INTER-AMERICAN TROPICAL TUNA COMMISSION

SCIENTIFIC MEETING

La Jolla, California (USA)
29 April-3 May 2013

MEETING REPORT

Chairman: Guillermo Compeán

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The 4th Meeting of the Scientific Advisory Committee was held in La Jolla, California, USA, on 29 April-3 May 2013. The attendees are listed in Appendix A.

1. Welcome, introductions, meeting arrangements

The meeting was called to order on 29 April 2013 by the Chairman, Guillermo Compeán, Director of the IATTC, who thanked the attendees for coming to the meeting. The Scientific Advisory Committee (SAC) was established by the Antigua Convention, and is composed of one representative designated by each member of the Commission. Only 12 members of 14 that were registered were present at the meeting, and the required two-thirds quorum was therefore not met. Pending the arrival of additional delegates, which did not materialize in the end, one participant noted that the presence of a quorum this year would be new for the SAC, and asked for clarification regarding the adoption of the report and recommendations of the meeting. Guillermo Compeán referred to provisions of Article XI, paragraph 7, of the Antigua Convention and confirmed that consensus was needed to adopt such recommendations. In the absence of consensus, the reports would reflect the majority and minority views.

2. Consideration of agenda

Guillermo Compeán reviewed the provisional agenda. He noted that this year there is an additional day of meetings for the SAC. One participant requested discussion of the issue of public domain data, and asked for an opportunity to make a short presentation on the subject, which was accepted under Item 16, *Other business*. Another participant requested discussion about the species that are associated with or dependent on tunas, in order to get clarification on which species are under the purview of the IATTC. This item was also accepted under Item 16, *Other business*. The agenda was approved without further changes.

3. The fishery in 2012 (SAC-04-03)

Nick Vogel reviewed the information on the fishery for tunas in the eastern Pacific Ocean (EPO) in 2012. He discussed EPO tuna catch statistics for 2012, including: total catches by species and by flag, purse-seine catch distributions for yellowfin, skipjack and bigeye, and size compositions of the three species. The catches of yellowfin, skipjack, bigeye, and Pacific bluefin tunas by purse-seine, pole-and-line, and recreational gear in 2012 of 537,000 metric tons (t) were about 25% less than the record catches in 2003, and about 16,000 t lower than the 15-year average of catches.

Colombian, Ecuadorian, Mexican, Panamanian, and Venezuelan vessels caught about 91% of the yellowfin, while Ecuadorian vessels caught about 59% of the skipjack and 63% of the bigeye.

The yellowfin catch distributions for 2012 were about the same as the average annual distributions for 2007-2011 in the inshore areas off southern Mexico and Central America. Yellowfin catches on unassociated schools decreased in the inshore area off Central America. There was an increase in the yellowfin catches on dolphins in the offshore areas around the equator. Yellowfin catches on floating objects increased in the inshore area off Peru, and were similar to the average annual distributions for 2007-2011 for the rest of the EPO. Yellowfin catches in 2012 of 190,000 t were 20,000 t lower than the 2007-2011 average, a 9% decrease.

The skipjack catch inshore off Ecuador was less in 2012 than the average annual catches during 2007-2011. A larger proportion of skipjack was caught on floating objects than in past years, especially in the area around the Galapagos Islands. Skipjack catches in 2012 of 271,000 t were 38,000 t higher than the 2007-2011 average, a 16% increase.

The bigeye catch distributions in 2012 were very similar to the average annual distributions for 2007-2011 throughout the EPO. The majority of the bigeye catches occurred between 10°N and 15°S on floating objects. Bigeye catches in 2012 of 69,000 t were 3,000 t higher than the 2007-2011 average, a 4% increase.

Nick Vogel also showed the length-frequency and species-composition sampling areas, and described the areas defined for stock assessments. Of the 954 wells sampled for length frequency and species composition in 2012, 592 contained yellowfin, 546 contained skipjack, and 196 contained bigeye. The average sizes of yellowfin in 2012 were greater than those of 2011 and 2010, but less than the 5-year high of 2009. The average sizes of skipjack were similar to those of the previous five years. The average size of bigeye in 2012 was less than that of 2011, but similar to the average for the previous five years.

One participant noted that the number of sets on fish associated with floating objects was very large during 2012, and asked for any opinions on the underlying reasons. Nick Vogel indicated that the staff did not have those figures readily available, but would examine the data and present an answer later in the meeting. Another participant commented on the use of the reference capacity of 158,000 metric tons for the fleet, and suggested that this capacity should be revisited, since the efficiency of the vessels continues to increase. Guillermo Compeán noted that these capacities are often presented to offer a view of the evolution of the fleet from year to year. A discussion developed regarding the decreasing catches of yellowfin in inshore areas off Central America. Nick Vogel suggested that closures or climate changes might have had an effect on these catches. Guillermo Compeán also pointed out that some vessels that target yellowfin were withdrawn from the fishery. Korea noted that its longline fishery data held at IATTC are different from those provided by Korea, and one participant noted that the longline fleet of Korea was shown to be changing considerably and asked for clarification of this trend. It was noted that the fishery data are provided by the individual countries to the IATTC staff and that it may not be clear why individual countries exhibit different trends, but that any updates or corrections are welcomed by the IATTC staff.

One participant asked about the timing of including all longline data in the fishery year report. Guillermo Compeán noted that longline data is not reported to the IATTC until June of the following year, due to the logistics of the long-distance longline vessels. Therefore, sometimes the staff does not receive complete longline data prior to the SAC meeting. Several participants noted that the fishery data by set type for multiple-year periods in the report may be influenced by oceanographic factors in different years and seasons. It was suggested that these data may be very raw and may require a year-by-year analysis as well as multiple-year analysis. It was noted that numbers and well volumes of purse seiners increased in previous years. It was also pointed out that overcapacity is a concern and is likely to affect the stocks. Guillermo Compeán indicated that the purpose of the staff's Fishery Status Reports is to present a general overview of the evolution of the fishery, and that specific details of factors affecting individual stocks are covered in the individual stock assessments.

4. Yellowfin tuna

4a. Recommendations of the external Review Panel (SAC-04-INF A)

Mark Maunder reviewed the recommendations of the Review Panel on the IATTC assessment of yellowfin tuna.

A participant expressed disagreement with the recommendation to shorten the time series, starting the model in the year 2000. Given the existence of some 60 years of data, he said that analyses of the condition of the fishery should be based on the full time period. Mark Maunder explained that some fundamental parameters such as growth may have changed during the 60-year period, although they are usually assumed to be constant over time. Also, Cleridy Lennert-Cody pointed out that information on species and size composition of the catch, based on an improved port-sampling method, was not available prior to 2000. Alexandre Aires-da-Silva added that the computation time is excessive when running the model with the full time series. The conclusions of the models for the Indian Ocean and the EPO are very different, and the Indian Ocean Tuna Commission (IOTC) recommended a meeting between the IOTC and IATTC to compare the models. Rick Deriso mentioned that the natural mortality rate (M) used in the western and eastern Pacific are essentially the same, but the M used in the Indian Ocean is quite different. Also, the average recruitment in the short time series will not be the same as that over a long time series, and the estimates of the spawning stock at the maximum sustainable yield (MSY) level can be greatly affected by differences in the average recruitment. Alexandre Aires-da-Silva welcomed this collaboration, and suggested the need to look closely at appropriate data-weighting schemes. Another participant agreed with the staff that it is important to streamline the analyses if the model is insensitive to cutting off the data for the early time periods. The Venezuelan program began 100% observer coverage in 1992, but they found that it was more appropriate to use data for 2000 onwards.

Other questions concerned the report's indication that the catch-per-unit-of-effort (CPUE) data are not reliable, and the possibility of splitting the area north and south or east and west. Mark Maunder indicated that other information, such as tagging data, could be used as an alternative to an index of abundance. However, that sort of program is not yet implemented. Regarding modeling the tropical EPO stock in two areas, Mark Maunder explained that the staff would need to consider the size structure of the population and the spatial structure of the fishery.

4b. Yellowfin assessment for 2012 (SAC-04-04b)

Carolina Minte-Vera presented the most current stock assessment of yellowfin tuna (*Thunnus albacares*) in the EPO. An integrated statistical age-structured stock assessment model, Stock Synthesis (Version 3.23b), was used in the assessment, which is based on the assumption that there is a single stock of yellowfin in the EPO. This model is the same as that used in the previous assessment, and is also used for the current assessment of bigeye tuna.

The stock assessment requires substantial amounts of information, including data on retained catches, discards, indices of abundance, and the size compositions of the catches of the various fisheries. Assumptions have been made about processes such as growth, recruitment, movement, natural mortality, fishing mortality, and stock structure. The assessment for 2012 is identical to that of 2011 except for updated and new data. The staff performed substantial investigative analyses in preparation for the external review of its assessment of yellowfin tuna, held in October 2012. The review resulted in a series of recommendations (Document SAC-04-INF A), which will be incorporated in an updated model for future assessments.

The catch data for the surface fisheries have been updated and new data added for 2012. New or updated longline catch data are available for China (2009, 2011), Chinese Taipei (2010-2011), Japan (2009-2011), Korea (2011), the United States (2010-2011), and Vanuatu (2005-2011). Surface fishery CPUE data were updated, and new CPUE data added for 2012. New or updated CPUE data are available for the Japanese longline fleet (2008-2011). New surface-fishery size-composition data for 2012 were added. New or updated length-frequency data are available for the Japanese longline fleet (2006-2011). For fisheries with no new data for 2012, catches were assumed to be the same as in 2011.

In general, the recruitment of yellowfin to the fisheries in the EPO is variable, with a seasonal component. This analysis and previous analyses indicate that the yellowfin population has experienced two, or possibly three, different recruitment productivity regimes (1975-1982, 1983-2002, and 2003-2011). The recruitments for 2010 and 2011 were estimated to be below average. The most recent recruitment (2012) was estimated to be above average, but this estimate is highly uncertain. As in previous assessments, a retrospective pattern is evident in the estimation of most recent recruitments. The wide confidence intervals of the estimate of recent recruitment, combined with this retrospective pattern, result in uncertain estimates of recent biomass. The productivity regimes correspond to regimes in biomass, with higher-productivity regimes producing greater biomass levels. A stock-recruitment relationship is also supported by the data from these regimes, but the evidence is weak, and this is probably an artifact of the apparent regime shifts.

The average weights of yellowfin taken from the fishery have been fairly consistent over time, but vary substantially among the different fisheries. In general, the floating-object, northern unassociated, and pole-and-line fisheries capture younger, smaller yellowfin than do the southern unassociated, dolphin-associated, and longline fisheries. The longline fisheries and the dolphin-associated fishery in the southern region capture older, larger yellowfin than the northern and coastal dolphin-associated fisheries.

Substantial levels of fishing mortality have been estimated for the yellowfin fishery in the EPO). These levels are highest for middle-aged yellowfin. Historically, the dolphin-associated and unassociated purse-seine fisheries have the greatest impact on the spawning biomass of yellowfin, followed by the floating-object fisheries. In more recent years, the impact of the floating-object fisheries has been slightly greater that that by unassociated fisheries. The impacts of the longline and purse-seine discard fisheries are much less, and have decreased in recent years.

There has been a large retrospective pattern of overestimating recent recruitment. This pattern, in combination with the wide confidence intervals of the estimates of recent recruitment, indicates that these estimates and those of recent biomass are uncertain.

The spawning biomass ratio (the ratio of the spawning biomass to that of the unfished population; SBR) of yellowfin in the EPO was below the level corresponding to the maximum sustainable yield (MSY) during 1977-1983, coinciding with the low productivity regime, but above that level during most of the following years, except for the recent period (2005-2007 and 2010-2012). The 1984 increase in the SBR is attributed to the regime change, and the recent decrease may be a reversion to an intermediate productivity regime. The different productivity regimes may support different MSY levels and associated SBR levels. The SBR at the start of 2013 was estimated to be 0.22, below the MSY level (0.26). The recent SBR levels (2011-2012) estimated by the current assessment are more pessimistic than those produced by the previous assessment, which indicated a sharp decline in the levels of spawning biomass since 2009 followed by an increase in 2011 (IATTC Stock Assessment Report 13). In the current assessment, the recent SBR levels off. This result is due to an increase in the fishing mortality levels for middle-age yellowfin tuna since 2009, which is estimated by the current assessment. The effort is estimated to be at the level that would support the MSY (based on the current distribution of effort among the different fisheries), and recent catches are at that level. It is important to note that the curve relating the average sustainable yield to the long-term fishing mortality is flat around the MSY level. Therefore, moderate changes in the long-term levels of effort will change the long-term catches only marginally, while changing the biomass considerably. Reducing fishing mortality below the MSY level would result in only a marginal decrease in the long-term average yield, with the benefit of a relatively large increase in the spawning biomass. In addition, if management is based on the base case assessment (which assumes that there is no stock-recruitment relationship), when in fact there is such a relationship, there would be a greater loss in yield than if management is based on assuming a stock-recruitment relationship when in fact there is no relationship.

The MSY calculations indicate that, theoretically at least, catches could be increased if the fishing effort were directed toward longlining and purse-seine sets on yellowfin associated with dolphins. This would also increase the SBR levels.

The MSY has been stable during the assessment period (1975-2012), which suggests that the overall pattern of selectivity has not varied a great deal through time. However, the overall level of fishing effort has varied with respect to the MSY level.

If a stock-recruitment relationship is assumed, the outlook is more pessimistic, and current effort is estimated to be above the MSY level. Previous assessments have indicated that the status of the stock is also sensitive to the value assumed for the average size of the oldest fish, and more pessimistic results are obtained when larger values are assumed for this parameter. At current (2010-2012) levels of fishing mortality and average levels of recruitment, the spawning biomass is predicted to increase slightly and remain at the MSY level. However, the confidence intervals are wide, a retrospective pattern exists in recent recruitment, and there is a moderate probability that the SBR will be substantially above or below this level. In addition, the spawning biomass is predicted to remain below the MSY level if a stock-recruitment relationship is assumed. Fishing at F_{MSY} (as well as fishing at recent effort levels) is predicted to both increase the spawning biomass and the catches under the assumption of average recruitment and no stock-recruitment relationship (base case). Fishing at recent effort levels is predicted to produce slightly lower catches if in fact such a relationship exists.

