified at fixed values rather than being treated as estimated parameters.

3.3. Use of pre-1975 information

3.3.1. Findings

The stock status of bigeye is based on two output metrics: (a) the ratio of the spawning biomass relative to the unfished spawning biomass, S/S_0, and (b) the ratio of the fishing mortality relative to the fishing mortality at which MSY is achieved, F/F_{MSY}. The base-case analysis from the 2009 stock assessment indicates that the spawning biomass was at 30% of S_0 during the first year of the stock assessment (Aires-da-Silva and Maunder 2009; Figure 4.7).

The size of the spawning biomass relative to S_0 is inferred using the data from 1975 onwards, and varying the assumptions of the stock assessment (*e.g.* estimating the length at age 40, L_2) leads to changes in this estimate (Document BET-01-03). Data on catches, catch rates and catch length-frequency exist for the years prior to 1975. However, there is some concern with the inclusion of the earlier data in the assessment owing to, for example, changes in the depths of sets, which are related to possible changes in targeting practices.

3.3.2. Recommendations

The Panel recommends that future model runs should start in about 1955 and use as much of the historical data as possible. Whether historical CPUE and length data should be included when fitting the model should be explored.

3.4. Modelling growth

The assessment is based on an age-structured population dynamics model fitted to a variety of data sources. The amount of available age data is limited to information on animals aged 4 years and less, while length-frequency data are available for a broad range of sizes and ages. Previous assessments have pre-specified the length at age 40 (L_2) and the variance of length-at-age.

3.4.1. Findings

The current status of the stock relative to the size of the spawning biomass at which MSY is achieved and the current fishing mortality relative to F_{MSY} change substantially if the value for L_2 is changed in the base-case model (Document BET-01-03). This is because, for example, if L_2 is large (>180 cm), the lack of large fish in the catch length compositions since 1975 implies that fishing must have been substantial prior to this because a considerable fraction of the population (very large fish) had been removed by this time. Likelihood profiles provide substantial support for lower values for L_2 than the current pre-specified values. However, estimating L_2, particularly if the Richards growth curve (which produces a better fit to the data) is assumed, leads to a growth curve which suggests that bigeye approach asymptotic size soon after age 4, which seems somewhat unrealistic. This low value for L_2 also seems inconsistent with the observations from tagging data (Schaefer and Fuller 2006; Figure 11) that the growth rate of larger bigeye (160-175 cm) is still relatively fast.

A plot of the length distribution of the catch by longline gear from an unexploited stock in which L_2 equals 185.5 cm was markedly different from length frequencies from catches during the late 1950s and early 1960s (the length frequencies predicted by the model contained far more large animals; Figure 4). These differences can be explained by: (a) L_2 for bigeye is less than 185.5 cm; (b) fishery selectivity during the late 1950s and early 1960s was not asymptotic (as might be expected, given that the fishery was operating in shallower waters than at present); (c) fishing mortality before 1975 was substantial; and (d) natural mortality is greater than the values assumed in the base-case model. During the review, the staff provided model runs in which scenarios (a), (b), and (d) were explored, separately and in combination.

3.4.2. Recommendations

Although there are several changes to the assumptions of the stock assessment which should be explored, understanding of the growth curve will be enhanced through collection of additional data, for example by tagging large bigeye tuna. The specific technical recommendations related to growth and its modelling are:

1. The values which determine the variance of length-at-age should be estimated rather than set to values estimated from A-SCALA.
2. The Richards growth curve is preferred to the von Bertalanffy growth curve. However, development of a more flexible growth curve (*e.g.* Maunder 2006) may be desirable, although this change will require modification of the Stock Synthesis platform.
3. Data provided to the Panel suggest that the maximum likelihood estimate for L_2 is inconsistent with growth increments from tagging data, and hence the Panel recommends that L_2 be pre-specified rather than estimated at present.
4. Sensitivity tests should explore the implications of removing the length-at-age data from the assessment, to assess the impact of including these data.

The Panel supports continued attempts to integrate the length-at-age data and the tagging data on growth within a single model framework.

3.5. Catchability and selectivity

The fit of the current base-case model to the length-frequency data for the southern longline fishery (Fleet

9) exhibits a pattern of correlated residuals (Figure 2). A variety of modifications to the base-case model, including assuming separate selectivity patterns before and after 1990 and conducting assessments for different spatial configurations were explored by the staff prior to the review (Document BET-01-05). However, none of these approaches, on its own, was able to remove these residual patterns.

3.5.1. Findings

The Panel proposed the following model specification that appeared to reduce the residual patterns (referred to as the "working base model", as several of the model runs examined by the panel were based on these specifications):

1. increasing the weight on the length-frequency data for the southern longline fishery;
2. splitting the data for the southern longline fishery (length-frequency and catch rate) in 1990, and treating the two resultant catch-rate time series independently and estimating a separate catchability coefficient and (dome-shaped) selectivity pattern for the pre-1990 years for this fishery; and
3. assuming the Richards growth curve, and estimating both L_2 and the variance of length-at-age.

