INTER-AMERICAN TROPICAL TUNA COMMISSION

10TH STOCK ASSESSMENT REVIEW MEETING

La Jolla, California (USA)
12-15 May 2009

MEETING REPORT

Chairman: Dr. Guillermo Compeán

AGENDA

		Documents
1.	Welcome, introductions, meeting arrangements	
2.	Consideration of agenda	
3.	Report of the IATTC scientific workshop on spatial analysis for stock assessment	
4.	The fishery in 2008	SARM-10-04
	a. Report on unilateral management actions taken in 2008	SARM-10-04a
5.	Report on the 78th and 79th IATTC meetings on management, June and November 2008	
	a. Method for evaluating individual purse-seine vessel closures	IATTC-79-04
6.	Yellowfin and bigeye tunas:	
	a. Stock assessment of yellowfin	SARM-10-06a
	b. Stock assessment of bigeye	SARM-10-06b
	i. EPO assessment	
	ii. Sensitivity analysis to extending the western boundary of the bigeye stock	
7.	Assessment of skipjack tuna	SARM-10-07
8.	Assessment of striped marlin	SARM-10-08
9.	Evaluation of aspects of the IATTC sampling design for purse-seine tuna catches	SARM-10-09
10.	Effects of choice of spatial resolution for bigeye tuna assessment	
11.	Preliminary natural mortality estimates for bigeye tuna based on integrated analysis including tagging data	SARM-10-11
12.	Update on proposal for EPO tuna tagging project	SARM-10-12
13.	Sharks: Review of information and ongoing activities	
14.	Reviews of papers contributed by scientists of other institutions	SARM-10-14a
	a. Proposal to add several years of data to the assessment of yellowfin tuna	
15.	Effects of the tuna fisheries on the ecosystem of the EPO	SARM-10-15
16.	Assessments by Working Groups of other international organizations:	
	a. International Scientific Committee: North Pacific bluefin	
	b. International Scientific Committee: Swordfish (preliminary)	
17.	Date and topics for October workshop (tentative: Modeling processes including selectivity, growth, natural mortality, and recruitment)	
	a. Technical workshop on shark assessment	
18.	Other business	
19.	Recommendations	
20.	Meeting report	
21.	Adjournment	

APPENDICES

A. Tentative IATTC staff recommendations
B. List of attendees

The 10th Stock Assessments Review Meeting was held in La Jolla, California, USA, on 12-15 May 2009. The attendees are listed in Appendix A.

1. Welcome, introductions, meeting arrangements

The meeting was called to order on 12 May 2009, by the Chairman, Dr. Guillermo Compeán, Director of the IATTC, who thanked the attendees for coming to the meeting. The Stock Assessment Review Meeting is not a formal subsidiary meeting of the IATTC, but rather an informal working group convened by the Director; it is intended to provide an external peer review of the IATTC staff's stock assessments, to give the scientists of member countries and cooperating non-parties of the IATTC (CPCs) a view of these assessments, to review the advice and recommendations from the staff, and to provide an opportunity to prepare for the formal consideration of the status of the stocks at the upcoming annual meeting in June.

2. Consideration of agenda

Dr. Compeán reviewed the provisional agenda and the documents that pertain to each agenda item. The agenda was approved without changes.