Key Results

1. There is uncertainty about recent and future levels of recruitment and biomass. There have been two, and possibly three, different productivity regimes, and the MSY levels and the biomasses corresponding to the MSY may differ among the regimes. The population may have recently switched from a high to an intermediate productivity regime.
2. The recent fishing mortality rates are at the MSY level, and the recent levels of spawning biomass are estimated to be below that level. As described in IATTC Stock Assessment Report 13 and previous assessments, these interpretations are uncertain, and highly sensitive to the assumptions made about the steepness parameter of the stock-recruitment relationship, the average size of the older fish, and the assumed levels of natural mortality. The results are more pessimistic if a stock-recruitment relationship is assumed, if a higher value is assumed for the average size of the older fish, and if lower rates of natural mortality are assumed for adult yellowfin;
3. The recent levels of spawning biomass predicted by the current assessment are more pessimistic than those from the previous assessment (IATTC Stock Assessment Report 13). This result is due to a recent increase in the fishing mortality levels for middle-age yellowfin tuna since 2008 which is estimated by the current assessment.
4. Increasing the average weight of the yellowfin caught could increase the MSY.

Following Carolina Minte-Vera's presentation, a participant asked why the spawning biomass of yellowfin is so low, less than 1% of the total biomass, but about 25% for bigeye. The estimate for yellowfin is based on the number of eggs that are produced using estimates of batch fecundity, spawning frequency, and proportion mature by size or age. So, it is an index and not a true biomass estimate *per se*. For bigeye, the estimate is an absolute measure of spawning biomass based on maturity data.

Another question focused on the forward projections, specifically how the uncertainty bounds are generated and what assumptions are made about recruitment. Carolina Minte-Vera explained that average recruitment and three-year averages of fishing mortality are used.

A participant noted that MSY has been extremely stable the last few years, but this appears to be a contradiction due to changes in the environment. The fishing mortalities are based on age over time, but do not take into account recruitment over time and over different environmental regimes. It was explained that the calculations only took consideration of changes in fishing mortality at age. Previous assessments have presented the influence of different recruitment regimes (years to average recruitment) in the calculation of MSY and related quantities. The participant further suggested that fishing mortality at age should be taken into account, and the L_2 length estimate should be lower than 160 cm because such large fish may not occur in the catch. Alexandre Aires-da-Silva acknowledged that fish of that size may not be available in the population any more, and that this is an important aspect that will be examined using the latest tagging data.

There was a question about what the report of the external Review Panel states about the stock-recruitment steepness parameter (h) and the stock-recruitment relationship. The report recommended continuing examining sensitivities to the steepness parameter in greater detail, by continuing to provide steepness options (h = 1, h = 0.75) and provide likelihood profiles over steepness. IATTC staff also mentioned that management strategy evaluations will be performed in the future, including different values of steepness, and separate northern and southern stocks.

A participant asked why a fixed coefficient of variation (CV) of 0.2 was used for the southern longline fishery, while others were estimated. Carolina Minte-Vera pointed out that currently this index is assumed to be the main index of abundance, and this is translated by assuming CV = 0.2 for this index and letting the model estimate the CV for the other indices, so the model will better fit the southern longline fishery standardized CPUE. In answer to a question about whether different recruitment indices are considered for yellowfin or bigeye in relation to oceanographic parameters, she explained that in the past the yellowfin model recruitment estimates were correlated with environmental variables. Currently, the immediate priority is to construct a model that best represents the population, considering the recommendations of the review panel. Following these recommendations, a model with a northern and a southern area will be constructed and different recruitment estimates will be obtained for those two areas that could then be correlated with environmental variables. The models have not yet been forced with oceanographic parameters.

Finally, a participant advised including only the Kobe plot with target reference points in the stock assessment document (SAC-04-04b) and to include the Kobe plot with limit reference points in a different document (SAC-04-09)..

4c. Analysis of CPUE indices (SAC-04-04c)

Cleridy Lennert-Cody presented an analysis of CPUE indices. Indices of relative abundance are an essential component of contemporary stock assessments, and standardization of indices is important to avoid bias. In the current yellowfin tuna assessment only longline indices are standardized. Because of the level of yellowfin catch by the purse-seine fishery and spatial distribution of effort of that fishery, computing a standardized purse-seine CPUE index may provide useful information to the assessment model. This presentation covers preliminary work on standardization of purse-seine CPUE data. Observer data of Mexican and Venezuelan vessels were used to compute standardized purse-seine indices for 1986-2012. The data set was limited to vessels making a minimum of 5% of their sets per year on tunas associated with dolphins, with a minimum of 3 years in the database. The data unit used in the analysis was a 1° area - month – trip. A delta-lognormal generalized additive model was used for CPUE standardization, with response variable metric tons yellowfin catch per day of fishing, and explanatory variables: year-quarter, latitude, longitude, gear and vessel characteristics (*e.g*., used of bird radar, sonar, purse-seine net length, vessel capacity), and vessel ID. Models were fitted separately to the data of Mexican vessels in purse-seine dolphin-set assessment areas 7 and 8, and to the data of Venezuelan vessels in assessment area 8. Standardized trends showed a general decline, except around the period 2001-2003. Standard errors for year-quarter effect coefficients were large, and the percent deviance explained and residual diagnostics indicated that model fit could be improved. Future work will focus on exploration of alternative ways of computing days fishing using detailed vessel activities recorded by observers, and also other distributional models for the CPUE data.

Following Cleridy Lennert-Cody's presentation, a participant asked why the use of helicopters was not considered, and whether the abundance of dolphins in the area of distribution was considered. Cleridy Lennert-Cody indicated that the vast majority of the vessel-trips in the data set analyzed had helicopters on board, and so this variable was not explicitly considered in this preliminary analysis. Because of the time line of the use of helicopters and bird radar, the bird radar effect estimated in the present analysis would also be capturing effects of the presence/absence of a helicopter on board. In the future, if indices continue to be based on aggregated data, it is intended to either explicitly model a helicopter effect or omit altogether any vessel-trips without helicopters onboard. However, an alternative that will also be explored is using detailed observer data on hourly vessel activities instead of aggregated data. In this type of analysis, detailed sighting information will be used for modeling the effects of different gear types and searching methods used by vessels. It is also intended to compute indices of abundance for dolphins, and the analyses of detailed daily observer data will be useful for the estimation of indices for yellowfin and for dolphins. The abundance of dolphins was not considered in the present analysis of yellowfin indices, but may be taken into consideration in some way in future analyses of the detailed observer data.

A discussion developed regarding the areas used in the analysis. A participant noted that, in Venezuela, there have been attempts to evaluate the areas in which the fleet has operated. The managers have asked what scientific parameters the Commission has used to set the port sampling areas, and justifying how the areas were chosen requires going back to reports in 1960. In was noted that Area 8 shown on the map is a continuous area along the entire coast of the EPO, although the vessels from the different countries may not fish in the area uniformly. It was explained that the current stock assessment areas for yellowfin were constructed by aggregating the port sampling areas, which are shown in the stock assessment reports and in IATTC Special Report 18. The port-sampling areas were largely developed in the 1960s, but were revised somewhat in the 1990s. The boundaries of these areas were informed by catch data available at the time. A review of the development of the IATTC port-sampling areas can be found in Special Report 18.

A participant asked about the possibility of simultaneously modeling data for multiple species. It was noted that with the methods of the present statistical approach, it is necessary to take into consideration the types of catch data available for the various species and the frequency distribution of the catch of each species, which will determine the types of statistical models that might be considered for the data. In addition, depending on the type of purse-seine set, the amounts of target and non-target species may or may not be related. In the case of dolphin sets, there is a chase prior to setting the net, and species other than tunas and dolphins may not remain together during the chase. In the case of floating-object sets, species may be attracted to the object, and a proxy for the object-associated community size might be considered in the analysis. This is done in the model used by IATTC for standardization of CPUE for the silky shark.

It was pointed out that gear characteristics may change over time, and modeling the gear only in terms of presence-absence aboard the vessel is insufficient. Sonar has been used for many years, but the effective range and efficiency have improved gradually in recent years. It was noted that IATTC continues to try to obtain data on specific features and models of gear such as bird radar and sonar that are used by vessels, but that this information has not been part of the standard data collected by observers. If possible, the ancillary information will be included in future analyses. A participant also pointed out that what may be more important than the depth of the net is the fishing depth of the net (the depth at which the net is pursed) and the time taken to complete various phases of the set. It was noted that the IATTC data on net depth represent the depth of the net in terms of length of net material. It was also noted that IATTC observers, however, do collect data on the duration of the various phases of the setting process. In the future analyses of detailed observer data, this set duration information will be taken into consideration.

4d. Spatial analysis (SAC-04-04d)

Cleridy Lennert-Cody presented an analysis of large-scale spatial patterns in yellowfin tuna catch data from purse-seine and longline fisheries, with the purpose of defining alternative fishery strata for the yellowfin tuna EPO stock assessment model. The analysis used purse-seine data for yellowfin tuna from sets on tunas associated with dolphins of large (size-class 6) vessels. Length-frequency data for 2000-2011 was obtained from the IATTC port sampling program. Catch (tons) and effort (days fishing) data for 1975-2011 was obtained from observer and logbook data. Japanese longline data for yellowfin tuna was used for the longline fishery. The length-frequency data were from the period 2002-2010, and the catch (numbers) and effort (number of hooks) data from 1975-2011. Catch data summaries were computed on a fine-scale spatial-temporal grid. For the purse-seine fishery, this grid was: 5° latitude by 5° longitude by quarter (Jan-Mar; Apr-Jun; Jul-Sep; Oct-Dec). For the longline fishery, this grid was: 5° latitude by 10° longitude by quarter. For each fishery, the length data were summarized by bin frequencies, and the catch-per-unit-effort (CPUE) data were summarized by smooth trends using regression splines. For each fishery, large-scale patterns in bin frequencies and smooth CPUE trends were explored using a tree-based method. The predictor variables were 5° latitude, 5° (10°) longitude, and quarter. The response variables were the bin frequencies, and the first-differenced smooth CPUE trends. The tree-based method simultaneously subdivides the two data types (frequencies, trends) into less heterogeneous subgroups using the predictor variables. It was found that longline and purse-seine catch data share some similar large-scale spatial structure within the EPO, in particular: i) a north/south partition of the EPO near the equator; ii) an east/west partition of the northern EPO at about 120°W; and, iii) an east/west partition of the southern EPO at about 90°-100°W. This similar spatial structure was used to define alternative assessment strata. Candidate stratifications were limited to 4 areas, and were based on partitions of latitude at 10° and longitude at 20° in order to accommodate the coarser spatial resolution of some of the historical longline data used in the stock assessment model.

A participant asked how the results of this analysis will be utilized in the future. Cleridy Lennert-Cody explained that, of the five candidate assessment stratifications considered, stratification (1) had been selected because it performed slightly better in terms of average variability explained. Whether or not this stratification will become a permanent replacement in the stock assessments depends on whether the stock assessment models produce more plausible results with the new stratification, which will be evaluated by the stock-assessment group. A participant found candidate stratification (1) a logical choice. Another participant questioned why candidate stratifications (1) and (3) are slightly different in the size of the southwest area. It was explained that the five candidate stratifications represent different four-area options that were based on the results of the tree analyses.

5. Bigeye tuna:

5a. Bigeye Assessment for 2012 (SAC-04-05a)

Alexandre Aires-da-Silva presented the most current stock assessment of bigeye tuna (*Thunnus obesus*) in the EPO. The integrated statistical age-structured stock assessment model (Stock Synthesis 3.23b), used for yellowfin, was also used in the assessment of bigeye.

Bigeye tuna are distributed across the Pacific Ocean, but the bulk of the catch is made to the east and to the west. The purse-seine catches of bigeye are substantially lower close to the western boundary (150ºW) of the EPO. Bigeye are not often caught by purse seiners in the EPO north of 10ºN, but a substantial portion of the longline catches of bigeye in the EPO is made north of that parallel. It is likely that there is a continuous stock throughout the Pacific Ocean, with exchange of individuals at local levels. The assessment is conducted as if there were a single stock of bigeye in the EPO, and there is minimal net movement of fish between the EPO and the western and central Pacific Ocean. Its results are consistent with the results of other analyses of bigeye tuna on a Pacific-wide basis. Data from recent tagging programs, which will help to provide estimates of movement between the EPO and the western and central Pacific Ocean, are being collected and analyzed.

The assessment assumptions have been improved since the previous full assessment conducted in 2010, which had already been modified following the recommendations of the external review of the IATTC staff's assessment of bigeye tuna, held in May 2010. The current bigeye assessment includes several improvements. First of all, a new Richards growth curve estimated externally from an integrated analysis of otolith age-readings and tag-recapture observations was introduced. This curve reduced in particular the uncertainty about the average size of the oldest fish (L_2 parameter). In addition, the parameters which determine the variance of the length-at-age were also taken from the new externally-derived growth estimates. Diagnostic analyses with the previous base case model configuration indicated a dominant influence of the size-composition data in determining the productivity (the R_0 parameter) of the bigeye stock, and conflicts among datasets were also found. As a result, improvements were made in the current assessment on the weighting assigned to the different datasets. Specifically, the size-composition data of all fisheries were down-weighted. In addition, the number of catch per unit of effort (CPUE) data series used as indices of abundance was reduced in order to minimize conflict trends among data sets. Rather than fitting to a total of ten CPUE series (two purse-seine indices and eight longline indices), a reduced set of indices of abundance was chosen to best represent the bigeye stock trends (the early and late periods of the Central and Southern longline fisheries).

