INTER-AMERICAN TROPICAL TUNA COMMISSION

WORKING GROUP ON STOCK ASSESSMENT

7TH MEETING

REVIEW OF 2006 STOCK ASSESSMENTS

La Jolla, California (USA)
15-19 May 2006

MEETING REPORT

Chairman: Dr. Robin Allen

AGENDA

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APPENDIX

A. List of attendees

The 7th Meeting of the Working Group on Stock Assessments was held in La Jolla, California, USA, on 15-19 May, 2006. The attendees are listed in Appendix A.

1. Welcome, introductions, meeting arrangements

The meeting was called to order on May 15, 2006, by the Chairman, Dr. Allen, who thanked the attendees for coming to the meeting, and then asked them to introduce themselves. Drs. Olson and Piner were appointed Rapporteurs (Drs. Kleiber and Dorval also took notes during parts of the meeting). Dr. Allen reviewed the purpose of the meeting, which is convened by the Director. The Stock Assessment Working Group is to provide a peer review of the staff stock assessments, to give the scientists of CPCs an in-depth view of the staff's stock assessments, and to review the advice and recommendations from the staff (Agenda Items 13 and 15a). In recent years the Commission has asked that various other matters be reviewed by the Working Group. This year, the agenda includes discussion of: 1) the ratio of fin to body weight of sharks, 2) the impact of incidental catch of seabirds and identification of geographic areas where there could be interactions, and 3) the assessment of key shark species and the preparation of a plan for the comprehensive assessment of sharks, in cooperation with scientists of CPCs and the Western and Central Pacific Fisheries Commission (WCPFC).

2. Consideration of agenda

Dr. Allen reviewed the agenda and documents that pertain to each agenda item. It was decided to discuss item 10 immediately after item 5, to follow the presentations about seabirds. With this change, the provisional agenda was approved.

3. Update on data received since preparation of Fishery Status Report 3

The provision of data in accordance with IATTC Resolution C-03-05 was reviewed by Dr. Hinton (Document SAR-7-03). There were no additional data provided beyond what were available prior to the meeting. It was noted that the data from Chinese Taipei has been raised. There was brief discussion of the effect of missing data, particularly longline data, on the stock assessments. The general opinion was that there were not sufficient data missing to compromise the assessments.

Dr. Allen led a discussion of the IATTC's policy for release of data to the public domain. The letter he sent to the Commissioners, dated 21 March 2006, was reviewed for comment. The current policies of IATTC and other tuna commissions were summarized, and the proposed IATTC public domain policy was discussed. There was general support for the policy, although there may be circumstances in which the policy would be problematic for some countries. It was recommended that Dr. Allen consult with the Commissioners about the size of the areas over which to consolidate data within or near the EEZs, and national data confidentiality issues. Dr. Allen asked national scientists to brief their country's representatives so that a consensus can be reached at the upcoming Commission meeting. A suggestion was made that a 10º x 20º level of resolution be used for length-frequency for longline fisheries, instead of 5º x 5º.

4. Report of the workshop on stock assessment methods

Dr. Maunder presented the report of the *Workshop on stock assessment methods*, held in La Jolla on November 7-11, 2005). The workshop reviewed three general stock assessment models, MULTIFAN-CL, Stock Synthesis II, and CASAL, which were compared with A-SCALA, the model used to assess tunas in the eastern Pacific Ocean (EPO). Eight questions were posed in advance of the workshop: 1) how to model fishing mortality; 2) how to model selectivity; 3) do we need to integrate across random effects; 4) how to estimate uncertainty; 5) how to include environmental data; 6) how to perform forward projections; 7) what likelihood functions to use and how to weight data sets; and 8) spatial structure in the population dynamics. Several suggestions were made by the workshop participants for improvements for the current A-SCALA model, and for improvements that would require transition to a new modeling environment. Several research priorities were identified and discussed.

The workshop report was briefly discussed, and it was noted that adaptations to the A-SCALA model that were recommended at the workshop have not been incorporated because the Commission staff is considering using the Stock Synthesis 2 model, which already has many of the improvements incorporated, for future assessments.

5. Presentation of contributed papers

The contributed papers were presented as reviews of ongoing work. The Working Group did not review these documents at the same level as the stock assessment documents.

Dr. Hall reviewed the major bycatch issues of the EPO tuna purse-seine fishery. Dolphin mortality has been at a very low level for over a decade, and in 2005 the lowest mortality in the history of the fishery was observed. Bycatches in sets on fish aggregating devices (FADs) are greater than those in dolphin sets, and research and management programs to mitigate their impacts will be required. Of those bycatches, the main concerns include discards of juvenile bigeye and yellowfin tunas, bycatches of dorado, wahoo, and several other species because of the potential conflicts with artisanal fisheries, silky sharks because of an apparent decline in recent years, and manta rays because of the potential for localized impacts on poorly known stocks. The mortality of sea turtles in purse seines has been reduced from an annual average of over 100 during 1993-2004 to fewer than 30 in 2005. Sea turtle bycatch is the major issue for the longline fisheries. Seabirds were not taken by the majority of the artisanal vessels that carried observers in recent years.

Dr. Kleiber outlined progress in updating a North Pacific blue shark assessment from 2001 (Document SAR-7-05a). At that time a variety of scenarios were evaluated using MULTIFAN-CL with various structural assumptions that give a range of results in terms of biomass trajectories and yield curves. However, despite the uncertainty indicated by the range of yield curves and biomass trajectories, the fishing mortality levels near the end of the time series were below fishing mortality at MSY in all scenarios, and similarly biomass levels were above biomass at MSY in all scenarios.

Since that assessment, three years of data for Japanese and Hawaiian catch and effort data for blue sharks have been added to the analysis, along with updated, but still incomplete, longline effort data from Chinese Taipei and Korea. The Japanese longline effort data have undergone a statistical habitat standardization procedure. Large- and small-mesh drift net data from the original assessment have been retained in the current work. The MULTIFAN-CL model used in the original analysis has also been improved in various ways, including the methods by which yield curves and MSY reference points are reckoned. As before, details of the results vary according to various settings in the model. The variation among scenarios indicates that uncertainty is greater than implied by the statistical uncertainty calculated for individual scenarios. Nevertheless, fishing mortality remains well below F_{MSY} and biomass above B_{MSY} in all scenarios investigated. These "optimistic" results have also been confirmed by Dr. Shelley Clarke with Bayesian surplus production analysis of the standardized Japanese longline CPUE. The meeting participants acknowledged that these results should be treated as preliminary.