3. Report of the IATTC scientific workshop on spatial analysis for stock assessment

Dr. Mark Maunder presented a summary of the IATTC Workshop on spatial analysis for stock assessment, held in La Jolla on 14-17 October, 2008, preceded by a workshop on Stock Synthesis II on 15 October[1]. The topics covered at the workshop included spatio-temporal interactions in the standardization the catch per unit of effort (CPUE), spatial structuring of fisheries in assessment models, spatial population dynamics models, information about movement among sub-populations, spatial analysis of fleet dynamics, and management of spatially-heterogeneous populations. Some important aspects of spatial analysis that were discussed included: If there are substantial differences among areas in the trend in the [CPUE] year effect, then the areas should be modeled as either separate populations or separate fisheries. Sensitivity analyses should be conducted to determine the impact of spatial structure on the management advice. Tagging data are considered the most useful method to provide the necessary information to define areas and movement among areas for many species. It is important to model differences in biological processes among areas. However, it becomes more difficult to model them if there is movement among the areas. Of particular interest were the comments with respect to the question "Is a Pacific-wide assessment of bigeye tuna necessary?" Initial tagging data indicate that movement of bigeye tuna is restricted. There are some issues with limited tagging data throughout the Pacific Ocean. There is also concern about the limited size and spatial distribution of bigeye tagged. Preliminary analyses show differences in CPUE trends among subareas within the eastern Pacific Ocean (EPO) and differences in the depletion levels of independent assessments based on these sub-areas. These results suggest that smaller spatial scales are important. However, similar trends in recruitment suggest that stocks may be connected through recruitment or similar recruitment processes. A Pacific-wide bigeye tuna assessment is worthwhile for research purposes to confirm that the regional assessments provide similar conclusions, as previous studies have shown. Pacific-wide assessments also provide a forum for collaboration between scientists of the different regional fishery management organizations (RFMOs). More comprehensive tagging data and life history samples throughout the Pacific Ocean are required.

[1] See report at http://www.iattc.org/PDFFiles2/Tagging-WS-Oct-2007-Report-ENG.pdf

4. The fishery in 2008

Mr. Ed Everett reviewed the information on the fishery for tunas in the EPO in 2008. He discussed EPO tuna catch statistics, 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 2008 were about 563,000 metric tons (t), which was about 21% less than in the record catch year of 2003, and about 11% greater than the 15-year average of catches of 509,000 t.

Ecuadorian, Mexican, Panamanian, and Venezuelan flag vessels took about 80% of the catch of yellowfin, skipjack, and bigeye in the EPO during 2008. Mexican, Panamanian, and Venezuelan vessels accounted for about 72% of the yellowfin catch, and Ecuadorian vessels accounted for about 49% of the total catches of skipjack. The catches of yellowfin associated with dolphins were significantly lower in both the inshore and offshore areas off Mexico and Central America. The yellowfin catches off South America were also lower in 2008 compared to the average during 1998-2007. The catches of yellowfin in 2008 were 228,000 t lower than the record catch in 2002, and were 98,000 t (34%) lower than the 10-year average. The skipjack catches were significantly greater in the inshore areas off Ecuador and Peru and in the Galapagos Island region as compared to the 1998-2007 average of catches. The total skipjack catches in 2008 were 1,000 t lower than the record catch in 2006, and 38% greater than the 10-year average of catches. The 2008 catch distributions of bigeye showed an increase of catch in the Equatorial region from about 90°W to 100°W. Catches of bigeye in 2008 were about 19,000 t lower than the record catch in 2000, and about 17% greater than the 1998-2007 average.

Length-frequency and species composition sampling areas were shown, and areas defined for stock assessments were described. Of the 1,027 wells sampled for length frequencies and species composition in 2008, 630 contained yellowfin, 837 contained skipjack, and 271 contained bigeye. In 2008, larger yellowfin (>100 cm) were taken in the inshore dolphin fishing area throughout the year, in the northern dolphin area during the 1st, 2nd, and 3rd quarters, and in the southern dolphin and unassociated fishery in the 1st and 4th quarters. A mode of smaller yellowfin, from 40 to 60 cm, was evident in all of the floating-object fisheries throughout the year, and in the northern unassociated fishery area in the 1st, 2nd and 3rd quarters. In 2008, the average size of yellowfin from all sets and areas combined was greater than in 2006 and 2007, but was considerably lower than during the 2003-2004 period. Large amounts of skipjack in the 40 to 50 cm size range were caught in all of the floating-object fishing areas, and in the southern unassociated area, throughout the year. Skipjack in the 50 to 70 cm size range were caught in all of the floating-object areas, primarily in the 3rd and 4th quarters. The average weights of skipjack in 2008 were less than the average weights observed in the 2003-2007 period. In 2008, smaller bigeye (40-80 cm) were caught primarily in the southern floating-object area throughout the year, in the equatorial floating object fishery primarily in the 2nd quarter, and in the northern floating-object fishery in the 2nd, 3rd, and 4th quarters. Most of the larger bigeye (>80 cm) were caught in the equatorial and southern floating-object fishery in the 1st and 2nd quarters. The average weights of bigeye in 2008 were considerably higher then the average weights observed in 2003-2007.