The stock assessment requires a substantial amount of information. Data on retained catch, discards, CPUE, and size compositions of the catches from several different fisheries have been analyzed. Several assumptions regarding processes such as growth, recruitment, movement, natural mortality, and fishing mortality, have also been made. Catch and CPUE data for the surface fisheries have been updated, and include new data for 2012. New or updated longline catch data are available for China (2009 and 2011), Chinese Taipei (2009-2011), Japan (2009-2011), Korea (2011), the United States (2010-2011), and Vanuatu (2005-2011). Longline catch data for 2012 are available for China, Chinese Taipei, Japan, Korea, and Vanuatu from the monthly report statistics. New or updated CPUE data are available for the Japanese longline fleet (2009-2011). New purse-seine length-frequency data are available for 2012 and updates are available for 2011. New or updated length-frequency data are available for the Japanese longline fleet (2006-2011). A prominent feature in the time series of estimated bigeye recruitment is that the highest recruitment peaks of 1983 and 1998 coincide with the strongest El Niño events during the historic period of the assessment. There was a period of above-average annual recruitment during 1994-1998, followed by a period of below-average recruitment in 1999-2000. The recruitments were above average from 2001 to 2006, and were particularly strong in 2005. More recently, the recruitments were below average during 2007-2009, and have fluctuated around average during 2010-2012. The most recent annual recruitment estimate (2012) is slightly below average levels. However, this estimate is highly uncertain, and should be regarded with caution, due to the fact that recently-recruited bigeye are represented in only a few length-frequency data sets.

There have been important changes in the amount of fishing mortality caused by the fisheries that catch bigeye tuna in the EPO. On average, since 1993 the fishing mortality of bigeye less than about 15 quarters old has increased substantially, and that of fish more than about 15 quarters old has also increased, but to a lesser extent. The increase in the fishing mortality of the younger fish was caused by the expansion of the purse-seine fisheries that catch tuna in association with floating objects. It is clear that the longline fishery had the greatest impact on the stock prior to 1995, but with the decrease in longline effort and the expansion of the floating-object fishery, at present the impact of the purse-seine fishery on the bigeye stock is far greater than that of the longline fishery. The discarding of small bigeye has a small, but detectable, impact on the depletion of the stock.

Over the range of spawning biomasses estimated by the base case assessment, the abundance of bigeye recruits appears to be unrelated to the spawning potential of adult females at the time of hatching.

Since the start of 2005, the spawning biomass ratio (SBR; the ratio of the spawning biomass at that time to that of the unfished stock) gradually increased, to a level of 0.31 at the start of 2010. This may be attributed to a combined effect of a series of above-average recruitments since 2001, the IATTC tuna conservation resolutions during 2004-2009, and decreased longline fishing effort in the EPO. However, although the resolutions have continued to date, the rebuilding trend was not sustained, and the SBR gradually declined to a low historic level of 0.22 at the start of 2013. This decline could be related to a period dominated by below-average recruitments that began in late 2007 and coincides with a series of particularly strong la Niña events.

At the beginning of January 2013, the spawning biomass of bigeye tuna in the EPO appears to have been about 8% higher than S_{MSY}, and the recent catches are estimated to have been about 3% lower than the maximum sustainable yield (MSY). If fishing mortality is proportional to fishing effort, and the current patterns of age-specific selectivity are maintained, F_{MSY} is about 5% higher than the current level of effort.

According to the base case results, the most recent estimate indicates that the bigeye stock in the EPO is likely not overfished ($S>S_{\mathrm{MSY}}$) and that overfishing is not taking place ($F<F_{\mathrm{MSY}}$). In fact, the current exploitation is very close to the MSY target reference points. Likewise, interim limit reference points (0.5 S_{MSY} and 1.3 F_{MSY}) have not been exceeded under the current base case model. These interpretations, however, are subject to uncertainty, as indicated by the approximate confidence intervals around the most recent estimate in the phase plots. Also, they are strongly dependent on the assumptions made about the steepness parameter of the stock-recruitment relationship, the assumed levels of adult natural mortality, and the weighting assigned to the size-composition data.

The MSY of bigeye in the EPO could be maximized if the age-specific selectivity pattern were similar to that of the longline fisheries, because they catch larger individuals that are close to the critical weight. Before the expansion of the floating-object fishery that began in 1993, the MSY was greater than the current MSY and the fishing mortality was much less than F_{MSY}.

At current levels of fishing mortality, and if recent levels of effort and catchability continue and average recruitment levels persist, the SBR is predicted to further decline, to an historic low of 0.19 by 2015. After that, the SBR is predicted to gradually increase, and stabilize at about 0.21 around 2018, slightly above to the level corresponding to MSY (0.20). If a stock-recruitment relationship is assumed, it is estimated that catches will be lower in the future at current levels of fishing effort, particularly for the surface fisheries.

These simulations are based on the assumption that selectivity and catchability patterns will not change in the future. Changes in targeting practices or increased catchability of bigeye as abundance declines (*e.g*. density-dependent catchability) could result in differences from the outcomes predicted here.

Key Results

1. The results of this assessment indicate a recent recovery trend for bigeye tuna in the EPO (2005-2010), subsequent to IATTC tuna conservation resolutions initiated in 2004. However, a decline of the spawning biomass began at the start of 2011, persisted through 2012 and reduced both summary and spawning biomasses to their lowest historic levels at the start of 2013. This recent decline may be related to a series of recent below-average recruitments which coincide with a series of strong la Niña events. However, at current levels of fishing mortality, and if recent levels of effort and catchability continue and average recruitment levels persist, the SBR is predicted to stabilize at about 0.21, very close to the level corresponding to MSY.
2. There is uncertainty about recent and future recruitment and biomass levels.
3. The recent fishing mortality rates are estimated to be slightly below the level corresponding to MSY, and the recent levels of spawning biomass are estimated to slightly above that level. These interpretations are uncertain and highly sensitive to the assumptions made about the steepness parameter of the stock-recruitment relationship, the assumed rates of natural mortality for adult bigeye, and the weighting assigned to the size-composition data, in particular to the longline size-composition data. The results are more pessimistic if a stock-recruitment relationship is assumed, if lower rates of natural mortality are assumed for adult bigeye, and if a greater weight is assigned to the size-composition data, in particular the longline fisheries.

Following Alexandre Aires-da-Silva’s presentation, one participant commented on the complexity in possible causative factors in recruitment patterns of bigeye. Possible causative factors could include environmental periods, changes in oceanographic conditions, time and space distributions of fish, or changes in efficiency of fishing gear. Alexandre Aires-da-Silva agreed that this pattern has been persistent in the bigeye assessment: in fact, it is commonly found in tuna assessments in which there are abrupt changes in the mix of selectivities operating in the fishery. This is the case with bigeye, in which there is a rapid expansion of the floating-object fishery in the mid-1990s along with large samples of smaller fish which are strongly informative on recruitment. The pattern was substantially minimized (about halved) in the current base case model after down-weighting the longline size-composition data. Spatially-stratified assessment and natural mortality have also been shown in previous sensitivity analyses to minimize the pattern. Additional modeling process may be needed to eliminate remaining patterns, and the IATTC staff will explore these in future assessments.

Another participant commented on the impact of fixing L_2 and the variance of length-at-age, and on the model’s inability to respond through those parameters. It was suggested that a different fixed value of L_2 at a slightly lower level might produce a different outcome. Another comment was made regarding sensitivity to steepness, which is a big issue for MSY-based assessments. It was noted that the Western and Central Pacific Fisheries Commission (WCPFC) has chosen 20% of the unfished spawning biomass as a limit reference point for skipjack, yellowfin, bigeye, and south Pacific albacore. Management would need to ensure that spawning biomass has a high probability of remaining above this reference point. Alexandre Aires-da-Silva indicated that the staff will consider the effect of alternative L_2 assumptions in the next assessment, and will also investigate the logistic assumption taken for some longline fisheries and how it interacts with growth.

A discussion developed regarding the level of decline in the longline CPUE data. One participant noted a fairly minor decline in the longline CPUE, while Alexandre Aires-da-Silva interpreted the decline as being steady and more substantial. One participant pointed out that one weakness of the bigeye analysis is the assumption of a frontier at 150°W longitude, which seems artificial and unsupported by biological data. It was noted that a full-scale Pacific-wide bigeye stock assessment had been recommended for the Western Pacific, and it was suggested that the IATTC assessment should include a reference to this recommendation. Alexandre Aires-da-Silva indicated that the 150°W frontier is used as a management boundary, and cited new tagging data to be presented at this meeting which may challenge that assumption. Another participant noted that there are plans to revisit the idea of a Pacific-wide assessment of bigeye between Western Pacific assessment groups and the IATTC. However, there are difficulties in such an assessment due to differences in growth of bigeye across the Pacific. There are also differences in growth of bigeye between the Indian Ocean and the EPO, and growth measurements using otoliths are very difficult and can be problematic for bigeye. One participant cautioned that care should be taken to report the sex of recovered tagged adult bigeye. For example, in the Indian Ocean, large male bigeye that were tagged and recovered tended to be larger by 10 cm than the females, while the sex ratios of adult recovered bigeye were fairly consistent at 50:50, indicating a similar M for adult males and females.

A final discussion developed considering the relationship between oceanographic conditions and CPUE of bigeye. It was suggested that an analysis of abundance of bigeye and environmental conditions would be very instructive, especially the association between strong El Niño events and CPUE. Alexandre Aires-da-Silva indicated that sensitivity analyses are always conducted to establish a precautionary approach in the bigeye assessment.

5b. Analyses of Japanese longline catch and effort data for bigeye (SAC-04-05b)

Cleridy Lennert-Cody presented analyses of operational-level Japanese longline data for bigeye tuna in the eastern Pacific Ocean to study the effects of differences in fishing efficiency among vessels on the estimated long-term trend in the index of relative abundance. Negative binomial generalized linear models were fitted to the data from each of the four EPO stock assessment area used for longline. The response variable for these models was the catch of bigeye tuna (in number of fish) and the predictor variables were the year-quarter, the number of hooks, the 5° area, the number hooks between floats and the vessel call sign. Year-quarter effect coefficients from these models for three of the four areas were somewhat smaller than those from models without a vessel call sign effect, beginning in the mid-1990s. For the central stock assessment area, standardized trends from fitted models, with and without vessel call sign effects, suggest that when differences in fishing efficiency among vessels are taken into consideration, the long-term trend in the index is slightly more pessimistic. This result is consistent with findings of similar analyses of data for bigeye from the western Pacific Ocean. Inspection of residuals from the standardization models suggests that incorporation of environmental variables, and terms for interactions between the number of hooks between floats and location and environment, might help to improve model fit.

Following Cleridy Lennert-Cody's presentation, a discussion developed about the call-sign effect. She explained that including the call-sign effect in the standardization model allows the model to account for differences among vessels in their individual fishing efficiencies and to remove the effect of these differences on the estimate of the long-term CPUE trend. Call-sign information was not available prior to 1979. Cleridy Lennert-Cody explained that vessels with limited fishing effort between 1979 and 2011 were not included in the analysis, and that after excluding data of such vessels, the final data set retained 63-74% of the bigeye catch, depending on the assessment area.

A participant explained that the impetus for this work was the expectation that when a fleet is declining in size, it is likely that the more-efficient vessels would remain in the fishery and the lower-efficiency vessels would drop out, thus making the fleet more efficient overall. The South Pacific Commission (SPC) had discussed doing this sort of analysis for the fleets of longline fishing nations, since it would be very useful and valuable to compile the data in this form. The IATTC does not have operational longline data.

A question entailed if there are sufficient operational-level data available to compute standardized indices for all areas, not just the central area, which could be used in the stock assessment model for bigeye. Cleridy Lennert-Cody indicated that there are sufficient data for computing the standardized index for all areas.

A participant asked Cleridy Lennert-Cody to elaborate on a potential conclusion from presentations yesterday and today that the CPUE for longline gear in general is going down. Cleridy Lennert-Cody noted that the trend of the standardized index for the central area was slightly more pessimistic with the call-sign effect than without. Including standardized indices from models with vessel effects into the stock assessment has been suggested, but not yet been done. In response to a comment that Document SAC-04-05b mentioned an inversely proportional relationship between catches of yellowfin and bigeye, that was not in her presentation. Cleridy Lennert-Cody noted that the document referred to a qualitative comparison of maps of average CPUE for the two species, not an overall quantitative relationship. She explained that these maps appeared to indicate areas within the EPO where catch rates for both yellowfin and bigeye were higher or lower, or higher for one species but lower for the other. She noted that during her visit to Japan she did not have time to study this further.

Another participant asked if an exercise had been conducted to compare satellite images to a time series in areas where yellowfin and bigeye overlap, and whether there are areas that have been fully identified for each species. Cleridy Lennert-Cody explained that there was no opportunity to consider targeting or physical correlates during her visit to the National Research Institute of Far Seas Fisheries. Another participant suggested that satellite data are probably not necessary, because low oxygen levels are probably the factor that prevents longline vessels from catching bigeye at depth.

Rick Deriso stressed the staff’s interest in collaborating with scientists in member countries without having to travel, for example, obtaining remote access to data.

5c. Update on tagging program in the central Pacific (presentation only, no document)

Kurt Schaefer presented an update on the tagging program in the central Pacific Ocean (CPO). The tagging cruises have been highly successful, tagging and releasing 31,730 bigeye tuna, 31,243 with dart tags and 487 with archival tags. This was possible only because of the presence of the Tropical-Atmosphere Ocean (TAO) moorings at 140°W, 155°W, 170°W, and 180°W, the skill and efforts of the captains and crews of the chartered fishing vessels, and the governments and institutions that have supported the program.

Tag recovery percentages were 22.9% for dart tags, and 19.5% for archival tags. Times at liberty ranged from 0 to 1054 days (mean = 180.7), and linear displacements, from release to recapture positions, from 2.4 to 5176.0 nautical miles (mean = 1176.0). Of the 3,151 bigeye at liberty for 30 days or longer, 95% were recaptured within 3230 nm of their release positions. The linear displacements illustrate both eastward and westward movements, are mostly restricted to between about 10°N and 10°S, and spatial patterns vary depending on release location.

The archival tag data sets are being processed with the unscented Kalman filter model with sea-surface temperature (SST) measurements integrated in order to obtain improved estimates of geographic positions, most probable tracks, and movement parameters. The archival tag data sets processed to date for bigeye released at 140°, 155°, 170°, and 180°W indicate that these bigeye exhibited mostly restricted movements from their release locations, and fidelity to the CPO.

Both data sets indicate mixing among bigeye in the eastern, central, and western Pacific.