At the 73rd meeting of the IATTC in June 2005, Resolution C-05-01 was adopted to encourage reporting of seabird mortalities in longline and other tuna fisheries, and four presentations were prepared in response.

Dr. Small, BirdLife International, presented an analysis (Document SAR-7-05b) of data from the Global Procellariiform Tracking Database, which includes 95% of existing tracking data for albatrosses and petrels worldwide. Albatrosses and petrels have been identified as among the species most vulnerable to bycatch in longline fisheries: 19 of the 21 albatross species are listed by International Union for the Conservation of Nature and Natural Resources (IUCN) as under global threat of extinction. The IATTC area overlaps with 5% of the global breeding distribution of albatrosses and petrels, reflecting the fact that there are few breeding sites within the EPO. The greatest overlap is with the breeding distribution of waved albatross in the Galápagos Islands, and with the small population of Laysan albatross from Isla de

Guadalupe, Mexico. The results also emphasize the importance of the IATTC area for non-breeding albatrosses and petrels, including 36% of the non-breeding distribution of black-footed albatross. Data being collected by the Tagging of Pacific Pelagics (TOPP) program indicate that non-breeding Laysan albatross also disperse into the IATTC area. In the South Pacific, the IATTC area overlaps with over 50% of the non-breeding distribution of black-browed albatross from Chile, and with over 50% of the non-breeding distribution of several albatross species from New Zealand, which migrate across the South Pacific to the rich foraging grounds in the Humboldt Current. The distribution is concentrated mostly within EEZs, but includes some high seas areas. The distributions of many albatross species span both the WCPFC and IATTC Convention Areas, indicating the potential benefit of coordination among the two Commissions to assess and address seabird bycatch in the Pacific.

Dr. Scott discussed Agenda Item 10, summarized in Document SAR-7-10. The IATTC has two data sets that can provide information on seabird mortality: the IATTC observer data base, which has data on seabird sightings associated with purse-seine sets, and longline effort data in the EPO. Based on staff and observer experience, seabird mortalities during purse-seine sets are exceedingly rare. Sightings data from IATTC observers provide information on seabird distributions. By overlaying the distribution plots for particularly vulnerable seabird species (such as albatrosses) on longline effort, areas of potential vulnerability can be identified. The area of most concern is between the Galápagos Islands and mainland South America, where the distribution of the longline fishery overlaps that of the waved albatross.

Ms. Rivera presented a report, *Seabirds and Fisheries in the IATTC Area* (Document SAR-07-05c). The report addressed the indirect and direct effects of fisheries on seabirds in the IATTC area, some of the key seabird species affected by fisheries interactions, monitoring bycatch, bycatch estimates, mitigation measures, and priorities for scientific research. Information was presented in the context of IATTC Resolution C-05-01 on seabirds and the United States' implementation of the FAO International Plan of Action on Seabirds. The conservation status of several key seabird species was reviewed. Seabird bycatch estimates for various US longline fisheries range from 0.004 to 0.23 birds per 1,000 hooks, partly depending on whether mitigation measures are used. Bycatch of the waved albatross appear to contribute to recent, dramatic declines in the breeding population. Recent research in Hawaii and Alaska longline fisheries has resulted in mandatory mitigation measures, side-setting and paired streamer lines, respectively. Other research efforts for pelagic longline gear include an underwater bait-setting capsule, a streamer line system, an underwater setting chute, and a bait-setting pod). Two population modeling studies are underway (one by IATTC staff) to assess whether past and present levels of bycatch are likely to affect the populations of black-footed and Laysan albatross. Priorities for scientific research on seabirds include collection of seabird bycatch data by observers, data analysis of seabird flock associations with tuna schools in the EPO, improved understanding of the movements and the overlap of albatrosses with fisheries, and continued development of seabird mitigation measures for pelagic longline vessels.

Dr. Dai gave a presentation (Document SAR-7-05e) on seabird bycatch by the Chinese longline fishery in the IATTC region. The Chinese tuna fleet targets bigeye tuna in the EPO, and observers have been collecting bycatch data since 2003. During a four-month cruise in 2003, the incidental mortality of six seabirds was recorded either due to diving on baited hooks or by collision with the vessel due to rainy weather. The mortalities involved two species of petrel and the blue-footed booby.

There was considerable discussion about the seabird presentations. Seasonal variability is typically great for seabird distribution data. Bycatch analyses could be improved by using spatial and temporal bycatch data. Some participants requested standard protocols for recording seabird bycatch and for identifying seabirds, which Ms. Rivera offered to provide. It was mentioned that some of the small longline vessels in Ecuador and Peru use side-setting methods, which minimizes seabird bycatch. Dr. Allen indicated that the staff will extract information from the three papers and present a review of the seabirds that may interact with the EPO fisheries to the Commission. Collaboration with the other tuna commissions to avoid duplication of efforts was especially encouraged, given that seabirds are highly mobile.

At this point Dr. Hall presented the results of circle hook experiments (Agenda item 8, Document SAR-7-08). Several countries are working with the IATTC, the U.S. National Oceanic and Atmospheric Administration, the World Wildlife Fund, and other organizations to try to reduce sea turtle mortality in the longline fisheries of the region. The voluntary program allows fishers from the region to exchange their normal J hooks for circle hooks to evaluate their effectiveness. Observers are placed on the boats to collect data, and instruments to remove the hooks from the sea turtles and instructions on release procedures are provided. The turtle hooking rates in the fisheries that target tunas, billfishes, and sharks are reduced by a significant amount (in most cases > 60%) using a 16/0 circle hook versus a J hook. An additional benefit of circle hooks is that they tend to become lodged in locations on the turtles where removal of the hook is easier, and the probability of survival is higher. Catch rates of the target species have been similar for the two types of hooks. In the dorado fisheries, where smaller J and circle hooks are used, turtle hooking rates are reduced for circle hooks, but to a lesser degree than in the tuna, billfish, and shark fishery. Another recent experiment using circle hooks with a wire appendage attached was also reported. The wire adds to the width of the hook, and makes it more difficult to swallow. These circle hooks were very effective at reducing hooking rates, but more testing is needed.