During 2008, Pacific bluefin tuna were caught from May through September from about 26°N to 32°N. Catches were about 4,000 t in 2008, about 6,000 t less than catches recorded in 2006.

One participant asked if fishing effort is still expanding to the west. Mr. Everett indicated that there is more expansion to the west. In the past, fishing west of 150ºW was mostly during closures, but now there was continuous effort west of 150ºW.

Another participant asked why there were very high skipjack catches in some 1-degree areas around the Galapagos. Mr. Everett noted that there was nothing out of the ordinary observed in the oceanography of the region. There was a large amount of fishing effort in the Galapagos throughout 2008 and skipjack catches persisted throughout the year. Skipjack were being caught close to shore and small boats are able to fish nearshore.

It was also noted that 2008 was unusual in that the price of skipjack and fuel was high, giving a premium to fishing skipjack closer to shore.

A question was asked about potential overlap between catches reported by the IATTC and the Secretariat of the Pacific Community (SPC). Dr. Compeán noted that the IATTC data in the figures of the report are for the EPO only and that there is no double reporting. The IATTC has a memorandum of understanding with the SPC that provides for the interchange of data between the two organizations for scientific purposes.

4a. Report on unilateral management actions taken in 2008

Dr. Deriso reported on unilateral management actions taken in 2008 (SARM-10-04a).The IATTC did not adopt a resolution on tuna conservation for 2008; however, ten member countries adopted unilateral management measures intended to conserve tuna. Nine of the countries implemented closures of the entire EPO. The duration of the unilateral closures for the entire EPO for Class-6 vessels varied from 42 to 49 days. Therefore, their effectiveness ranged from 50% to 58% of the recommended closure for vessels that complied fully with their flag state's closure.

Four countries enacted separate closures of an offshore area. Three of these used the area in the staff's proposal, and only one covered a period longer than that in the proposal. In aggregate, the conservation effectiveness of these closures was less than that of the recommended closure.

About 18% of purse seine vessels made sets on tunas during closures of the entire EPO enacted by their respective flag states, and about 29% during closures of the offshore area.

The only country with a major industrial longline fishery in the EPO that enacted a conservation measure for the longline fishery was Japan, which set a limit higher than that in the staff's proposal. However, the landings reported by the four CPCs with the largest longline fleets for 2008 were well below those in the staff's proposal.

Clarification was requested about whether the effectiveness of measures referred to the staff's recommendations or to the agreement arrived at by the Commission. The comparisons presented by Dr. Deriso were based on the staff's recommendations. The staff does not know, at this time, if the reduction in bigeye catch by longliners was due to lower fishing effort because effort measures for 2008 are not yet available and deferred the question to a later presentation on the assessment of bigeye tuna.

In response to a question about the scope and effectiveness of unilateral actions, Dr. Compeán pointed out that the staff stated in the November meeting that the agreed-upon measures were less than recommended by the staff. Many of the unilateral measures were not enforced, with about 30% of the vessels fishing during the closure of the offshore area and about 20% of the purse-seine vessels made sets during their flag countries' entire EPO closure. In summary, the fishery had fishing mortality levels greater than those recommended.

A participant asked about other unilateral measures, such as the use of a sorting grid in the purse seine in Ecuador. Dr. Deriso replied that sorting grids were not required in 2008, but will be in 2009 for Ecuadorian flagged vessels. The primary actions in the unilateral resolutions were a 12-week EPO closure and a time-area closure for the offshore area. There were other minor actions as shown in Table 1 of the paper.

5. Report on the 78th and 79th IATTC meetings on management, June and November 2008

a. Method for evaluating individual purse-seine closures

Dr. Deriso summarized the paper (IATTC-79-04), which is an evaluation of purse seine individual-vessel closures (IVC) for the conservation of bigeye and yellowfin tunas in the eastern Pacific Ocean.