Following Kurt Schaefer's presentation, one participant asked whether any size-specific, sex-specific or timing effects had been noted in the movements of bigeye in the CPO. Kurt Schaefer indicated that these were preliminary results, and that many of those analyses had not yet been performed. However, published results for bigeye tagged in the EPO did not indicate definitive patterns of movements by size.

Another participant noted that the distributions of bigeye in the studies seemed related to the displacement of fish-aggregating devices (FADs) as they move from east to west, and it was suggested that perhaps there is noise in the data, since fish are caught and recaptured predominantly on FADs, thus creating some bias in the results. The question of the Pacific-wide stock structure of bigeye was also raised in relation to the tagging results. Kurt Schaefer indicated that the tagging studies were only possible because of the concentrations of bigeye around the TAO moorings, which act as FADs. Efforts had been made to disperse the schools tagged at the moorings by attracting the fish to lights and drifting away from the moorings . He suggested that the tagged bigeye had probably not developed an affinity to FADs any more than their conspecifics in the population. A publication in 2010 showed that only about 20% of bigeye remained associated with FADs, and that these were mostly smaller (< 60 cm) fish. In the CPO tagging, there was some restriction of the spatial distribution of bigeye because of their vulnerability, since they were mostly caught by purse-seine vessels. Regarding stock structure of bigeye, Kurt Schaefer offered the opinion that there is stock structure in both the CPO and EPO with some mixing of fish between the regions, citing the results of past genetic studies demonstrating no genetic differences in bigeye in the Pacific. Movements of thousands of miles in this study were limited, and most of the movement at 140°W was eastward. That is not to say there was no mixing between the EPO and CPO. Perhaps there are separate stocks in the EPO, CPO and WPO, with some mixing among them. Kurt Schaefer also noted published results indicating clear phenotypic differences in bigeye between the EPO and WPO, such as in growth rates, size at maturity, and maximum size, indicating evidence of stock separation across the Pacific.

Another participant expressed the hope that these results would soon be incorporated into the stock assessment. It was noted that the tagging results demonstrated that bigeye are highly mobile, that there is no barrier to movement at 150°W, and that there is considerable mixing between the CPO and EPO. The conclusion about eastward movement of fish at 140°W should be considered preliminary, since the movement must be connected to the fishery, which can have a large effect on the return data. Kurt Schaefer noted that this highlighted one of the inherent problems with the data from dart tags – the spatial patterns are highly dependent on the position of release and on fishing effort. Archival tagging data are very useful because they do not have the same biases, but the tags are very expensive.

A participant noted, from past tagging studies in the WPO, differences in behavior between bigeye associated with large islands and those in areas free of islands, with island-associated movements much more restricted and a far greater degree of movement in oceanic areas. It was suggested that one method for better understanding of these data in the context of stock structure is the use of spatially-structured population dynamics. As an example, the SPC is attempting to assimilate tagging data into the SEAPODYM model, which is driven by environmental variability.

Martín Hall referred to a map of the distribution of set types developed at a recent meeting of the International Seafood Sustainability Foundation (ISSF), which showed a striking difference in set type occurrence east and west of 150°W, with FAD fishing dominating in the east and a more balanced distribution of FAD and unassociated sets in the west. He cautioned that if the probability of recovering tags on FADs was different than in unassociated sets, this may influence the distribution of tag recoveries. He also noted that if there is an island effect, it may affect growth and, if tagging is more intensive in this area, then the growth parameters may show an island effect and may not be representative of overall pelagic growth rates.

A participant noted that large numbers of bigeye are tagged off Hawaii, and asked if there are any relationships apparent between those fish and the fish tagged in this CPO equatorial study. Kurt Schaefer reiterated that there was no apparent relationship between bigeye of those two regions. Of over 20,000 bigeye tagged in the EPO, there were few recaptures north of 10°N by either distant-water longline fleets or vessels fishing out of Hawaii. Also, none of the many bigeye tagged and released around Hawaii were recovered in the equatorial Pacific.

A discussion developed regarding the connection of bigeye movements with horizontal currents. One participant suggested that bigeye movements could be related to feeding in currents or oceanographic conditions in specific areas rather than migrations, and asked whether bigeye had been tagged in the high-seas area of the EPO closed to purse-seine fishing in October ("corralito"). Kurt Schaefer indicated that from archival data in the EPO, most bigeye remained in the area between 95 and 110°W. He agreed that tagging results in the CPO indicated greater movements compared to those in coastal areas and around islands, probably related to the productivity and oceanography of those regions. These differences in behavior could be addressed with archival tagging.

Guillermo Compeán noted that the bigeye fishery is well known, and is a fishery that has grown very fast in spatial terms, and it is important to adapt the research to the fishery. This is not a new issue: the IATTC has been looking at bigeye assessment constantly, and has a good collaborative relationship with the WCPFC in this regard. The purpose is to review the possibility of joint assessments, although the staff cannot make quick decisions when using new data. The staff will explore all possibilities and take into account all comments of the SAC when considering research planning.

6. Skipjack tuna:

6a. Indicators of stock status (SAC-04-6a)

Mark Maunder presented indicators of the stock status of skipjack tuna in the EPO. Eight data- and model-based indicators are used to evaluate the stock status based on relative quantities. Rather than using reference points based on MSY, they compared current values of indicators to the distribution of indicators observed historically. The results are updated to include data up to 2012. To evaluate the current values of the indicators in comparison to historical values, the staff uses reference levels based on the 5th and 95th percentiles, as the distributions of the indicators are somewhat asymmetric.

The purse-seine catch has been increasing since 1985, and has fluctuated around the upper reference level since 2003. The floating-object CPUE has generally fluctuated above the average level since 1990 and was at the upper reference level in 2011. The unassociated CPUE has been higher than average since about 2003, and was at its highest level in 2008; it declined in 2010, and then increased to around the upper reference level in 2012. The standardized effort indicator of exploitation rate increased starting in about 1991, but decreased in 2009 and 2010. The average weight of skipjack has been declining since 2000, and in 2009 was below the lower reference level, but increased slightly in 2010 and 2011, although it declined again in 2012. The biomass, recruitment, and exploitation rate have been increasing over the past 20 years, and have fluctuated at high levels since 2003. The biomass and recruitment were close to the upper reference level in 2012.

The main concern with the skipjack stock is the constantly increasing exploitation rate. However, this appears to have leveled off in recent years, and the effort has declined. The data- and model-based indicators have yet to detect any adverse consequence of this increase. The average weight was below its lower reference level in 2009, which can be a consequence of overexploitation, but can also be caused by recent recruitments being greater than past recruitments or expansion of the fishery into areas occupied by smaller skipjack. Any continued decline in average length is a concern and, combined with leveling off of catch and CPUE, may indicate that the exploitation rate is approaching, or above, the level associated with MSY.

Following Mark Maunder's presentation, one participant questioned the apparent trend of increasing recruitment in the analysis. It was suggested that the trend in increasing biomass of skipjack is probably due to increasing size of fishing zones rather than an increase in biomass, and is most likely related to a FAD and area effect, since most skipjack are caught around FADs.

Another participant noted that the average weight of skipjack was below its lower reference level in 2009, which could be evidence of overexploitation, due to a pattern of increased recruitment in recent years, or expansion of the fishery to the west where skipjack tend to be smaller. The question was asked as to how to find an answer among these causes. Mark Maunder indicated that it is difficult to distinguish between exploitation and recruitment effects, since catches and methods of exploitation are changing over time and skipjack are short-lived. Indicators such as CPUE are used, and this has not been declining for skipjack.

One participant noted that the price of skipjack can be another indicator of fishing pressure on the species, and indicated that the price value of skipjack is tracked in the WPO.

7. Assessments of other species

7a. Pacific bluefin tuna: Report of ISC Working Group

Yukio Takeuchi, chair of the ISC Pacific Bluefin tuna working group, reported the results of the latest stock assessment of Pacific bluefin tuna (PBF) conducted by ISC in 2012. Stock Synthesis was used as the stock assessment platform, using fishery data from 1952 to 2010. The results of the stock assessment indicated that the current (2010) PBF biomass level is near a historic low level and experiencing high exploitation levels above all potential biological reference points (BRPs). Extending the status quo (2007-2009) fishing levels is unlikely to improve the stock condition. The stock assessment results also indicated that recently implemented WCPFC (entered into force in 2011) and IATTC (entered into force in 2012) conservation and management measures combined with additional Japanese voluntary domestic regulations aimed at reducing mortality, if properly implemented and enforced, are expected to contribute to the recovery of the stock.

Based on those findings, the ISC concluded "It should be noted that implementation of catch limits is particularly effective in increasing future SSB (spawning stock biomass) when strong recruitment occurs. It is also important to note that if recruitment is less favorable, a reduction of *F* (fishing mortality) could be more effective than catch limits to reduce the risk of the stock declining."

Following Yukio Takeuchi's presentation, a discussion developed on a size limit for the Pacific bluefin fishery. The ISC bluefin working group did not evaluate the benefit of having a size limit, but the IATTC staff did a study of the benefit of increasing the average size of the fish in the catch. Presently, natural mortality estimates by age are used, based on tagging. Yukio Takeuchi suggested that another natural mortality schedule be considered, but those calculations have not been done.

Guillermo Compeán indicated that Mexico explored the possibility of having a size limit for the eastern Pacific bluefin fishery, limiting the fishery to fishes of age two or three. He also noted the problem of the catch of juveniles in this fishery, which has increased, and recognized the difficulties in regulating this fishery in Japan. The staff recommended a quota last year as a precautionary approach, and this year the staff reviewed this recommendation.

7b. Silky shark (no document, slide presentation available)

Alexandre Aires-da-Silva presented an update on the collaborative efforts to conduct a first stock assessment for the silky shark in the eastern Pacific Ocean (historic period 1993-2010). Since 2009, IATTC staff, national observer program staff, scientists of member countries and NGOs have worked together to accumulate, process, and analyze biological and fishery data for the silky shark in the EPO. This collaborative effort has produced a wealth of information on stock structure, biological parameters (length-weight, age and growth, reproduction), and fishery data (catch, effort, CPUE indices), and a silky shark stock assessment model was attempted with this information. Configuring a stock assessment model that is consistent with the data has been problematic. Incomplete knowledge of total catch for the EPO is a serious problem, particularly in the early period of the assessment.

Based on life history, genetics, and oceanographic information, there appear to be two populations, north and south of the equator, with the exception of the animals located near the South American coast but south of the equator being more closely allied with the northern stock. Based on the available data, the purse-seine and high-seas longline fisheries that target tuna in the EPO apparently take a minor component of the catch when compared to the fisheries of coastal and non-coastal nations that target the shark-billfish-tuna group. A great amount of knowledge was obtained about the length ranges and sexes taken by each fishery (length-selectivity curves), but there is substantial uncertainty in the historical catch for most fisheries and the following biological processes: the average length of the oldest sharks (the L_2 parameter), the variation of the length-at-age, natural mortality, and the stock-recruitment relationship. Taking these uncertainties into account, the stock assessment model predicts that the total biomass of silky sharks declined from 1993 to 2005, followed by a gradual rebuilding trend until 2010. This rebuilding coincided with the following events: 1) fishery closures associated with IATTC tuna conservation measures; 2) restrictions by Central American coastal nations of shark finning operations; 3) a decline of tuna longline fishing effort related to increased fuel prices. The stock assessment model also predicted that the current (2008-2010 average) fishing mortality rates will allow the stock size to increase in the future.

More recently, the IATTC staff updated available fishery indicators (*i.e*. standardized purse-seine CPUE) for the most recent years not covered by the stock assessment model. In contrast to the stock assessment predictions, updated purse-seine CPUE indices show declines in the catches of silky sharks during 2011-2012 for all three tuna set types (on floating objects, unassociated schools, and dolphins) and all areas in the EPO north of the equator, including the whole range of the floating-object fishery in the north. There are no substantial changes in the recent purse-seine and Mexican time series of average length that correspond to the decline in CPUE.

Although a full stock assessment report is still in progress, the staff considers that there is sufficient scientific information obtained from the stock assessment work and fishery indicators to provide recommendations for data collection and management. Regarding data collection, it is vital that all catches of silky sharks are reported by all fisheries that catch the species, whether as target or bycatch. This also applies to other species of sharks and billfishes for which stock assessments and conservation advice is desired. For stock assessment purposes, it would be useful to obtain information on catch, effort, length composition, sex composition by spatial resolution, growth, natural mortality, and reproductive biology. With respect to management advice, the IATTC recommends limiting fishing mortality rates to recent levels of 2008-2009 to allow further rebuilding.

Following Alexandre Aires-da-Silva's presentation, a question was posed regarding the declining trend in the abundance of silky sharks during 2011-2012, which appears to be too abrupt. Alexandre Aires-da-Silva agreed, noting that potential causes could be higher exploitation rates than those estimated for recent years (late 2000s), environmental changes, or a combination of both. Since there is no catch and effort information available for those two years, the staff cannot provide an explanation for this abrupt decline. If the fishery mortality rates estimated for 2008-2010 are applied, the stock is predicted to recover; therefore, the first step that countries should take is to limit fishing mortality of silky sharks to those levels. Improved data collection should be a priority, in order for future stock assessment work to be possible.

A participant from Ecuador noted the excellent job of the IATTC staff in collecting the information and conducting this analysis. Until updated information is available, there is an indication from recent data that the silky shark stock may be decreasing in Ecuador and other countries. Efforts should continue to rebuild the stock and to check if measures applied in countries of the EPO are appropriate. New estimates by Oscar Sosa and colleagues based on ageing vertebrae indicate that silky sharks are long-lived, with estimates of 18 years for males and 16 years for females. There was a discussion regarding the estimation of natural mortality in the analysis. Alexandre Aires-da-Silva indicated that a published method (Frisk's equation), which is widely applied to sharks, was used, with 0.2 as the annual estimate of natural mortality for age-1 and older fish, and a higher rate was assumed for age-0 sharks. A participant noted that there is information from an ISSF study in the Indian Ocean indicating cryptic mortality of sharks in nets hanging from FADs, so there could be higher mortality that observers are not able to document. Alexandre Aires-da-Silva expressed interest in learning more about this information on cryptic mortality related to sharks and FADs.