Dr. Ariz presented preliminary results of experiments (Document SAR-7-05d) using circle hooks on two Spanish longliners in the southwest Indian Ocean during 2005. The experimental fishing was designed to compare the effectiveness of different types of hooks and bait on reducing sea turtle hooking rates. Four types of hooks were used, two conventional 16/0 J hooks and 18/0 circle hooks of two colors, and two types of bait, squid and mackerel. In 529 sets using 531,916 hooks, 25 sea turtles were caught and returned to the sea alive. Most were either hooked in the flippers or tangled in the lines, and only four animals bit the hooks. Due to the low sample size, the results of the experiment were not conclusive.

The discussion of both sea turtle studies focused on the relative cost of the J and circle hooks. Circle hooks are more expensive, but are more durable than J hooks. When asked if the Commission could provide economic incentives for purchasing circle hooks, Dr. Allen indicated that special funding would be required.

Dr. Chang informed the Group about an experimental trip of a commercial deep longliner with an observer onboard in the EPO and western Pacific Ocean (WPO) for about one month in March, 2005. Of 78,000 hooks deployed on the trip, 26,000 were circle hooks. No sea turtles were hooked during the trip, but preliminary results showed no significant differences in baiting time and bigeye hooking rate between circle and traditional J hooks, and the survival rate of the catch was greater with circle hooks. A second trip is in progress, and a workshop for educational purposes and for encouraging the industry to join the circle-hook exchange program is being planned.

6. The fishery in 2005

Mr. Everett reviewed the information on the fishery for tunas in the EPO in 2005 (Document SAR-7-06, Section A). Mr. Everett discussed EPO tuna catch statistics for 2005; 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 tuna by purse seine, pole-and-line, and recreational gear in 2005 were about 1% less than the catches in 2004, and about 1% less than the average of catches for 1990-2004.

Together, the Ecuadorian-, Mexican-, and Venezuelan-flag vessels caught about 80% of the total yellowfin, skipjack, and bigeye catch in the EPO during 2005. Mexican vessels caught about 43% of the yellowfin, and Ecuadorian vessels caught about 49 and 48% of the skipjack and bigeye, respectively. Yellowfin catches in 2005 were less than the 1990-2004 average inshore and offshore off Mexico and most of Central America, but somewhat greater inshore off Peru. Skipjack catches were slightly higher inshore off Mexico and considerably higher inshore off South America from about 0° to 20°S. The 2005 catches of bigeye were similar to the 1994-2004 average; bigeye catches inshore off South America have declined for several years.

Length frequency and species composition sampling areas were shown, and areas defined for stock assessments were described. Of the 789 wells sampled for length frequency and species composition in 2005, 603 contained yellowfin, 627 contained skipjack, and 209 contained bigeye tuna.

It was noted that the report of the meeting should highlight the fact that, in spite of Resolution C-04-09 and its objective to reduce the fishing mortality, the bigeye catch in 2005 was 21% higher than the 1994-2004 average purse-seine catch.

7. Review of staff stock assessments

Yellowfin, bigeye, swordfish, and silky shark assessments were presented by IATTC staff. The assessments of yellowfin and bigeye were conducted using A-SCALA (*Age-Structured Statistical Catch-at-Length Analysis*). All of the quantitative references to biomass, abundance, recruitment, fishing mortality (F), and quantities related to average maximum sustainable yield (AMSY), are estimates produced by the relevant model.

a. Longline CPUE

Mr. Hoyle described an analysis of catch per unit of effort (CPUE) data from the Japanese longline fleet between 1975 and 2005 presented in Document SAR-7-07. The data were standardized using a generalized linear model, to provide indices of relative abundance for the IATTC bigeye and yellowfin stock assessments. A two component (delta) model was used in order to account for zero catch strata in the analysis. A binomial distribution was used to model the proportion of positive catch strata and either a lognormal or a gamma distribution was used to model the catch rate in a positive catch strata. The lognormal distribution was a better fit for the positive values than the gamma distribution used in the 2005 stock assessments. In addition to time in quarters, significant effects were a latitude-longitude interaction term and the number of hooks between floats. Including these effects gave lower relative abundance in recent years than a model that included only time for both bigeye and yellowfin tuna.

b. Yellowfin

Dr. Maunder described an analysis presented in Document SAR-7-07a.ii. An index of relative abundance for yellowfin tuna in the EPO was calculated by standardizing catch-per-day-fished data from purse-seine vessels that set mainly on yellowfin tuna schools associated with dolphins. The explanatory variables month, latitude, vessel, use of aircraft, and use of sonar, had little effect on the estimated index of relative abundance. The estimated index of abundance was similar to the relative vulnerable biomass for the fisheries on schools associated with dolphins from the yellowfin tuna stock assessment.

The Group discussed the pros and cons of using purse-seine search time as a measure of effort. It was agreed that search time could be a useful measure, but that it is difficult to make decision rules about when a vessel is in a searching mode or not. It was pointed out that previous studies indicated that raw CPUE gave the same result as a model that incorporates search time.

Mr. Hoyle reviewed the yellowfin assessment presented in Document SAR-7-07a.i. The assessment for 2006 differs from that of 2005 in the following ways:

The catch, effort, and length-frequency data for the surface fisheries have been updated to include new data for 2005 and revised data for 1975-2004. The catch data for the Japanese longline fisheries for 2000-2003 have been updated, and new data for 2004 have been added. The catch data for the longline fisheries of Chinese Taipei have been updated to include new data for 2002. The catch data for the longline fisheries of China have been updated to include new data for 2003 and revised data for 2001 and 2002. The longline catch-at-length data for 2001-2002 have been updated, and new data for 2003 have been added. The longline effort data have been standardized by means of a delta-lognormal generalized linear model standardization of the CPUE, using data for 1975-2004, rather than the delta-gamma generalized linear model that was used previously.