However, as noted above, the estimate of L_2 seemed unrealistically low. This model run also led to a substantially larger estimate of spawning biomass than the base-case model.

The choice of appropriate selectivity and catchability assumptions could not be fully resolved during the review. However, it is clear that the assumption of logistic selectivity for the southern longline fishery throughout the entire period of the assessment must be relaxed if the model is to be able to fit the catch length-frequency data for the longline fishery within an assessment which assumes a single homogeneous stock.

The length residuals are a useful diagnostic for evaluating how well the model predicts fish length. In some cases the residuals appear to be correlated both over time and between sizes. There is no well-established method to compare patterns from different fits quantitatively.

3.5.2. Recommendations

The Panel recommends that further consideration be given to allowing the selectivity parameters for both the longline and surface fisheries to change over time. Selection of an appropriate structure for selectivity could be based on residual patterns for the size-composition data.

The Panel recommends developing methods for testing for lack of randomness in residual patterns and for comparison of particular residual patterns among model runs. Existing spatial statistics for lattice data, randomization procedures for spatial data, and statistical techniques used for pattern recognition in image analysis might be useful approaches.

The Panel recommends that future model runs should evaluate whether better fits are achieved by assuming that selectivity is a function of age rather than of length.

3.6. Natural mortality

Natural mortality, M, is assumed to decrease from 0.25 qtr^{-1} at age 0 to 0.1 qtr^{-1} at age 4 quarters in the base-case assessment (Document BET-01-06). Female M is assumed in the base-case model to be independent of age after age 4 quarters, while male M increases with age from 15 quarters of age. Document BET-01-06 explored the implications of changes to the rate of natural mortality for males.

3.6.1. Findings

Further sensitivity tests were presented to the Panel, in which M for females was varied from 0.15 qtr^{-1} to 0.3 qtr^{-1}, with the remaining specifications set to those for the "working base model", except that L_2 was set to 185.5 cm (the value for L_2 in the original base-case model). The best fit to the data occurred for the highest level of natural mortality, M (0.3 qtr^{-1}; equivalent to 1.2 yr^{-1}). However, the Panel and staff considered this value to be implausibly high.

Changing the value for M is one way to eliminate the residual patterns for the length-frequency data if L_2 is set to 185.5 cm. However, while the Panel recognizes that M is poorly known for bigeye in the EPO, there are better ways to eliminate the residual patterns.

3.6.2. Recommendations

The Panel recommends that natural mortality continue to be evaluated and, as new data become available, such as from tagging studies, they be integrated into the assessment.

3.7. Stock-recruit relationship

Steepness is a critical, but poorly estimated, parameter that describes the relationship between spawning biomass and recruitment. The current base-case model assumes that steepness equals one, *i.e.* reductions in spawning biomass do not result in reductions in recruitment on average. This assumption results in an estimate of S_{MSY}/S_0 of around 20%. The staff includes results for the assumption that steepness equals 0.75 in the 2009 assessment. This value of steepness results in negligible changes to the estimated time series of recruits, *i.e.* small impacts on S_0, but a major effect on the MSY-based management quantities and, consequently, on estimates of stock status relative to these reference points.

The main rationale for the base-case assumption that steepness equals 1 was that there is little evidence in the estimates of spawning biomass and recruitment from the assessment that recruitment is lower at reduced stock size.

3.7.1. Findings

Several recent simulation studies, and historical work by the staff, have found that it is a) difficult to accurately estimate steepness within assessment models; and b) estimated values often tend to one when the true value is less than one. Moreover, trends in estimated recruitment from the base-case model make it difficult to conclude that steepness is less than one. However, this trend in recruitment (a step function increase in mean recruitment in about 1990) was shown to be an artifact of the low weighting assigned to the catch length-frequency data.

Episodes of high recruitment of bigeye appear to be associated with strong El Niño-Southern Oscillation (ENSO) events, suggesting some level of environmental control over recruitment. Attempts to use ENSO indices as environmental correlates in stock assessments have not been useful. However, ENSO events do not affect the EPO uniformly, and may have a larger influence on recruitment in equatorial or coastal regions.

3.7.2. Recommendations

The Panel recommends that:

1. the difficulty in estimating steepness and the sensitivity of the stock status conclusions should be acknowledged in the assessment, and the staff should present stock status estimates over a ‘plausible’ range of steepness values.
2. the staff examine likelihood profiles for steepness.
3. the staff evaluate possible seasonal and ENSO effects on the stock-recruitment relationship in a spatial context.

3.8. Other recommendations

The Panel noted that length-frequency data by sex exist for the longline fleets. These data should be obtained, and model runs conducted in which sex-specific as well as sex-aggregated length-frequency data are included in the assessment.