The IVC proposal has a number of potential positive and negative attributes. The potential benefits include: flexibility to schedule closures optimally for each vessel, a more continuous flow of catches to

canneries, and more continuous employment. The potential drawbacks of this proposal include: complications in enforcement of closures, difficulties in calculating the recommended duration of closures, and unknown reductions in effectiveness due to vessels carrying out major maintenance during the IVC. In order for this approach to work, there must be transparency in the scheduling of IVCs and a system for keeping track of compliance by vessels.

A participant noted that an additional negative effect could be a decrease in competition by fewer boats at sea at any particular time, and greater catches could result.

Clarification was requested about the percentage change of a year-round IVC versus a closure in the summer time, and the Dr. Deriso answered that the estimate was about 3-4% less bigeye tuna conserved with a 12-week IVC as compared to the June 20th start date for a 12-week EPO closure, as recommended by the staff at the 78th meeting of the IATTC, which is about equivalent to the estimated conservation benefit of the offshore-area closure.

The Director pointed out that IVCs would need to be agreed upon one year in advance in order to not be discriminatory to the vessels whose owners or captains prefer an IVC early in the year. The intention of the original proposal by Colombia was uniform IVCs decided upon before the start of the year for vessels of class 5 and 6.

6. Yellowfin and bigeye tunas

a. Stock assessment of yellowfin

i. EPO assessment

Dr. Maunder presented the stock assessment of yellowfin tuna in the EPO. An integrated statistical age-structured stock assessment model (Stock Synthesis Version 3; Methot 2005, 2009) was used in the assessment, which is based on the assumption that there is a single stock of yellowfin in the EPO. This model differs from that used in previous assessments. Yellowfin are distributed across the Pacific Ocean, but the bulk of the catch is made in the eastern and western regions. The purse-seine catches of yellowfin are relatively low in the vicinity of the western boundary of the EPO. The movements of tagged yellowfin are generally over hundreds, rather than thousands, of kilometers, and exchange between the eastern and western Pacific Ocean appears to be limited. This is consistent with the fact that longline catch-per-unit-of-effort (CPUE) trends differ among areas. It is likely that there is a continuous stock throughout the Pacific Ocean, with exchange of individuals at a local level, although there is some genetic evidence for local isolation. Movement rates between the EPO and the western Pacific cannot be estimated with currently-available tagging data.

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 2009 differs substantially from that of 2008 because it uses the Stock Synthesis program. Previous assessments have used the A-SCALA program. The main differences include: use of a sex-specific model, inclusion of indices of abundance rather than effort, and use of functional forms for selectivity. The catch and length-frequency data for the surface fisheries have been updated to include new data for 2008. New or updated longline catch data are available for China (2007), Chinese Taipei (2005-2007) and Japan (2003-2007).

In general, the recruitment of yellowfin to the fisheries in the EPO is variable, with a seasonal component. This analysis and previous analyses have indicated that the yellowfin population has experienced two, or possibly three, different recruitment productivity regimes (1975-1982, 1983-2002, and 2003-2006). The productivity regimes correspond to regimes in biomass, 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 is probably an artifact of the apparent regime shifts. Larger recruitments in 2007

and 2008 have caused the biomass to increase in recent years.

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 do the northern and coastal dolphin-associated fisheries.

Significant levels of fishing mortality have been estimated for the yellowfin fishery in the EPO. These levels are highest for middle-aged yellowfin. Despite more catch being taken in schools associated with dolphins than the other fisheries, the floating object and purse seine sets on unassociated schools have a greater impact on the yellowfin spawning biomass.

The estimated biomass is significantly lower than estimated in the previous assessment indicating that the results are sensitive to the changes in assessment methodology. There is also a large retrospective pattern of overestimating recent recruitment. The pattern is due to the floating object size composition data. These in combination with the large confidence intervals for estimates of recent recruitment indicate that estimates of recent recruitment and recent biomass are uncertain. The results of the assessment are also particularly sensitive to the level of natural mortality assumed for adult yellowfin.

Historically, the SBR of yellowfin in the EPO was below the level corresponding to the MSY during the lower productivity regime of 1975-1983 (Section 4.2.1), but above that level for most of the following years, except for the recent period (2004-2007). 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 two different productivity regimes may support two different MSY levels and associated SBR levels. The SBR at the start of 2009 is estimated to be above the level corresponding to the MSY. The effort levels are estimated to be less than those that would support the MSY (based on the current distribution of effort among the different fisheries), but recent catches are substantially below MSY.