The results of the 2006 assessment are similar to those of the previous six assessments, except that the

spawning biomass ratio (SBR) at AMSY is less than estimated in the 2005 assessment and similar to the five assessments before that. Historically, the SBR of yellowfin tuna in the EPO was below the level corresponding to the AMSY during the lower productivity regime of 1975-1983, but above that level for most of the last 21 years. The SBR at the start of 2006 is estimated to be very close to the level corresponding to AMSY. The effort levels are estimated to be close to those that would support the AMSY (based on the current distribution of effort among the different fisheries), and the catch levels are a little above the corresponding values at AMSY. The results are sensitive to the assumption about the stock-recruitment relationship. Alternative assumptions about the asymptotic length do not substantially affect the outlook for the fishery. Under 2005 levels of effort, the biomass and SBR are predicted to not decline significantly over the next five years. Both the purse-seine and longline catches are expected to remain close to 2005 levels.

The participants sought clarification on a number of elements of the assessment model and its application to yellowfin tuna. Salient points from those queries and the associated recommendations of the Working Group are outlined below.

The biomass and other estimates have changed from the 2003 to the 2006 assessments. For example, the 2003 assessment showed a sharp decline in biomass for that year, while the 2006 assessment estimated 2003 biomass to be the fourth highest in the time series. The Group suggested doing a retrospective analysis to separate data changes from model changes.

Next there was discussion about the influence of oceanographic conditions, especially El Niño Southern Oscillation (ENSO) and interdecadal regimes, on the yellowfin stock in the EPO. In previous assessments, the relationship between recruitment and an El Niño index and sea-surface temperature was examined. There was little effect, probably because recruitment is well estimated in the model due to substantial length-frequency data. Also, the staff has examined the effects of the thermocline depth and ENSO on catchability, and in this year's assessment there was no relationship for yellowfin, but there was for bigeye. The Group pointed out that we appear to be entering a cold interdecadal period, and availability of the fish to surface fishing gear may decline. Whereas the effects of including oceanographic factors in the model are sometimes significant, they often do not improve our estimates of recruitment. An index based on the southern oscillation does not appear to be fine enough in scale to be useful for this purpose. The Group recommended there be further analysis of the assumption that a regime shift took place in about 1984, by extending the data series back to earlier years. Several problems of doing such an analysis, such as expansion of the fishery, were discussed.

There was discussion of the fact that this year's assessment for yellowfin indicates a healthier stock status than that for last year, but catches are down in 2006. A number of reasons why catches might be down even though stock appears to be in good condition were discussed. These include lower catchability now than in 2003-2004, changes in distribution, and possibly changes in other components of the ecosystem.

The staff has been aware of the increase in recruitment and stock size after 1985, and has for 20 years attributed the increased recruitment to an environmental change that led to greater spawning biomasses, rather than to dependence of recruitment on spawning stock size. Nevertheless, it is possible that this interpretation is wrong and that the increase after 1985 was related to a stock-recruit relationship with steepness significantly less than 1. If that were the case, the stock would currently be overfished, and the fishing mortality would need to be reduced by about 40% to bring it to the level corresponding to the AMSY.

There was concern expressed about the statement in the Executive Summary of Document SAR-7-07a.i, that fishing on schools associated with dolphins has the greatest impact on the yellowfin tuna population, is misleading due to the beneficial yield per recruit characteristics of the dolphin-associated fishery.

It was suggested that the equations that describe the updates to the A-SCALA model be documented.

c. Bigeye

Eastern Pacific assessment

Dr. Maunder presented the current stock assessment of bigeye tuna in the EPO, which is summarized in Document SAR-7-07c.i. This assessment, and the previous ones, were conducted with A-SCALA. The current version of A-SCALA is similar to that used for the most recent previous assessment. The assessment is based on a single stock in the EPO. The main changes from the previous assessment are the update and addition of catch, effort, and length-frequency data. Analyses were carried out to assess the sensitivity to the steepness of the stock-recruitment relationship, to the assumed value for the asymptotic length parameter (L_∞) of the Richards growth curve, to the inclusion of the Chinese Taipei longline length-frequency data, and to inclusion of a relationship between recruitment and an El Niño index. The base case assessment included an assumption that recruitment was independent of stock size, and a Beverton-Holt stock-recruitment relationship with steepness of 0.75 was used for the sensitivity analysis. Sensitivity to the assumed value for the L_∞ of the Richards growth curve was carried out using a lower value of 171.5 cm, which is around the value estimated by stock assessments for the western and central Pacific Ocean (WCPO) (Adam Langley, Secretariat of the Pacific Community, pers. com.), and an upper value of 201.5 cm. Sensitivity to including the Chinese Taipei longline fleet was carried out by treating it as a separate fishery with the associated length-frequency data.

On average, the fishing mortality on bigeye younger than about 18 quarters (4.5 years) old has increased substantially since 1993, and that on fish older than about 4.5 years has increased slightly since then. The increase in average fishing mortality on the younger fish was caused by the expansion of the fisheries that catch bigeye in association with floating objects. The biomass has increased in 2004 and 2005 due to two recent spikes in recruitment. Fishing has reduced the total biomass of bigeye in the EPO. The estimates of recruitment and biomass were only moderately sensitive to the steepness of the stock-recruitment relationship. The estimates of recruitment and biomass were very sensitive to the assumed value of the L_∞ in the Richards growth equation. A lower value gave higher biomass and recruitment. Estimates of recruitment and biomass were insensitive to the inclusion of the Chinese Taipei length-frequency data and the El Niño-recruitment relationship. The relationship between recruitment and the El Niño index was found to be significant, but explained only a small portion of variation in recruitment. At the beginning of January 2006, the spawning biomass of bigeye tuna in the EPO was increasing from a recent historical low level. At that time the SBR was about 0.20, about 12% less than the level corresponding to the AMSY. The level of fishing effort corresponding to the AMSY is about 68% of the current (2003-2004) level of effort. The AMSY of bigeye in the EPO could be maximized if the age-specific selectivity pattern were similar to that for the longline fishery that operates south of 15ºN because it catches larger individuals that are close to the critical weight. All analyses, except the low assumed value for the asymptotic length of the Richards growth curve, suggest that at the start of 2005 the spawning biomass was below the level corresponding to the AMSY. Recent spikes in recruitment are predicted to result in increased levels of SBR and longline catches for the next few years. However, high levels of fishing mortality are expected to subsequently reduce SBR. Under current effort levels, the population is unlikely to remain at levels that support AMSY unless fishing mortality levels are greatly reduced or recruitment is above average for a number of consecutive years.