Joint likelihood profiles for virgin recruitment (average recruitment in the absence of fishing; R_0) and L_2 should be constructed using model configurations in which selectivity is a logistic as well as a dome-shaped function of length, to help assess a plausible range for the current stock size and its status relative to biological reference points.

The Panel recommends that cryptic biomass estimates be evaluated and reported for model runs in which selectivity is dome-shaped for all fleets.

The Panel recommends that the staff re-evaluate fishery definitions. In particular, disaggregating fleets to flag should be considered. This should include an examination of available size data by different fleets.

4. REFERENCES

Aires-da-Silva, A and M.N. Maunder. 2009 Status of bigeye tuna in the eastern Pacific Ocean in 2008 and outlook for the future. Document SARM-10-06b. 90pp.

Lawson, T. 2009. Selectivity bias in grab samples and other factors affecting the analysis of species composition data collected by observers on purse seiners in the Western and Central Pacific Ocean. WCPFC-SC5-2009/ST-WP-03

Maunder, M. 2006. Report - Workshop on stock assessment methods, 7-11 November 2005. Inter-American Tropical Tuna Commission. 23 pp.

Methot, R. D. 2009. User manual for Stock Synthesis. Model Version 3.04b. NOAA Fisheries

Schaefer, K.M. and D.W. Fuller. 2006. Estimates of age and growth of bigeye tuna (*Thunnus obesus*) in the eastern Pacific Ocean based on otolith increments and tagging data. Bull. Inter-Am Trop. Tuna Comm. 23(2): 35-76.