A participant asked about any recommendations for assessing silky sharks by area, perhaps north and south, and Alexandre Aires-da-Silva indicated that the best available science is the genetics work by J. Hyde (NMFS), which indicated two separate stocks around the equator. The current assessment was done for the northern stock where most of the exploitation occurs. Indicators are available for the southern stock. Cleridy Lennert-Cody added that spatial analysis, such as north-south stratification and further genetics and size composition comparisons, was ongoing. The question of differences in oceanographic parameters in the EPO was raised, and whether this could influence the spatial distribution of the species. Alexandre Aires-da-Silva agreed that an analysis of oceanographic influences on the distribution and abundance of silky sharks is promising, and indicated that the staff will continue to study the species by spatial stratification.

Martín Hall noted that there is an area of cooling in the northern region of the study area that is near an area of recruitment for the species. He also commented that the possible cryptic mortality observed in the Indian Ocean associated with FADs does not appear to occur in the EPO to the same extent, and indicated that in the EPO observers are quite often able to record fauna, such as turtles or sharks, entangled in FAD netting.

A participant noted the need for training and support for data collection and harmonization of databases regarding silky sharks, and that these efforts should be expanded so that multiple countries can access the data collection system. Guillermo Compeán added that the IATTC continues to work with Central American countries in this area, and has received help from the Overseas Fishery Cooperation Foundation (OFCF) of Japan.

A discussion developed regarding the contiguous nature of the distribution of silky sharks. Since these are contiguous distributions of floating-object sets, it is important to understand the abundance of individuals. Alexandre Aires-da-Silva noted that the staff used the floating-object index for this assessment, since reliable indices are not available for other fisheries (longline, for example), although there are concerns about hyperstability and other problems related to floating-object indices. However, the trends in abundance are very similar to those seen with other purse-seine set types (dolphin and unassociated). Considering these consistencies, the staff feels confident that the floating-object index is acceptable, although additional indices derived from longline data would be welcomed.

Martín Hall suggested that the number of floating objects deployed is available, particularly from the southern areas of the EPO, and could be added to the analysis. Another participant noted that there appears to be a stock-recruitment relationship for silky shark, and although the model has positive predictions, this is not the case in areas such as Colombia. Although very abundant in Colombia prior to 1995, silky sharks have decreased in abundance since the late 1990s, and appear to have been replaced by thresher sharks. It would be very informative to study nursery areas for the species in Central America, and feeding studies might be helpful in understanding abundance patterns in the EPO. Alexandre Aires-da-Silva agreed that these declines are consistent with the purse-seine and Mexican longline indices presented. In addition, localized depletion patterns must have occurred in the EPO region. Having access to finer-scale data would help the IATTC staff to understand these patterns better.

7c. Sailfish (SAC-04-07c)

Michael Hinton presented the results of the first assessment of sailfish in the eastern Pacific Ocean. The unrealistically low estimates of stock productivity that resulted from the assessment indicated that there are significant quantities of unknown or unreported catch. As long as this situation persists, it is not possible to provide reliable estimates of quantities of interest for management, such as MSY and stock productivity.

Based on the CPUE indices used in the model, the abundance of sailfish trended downward during 1994-2009, after which it remained relatively constant or increased slightly, based on the single abundance index available after 2009.

The reported level of recent catch is on the order of 500 t, which is significantly less than the average reported annual catch of about 2,100 t during 1993-2007. Considering the fisheries of the EPO, the actual catch prior to 1993 was likely at least on the order of the recent average annual catch.. Since the current level of harvest has continued for a long period of time, it is expected that the stock condition will not deteriorate if catch is not increased above current levels.

A precautionary approach that does not increase fishing effort directed at sailfish and which closely monitors catch is recommended. A reliable assessment of status and trends of the sailfish stock in the EPO is not possible without reliable estimates of catch.

It is recommended that historical data on catches of sailfish be obtained wherever possible, and that existing data from current fisheries, including recreational, smaller longline vessel operations, and artisanal fisheries, be identified for use in assessments.

Following Michael Hinton's presentation, one participant asked if a yield/recruit model had been used in the assessment. Michael Hinton explained that lacking catch data, no yield/recruit model was used in the analysis.

One participant asked if there were tagging data on movement of sailfish in the Pacific, which could be compared to the abundant tagging data on sailfish from the Atlantic. Michael Hinton indicated that there were some pop-off satellite archival tag (PSAT) and archival tag data for the EPO, showing mostly limited movement in coastal waters and in a north-south direction, with fish seemingly following the 28°C isotherm. According to a published study, in the Pacific there is a significant difference in genetic structure that indicates that the sailfish in the EPO and WPO are separate stocks. Reproduction in the EPO takes place somewhere along the coast almost continuously, though it may occur seasonally in a single location. There always appear to be high abundances of sailfish in equatorial waters near and east of the Galapagos Islands, but catches become low in open ocean areas.

Another participant indicated that Central American countries are working with the IATTC to standardize formats for collecting data on sailfish and billfish from regional fisheries. Michael Hinton agreed that this is a very positive step and will contribute to better assessments of sailfish as data are accumulated.

7d. Dorado (no document available, due to new information)

Alexandre Aires-da-Silva presented a research plan developed by the IATTC to deal with c tuna fisheries bycatch species, including dorado. Under the Antigua Convention, the IATTC staff may be asked to provide conservation advice for many species that are taken as bycatch in the tuna fisheries. For several reasons, there is a need for alternative assessment methodologies to deal with these species. First of all, the high-quality fishery-dependent data needed to apply conventional assessment methodologies for these species are not available. Second, the IATTC staff lacks the human resources needed to conduct conventional assessments for all these species on a regular basis. Finally, the high productivity of most of these species, and their large recruitment fluctuations driven by the environment, make the use of conventional stock assessment methods problematic. The IATTC staff elaborated an assessment framework plan to deal with the low information stocks and bycatch species in the EPO, which includes the following tasks: 1) develop quantitative methods to define stock structure; 2) conduct “semi-quantitative” analysis (productivity-susceptibility analysis and ecological risk assessment tools); 3) extensive review of fisheries indicators, decision rules and management strategy evaluation (MSE); 4) select candidate fishery indicators and decision rules; 5) MSE work to investigate indicator performance and, 6) apply indicators to selected species.

Alexandre Aires-da-Silva presented an overview of recent collaborative efforts on dorado research with Latin American countries. There are ongoing collaborative studies with Ecuador, which include regression tree analyses of species composition data to identify artisanal fishery units and development of fishery indicators (standardized CPUE). There are also collaborative efforts with Central American countries, via OSPESCA, which include development of data collection forms and database software. The IATTC is also developing purse-seine fishery indicators (standardized CPUE) which show consistency with the Ecuadorian indicators for the artisanal longline fleet.

After Alexandre Aires-da-Silva’s presentation, a general discussion of the preliminary work ensued. Much of this work was in collaboration with scientists in Ecuador, and the work appeared to the participants to be in the right direction. There are several other species that need attention, but dorado are important for several Central and South American countries. Other countries are encouraged to provide funding and support this sort of research. In addition, training is needed so analyses can be conducted by stock assessment scientists within the countries. Alexandre Aires-da-Silva and many others on the staff are particularly interested in developing capacity-building activities for countries in need. The lack of funding is a problem, and some work cannot be done because there is no budget for it. The participants in the SAC meeting were encouraged to appeal to their Commissioners if the work is found to be important.

Discussion developed about the fact that there are two Coryphaenidae species, *Coryphaena hippurus* and *C. equiselis*, that are sympatric in the EPO, but have different characteristics. Cleridy Lennert-Cody explained that, since 2005, observers have recorded species identifications for coryphaenid catches, and it is clear that the dominant species is *C. hippurus*, which is also the dominant species in the ecosystem. This preliminary work is based on both species. A participant added that, in a single fishing trip, upwards of 11,000 individuals were examined in Ecuador, and only three *C. equiselis* were found.

A participant encouraged people in the various countries to start generating the basic information required for possible assessments of a variety of species. It is very important to have this basic information available before it is needed for the stock assessments. These studies constitute good thesis projects for students. Another participant noted that the catch proportion graphs shown for Costa Rica show a strong seasonality, with the dorado season apparently going from October to February in the following year.

7e. Southern albacore

John Hampton presented the most recent stock assessment of albacore tuna in the South Pacific Ocean. The catch of South Pacific albacore has increased strongly over the past 20 years, reaching a level in excess of 20,000 t in 2009 and 2010. The catch is primarily of older fish taken by longline. The fishery occurs primarily in the southern western and central Pacific, but significant catches are also taken to the east of 150°W. An assessment of the stock was conducted by the Secretariat of the Pacific Community (SPC) in 2012, using the statistical length-based model MULTIFAN-CL. The model assumed a single well-mixed stock in the South Pacific. A number of biological parameters, including maturity at age and the natural mortality rate, were fixed. Estimated parameters included growth, recruitment, and the catchability and age-based selectivity of 30 fisheries defined in the assessment. Estimated recruitment is relatively stable, with some inter-annual variability. Spawning biomass has shown a gradual decline since 1980, but is still above the MSY level and well in excess of the limit reference point recently adopted by the WCPFC (20% of unfished spawning biomass). The impact of the fisheries on the stock is estimated to be moderate, with fishery-related depletion of the spawning biomass currently about 35% (reduction from unfished levels). However, the impact is stronger on the larger albacore vulnerable to Pacific Island-based longline fisheries (currently a depletion of about 50%). The assessment included a comprehensive sensitivity analysis resulting in 756 alternative models. The median estimate of MSY from this model grid was approximately 100,000 t. The 2010 effort regime was assessed through spawning biomass projections across the range of models. The results indicate considerable variability related to model selection; however the spawning biomass is likely (96% probability) to remain above the limit reference point under the assumptions of the projections. The main current management issue concerns limiting catch to levels that allow Pacific Island-based longline fleets to remain profitable. To this end, negotiations are currently underway to implement zone-based catch limits covering both EEZs and high seas in the South Pacific.

Following John Hampton's presentation, a participant asked if the research is finding that these albacore are more or less productive (*i.e*. faster or slower growth rates) than current assumptions, and if a length-based selectivity is being used. John Hampton's recollection was that age estimates based on otoliths were reasonably consistent with the growth curve used in the model, and that age-based selectivity was used.

Another participant asked if tagging information is available. A large-scale tagging program has not yet been mounted for South Pacific albacore. Limited tagging data showed that juveniles from the south move in all directions over the longitudinal extent of the fishery. But in some of the recent biological work, some strong regional differences in growth were found, which suggests that mixing is not complete or is not very rapid across the South Pacific.

8. Ecological and physical changes in the EPO (SAC-04-08)

Robert Olson presented excerpts of published and original research highlighting physical and biological changes taking place in pelagic open-ocean ecosystems, with focus on the eastern Pacific Ocean. The Oxygen Minimum Zone (OMZ) is a prominent feature in the EPO, and it includes a greater body of almost oxygen-free water than any other region in the world. A study site in the EPO shows that, since the mid-1990s, the OMZ has intensified and expanded vertically and horizontally, which is attributed to global warming, enhanced near-surface stratification, and decreased vertical oxygen transport. There are important implications for pelagic fishes and the food web due to hypoxia-based habitat compression. Large-scale reductions in primary production have been reported, and small (1 μm) picophytoplankton species are becoming more prominent (versus larger forms classified as nano- and microphytoplankton), which results in longer, less efficient food chains leading to pelagic animals. Yellowfin tuna are ubiquitous, generalist predators that are considered effective samplers of micronekton prey communities. A recent analysis of the diet of yellowfin during two 2-year periods separated by a decade in the EPO shows a large-scale diet shift had taken place, indicating a change in the food web. Epipelagic fishes, most notably frigate and bullet tunas (*Auxis* spp.), declined markedly, and were replaced by a suite of mesopelagic species and a crustacean that apparently shifted its distribution further south. These physical and ecological changes should be taken into account when contemplating management recommendations.

Following Robert Olson's presentation, one participant requested a forecast for ecosystem and physical changes in the EPO over the next 20 years. Robert Olson indicated that pelagic fishes are mobile, so it would be logical to expect that horizontal distribution of tunas would change. For smaller species that are not quite so migratory, the implications are more difficult to predict, but that is the subject of current studies. What is clear is that the pelagic habitat is changing in the EPO, and that the food web may be different in the future, though not necessarily diminishing its capacity to support pelagic fish. These patterns can be seen from recent stock assessments, such as the periods of different production regimes apparent in the assessment of yellowfin.

Martín Hall asked if the analysis included life history parameters, such as growth rates, for different tuna species over decades. Robert Olson explained that the staff does not have those samples, although the collection of long-term biological samples would be very valuable for such an analysis.

Another participant noted that the SeaWiFS system is no longer functioning, but that NASA has recently switched to the MODIS system of satellite data, and there are also other ocean-color satellites available. Since many species can adapt to environmental change, it was asked if there are any IATTC researchers working on environmental data. Robert Olson indicated that Michael Hinton is working with the Pelagic Habitat Analysis Module (PHAM) system with collaborators to conduct this type of analysis and to explore its application to stock assessments.

A participant asked if the apparent change in diet of yellowfin could be correlated with changes in yellowfin recruitment, and in particular, to the different stanzas of recruitment reported in the yellowfin assessment. Robert Olson indicated that the diet data were collected only during two 2-year periods, and would be insufficient to attempt an analysis with recruitment data. It was also noted by the participant that the presentation left the impression that the ecosystem in the EPO is changing, and the dynamics of the fisheries should be considered. Robert Olson agreed that physical and ecological changes have the potential to affect the availability of pelagic fishes to fishing gear and the productivity of the stocks, which should be taken into account for stock assessments.

A comment was made that the EPO, as well as the eastern Atlantic, are both highly productive oceanic areas in terms of overall biological productivity, yet there is a paradox that both areas are characterized by fairly low production of tuna, compared with the western and central Pacific, for example. Another participant asked if the shoaling of the OMZ in the EPO could increase cannibalism by tunas. Robert Olson explained that diet studies of yellowfin in the EPO have indicated a low incidence of cannibalism. However, bullet and frigate tunas are very abundant in the EPO, and the shoaling of the OMZ could concentrate their distribution in epipelagic habitats and lead to increased predation pressure on tuna in their early life stages.