In contrast to yellowfin, there is no information in the history of the fishery that supports a stock-recruitment relationship with steepness significantly less than 1. Nevertheless, the steepness is very difficult to estimate, and there remains a possibility that inferences made using the base case assessment underestimate the extent to which the stock is overfished.

Sensitivity analysis to updated Japanese catch data

Dr. Maunder presented a sensitivity analysis summarized in Document SAR-7-07c.i SUP. An updated estimate of the catch of bigeye tuna by the Japanese longline fleet in the EPO in 2004 was received after the assessment of the status of bigeye tuna in the EPO in 2005 was completed. The estimate (18,500 t)

was approximately 23% less than the value used in the assessment (24,000 t). The effort used for forward projections is also a function of the catch in 2004 and is therefore influenced by the updated catch. The assessment and projections were conducted with these revised estimates. The results were essentially the same as those obtained using the initial estimate. The inclusion of the updated Japanese longline catch data for 2004 does not affect the conclusions of the assessment.

The general discussion of the bigeye assessment and the sensitivity analysis followed Dr. Maunder's presentations. More details about the Japanese longline data were given by the Japanese scientists. It was suggested looking at the likelihood profile for the length parameter (L_∞) of the Richards growth curve to further investigate the sensitivity of the results to this parameter.

There was more discussion of oceanographic effects in the context of the bigeye assessment. The Group pointed out that an El Niño index averages over a very broad region, while much of the bigeye catch is taken west of the Galápagos Islands. Perhaps an index could be developed using data from the TOGA TAO buoy array.

There was also discussion of the concept of FADs acting as an ecological trap, moving the fish from productive regions into regions of lower productivity. It was noted that recent tagging data indicate that bigeye are at FADs an average of only 20% of their time at liberty, but that this amount of association could account for a net westward movement if the movements are random during the remaining 80% of the time.

Pacific-wide assessment

Dr. Hampton presented an update of the assessment of bigeye tuna on a Pacific-wide basis, Document SAR-7-07c.ii. The Pacific-wide (PO) model is spatially structured (9 regions) with movement (and a host of other parameters) estimated. The model results indicated that overfishing is occurring on a Pacific-wide basis, with fishery impacts greatest in the tropical regions. SBR remains above the MSY level in the base-case analysis, but approaches the MSY level in the most recent year when growth is fixed to that assumed in the EPO bigeye assessment (IATTC growth). Various comparisons of the results of the PO model for the EPO region with those of the EPO bigeye assessment carried out by the IATTC were shown. Generally there was a high degree of consistency in the estimates of biomass, recruitment, fishing mortality, and SBR when IATTC growth was assumed, but the PO model produced higher biomass-related quantities when growth was estimated within the PO model. The model estimates of movement indicated a net west-to-east movement of bigeye, although movement to the west from the EPO also occurred. The different growth parameters estimated by the PO model and estimated from otolith data in the EPO may be indicative of regional growth variation. Such variation, if it exists, cannot be accommodated by the current PO model. Increases in average size of the longline catch from west to east are, therefore, explained in the PO model by differences in age structure of the region-specific populations, which in turn influence the estimated movement parameters. It is possible that a model in which these differences in average size could be explained by growth variation might produce different estimates of movement and stock structure interpretations.

The Group sought clarification on the net west-east movements indicated by the PO model, which does not match the tagging data in the EPO. There was further discussion of the reasons, described in the previous paragraph, that the model shows this result.

There was discussion about the uncertain nature of the data from Region 7 of the PO model (Indonesia and the Philippines). Region 7 was identified to limit the impact of the uncertain data on the other areas in the model.

The Group suggested treating the Pacific-wide model as a semi-closed model by not allowing movement past 150ºW, but permitting movement within each of the two larger regions. The western and central Pacific Ocean (WCPO) bigeye model is essentially built this way, and results were consistent with the PO model.

d. Skipjack

Dr. Maunder reviewed an analysis of skipjack CPUE presented in Document SAR-7-07b. A method was developed to generate indices of relative abundance from purse-seine catch data. The ratios through time of catches of the species of interest to a species with known abundance were used to create the index. This index was adjusted by the estimated abundance of the second species. The method was put into a general linear model (GLM) context to eliminate variation caused by other factors (*e.g.* latitude). The method was applied to skipjack tuna caught in purse-seine sets on floating objects in the EPO, using the estimated abundance of bigeye tuna from stock assessments. Additional analyses for yellowfin tuna were used as a test of the method by comparing the estimated index of relative abundance with stock assessment estimates of abundance. The results showed some consistency with the stock assessment. However, adjusting for the estimated abundance of bigeye tuna reduced the correlation. Including additional explanatory variables in the GLM had little influence on the estimated index of relative abundance.

The Group discussed the changing species composition in successive sets on FADs shown in IATTC data. The ratio of skipjack to bigeye decreases as successive sets on the same object occur. Perhaps more information would be obtained by having two species in one model and sharing variables. The ratio estimator index of abundance could be used in A-SCALA or Stock Synthesis 2. Other suggestions were to borrow some of the parameter estimates from the WCPO skipjack model, in which extensive tagging data were used to determine natural mortality, or to share catchability parameters in a multi-species model.

The need to assess and manage skipjack tuna was questioned due to their life history characteristics and high productivity. A comprehensive tagging study was recommended.

The ratio method is based on the catchability not changing over time. However, the vessels increasingly target bigeye tuna, which causes catchability to change. It was suggested that the age of the fish should be accounted for in the analysis.

The ratio could be different for different vessels, particularly those that target bigeye. Vessel was included in the analysis to account for the differences.

In summary, the results of the analysis were consistent with previous assessments, and suggest there is no management concern for skipjack tuna, apart from the associated catch of bigeye in floating-object sets.

e. Swordfish

Dr. Hinton reviewed the swordfish stock assessment presented in Document SAR-7-07d. The southeastern Pacific Ocean stock of swordfish is distinct from stocks in the northern EPO, the southwestern Pacific Ocean, and the WCPO/Hawai'i regions, based on genetics and fisheries analyses. Preliminary analyses of the status of the southeastern Pacific Ocean stock of swordfish indicate that the spawning biomass has declined significantly over the 1945-2003 period, and is now about twice the level that will support fisheries at AMSY. Catches have increased substantially since 2001. Recent harvests are on the order of 14,000–15,000 t annually.