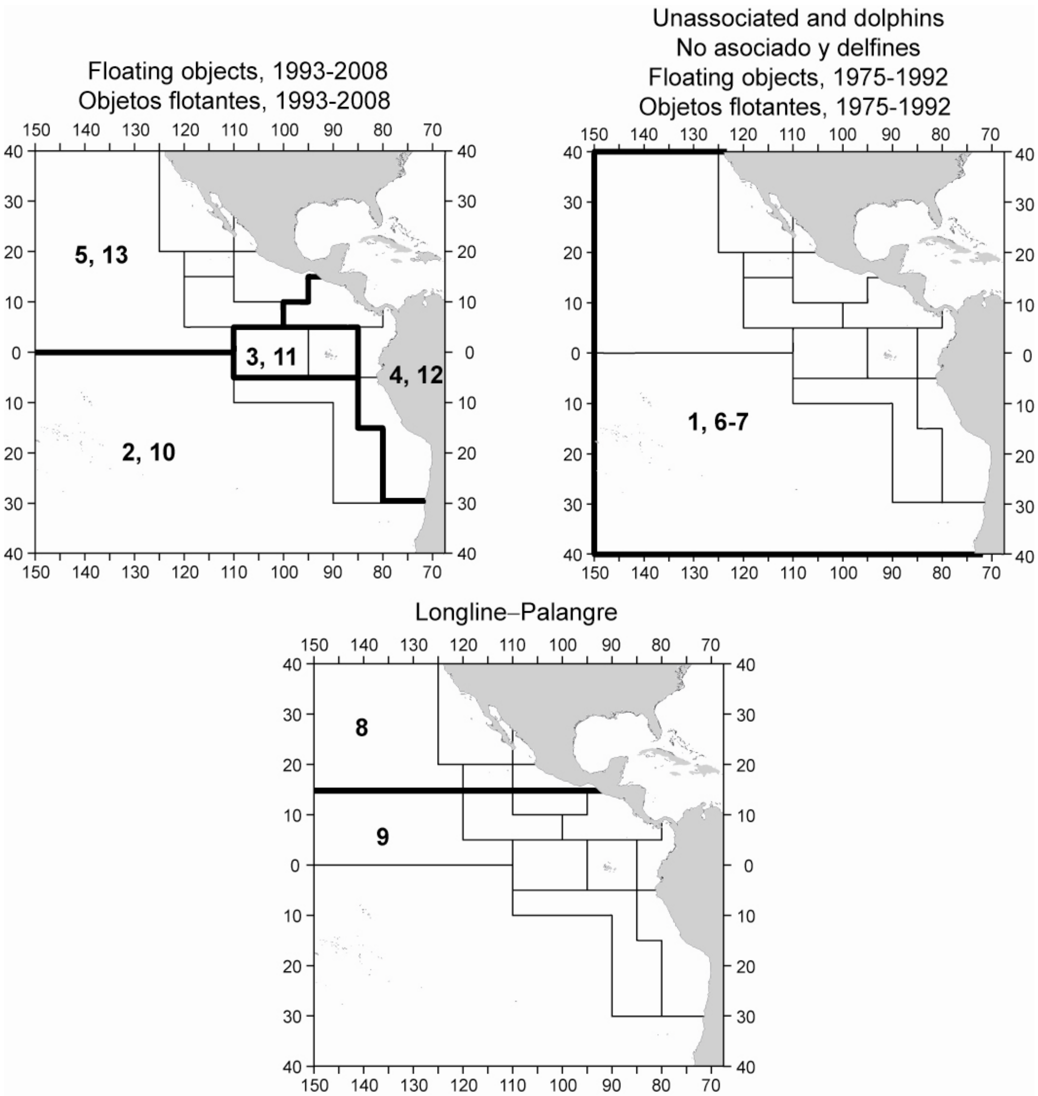

FIGURE 1. Spatial extents of the fisheries defined for the stock assessment of bigeye tuna in the EPO. The thin lines indicate the boundaries of 13 length-frequency sampling areas, the bold lines the boundaries of each fishery defined for the stock assessment, and the bold numbers the fisheries to which the latter boundaries apply.

FIGURA 1. Extensión espacial de las pesquerías definidas para la evaluación de la población de atún patudo en el OPO. Las líneas delgadas indican los límites de 13 zonas de muestreo de frecuencia de tallas, las líneas gruesas los límites de cada pesquería definida para la evaluación de la población, y los números en negritas las pesquerías correspondientes a estos últimos límites.