9a. Options for reference points and harvest control rules (SAC-04-09)

Mark Maunder presented a report on reference points and harvest rate control rules. Target reference points indicate a state that is considered desirable. A fish stock or fishery is expected to approach or fluctuate around a target reference point. Traditionally they have been set with the aim of maximizing yield (*e.g*. maximum sustainable yield; MSY), economic benefits (*e.g*. maximum economic yield; MEY), or some other measure of benefits (*e.g*. optimal yield; OY). Limit reference points indicate a state of a fish stock or fishery that is considered undesirable. A fish stock or fishery is expected to have a very high probability (*e.g*. at least 90%) of not exceeding a limit reference point. Traditionally they have been set on biological grounds to protect a stock from serious, slowly reversible, or irreversible fishing impacts, which include recruitment overfishing and genetic modification.

Article IV of the Antigua Convention states that the precautionary approach should be followed. "*The members of the Commission, directly and through the Commission, shall apply the precautionary approach, as described in the relevant provisions of the Code of Conduct and/or the 1995 UN Fish Stocks Agreement, for the conservation, management and sustainable use of fish stocks covered by this Convention.*" The UN Fish Stocks Agreement states "*The fishing mortality rate which generates maximum sustainable yield [F_{MSY}] should be regarded as a minimum standard for limit reference points*" and "*Fishery management strategies shall ensure that the risk of exceeding limit reference points is very low*." (Annex II UNFSA 1995)

There are problems with using F_{MSY} as a limit reference point. First, it is inconsistent with traditional management objectives (*e.g*. obtaining MSY). Limit reference points should, as traditionally intended, be developed to protect the stock from serious, slowly reversible, or irreversible fishing impacts, which include recruitment overfishing and genetic modification. Evidence for tunas is that fishing at a level that moderately exceeds F_{MSY} is not unsustainable, and therefore requiring a very low probability (*e.g*. 10%) of exceeding F_{MSY} is unreasonable. Arguments for F_{MSY} as a limit are based on an overarching notion that it may protect the ecosystem.

The IATTC staff recommends interim reference points based on those adopted by the Indian Ocean Tuna

Commission (Table 1). The Kobe Plot and Strategy Matrix should be presented based on these limit reference points.

TABLE 1. Interim reference points recommended by the Indian Ocean Tuna Commission.[1]

Stock	Target reference point	Limit reference point
Albacore tuna	B_{MSY}; F_{MSY}	40% of B_{MSY}; 40% above F_{MSY}
Bigeye tuna	B_{MSY}; F_{MSY}	50% of B_{MSY}; 30% above F_{MSY}
Skipjack tuna	B_{MSY}; F_{MSY}	40% of B_{MSY}; 50% above F_{MSY}
Yellowfin tuna	B_{MSY}; F_{MSY}	40% of B_{MSY}; 40% above F_{MSY}
Swordfish	B_{MSY}; F_{MSY}	40% of B_{MSY}; 40% above F_{MSY}

The IATTC staff has an informal harvest control rule that is based on reducing fishing mortality to F_{MSY} when it is above F_{MSY}, and it recommends its adoption. Simple management strategy evaluation (MSE) has been applied to test this harvest control rule under alternative states of nature and evaluate it against the interim limit reference points.

Following Mark Maunder's presentation, clarification was requested about this proposal, in particular why only yellowfin and bigeye are being considered and not other species. Mark Maunder's opinion was that, since stock assessments are being done for bigeye and yellowfin tuna, those will be the two of the species for which reference points will be provided, but the staff will recommend reference points for all the species recommended by IOTC plus Pacific bluefin (see conservation recommendations in Appendix B). The interim reference points for Pacific bluefin are the same as those for bigeye tuna recommended by the IOTC, because the bigeye reference points were the most conservative, which seemed more appropriate for bluefin than the other reference points for tunas. The reference points have not yet been evaluated, and this is the reason they are termed "interim" target and limit reference points. Regarding a schedule for incorporating the interim reference points, Rick Deriso mentioned that, at the Kobe III meeting in 2011, it was decided to form a working group to look at management strategy evaluations for various tuna stocks. If the management strategy evaluation is successful, the staff plans to evaluate whether or not "interim" can be changed to "permanent." Until the analysis is done, the staff will not know if these reference points will work. Obviously, more work needs to be done. There are other alternatives to the reference points the staff proposes, but this is a reasonable interim measure.

A participant offered the viewpoint that the objective of having reference points is to avoid irreparable harm to the fish stocks, *i.e*. avoiding recruitment overfishing, and he could not see the case for making these reference points different for the different tunas. In addition, simply borrowing reference points proposed by the IOTC and applying them here is not advisable, particularly if different values of steepness are being assumed. Rick Deriso agreed, and stated that it is best to base this on a management strategy evaluation. Carolina Minte-Vera's presentation would provide information about the management strategy evaluations being done.

Another participant thought that this proposal was a very good way forward: it is good to propose interim levels and proceed to test them. It is also necessary to consider how to approach the situation of a much depleted stock. Also, it is reasonable to define target reference points based on an interpretation of the Antigua Convention, but there may be other reference points that the Commissioners would like to consider, and other targets can be defined. He expressed the hope that the Commission would pay close attention to this and have a good dialogue with the scientists and others about potential objectives of the management strategy evaluation.

It was also mentioned that there is no ecosystem component to this proposal. Considering ecosystem

[1] S_{MSY}: Spawning stock biomass corresponding to the maximum sustainable yield (MSY); F_{MSY}: fishing mortality rate corresponding to the maximum sustainable yield

issues is an obligation in the Convention, and a workshop to discuss this complex issue might be useful.

9b. Kobe II strategy matrix (SAC-04-05d)

Carolina Minte-Vera presented the Kobe II strategy matrix for bigeye and yellowfin tuna stocks of the eastern Pacific Ocean in 2012. The second joint meeting of the tuna regional fisheries management organizations (Kobe II) recommended the computation of a "strategy matrix" in order to improve further the standardization of the presentation of stock assessment results for fishery managers. The Kobe II strategy matrix "would present the specific management measures that would achieve the intended management target". Following this recommendation, the IATTC staff computed the following Kobe II strategy matrices and decision matrices for yellowfin tuna and bigeye tuna in the EPO in 2012. For this exercise, the reference points that will be recommended by the staff for adoption as an interim measure by the Commission were used:

Stock	Target reference point	Limit reference point
Bigeye tuna	S_{MSY}; F_{MSY}	50% of S_{MSY}; 30% above F_{MSY}
Yellowfin tuna	S_{MSY}; F_{MSY}	40% of S_{MSY}; 40% above F_{MSY}

The Kobe II strategy matrix was computed with F_{MSY}, because the IATTC staff recommendations have treated F_{MSY} as a target reference point, and the informal havest rule used to manage tunas in the EPO has been based on reducing fishing mortality to F_{MSY} if it exceeds that level. The Kobe II strategy matrix is substantially more demanding computationally for calculating biomass reference points than for calculating fishing mortality reference points. Therefore, biomass reference points were presented only as a traditional decision table. The normal approximation was used for the computations using the maximum likelihood estimates and standard errors of F_{mult}[2] obtained from the stock assessment models implemented in Stock Synthesis. Two model structures were applied: the base case and the case with the steepness of the stock-recruitment relationship (h) set low, at 0.75. The Kobe II strategy matrix for yellowfin was computed using two variability scenarios. In order to assess the implications of wrong assessments, two "misspecification cases" were run. In the first case, h = 0.75 was assumed to be the true state of nature, and the assessment was performed using a model that assumes h = 1. In the second case, these were reversed: h = 1 was assumed to be the true state of nature, and h = 0.75 was used for the assessment. The management advice from the assessment model was then applied when projecting from the model that represented the true state of nature.

The results indicate that, for bigeye, there is a high probability that the current F is below the fishing mortality limit reference point. even with h = 0.75. For example, the Kobe II Matrix suggests that F would only have to be reduced 4% to have a 90% probability that it is below the fishing mortality limit reference point for bigeye (1.3 F_{MSY}) if h = 0.75. In contrast, F would have to be reduced by 14% to 17% under the same conditions for yellowfin.

The probability of being above the spawning biomass limit reference point with current F is high for both yellowfin and bigeye, even with h = 0.75. However, if the steepness is 0.75 and the fishing mortality is set appropriately at F_{MSY} for that assumption, the bigeye population would not rebuild to the biomass corresponding to MSY within 10 years. For both yellowfin and bigeye, there is a high probability of being above the limit biomass reference point even if F is set based on F_{MSY} under an assessment that assumes that h = 1 when in fact it is 0.75. However, there is a low probability of being below the limit fishing mortality reference point for yellowfin if F is set based on F_{MSY} under an assessment that assumes that h = 1 when in fact it is 0.75. This indicates that there may be an inconsistency between these fishing mortality and biomass limit reference points. Other model structure uncertainty and mispecification (*e.g.* natural mortality and the average length of old individuals) should also be included in the evaluation of the Kobe

[2] F multiplier: the number of times the effort would have to be effectively increased relative to the average fishing mortality during a certain period (in this case 2010-2012) to achieve MSY

II Strategy Matrix and limit reference points.

The analyses presented in this report evaluate the current informal harvest control rule used for managing tunas in the EPO (*i.e.* set the fishing mortality at F_{MSY}). This is a form of management strategy evaluation (MSE). The harvest control rule was evaluated under different states of nature through two assumptions about the steepness of the stock-recruitment relationship. This MSE should be extended to include additional states of nature. Other harvest control rules could also be evaluated.

Following Carolina Minte-Vera's presentation, discussion developed about alternative ways to conduct these analyses. Additional states of nature need to be evaluated, weighted by prior probabilities and integrated across the priors. At the ISSF workshop, a meta-analysis was done to identify what types of priors might be appropriate for tunas in general. The organizations that continue with MSY based methods should come to agreement on what an adequate prior for steepness should be. In regard to limit reference points, there should be strategies that avoid those with high probability. Consideration should be given to how much uncertainty to admit. An uncertainty framework is necessary that is flexible enough to use year-by-year.

10. Purse-seine fleet capacity (SAC-04-INF B)

Dale Squires presented "Fishing Capacity and Efficient Fleet Configuration for the Tuna Purse Seine Fishery in the Eastern Pacific Ocean: An Economic Approach," by J. Shrader and D. Squires of U.S. NOAA Fisheries, Southwest Fisheries Science Center. The study estimated the annual optimum fleet configuration which would allow individual vessels to maximize their potential catch and the collective meets or is less than the MSYs for yellowfin and bigeye tunas and observed skipjack catches, with control variables of yellowfin and bigeye biomass and sea surface temperatures. The annual data are from the IATTC and are derived from the same data set that enters the annual report. The optimal fleet is measured in vessel numbers and cubic meters (m^3) of well capacity. Vessels were classified into four groups ((1): class 2 and 3; (2) class 4 and 5; (3) class 6 with Dolphin Mortality Limits; and (4) class 6 without Dolphin Mortality Limits), and separate estimates are obtained for each group, and then added together to obtain the fleet. The optimization method was Data Envelopment Analysis, a linear programming approach in which a separate linear program is run for each vessel.

During 1993-2010, the annual average optimum fleet capacity was 167,000 m^3 of well capacity, compared to the current observed capacity of 219,000 m^3 and the IATTC optimum of 158,000 m^3. The current capacity should be reduced by 22% to 24% to achieve economic efficiency (defined as maximum potential catches), depending upon the MSYs and catch restrictions imposed. Current vessel numbers should be reduced by 18% to 24% to achieve economic efficiency, again depending upon the MSYs and catch restrictions imposed. The relative (proportional) number of vessels within each vessel group remained the same in the optimum fleet.

Following Dale Squires' presentation, there was discussion of the fact that the document was not available sooner for the participants to review it, and not translated to Spanish. Guillermo Compeán explained that the document is for scientific discussions only, and offered to withdraw it from discussion if the participants have not had time to read it. He also reminded the participants that this analysis was requested by a member country, and that many documents need to be translated prior to meetings.

Discussion of the presentation proceeded. It was described by one participant as something quite new and interesting. Concern was expressed that the rate of landings (*i.e.* tons per day) is much greater than in previous years, so vessels can effectively fish much more than in the past. Dale Squires explained that this is accounted for indirectly: the effect of vessel size and other factors on landings is calculated independently each year.

There was a question about catch efficiency: purse-seine vessels operate in code groups, and could an optimum code group size be determined. Dale Squires explained that this is called a "network effect," and it is indirectly evaluated in the model each year. If information on the code groups were available, the model could be run for just a particular group of vessels, and group size can be expanded and contracted.

There was another question about whether or not fishing days are regulated by size of vessel and how fishing rights are allocated among the parties. Distribution of fishing days to each vessel is by equal percentages. Allocation, of course, is the most important factor. Much of the literature on allocation is reviewed in paper 571 published by the FAO. A discussion ensued about efficiency versus capacity. The model accounts for efficiency versus capacity. A vessel with the highest catch per unit effort achieves the highest output values on the "best practice frontier" graph.

A participant reminded the group that fishing capacity and fishing rights already belong to the countries, and while the importance of keeping the stocks at MSY is understood, reducing capacity has social and economic impacts on the nations. Dale Squires expressed a preference for each country deciding how to divide up its capacity.

A participant suggested taking this presentation to the working group on capacity, which would have better elements of judgment. Guillermo Compeán thought this was a good suggestion, and the document may be translated in time for the annual meeting.

11. Individual vessel quotas (SAC-04-11)

Rick Deriso presented information on individual-vessel quotas (IVQs) for purse-seine vessels that fish on fish-aggregating devices (FADs). The staff carried out four analyses of IVQ limits on the total catch (retained catch plus discards) of bigeye and yellowfin by purse-seine vessels, in order to determine the size of the quotas that would be equivalent to a closure in terms of limiting catches. The data and analysis are restricted to floating-object sets only for 100 vessels. The 100 class-6 (carrying capacity greater than 363 metric tons (t); 425 m^3 of well volume) purse-seine vessels were those identified whose annual catches of bigeye in sets on floating objects during 2009-2011 averaged at least 50 t. As expected, the size of the IVQ varies inversely with the length of the closure period. A comparison was made of IVQ rates based on past (2009-2011) vessel catches versus the maximum catch permitted with an IVQ; with no area closure the IVQ rates are reduced from 0.86 t/m^3 to 0.59 t/m^3 for bigeye and yellowfin combined, and from 0.59 t/m^3 to 0.38 t/m^3 for bigeye only.