The principal fisheries capturing swordfish in the EPO are the fisheries of Chile and Japan, which have taken a combined average annual catch of about 5,200 t during the 1990s and about 5,500 t since. The dominant fishery in most recent years is that of the European Union (Spain), which has taken on average about 5,700 t per year since 2002. Longline fisheries that operate in the area and that are considered similar in style to the Japanese fishery were modeled with it.

There have been indications of increasing efficiency and targeting of swordfish in the southern EPO, which has resulted in increased harvests of this stock. It is also noted also that some of the increased catch may have resulted from the high recruitments noted previously. It is not expected that further increases in the catch levels observed in recent years would be sustainable.

No calculations have been made to determine the level of AMSY that could be obtained by each fishery

operating exclusively. However, it is likely that the fisheries that capture younger fish (*e.g.* the longline fisheries of Chile, Japan and Spain) are less efficient at maximizing yield. There is potential for growth overfishing analogous to that of longliners and purse seiners fishing for bigeye tuna in the EPO, with the Chilean artisanal fishery in the role of longliner and the Chilean/Japanese/Spanish longliners, which capture the younger fish, in the role of purse seiner.

A general discussion of the swordfish assessment followed. The assessment results should be considered preliminary, at least until such time that all CPUE series are standardized for relevant factors. The Group questioned the use of a high natural mortality rate of 0.4 in the model, given that there are 15-year old and older fish in the catch. A natural mortality rate of 0.2 is commonly used in the Atlantic Ocean. The probability of 15-year-old and older fish in the population is a function of total mortality, population size, and selectivity. In a previous assessment, a sensitivity analysis showed low sensitivity to the natural mortality parameter. It was also suggested that the lack of fit to the CPUE data could be caused by the high natural mortality assumed in the model. The model was re-run with a natural mortality of 0.2, and the results showed that the natural mortality of 0.2 was less consistent with the age data but more consistent with the CPUE data.

It was noted that the Comisión Permanente del Pacífico Sur is working on swordfish, and could provide data to the IATTC.

Dr. Miyabe presented data that show a marked change in the distribution of the Japanese longline fishery during 2001-2003. There has been a southern expansion of the fishery into coastal areas off Peru and Chile, targeting swordfish.

f. Silky shark

Dr. Lennert-Cody summarized a study to model silky shark bycatch data, presented in Document SAR-7-07e. A brief summary of the methods currently being used to standardize silky shark bycatch per set in floating-object sets was presented. The current approach is to use generalized linear and generalized additive models to standardize bycatch (numbers of sharks) per set data. Silky shark bycatch per set data are characterized by a large proportion of zero-valued observations, but also large bycatches. Because the true processes that generated the data are unknown, four related probability functions have been explored to model the shark bycatch data: Poisson, negative binomial, zero-inflated Poisson and zero-inflated negative binomial. The negative binomial is an extension of the Poisson distribution that can better model highly variable count data. The zero-inflated probability functions are better able to fit data with many zero-valued observations, with the zero-inflated negative binomial distribution an extension of the zero-inflated Poisson distribution. Overall, the zero-inflated negative binomial regression model was found to provide the best fit to the silky shark bycatch data. Trends in standardized bycatch per set from all four type of regression models were found to be decreasing over the period from 1994-2004. Future work is planned to explore in detail spatial and environmental effects on these trends.

A general discussion of the analysis of silky shark bycatch followed. The Group asked if procedures for enumerating sharks have changed, and if the sharks returned to the sea alive are considered as bycatch or as survivors. Dr. Lennert-Cody mentioned there have been no procedure changes, but new data are being collected on the numbers and sizes of sharks released alive. We have no scientific evidence as to whether released sharks survive, but the general feeling among the staff and observers is that they probably do not survive due to anoxia and injuries.

It was noted that there was a species identification problem between silky and blacktip sharks. This is being addressed by new identification guides and additional data collected by observers at sea on diagnostic characteristics, which are used to confirm identifications (see PFRP Newsletter, July-September 2005, pages 4-5, http://www.soest.hawaii.edu/PFRP/newsletters/July-Sept2005.pdf).

It was noted that silky sharks are the most numerous shark in the bycatch of purse-seine vessels in the EPO, and also comprise a significant portion of the catch of artisanal fisheries. For example, the silky

shark is the third most numerous shark caught by the artisanal longline fleet in Ecuador. There is, therefore, considerable fishing pressure on silky sharks in the EPO. Ecuador has addressed this issue by adopting a National Plan of Action for the Conservation and Management of Sharks.

The research plan for shark stock assessment was mentioned, which Mr. Hoyle will present under Agenda Item 11. The Group recommended taking into account the effects of environmental variability on shark bycatch and group size.

8. Results of circle hook experiments

These experiments were reviewed under Agenda Item 5 by Dr. Hall.

9. Ratio of fin weight to body weight of sharks

Dr. Ariz (Document SAR-7-09) explained that this agenda item resulted from IATTC Resolution C-05-03 concerning the conservation of sharks. Paragraph 4 of the resolution states, "CPCs shall require their vessels to have onboard fins that total no more than 5% of the weight of sharks onboard, up to the first point of landing", and Paragraph 5 states that "The ratio of fin-to-body weight of sharks described in paragraph 4 shall be reviewed by the Working Group on Stock Assessment and reported back to the Commission in 2006 for revision, if necessary ." Although the specimens studied by Dr. Ariz were caught in the south-western Indian Ocean, they comprise four species that are also common components of the bycatch in the EPO. For 607 sharks, the percentages of fin weight (all fins) to dressed body weight of blue, mako, silky, and oceanic whitetip sharks ranged from 6.3 to 16.1%, all greater than the 5% value stated in the resolution.

The Group agreed that the paper has identified several problems with the use of a 5% ratio of fins to body weight. For example, it is not specified if the standard applies to the wet or dry weight of the fins, the dressed weight or whole weight of the shark, the whole fin or just what is sold in the market, *etc*. It was recommended there should be different weight ratios for different species.

Following general discussion of Dr. Ariz's presentation, Dr. Dai presented Document SAR-7-09a, which reported observations made while aboard a longline cruise in the EPO. The weight of the dorsal, caudal, and pectoral fins and the round weight of the shark carcasses were recorded. For blue and whitetip sharks, the ratio averaged 5.4% and 7.0%, respectively.