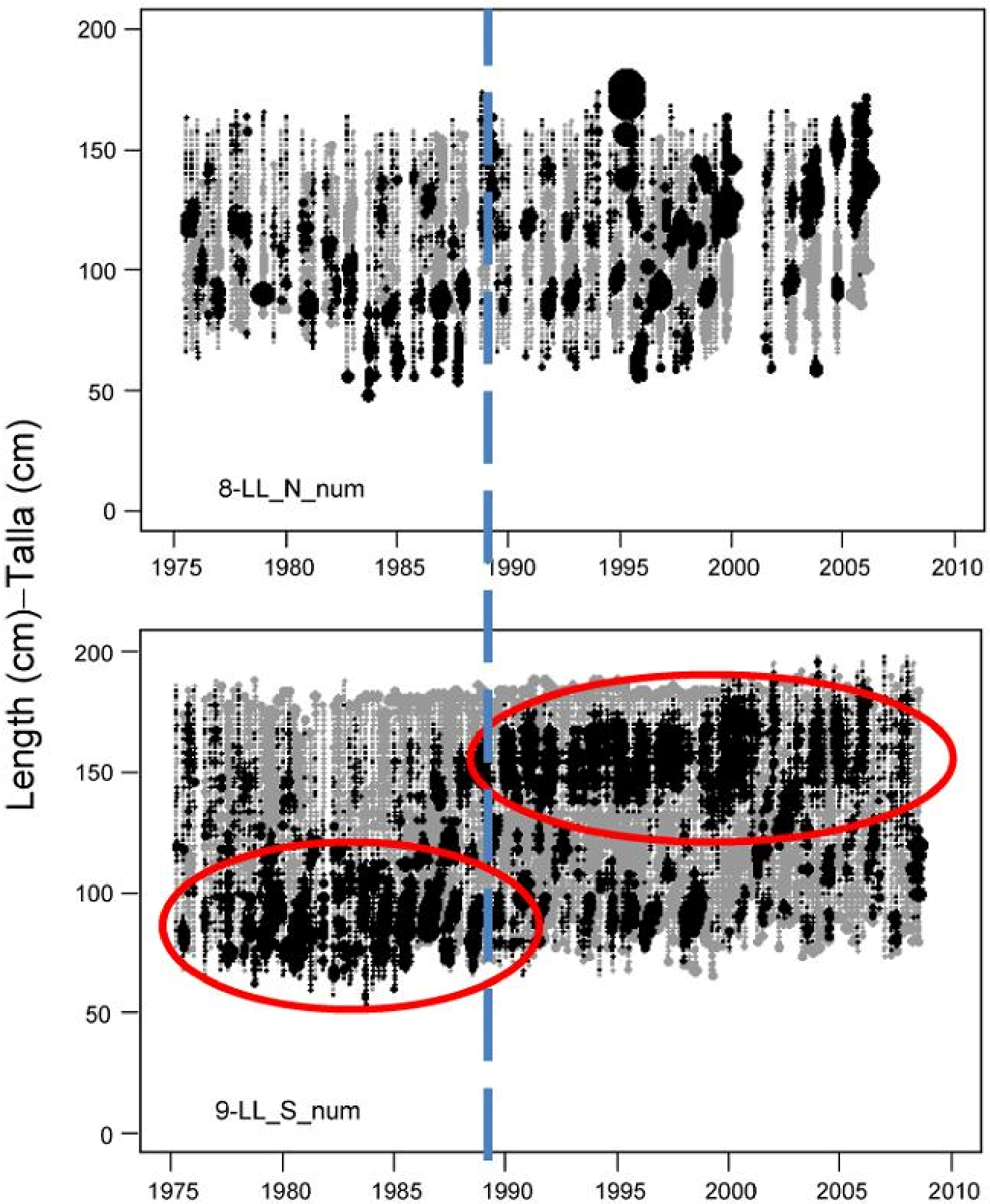

FIGURE 2. Pearson residual plots for the model fits to the length-composition data for the longline fisheries (top – northern, bottom – southern) assumed in the base-case assessments (Aires-da-Silva and Maunder 2009). The gray and black circles represent observations that are lower and higher, respectively than the model predictions. The sizes of the circles are proportional to the absolute values of the residuals.
FIGURA 2. Gráficas de residuales de Pearson para los ajustes del modelo a los datos de composición por talla de las pesquerías de palangre (arriba – norte; abajo – sur) supuestas en las evaluaciones del caso base (Aires-da-Silva y Maunder 2009). Los círculos grises y negros representan observaciones mayores y menores, respectivamente, que las predicciones del modelo. El tamaño de los círculos es proporcional al valor absoluto de los residuales.

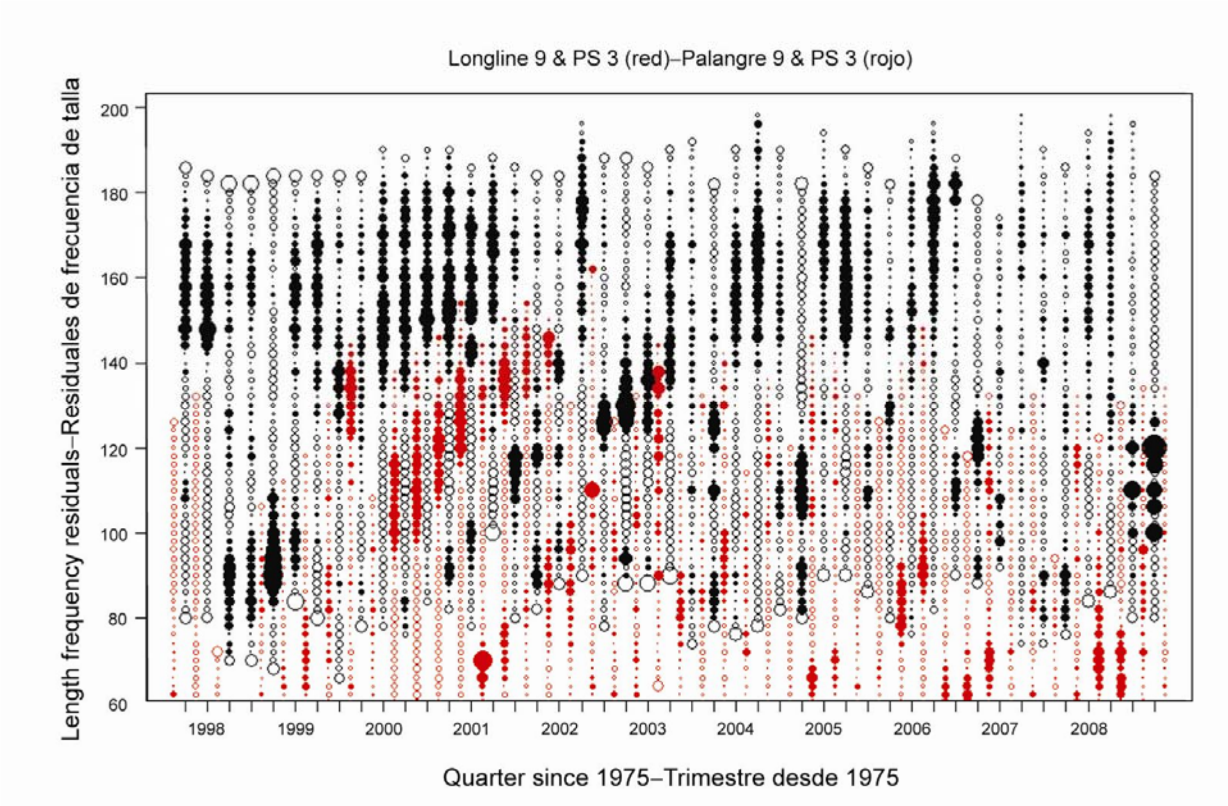

FIGURE 3. Pearson residual plots for the model fits to the length-composition data for the southern longline fishery 9 (black) compared to the central area floating-object fishery 3 (red). The sizes of the circles are proportional to the absolute values of the residuals.

FIGURA 3. Gráficas de residuales de Pearson para los ajustes del modelo a los datos de composición por talla de la pesquería de palangre del sur 9 (negro) comparada con la pesquería sobre objetos flotantes central 3 (rojo). El tamaño de los círculos es proporcional al valor absoluto de los residuales.