Following Rick Deriso's presentation, a participant offered some comments on the information provided. He expressed concern that part of the fleet could shift from FAD fishing to dolphin-associated fishing in response to the system, thus increasing the fishing mortality on yellowfin, and possibly increasing the likelihood of dolphin mortalities. Other concerns included the fishing mortality for different age components, as well as how the vessel quotas will vary and how days of closure will vary. It is unthinkable to reduce the number of closure days, since the projections for yellowfin and bigeye are based on the number of closure days. Also, who would control this system – vessel captains, observers? Since the system is based on observer data, and there is a significant part of the fishery that is not covered by observers, would those vessels be excluded from this system? There also appears to be a pattern of some vessels catching larger amounts of bigeye, in which case it would be the responsibility of the staff to analyze where those vessels fish.

Rick Deriso responded by agreeing that that some vessels might shift from fishing on FADs to fishing on dolphins unless there were rules to prevent that. A shift to dolphin-associated sets was unlikely to increase mortality of dolphins, since the mortality rate on dolphins is currently quite low. This is an informational document from the staff, not a proposal, in response to a request that this type of analysis be undertaken, and it describes an analysis that would be a first step if the EPO fleet wanted to address rights-based management. The control of this system is difficult, since it is unrealistic to ask observers or vessel captains to police the process.

Martín Hall commented that it might be possible to control the fleet through a global quota, possibly distributed to vessels in different ways. Equal distribution is an option, as well as using a proportion of historical catch for individual vessels. The first option is more equitable, while the second is less disruptive of the fleet. With dolphin-associated fishing, mortality was controlled through observer data and this was successful. On purse seiners, perhaps some electronic assistance could be added to improve monitoring.

A participant questioned the part of the system whereby individual quotas can be a mix of yellowfin and bigeye. If this issue is addressed for both species together, it would be easier than directing it toward one species only. Rick Deriso reiterated that the analysis used data from sets on floating objects only.

A question was asked regarding the potential of using cannery information for this type of system, and whether canneries do a good enough job of disaggregating the catches for estimates by species. Rick Deriso noted that the staff has used cannery data, but not species-sorted data before, but if all canneries cooperated in providing those sorts of data, then, with the help of the ISSF, perhaps the staff could use this information.

A participant suggested that global annual quotas might be better. Another participant asked why some vessels catch more bigeye than others. Martín Hall noted that the vessels that catch most of the bigeye are the same every year, possibly due to differences in the design of nets that may fish differently. Rick Deriso added that the staff would be interested in analyzing the pattern of disproportionate catches of bigeye by some vessels.

It was noted that Colombia had asked the staff to do some work on the IVQ issue. There is an issue of compliance which depends on the size of the purse-seine fleet: it is easy to ensure compliance by small fleets, but hard for large ones.

A question was asked whether total catches would exceed the total catch of purse seiners if every vessel caught its full quota. Rick Deriso indicated that, in that case, the calculation is the total catch divided by the total aggregate capacity of the fleet, and that is the rate that would be used in the calculation of IVQs.

12. Staff activities and research plans (SAC-04-12)

Rick Deriso presented the document on staff activities and research plans.

Following the presentation, a participant noted that assessment of Pacific bluefin was not included in the report. Alexandre Aires-da-Silva indicated that the recent assessment of Pacific bluefin was presented earlier in this meeting. The staff is always closely involved with ISC and other groups, and participates in the full assessments of Pacific bluefin, and that strong commitment will continue. Rick Deriso added that when the last full assessment of Pacific bluefin was conducted, both Mark Maunder and Alexandre Aires-da-Silva participated and played a large role. The staff is interested in seeing what will happen in the WCPFC as a result of the recent assessment, and whether changes will be made in its conservation resolutions.

A participant asked about aspects of capacity building, and noted that training by IATTC staff and visits by staff from the countries and IATTC would be extremely productive. Guillermo Compeán responded that the problem is a lack of funding, but that the IATTC staff has done everything it can to promote training and staff visits with available funds.

13. Management options: Total Allowable Catch (TAC) scheme (SAC-04-INF D)

Guillermo Compeán presented Document SAC-04-INF-D, commencing by noting that it is an informational document whose aim is to illustrate the difficulties that arise when attempting to implement a program of allocation of fishing rights. It outlines the implementation of a system of allocation of fishing rights which uses as a basis several of the scenarios in Document IATTC-82-INF-A, presented at the 82nd meeting of the Commission in 2011. This new scheme is based on various general principles, among them the use of catches corresponding to F_{MSY} to define a global quota, the allocation of fishing rights for the two species, yellowfin and bigeye, combined, the separation of the tuna resources into those in national Exclusive Economic Zones and those outside such zones, and the use of the Regional Vessel Register as a basis for requests by vessels for catch allocations.

Following Guillermo Compeán's presentation, some participants indicated that this matter is very complicated for a large group like this, and should be considered at the meeting of the Commission, or by a small group of Commission representatives, but not in the SAC. They also asked what the staff expected as a response from the SAC. Guillermo Compeán responded that this issue is presented for information purposes, and no decisions are required. It is important to have a base document available for discussing individual vessel quotas. He reiterated that it was an informational document intended to illustrate the difficulties that arise when attempting to implement a program of allocation of fishing rights, like Document SAC-04-11 on the possible establishment of Individual Vessel Quotas for bigeye and/or yellowfin tuna. The goal is to keep the population at a sustainable level.

Regarding another series of questions, Guillermo Compeán explained that once a vessel is in the Regional Vessel Register, it cannot transfer its quota and the allocation would be controlled by the flag State. A vessel that fishes on FADs could also request a Dolphin Mortality Limit at the beginning of the year, and after meeting its quota on FADs it could continue fishing on dolphins. So, some vessels could operate all year and some might reach their quota by the middle of the year and have to stop fishing. All vessels could continue fishing provided that the overall effort is reduced. There would be incentives to have low catches of juveniles.

14. Review of 2013 staff conservation recommendations and IATTC Resolution C-12-01

Rick Deriso reviewed the draft recommendations by the staff for the conservation of tunas and sharks in the EPO (Appendix B). He commented that the draft recommendation by the staff for the conservation of silky sharks is substantially the same as that for 2012.

Following the presentation, a discussion developed among the participants about recommendations for 2014 in addition to 2013. A participant stated that, although the recommendation for the tropical tunas will be to maintain the existing resolution for 2013, recommendations for 2014 are also needed. Rick Deriso noted that 2014 recommendations would need further consideration by the staff. Guillermo Compeán reminded the participants that the resolution contains a provision that it be reviewed each year.

Further discussion ensued about the interim reference points, and the basis for assigning them. Rick Deriso explained that the staff used the reference points that the IOTC recommended, which included swordfish. Regarding Pacific bluefin, the staff is open to suggestions for alternatives. The staff's suggestions for reference points and harvest control rules were considered good starting points. Concern was expressed, however, about yellowfin, skipjack, and bigeye tunas. Last year the recommendation was to extend the season a little because of the condition of the stock and increasing capacity. However, capacity has not increased since last year. This year the yellowfin assessment is a little more negative than last year, considering the data and not the projections. Measures to allow the stocks to recover a little would be in order, and a participant encouraged the same extension of the closure that was recommended last year. Rick Deriso explained that this year the assessments for both yellowfin and bigeye have the *F* multiplier greater than 1, and the assessment for this year is more optimistic for bigeye. Regarding Pacific bluefin, according to the ISC stock assessment in 2012, current management measures in the eastern and western Pacific are expected to increase the spawning stock. A participant suggested evaluating the effect on this stock when F is reduced to F_{MAX}.

Discussion about the desirability of a Kobe plot for Pacific bluefin then took place. A Kobe plot has not been produced by the ISC Working Group because reference points have not been developed, although the group has been working in that direction. A participant said that it is not necessary to have good reference points to make Kobe plots. While reference points are sensitive to steepness, people are used to seeing these plots when management advice is given. From a technical standpoint, the staff can produce a Kobe plot if asked to. Rick Deriso reminded the participants that three years ago Mark Maunder produced impact plots that showed quite clearly that the fisheries impact was coming from the western Pacific, and that was the basis for the staff's recommendation.

15. Bycatch management (no document)

Martín Hall and Marlon Román presented information on bycatch management in the EPO.

Following the presentations, a participant asked if the recommendations in this presentation, particularly recommendation #16 ("that webbing used under FADs be prohibited and subsequently replaced by non-entangling materials and structures no later than 1 January, 2014"), would be included in the recommendations of the SAC meeting. It was suggested that this meeting report reflect some of these recommendations.

A comment was made regarding management for non-target species. There are efforts in Ecuador to develop an environmentally friendly FAD, conservation practices for hammerhead sharks and manta rays are being examined, and certain foundations are already supporting some of this research.

Martín Hall indicated that the bycatch work by IATTC does not advocate not exploiting certain resources, but rather promotes the practice of making every effort to release manta rays and sharks alive in fisheries that do not target those species. Responsible fisheries are promoted through a precautionary approach. A participant added that in some countries, megafauna have strong ecotourism potential for sightseeing and scuba diving, and these resources should be protected. Another participant reported that, in Colombia, sharks are being studied routinely, and there is legislation about non-target species, such as regulations against finning. This work also includes studies of turtle entanglement and shark tagging.

16. Other business

16a. Proposal on the collection and presentation of outside scientific documents (SAC-04-PROP A-1)

A proposal was presented for a system for collecting and reporting scientific documents produced and presented by outside or collaborating researchers at the various technical meetings and working groups or before the Scientific Advisory Committee. Such documents are not always available, or are scattered among the documents presented and discussed at the meetings for which they were prepared. It was suggested that the various categories of documents in such a collection could include a national scientific report from each country on the species regulated by the Commission, which would be submitted to the SAC.

Following the presentation, Guillermo Compeán expressed appreciation for this initiative and addressed some of the issues raised. For publication of the scientific papers brought to this meeting, the very well-known IATTC bulletin series can be used. Usually an *ad hoc* review committee is created to decide about publication acceptance. The IATTC website contains data and cruise information and data presented at Commission meetings, but it can be improved to make it easier to find information, perhaps with the addition of a search mode. The Commission already maintains summaries of research performed in a particular region, and this information should be updated. The Commission produces special publications, such as bibliographic reviews and reports of conferences on specific issues. Special reports have been published such as the report of the external review of the yellowfin stock assessment, methodology on sampling area protocols, and a 20-year review of research at the Achotines Laboratory.

A participant suggested that all the working documents that are submitted to IATTC working groups should be identified in accordance with an international system to aid in location of those documents externally on the web. ASFA rules should be followed so that the documents can be found from search engines outside the IATTC.

16b. Recommendation on data sharing (no document available)

Alain Fonteneau presented a discussion of the IATTC data that are presently available in the public domain. The lack of longline catch and effort data by 5°-month in the IATTC area has been a serious problem for all scientists interested in tunas and pelagic ecosystems since 2005. This lack of data was due to the IATTC rules of confidentiality. The same rules of confidentiality are also introducing serious difficulties in the interpretation of the total yearly catches by flag and gears (that are often classified as "other countries"), and in the catch and effort statistics by 1°- and 5°-squares for all surface fisheries. The presentation reviewed these problems and made the recommendation that the IATTC should adopt the fully transparent confidentiality rules of ICCAT and IOTC, whereby all the aggregated catch and effort data submitted by each country or processed by the IATTC staff should be fully in the public domain: by 5°-month for longliners and by 1°-month for surface fisheries, by gear and flag. The IOTC and ICCAT data for all countries are in the public domain, independently of the numbers of vessels or companies that are active in the fishery.

Following Alain Fonteneau's presentation, Guillermo Compeán noted that at the annual meeting last year, the IATTC examined a similar resolution that was not approved but left pending. This year, the resolution will be discussed and possibly approved, but prior to the annual meeting the resolution should be reviewed and improved. The issue is not just transparency, it is also related to access to data for researchers related to or working with IATTC staff. The staff has access to the data for research purposes, but the issue is providing the data to outside parties.

Rick Deriso explained that the oldest resolution in place for the IATTC is the 1951 resolution C-51-01 about confidentiality of catch statistics of individual vessels and records of individual companies. This resolution must be followed by the staff. He noted that in the Western and Central Pacific, a system is used that estimates the number of hooks per vessel by longliners, and then multiplies this by three. If the number of hooks in the stratum exceed that number, then the assumption is made that there were at least three longline vessels in that stratum, which then allows that information to be provided. The IATTC staff has not made that assumption or calculation, but could if permitted. Michael Hinton described an analysis conducted with similar assumptions on hooks using IATTC data. The results indicated that in some instances the staff would still be releasing information about individual vessels and operations, so the system was not adopted.

Alain Fonteneau indicated that catch information was received from the Indian Ocean by area, with no concern about how many vessels are working there, and there was no knowledge of the company or the vessels.

A participant confirmed the three-vessel rule used by the WCPFC, and offered the opinion that release of aggregated catch and effort data, even when it involves fewer than three vessels, does not compromise the records of individual vessels or companies. However, one or two countries insist on strict rules for the release of data.

Guillermo Compeán explained that the confidentiality resolution of the IATTC was drafted because the information comes directly from the vessels and the companies, which is different from other RFMOs, which get their data from governments. IATTC data are collected by the Commission staff for research purposes, not for economic reasons. If the confidentiality rules are changed, information will be lost, and for this reason the staff continues to support the confidentiality rules now in place for the information collected by the staff.

Martín Hall and Guillermo Compeán confirmed that IATTC-derived data are quite often provided to collaborating scientists and students for research purposes, as long as Commission rules are followed and the project is approved internally.

Mark Maunder raised the issue of getting more and better data inside the IATTC. He requested that all countries, especially those with longline data, assist the staff by providing data to improve stock assessments.