The Group noted that the results of these two studies were quite different, and the reasons (among others) included the number of fins included in the analyses, how the fins were cut (L or straight cut), the state of the shark carcasses (dressed or round), the length of the trip (which determines how dry the fins are) and the sizes of the sharks. It was suggested that it would be better and easier to match the number of fins to the number of carcasses, rather than matching weights.

10. Interactions between longline fisheries and seabirds

This presentation was included with the other presentations on seabirds under Agenda Item 5 by Dr. Scott.

11. Draft research plan for comprehensive assessment of shark stocks

Resolution C-05-03 on the conservation of sharks requires that the IATTC, in cooperation with scientists of CPCs and, if possible, the Western and Central Pacific Fisheries Commission, shall propose a research plan for a comprehensive assessment of key shark stocks. Mr. Hoyle presented a proposal contained in Document SAR-7-11 that includes: 1. identification of key species; 2. compilation of available life-history data; 3. compilation and standardization of CPUE data and length frequency data; and 4. population dynamics modeling. A series of actions was proposed, along with the required funding and resources; these include salary for a 14-month research position, catch and effort data for fisheries that take sharks in the EPO, and unpublished life history data.

This topic was discussed at length. It was suggested that there are similar species not directly covered by

this plan that are of concern, such as manta rays, and that tagging of sharks to investigate release mortality would also be desirable. The study is intended as a Pacific-wide study, and the WCPFC would hopefully be involved, as would the national observer programs in the EPO.

It was proposed that the most effective way of pursuing such a project would be if IATTC staff coordinated efforts of experts from national programs.

Caution was expressed that the time allocated for data collection alone is optimistic. Dr. Kleiber underscored this by mentioning some of the difficulties in collecting the data for the blue shark assessment. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) produced a report at the Tenth meeting of the Conference of the Parties in 1997 that reviewed some life history and other data on sharks, and it was noted that this would be a useful starting point.

12. Review of 2004-2006 management measures

Resolution C-04-09 on the conservation of tuna in the EPO called for restrictions on purse-seine effort and longline catches for 2004 to 2006: a 6-week closure during the third OR fourth quarter of the year for purse-seine fisheries, and longline catches are not to exceed 2001 levels. Mr. Hoyle presented the results of an investigation (Document SAR-7-12) of the effectiveness of this management measure, first by examining the changes in purse-seine fishing effort and longline catches of bigeye, and then with a simulation of the effect of assumed purse-seine effort and longline catch in the absence of the Resolution.

Fishing effort (estimated days fishing) in the floating-object fishery was less in 2004 and greater in 2005 than in 2003. The average of the two years was about 5% less than that in 2003, compared to about 12% less, which was used for all purse-seine fishing in the simulation. Effort in the unassociated fishery was greater in both 2004 and 2005 than in 2003, and the average of the two years was 4.4% more than in 2003. Effort in the dolphin-associated fisheries was 15% higher in 2004 and 11% lower in 2005 than in 2003. The average of the two years was about 2.3% more than in 2003. The longline catch of bigeye tuna has decreased by more than the reduction required by the Resolution since 2001; in 2005 it was only 45% of that in 2001.

The capacity of the purse-seine fleet grew approximately 5% from 2003 to 2005. This growth in capacity, together with other adaptations to the closures, is diminishing the effect of the management measures.

The simulations, which used a reduction in purse-seine effort of 12%, estimated the spawning biomass of bigeye tuna at the end of 2005 with the management restrictions to be about 23% greater than if no restrictions had been implemented. The equivalent figure for yellowfin tuna was about 17%. Given that the effort reduction was less than 12%, these figures are likely to be overestimates of the outcome.

Dr. Maunder presented an analysis to investigate the use of trip limits for bigeye tuna (Document SAR-7-12a). The analysis was based on trip records held in the IATTC database. Data for each vessel were summed to provide total catch of bigeye, yellowfin, and skipjack for each year for each vessel. Two analyses were carried out. The first analysis ordered the data by descending catch of bigeye, to determine the number of vessels that captured the majority of bigeye catch. The second analysis investigated individual vessel catch limits by assuming that catch occurred at a constant rate throughout the year and that each vessel stopped fishing as soon as it reached its bigeye catch limit. The majority of bigeye is caught by a small number of vessels. These vessels capture a lesser proportion of the total catches of yellowfin and skipjack. During 1999-2005, between 11 and 15 vessels captured 50% of the bigeye catch, but only about 5% of the yellowfin catch and 18-32% of the skipjack catch. Between 23 and 30 vessels captured 75% of the bigeye catch, but only about 10% of the yellowfin catch and 32-50% of the skipjack catch. Many of these vessels frequently caught a large proportion of the bigeye catch. The individual-vessel bigeye catch limits required to reduce the catch to 30% and 50% of the levels in each year are about 660-930 and 350-520 t, respectively, except for 2000, which would have required 1520 and 889 t, respectively. These limits would have affected 16-26 and 30-40 vessels, respectively, and would have

resulted in a reduction of about 7-10% and 15-20%, respectively, of the total tuna catch if the vessels took no action to reduce the proportion of bigeye in their catches.

Dr. Maunder presented analyses investigating the use of a management action putting a quota on the catch of bigeye less than 60 cm in length, Document SAR-7-12b. Resolution C-00-02 required that the purse-seine fishery using FADs be closed if the catch of bigeye tuna less than 60 cm in length (bigeye <60 cm) reached the level achieved in 1999. This restriction is reevaluated as a possible candidate for future management measures for bigeye tuna. The amount of catch of bigeye <60 cm over time calculated from the stock assessment was compared to the sampling model estimates. This was also compared to the "small" category (<2.5 kg) in the observer data. The amount of catch of bigeye <60 cm over time (by quarter) was compared to many other indicators of the stock status: catch <60 cm as a ratio of the total surface fleet catch; catch <60 cm as a ratio of the total catch; spawning biomass ratio; the scaling parameter to scale the fishing mortality in that year to the level that would produce AMSY; average weight in the catch; the fishery impact; recruitment; and exploitation rate on fish <60 cm (ages 1-5 quarters). Yield-per-recruit analysis was carried out for bigeye tuna to determine the impact on yield if the catch of fish <60 cm was reduced.