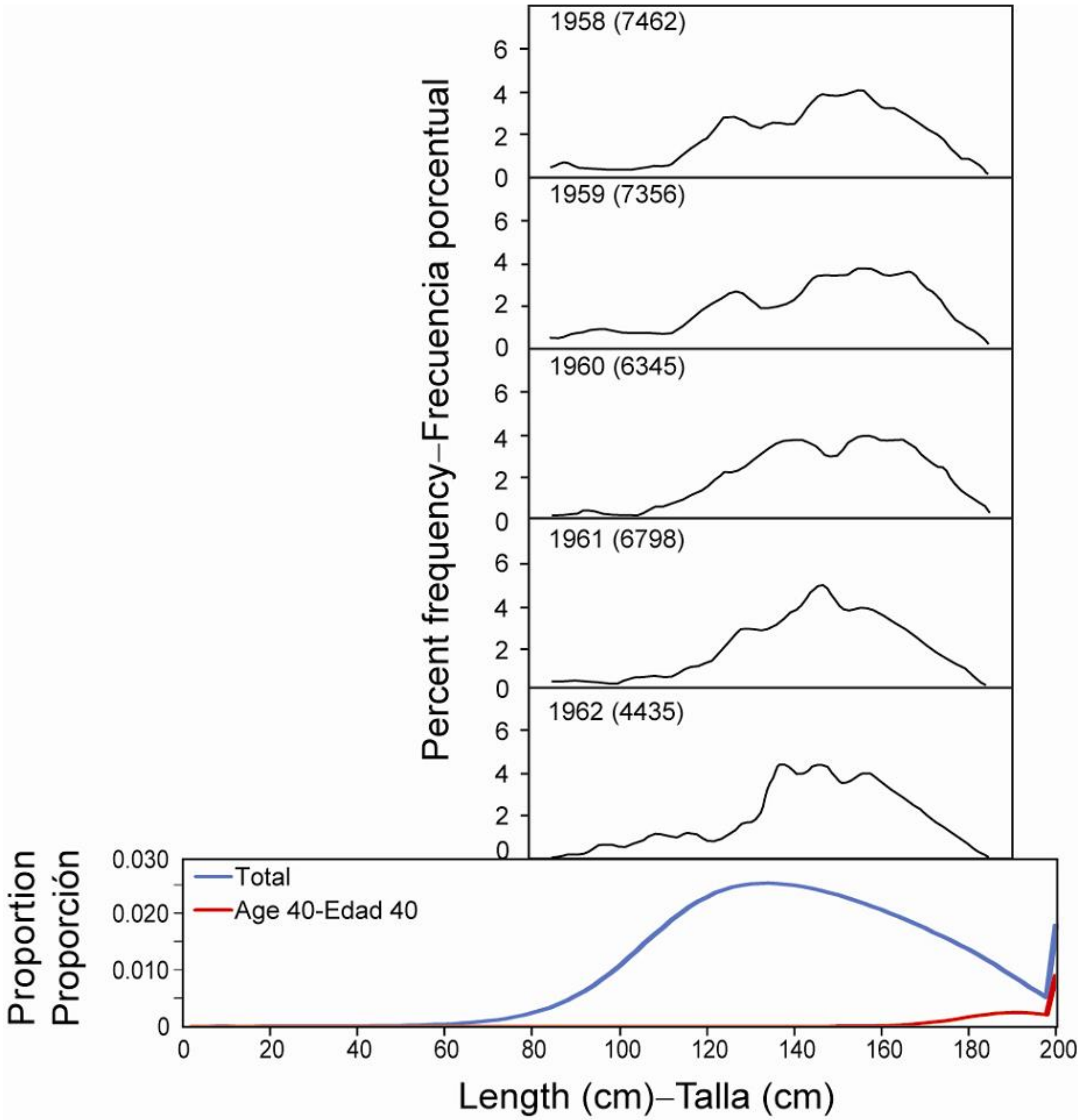

FIGURE 4. Length-frequency distributions for longline-caught bigeye tuna in the EPO (1958-62; upper 5 panels; source: Kume and Joseph, 1966) and the length-frequency distribution corresponding to applying the longline selectivity from the base-case model to an unfished population length-structure.

FIGURA 4. Distribuciones de frecuencia de talla de atún patudo capturado con palangre en el OPO (1958-62; 5 paneles superiores; fuente: Kume y Joseph, 1966) y la distribución de frecuencia de tallas correspondiente a la aplicación de la selectividad de palangre del modelo de caso base a la estructura de tallas de una población no pescada.

APPENDIX A - DOCUMENTS PRESENTED TO PANEL

Maunder, M. N., A. Aires-da-Silva, and C. E. Lennert-Cody. 2010. Summary of issues in the eastern Pacific Ocean bigeye tuna assessment. Document BET-01-01 (draft). External review of the IATTC bigeye tuna assessment. La Jolla, California (USA), 3-7 May 2010.