16c. Associated and dependent species (no document)

Several participants asked about the meaning of the terms "associated species" and "dependent species," which appear in the Antigua Convention. The 1949 IATTC Convention referred to four categories in relation to which the Commission had specific functions and responsibilities. The new convention defines the fish stocks that it covers as those "of tunas and tuna-like species" and "other species taken by vessels fishing for tunas and tuna-like species in the Convention Area." The Antigua Convention refers to two other categories for which the Commission may adopt conservation and management measures or recommendations: "species belonging to the same ecosystem and that are affected by fishing" for the species covered by the Convention, including through their incidental catch, and species "dependent on or associated with" the species covered by the Convention. With regard to the associated or dependent species, Guillermo Compeán recalled that this concept was embodied in the 1982 UN Convention on the Law of the Sea and other international legal instruments, and reminded the meeting of the definition contained in the FAO Fisheries Glossary: Associated species are "*Those species that (i) prey upon the target species, (ii) are preyed on by it, (iii) compete with it for food, living space, etc; or (iv) co-occur in the same fishing area and are exploited (or accidentally taken) in the same fishery or fisheries. These interactions can occur at any stage of the life cycle of one or other species and the range of species concerned can therefore be very large*." Dependent species are "*In general, species within the food chain (e.g. a predator) which depends heavily on another (e.g. a prey species) for its maintenance. Dependency may also be generated by other factors than predation (e.g. commensalism; habitat)*." Regarding the EPO, it would be up to the SAC to conclude which species fulfill these criteria, from a biological point of view. As an example, Guillermo Compeán stressed that sharks are clearly associated species, and the Commission is competent to adopt conservation and management measures and recommendations for them. An example of dependent species would be flyingfishes, common prey for tunas and billfishes. There is no fishery for these, but they are part of the food web and fundamental in the ecosystem.

Discussion was focused on the fact that these associated and dependent species may comprise a very small proportion of the catch of tuna fisheries, while the majority of the catch is taken by small vessels from coastal nations. According to the Convention, these species are under the purview of the IATTC, yet how can the Commission regulate fisheries that do not target tunas? However, Guillermo Compeán pointed out repeatedly that the point is not to regulate those fisheries, but to provide advice. The Commission has never taken measures on artisanal fisheries, but there have been measures for species such as sharks that are associated with tunas. The Convention limits the staff's activities to doing assessments, with emphasis on tuna or tuna-like species, and work on other species is done because it is urgent or because a request is approved by the Commissioners, as in the case of dorado. Although all species are inter-related in the food web, the staff's focus is on tuna and tuna-like species, and it will make proposals about what it considers to be important.

17. Recommendations and endorsements

Given that Pacific bluefin and northern albacore are Pacific-wide stocks, the need for consistency in their management in the western and eastern Pacific Oceans, including the need for biological reference points, was expressed. A participant informed the meeting that currently the ISC and the northern committee of the WCPFC are in the process of discussing biological reference points for these two species, and the IATTC staff is actively participating in the ISC bluefin analysis. Since 2005 the ISC has been using reference points to compare against estimated fishing mortality. Guillermo Compeán intends to recommend to the Commission that the measures for the stocks be harmonized between the IATTC and WCPFC. The only countries involved in the bluefin tuna fisheries are members of both organizations.

There was considerable discussion about using F_{loss} and B_{loss}[3] as reference points for northern albacore and Pacific bluefin. The IATTC staff is against this for some species: for example according to its recent bigeye assessment, the spawning biomass is the lowest that has been observed, and in that case F_{loss} would correspond to F_{MSY}. A participant noted that it is dangerous to use B_{loss} as a limit reference point, and to even consider the loss the probability distribution of the biomass estimates should be taken into account.

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[3] B_{loss} is the **l**owest ***o**bserved* **s**pawning **s**tock in the series of annual values of the spawning biomass. F_{loss} is the level of fishing (F) that will produce a long-term spawning biomass per recruit (S/R) associated to B_{loss}

Regarding bigeye, the SAC supported the use of common interim reference points by the WCPFC and IATTC. These points could change, and the IATTC staff considers that a management strategy evaluation process is necessary before reaching conclusions about what the reference points should be. Regarding yellowfin and bigeye, a participant stated that both models show that MSY is slightly higher than the current target, but he was concerned about using the base case. If a steepness parameter is used, the outlook is different: for yellowfin with a steepness of 0.75, a substantial reduction in catches is needed. Both models should be used as alternatives, but from a biological perspective it would be better to reduce fishing mortality. A longer closed season would help both yellowfin and bigeye.

Discussion of the staff recommendations on silky sharks took place. The participants endorsed the release of silky sharks caught in good condition from vessels not targeting sharks. However, as a practical matter, there are small longline vessels that fish with different gear (hooks and lines) and target different species during different seasons, and it is often not clear whether sharks are bycatch or not. Guillermo Compeán and others stressed that the idea is to freeze the amount of fishing effort of vessels that target sharks.

The following are recommendations and endorsements made by the meeting participants, in no particular order:

1. That the reference capacity of 158,000 tons for the EPO purse-seine fleet be revisited.
2. That a Pacific-wide assessment of bigeye be conducted by the western Pacific assessment groups and the IATTC staff.
3. That training and support for data collection and harmonization of databases regarding silky shark be carried out. These efforts should be expanded so that multiple countries can access the data collection system.
4. That historical data on catches of sailfish be obtained wherever possible, and that existing data from current fisheries, including recreational, small longline, and artisanal fisheries, be identified and compiled for use in assessments.
5. That IATTC Members be encouraged to provide funding and to support research on dorado and other associated and dependent species. In addition, training is needed so that analyses can be conducted by stock assessment scientists within the countries.
6. That the basic information required for possible assessments of a variety of associated and dependent species begin to be gathered.
7. That the long-term collection of biological samples of tunas, for monitoring changes in diet, growth, reproduction, *etc*., be initiated.
8. That the presentation on purse-seine fleet capacity from this meeting be taken to the Permanent Working Group on Capacity for consideration.
9. That a system for preparing and collecting national scientific documents be established, for reporting to the SAC.
10. That the IATTC adopt fully transparent confidentiality rules for information provided by the Members.
11. That F_{loss} and B_{loss} be considered as potential limit reference points for northern albacore and Pacific bluefin tunas, since both stocks have fluctuated in size historically and have probably experienced very low biomass levels without undesirable reductions in recruitment in the past.
12. That the staff’s stock assessment documents be made available for the SAC meeting participants at least one week in advance of the meeting.
13. That management advice be robust to uncertainty in steepness.

14. That the countries that fish in the EPO apply best-practice methods for the mitigation of bycatches of megafauna.

18. Meeting report

The meeting report was adopted.

19. Adjournment

The meeting was adjourned at 3:00 pm on 3 May 2013.

Appendix A.

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Appendix B.

RECOMMENDATIONS BY THE STAFF FOR THE CONSERVATION OF TUNAS AND SHARKS IN THE EASTERN PACIFIC OCEAN, 2013

IATTC Resolution C-12-01 on the conservation of tunas, paragraph 14, calls for the IATTC scientific staff to "…propose, if necessary, appropriate measures to be applied in future years." At the meeting of the Scientific Advisory Committee in May 2013, the staff presented its recommendations for the conservation of tunas, as well as for silky sharks (Resolutions C-05-03 and C-11-10).

A. CONSERVATION OF TUNAS

The staff's recommendations are based on its assessment of bigeye tuna (Document SAC-04-05) carried out in 2013. A similar full assessment of yellowfin is planned for 2014; Document SAC-04-04b is an update of the 2012 assessment..

For bigeye, the staff's conclusion from this year's assessment is that fishing mortality (F) is slightly below F_{MSY}, the level corresponding to the maximum sustainable yield (MSY), as is indicated by the base case point estimate for the F multiplier[4] of 1.05 (SAC-04-05, Table 5.1), and that the measures established in Resolution C-12-01 have had the intended effect of reducing the fishing mortality of bigeye to a level not exceeding the MSY . However, there is a considerable overlap between the target F multiplier of 1.0 and the 95% confidence intervals for the F multiplier of 1.05, indicating that the evidence supporting a conclusion that fishing mortality is below the level of F_{MSY} is not definitive. Nonetheless, the staff considers that the results support the continuation of Resolution C-12-01. Another factor supporting this is the stock assessment of yellowfin, which concludes with the base case point estimate for the F multiplier of 1.01 (SAC-04-04b, Table 4.1).

As of 7 April 2013, the capacity of the purse-seine fleet operating in the eastern Pacific Ocean[5] (EPO) was 214,979 cubic meters (m^3) of well volume. It has been increasing since May 2011, when it was 208,100 m^3 after a year of an apparent declining trend; it had increased to 211,231 m^3 by June, 213,008 m^3 by the end of 2011, and 214,422 m^3 by May 2012. Consequently, the duration of closures of the fishery cannot be reduced on the basis of a reduction in fleet capacity.

1. YELLOWFIN, SKIPJACK, AND BIGEYE TUNAS

The staff recommends maintaining Resolution C-12-01 for 2013 and extending it through 2014.

The staff recommends that the monthly reporting requirement for longline catches of bigeye in Resolution C-12-01 (paragraph 11) be extended to include longline catches of yellowfin. All CPCs with annual catches of yellowfin greater than 500 metric tons (t) should provide those reports to the Director.

2. PACIFIC BLUEFIN TUNA

A new assessment of Pacific bluefin tuna was completed during the last year. Projections in which Resolution C-12-09 was extended into the future, with appropriate levels of fishing mortality, indicate that would likely lead to increases in stock abundance. The staff therefore recommends that all the provisions of the resolution remain in force through 2013 and be extended through 2014, with catches in

[4] The ratio of the current fishing mortality ($F_{current}$, defined as the average fishing mortality for the three most recent years (2009-2011)) to the fishing mortality that will produce the maximum sustainable yield (F_{MSY}). An F multiplier of 1.0 means that $F_{current} = F_{MSY}$; if it is below 1.0, fishing mortality is excessive ($F_{current} > F_{MSY}$)

[5] Defined as the IATTC Convention Area, established in Article III of the Antigua Convention

the latter year limited to 5,000 t, half the amount specified in Resolution C-12-09 for the 2012-2013 period.

3. NORTHERN ALBACORE TUNA

The staff recommends that Resolution C-05-02 be amended to require that the required six-monthly reports include information on effort as well as catch, and clarify that data provided should be for the EPO only. A new assessment of northern albacore tuna is planned for the first half of 2014.

B. REFERENCE POINTS

As an interim measure, the staff recommends that the Commission adopt the following target and limit reference points[6], approved by the Indian Ocean Tuna Commission (IOTC):

Stock	Target reference point	Limit reference point
Albacore tuna	B_{MSY}; F_{MSY}	40% of B_{MSY}; 40% above F_{MSY}
Bigeye tuna	B_{MSY}; F_{MSY}	50% of B_{MSY}; 30% above F_{MSY}
Skipjack tuna	B_{MSY}; F_{MSY}	40% of B_{MSY}; 50% above F_{MSY}
Yellowfin tuna	B_{MSY}; F_{MSY}	40% of B_{MSY}; 40% above F_{MSY}
Swordfish	B_{MSY}; F_{MSY}	40% of B_{MSY}; 40% above F_{MSY}

In addition, the staff recommends that the same reference points be used for Pacific bluefin tuna as for bigeye tuna in the table above.

C. HARVEST CONTROL RULE

The staff has consistently recommended the harvest control rule that, if fishing mortality exceeds the level corresponding to MSY, it be reduced to that level. The staff recommends that the Commission adopt this rule .

D. CONSERVATION OF SILKY SHARKS

Since 2009, IATTC staff, national observer program staff, scientists of member countries, non-governmental organizations, and industry collaborators have worked together to accumulate, process, and analyze data for the silky shark (*Carcarhinus falciformis*) in the EPO. This collaborative effort has produced a great deal of fishery data and information on stock structure and biological parameters. An assessment of the stock covering the 1993-2010 period was attempted, based on the information accumulated for this period. However, incomplete knowledge of the total catch in the EPO is a problem, particularly for the early period of the assessment (1990s and early 2000s).

Although a formal assessment of the silky shark could not be completed, there is sufficient information to form the basis for precautionary management recommendations. First, the fishing mortality of silky sharks has decreased substantially since 2004. This decrease coincided with three important events: IATTC tuna conservation measures, restrictions on shark finning[7] in Central America, and a reduction of effort in the high-seas tuna longline fishery due to increased fuel prices. Second, the stock is predicted to rebuild if the recent (2008-2010 average) levels of fishing mortality are maintained in the future. However, recent information about purse-seine catch rates and the distribution of catches in the EPO does not support a stock recovery in 2011 and 2012, as predicted by the stock assessment work (Figure 1).

The staff considers the above sufficient to warrant recommending the following precautionary measures for silky sharks in the EPO:

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[6] F_{MSY}: fishing mortality rate corresponding to the maximum sustainable yield; $B_{MSY:}$ spawning biomass corresponding to the maximum sustainable yield

[7] Defined as cutting off the fins and discarding the rest of the animal

a. Extend Resolution C-11-10 on oceanic whitetip sharks to include silky sharks, but apply to purse-seine vessels only.

b. For vessels other than purse-seiners, require that all silky sharks captured in fisheries that do not target this species be released as soon as they are seen in the net, on the hook, or on deck, to improve their chances of survival.

c. Longline vessels that target sharks in the EPO, defined as those whose catches of sharks for a given trip exceed 50% of their total catch, should not increase their fleet's fishing effort above the level applied in 2008-2009.

d. Change Paragraph 12 of Resolution C-05-03 to read "Paragraphs 2-10 of this resolution apply only to sharks caught in association with fisheries managed by IATTC" so that reporting of shark catches by species and of fishing effort, required by paragraph 11 of the resolution, is mandatory for all vessels.

e. Conduct experiments on mitigating shark catches, especially in longline fisheries, and on the survival of sharks captured by all gear types, with priority given to those gears with significant captures. Survival experiments should include studies of the effects on survival of shorter sets and of the use of circle hooks.

f. Establish a fund to support research on mitigation of shark captures and data collection projects.

FIGURE 1. Average bycatch per set (BPS) of silky sharks, in numbers of sharks, by 1° area for floating-object sets by purse-seine vessels of IATTC capacity class 6 in 1996 and 2012. Blue: BPS = 0; green: 0 < BPS ≤ 1; yellow: 1 < BPS ≤ 2; red: BPS > 2.