The amount of bigeye <60 cm caught is generally a function of the strength of the cohorts in the fishery. Therefore, annual variation in the amount of bigeye <60 cm caught is expected, and any controls on the catch of bigeye <60 cm would reduce fishing mortality rates on these fish in years of high abundance. Fishing mortality would not be reduced in years of low abundance when the reduction may be more beneficial. Reducing the fishing mortality on bigeye <60 cm would greatly increase the yield per recruit and yield. However, even if the catch of bigeye <60 cm could be eliminated, the current effort is still too high. These results are conditioned on the assumed values for age-specific natural mortality. The rate of natural mortality is uncertain, particularly for the younger fish. Changes in yield per recruit would be reduced if the rate of natural mortality for young fish was greater than currently used in the model. Hampton (2000, Canadian Journal of Fisheries and Aquatic Sciences 57: 1002–1010) estimates much greater rates of natural mortality than used in the EPO assessments, but this rate is confounded by possible high levels of tagging induced mortality.

13. Status of stocks of tuna and billfish in the EPO

The Group reviewed Document SAR-7-13, section by section, under this agenda item. This document, which will become Fishery Status Report 4, is the primary source of data and scientific information for the Commission in its consideration of the effects of the fishery and of any conservation measures. The sections on yellowfin, bigeye, and albacore are summaries of this year's assessments. The remaining species sections are mostly updates of information and assessments previously reported.

The Group made several suggestions for improving the report, such as adding effort distributions to the Fishery section (Section A), adding a summary of the analysis of CPUE to the skipjack section, investigating interactions when the longline fishery moved out of the areas that became the FAD fishery, adding a statement about the likelly effect of increases in longline effort for South Pacific albacore, including a summary of the recent swordfish stock assessment including stock structure, and noting that the swordfish stock assessment results are preliminary, and incorporating the ISC recent reviews for information on marlins.

The Ecosystem Considerations section of the report was reviewed. The section on seabirds should be updated to include information from the presentations at this SAWG meeting. Ms. Rivera offered to provide some text for this and for the section entitled "Actions by the IATTC and the AIDCP addressing ecosystem considerations." There was discussion about adding a section about bycatch mitigation in the next report, which would include ideas for future research.

14. Antigua Convention Article 11, Scientific Advisory Committee

Dr. Allen explained that this agenda item anticipated the entry into force of the Antigua Convention,

specifically Article 11 and Annex 4, which deal with the Scientific Advisory Committee. The first formal meeting of the Scientific Advisory Committee, which would be a subsidary of the Commission, could take place in 2008.

15. Recommendations

a. Review of staff recommendations

Dr. Allen reviewed the draft staff conservation recommendations in Draft Document IATTC-74-18. The Group considered the document, and during the discussion, some inconsistencies were noted and several suggestions for improving the language were made. Dr. Sun noted that the biomass and SBR of bigeye tuna estimated by Dr. Maunder for this year are higher than those of last year, and questioned the management objectives for bigeye tuna proposed by the IATTC staff. Dr. Dai noted that longline catches were much reduced already, and the need for a further 30% reduction of that gear's quota was questioned. Dr. Allen indicated that revised conservation recommendations will be presented at the Commission meeting in June. While not included in the draft, the staff had examined the effect of closing an area west of 92ºW and between 7ºN and 2ºS. In view of the discussion on closed areas, the recommendation would include consideration of the closed area, and the staff would further examine the effect of the above, and of closing an additional area to the south between 100º and 110ºW and to 10ºS.

b. Recommendations from the meeting

The six following recommendations were made to the Commission:

1. The participants in the IATTC Stock Assessment Working Group (SAWG) find the working group to be extremely helpful to their responsibility to advise their respective delegations. They noted that it has improved significantly each year. Therefore, the participants strongly recommend that the SAWG be continued in future years.

2. The SAWG meeting structure should be modified to allow for the possibility of making a few additional model runs during the meeting. In particular, the yellowfin and bigeye assessments should be presented on the first day of the meeting, allowing for a re-visit (as needed) later in the week.

3. The SAWG recommends that the Commission coordinate with the WCPFC, and other tuna Regional Fisheries Management Organizations (RFMOs) as appropriate, in its implementation of seabird resolutions and the development of scientific information and reports that support this implementation. This could include practical areas of cooperation on the mitigation of seabird bycatch.

4. The SAWG recommends that the IATTC, in collaboration with the WCPFC, conduct a Pacific-wide skipjack assessment. Inclusion of tagging data from the western Pacific Ocean has the potential to improve the current assessment of eastern Pacific skipjack, which is solely based on relative indices of abundance from purse-seine catch.

5. The IATTC should develop, in coordination with the other RFMOs, a strategy to mitigate bycatches in the different fisheries involved. The program should include standardization of data collection (whenever possible), discussion of research programs and activities to be undertaken in each, and a mechanism for the timely sharing of results. This item could be included in the agenda of the upcoming Kobe meeting.

6. The participants of the SAWG reiterated the recommendation made last year for a joint WCPFC-IATTC Pacific-wide tagging program for tropical tunas.

7. The SAWG recommends further analysis and consideration of the ramifications of large closed areas as a means to mitigate bycatch issues. The Group noted that the area would likely need to be large and persist over a number of years to have any positive effect. Area closures may partially mitigate

the need for long seasonal closures.

8. The SAWG recommends that the Commission consider providing for research recommended by the staff during closures. This would allow a vessel to operate in the EPO during a time when it would otherwise be prohibited under a Conservation Resolution. Particular research would be approved by the Commission on a case by case basis.

16. Time and topic for mid-year workshop

The Group discussed the topic recommended by the staff, management strategy evaluation, for the mid-year technical meeting (Document SAR-7-16). The Group agreed with the topic, and set the dates of 17-20 October, 2006.

17. Other business

Dr. Allen said that, following the recommendation of the 6th meeting of the Working Group and its endorsement by the Commission, a Workshop on economic incentives for fleet capacity reduction was being planned to take place in La Jolla in early October 2006.

The proposed cooperation between the IATTC and the WCPFC had been addressed in the meetings of both Commissions, and a draft memorandum of cooperation will be considered at the 74th meeting of the IATTC.

18. Meeting report

The meeting report was adopted.

19. Adjournment

The meeting was adjourned at 3 p.m. on 19 May 2006.

Appendix A.

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