Lennert-Cody, C. E., M. N. Maunder, and A. Aires-da-Silva. 2010. Preliminary analysis of spatial-temporal pattern in bigeye tuna length-frequency distributions and catch-per-unit-effort trends. Document BET-01-02a (draft). External review of the IATTC bigeye tuna assessment. La Jolla, California (USA), 3-7 May 2010.

Aires-da-Silva, A., and M. N. Maunder. 2010. An evaluation of spatial structure in the stock assessment of bigeye tuna in the eastern Pacific Ocean. Document BET-01-02 (draft). External review of the IATTC bigeye tuna assessment. La Jolla, California (USA), 3-7 May 2010.

Aires-da-Silva, A., and M. N. Maunder. 2010. Sensitivity analysis of bigeye stock assessment to alternative growth assumptions. Document BET-01-03 (draft). External review of the IATTC bigeye tuna assessment. La Jolla, California (USA), 3-7 May 2010.

Maunder, M. N., and A. Aires-da-Silva. 2010. Investigation of catch-per-unit-of-effort data used in the eastern Pacific Ocean bigeye assessment model. Document BET-01-04 (draft). External review of the IATTC bigeye tuna assessment. La Jolla, California (USA), 3-7 May 2010.

Aires-da-Silva, A., M. N. Maunder and C. E. Lennert-Cody. 2010. An investigation of the longline fishery length-frequency residual pattern in the stock assessment of bigeye tuna in the eastern Pacific Ocean. Document BET-01-05 (draft). External review of the IATTC bigeye tuna assessment. La Jolla, California (USA), 3-7 May 2010.

Aires-da-Silva, A., M. N. Maunder, and P. K. Tomlinson. 2010. An investigation of the trend in the estimated recruitment for bigeye tuna in the eastern Pacific Ocean. Document BET-01-06 (draft). External review of the IATTC bigeye tuna assessment. La Jolla, California (USA), 3-7 May 2010.

Maunder, M. N., C. E. Lennert-Cody A. Aires-da-Silva, W. H. Bayliff, P. K. Tomlinson, and K. M. Schaefer. 2010. Summary of data available for bigeye tuna in the eastern Pacific Ocean and its use in stock assessment. Document BET-01-07 (draft). External review of the IATTC bigeye tuna assessment. La Jolla, California (USA), 3-7 May 2010.

APPENDIX B - ADOPTED AGENDA

SESSION 1, Monday morning:
Data issues. What data are available to the Commission for bigeye tuna stock assessment? Which data are used? How do these data enter into the stock assessment process? Indices of abundance, size and age distributions, tagging data, oceanographic data; Document BET-01-07.

SESSION 2, Monday afternoon:
Growth issues. Alternative growth models, variance of length at age; Document BET-01-03

SESSION 3, Tuesday morning:
Spatial issues. Size at age, selectivity, movement and mortality, variability in CPUE trends; Documents BET-01-02a and BET-01-02b

SESSION 4, Tuesday afternoon:
Changes with time. Catchability and selectivity, evolution of effort, expansion of fishing grounds; Documents BET-01-04 and BET-01-05

SESSION 5, Wednesday morning:
Stock and recruitment. Effects of growth of surface fishery on recruitment estimates; Document BET-01-06

SESSION 6, Wednesday afternoon:

Assessment methods. Current method, model improvement, biological research to reduce model specification errors, environmental covariates, ...

SESSION 7, Thursday morning:
Issues arising from sessions 1-6.
Public comment.

SESSION 8, Thursday afternoon:
Issues arising from sessions 1-6 (continued).

SESSION 9, Friday
Panel to work on report

APPENDIX C – LIST OF PARTICIPANTS

Panel Members				
Harley	Shelton	Secretariat of the Pacific Community	New Zealand	sheltonh@spc.int
Ianelli	Jim	NOAA/National Marine Fisheries Service	USA	jim.ianelli@noaa.gov
Punt	Andre	University of Washington	USA	aepunt@u.washington.edu
Sibert	John	University of Hawaii	USA	sibert@hawaii.edu
Participants				
Aríz	Javier	Instituto Español de Oceanografía	Spain	javier.ariz@ca.ieo.es
Barbieri	María	Pontificia Universidad Católica de Valparaíso	Chile	angela.barbieri@ucv.cl
Crone	Paul	NOAA/National Marine Fisheries Service	USA	paul.crone@noaa.gov
Donnelly	Marydele	Caribbean Conservation Corporation	USA	marydele@cccturtle.org
Dreyfus	Michel	Instituto Nacional de la Pesca	México	dreyfus@cicese.mx
Fissel	Benjamín	UCSD	USA	ben.fissel@noaa.gov
Fonteneau	Alain	Institut de Recherche Pour le Developpement	France	fonteneau@ird.fr
Fox	William	World Wildlife Fund	USA	bill.fox@wwfus.org
García	José	Subsecretaría de Recursos Pesqueros	Ecuador	jlgarcia@pesca.gov.ec
Janofsky	Eric	NOAA/National Marine Fisheries Service	USA	aric.janofsky@noaa.gov
Martínez	Jimmy	Subsecretaría de Recursos Pesqueros	Ecuador	jimmy.martinez@pesca.gov.ec
Miyabe	Naozumi	National Research Institute of Far Seas Fisheries	Japan	miyabe@fra.affrc.go.jp
Miyake	Makoto	National Research Institute of Far Seas Fisheries	Japan	p.m.miyake@gamma.ocn.ne.jp
Monteagudo	Juan	OPAGAC	Spain	opagac@arrakis.es
Piner	Kevin	NOAA/National Marine Fisheries Service	USA	kevin.piner@noaa.gov
Squires	Dale	NOAA/National Marine Fisheries Service	USA	dsquires@ucsd.edu
Sun	Jenny	Nationa Taiwan Ocean University	USA	jennysun@ucsd.edu
Teo	Steven	NOAA/National Marine Fisheries Service	USA	steve.teo@noaa.gov
Yáñez	Eleuterio	Pontificia Universidad Católica de Valparaíso	Chile	eyanez@ucv.cl

IATTC Staff		
Compeán	Guillermo	gcompean@iattc.org
Da-Silva	Alexandre	alexdasilva@iattc.org
Deriso	Rick	rderiso@iattc.org
Hall	Martin	mhall@iattc.org
Hinton	Michael	mhinton@iattc.org
Lennert	Cleridy	clennert@iattc.org
Maunder	Mark	mmaunder@iattc.org
Schaefer	Kurt	kschaefer@iattc.org
Tomlinson	Pat	ptomlinson@iattc.org

APPENDIX D - PANEL BIOGRAPHIES

John Sibert *(Chair)* is Emeritus Researcher at the School of Ocean and Earth Science and Technology at the University of Hawaii. He received a BA in zoology from the University of the Pacific and a Ph D in zoology from Columbia University. He was a post-doctoral fellow in the Institute of Oceanography at the University of British Columbia. He worked for many years at the Pacific Biological Station in Nanaimo, British Columbia, before moving to a position in the Tuna and Billfish Assessment Programme at the South Pacific Commission in Noumea, New Caledonia. More recently he was the Manager of the Pelagic Fisheries Research Program at the University of Hawaii. He serves on the Scientific and Statistical Committee of the Western Pacific Regional Fishery Management Council and has served on the United States delegation to the Western and Central Pacific Fisheries Commission. His research interests include analysis of large-scale tuna movement and stock assessment.

Shelton Harley is currently a Principal Scientist with the Oceanic Fisheries Programme of the Secretariat of the Pacific Community (SPC) where he leads the Stock Assessment and Modelling Section. He received his PhD in Biology from Dalhousie University in 2002. Dr Harley has been involved in undertaking and reviewing tuna stock assessments for several tuna RFMOs, and is currently the lead scientist responsible for the Western and Central Pacific Ocean bigeye tuna assessment. His research interests include stock assessment methods, development of reference points, and methods for evaluating management options, and he has a strong interest in the provision of advice to fishery managers.

James Ianelli is an affiliate professor at the University of Washington and a stock assessment scientist with the Resource Ecology and Fisheries Management division of the Alaska Fisheries Science Center. He earned his PhD in Fisheries Science at the University of Washington in 1993, and is part of the stock assessment team responsible for producing annual assessments of a number of important groundfish species in the North Pacific. His research interests include developing statistical approaches for ecosystem/fisheries conservation management. He chairs the North Pacific Fishery Management Council's groundfish Plan Team and serves on the Advisory Panel for the Commission for the Conservation of Southern Bluefin Tuna. He is a senior editor for the journal "Natural Resource Modeling". Most recently he has served as an advisor to the South Pacific Regional Fisheries Management Organization involved with assessments of Chilean jack mackerel.

André E. Punt is a Professor of Aquatic and Fishery Sciences at the University of Washington. He received his B.Sc, M.Sc and Ph.D. in Applied Mathematics at the University of Cape Town. Before joining the University of Washington, Dr Punt was a Principal Research Scientist with the CSIRO Division of Marine and Atmospheric Research. His research interests include the development and application of fisheries stock assessment techniques, bioeconomic modelling, and the evaluation of the performance of stock assessment methods and harvest control rules using the Management Strategy Evaluation approach. He has published over 160 papers in the peer-reviewed literature, along with over 400 technical reports. Dr Punt is currently a member of the Scientific and Statistical Committee of the Pacific Fishery Management Council, the Crab PLAN Team of the North Pacific Fishery Management Council, and the Scientific Committee of the International Whaling Commission.