The MSY calculations indicate that, theoretically at least, catches could be increased if the longline fishing effort were increased and purse seine effort decreased. This would also increase the SBR levels.

The MSY has been stable during the assessment period, 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 level corresponding to MSY.

The SBR corresponding to MSY decreased substantially from the previous assessment indicating that the results are sensitive to the change in methodology. The change is attributed to the method used to model selectivity. However, the SBR relative to SBR corresponding to MSY and the F multiplier are similar to the previous assessment.

If a stock-recruitment relationship is assumed, the outlook is more pessimistic, and current biomass is estimated to be below the level corresponding to the MSY. The status of the stock is also sensitive to the value of adult natural mortality, the method used to model selectivity, and the assumed length of the oldest age modeled (29 quarters).

Under current levels of fishing mortality (2006-2008), the spawning biomass is predicted to slightly decrease, but remain above the level corresponding to MSY. Fishing at F_{MSY} is predicted to reduce the spawning biomass slightly from that under current effort and produces slightly higher catches

Key Results

1. The stock assessment method has changed to Stock Synthesis
2. The estimates of the key management quantities are similar to the previous assessments
3. Estimates of absolute biomass are lower than estimated in previous years

4. The SBR corresponding to MSY has reduced substantially from previous assessments and the reduction is attributed to the new method to model selectivity
5. There is uncertainty about recent and future recruitment and biomass levels and there are retrospective patterns of overestimating recent recruitment.
6. The recent fishing mortality rates are close to those corresponding to the MSY.
7. Increasing the average weight of the yellowfin caught could increase the MSY.
8. There have been two, and possibly three, different productivity regimes, and the levels of MSY and the biomasses corresponding to the MSY may differ between the regimes. The population may have recently switched from the high to an intermediate productivity regime.
9. The results are more pessimistic if a stock-recruitment relationship is assumed.
10. The results are sensitive to the natural mortality assumed for adult yellowfin, the method used to model selectivity, and the length assumed for the oldest fish.

A participant requested clarification about the basis for the different estimates produced by the A-SCALA program versus the Stock Synthesis program. A-SCALA uses weight-at-age at mid-year to calculate biomass, whereas Stock Synthesis uses weight-at-age at the beginning of the year. Using the weight-at-age at the beginning of the year makes the stock synthesis biomass estimates much more similar to the A-SCALA estimates. The reason for the difference between the estimates of spawning biomass has not yet been determined. However, due to the narrow range of ages that contribute to the spawning biomass the spawning biomass is much more sensitive to small changes in the analysis. The difference may be due to small differences in natural mortality and the use of sex specific natural mortality rates in Stock Synthesis.

In response to a participant's observation that S_{MSY} is estimated at about 1% of B_{MSY}, Dr. Maunder pointed out that the "spawning biomass" is actually a relative index of reproductive output. The SPC assessments are different, using age at maturity instead of an index of reproductive output.

A participant asked if the staff plans to drop the floating-object size composition data for the next assessment to remove the retrospective pattern in recruitment and biomass. Dr. Maunder said that they plan to research this issue and may deal with it through the use of changing selectivity over time or another appropriate modification of the assessment model.

A request was made to improve the figures, presenting the results by year instead of by quarter. The staff is endeavoring to continue improving data presentation, and has already changed to presenting annual parameter values in many cases.

The staff has focused on improving estimates of natural mortality for bigeye, and may do more work on yellowfin natural mortality. But, Dr. Deriso pointed out that using higher mortality schedules produces recklessly low estimates of the target spawning stock size and maximizing yield-per-recruit may be the wrong benchmark.

A participant requested an explanation of the basis for different natural mortality estimates for male and female yellowfin. The sex-ratio data show a reduction in the proportion of females at larger sizes, and growth data do not show a marked reduction in the growth rates of females. A participant recommended putting priority on recovering tagged female yellowfin, although the sex of tunas is not possible to determine at the time of tagging. Some scientists believe that female yellowfin have a smaller L_∞ than the males. The International Commission for the Conservation of Atlantic Tunas recommended formation of an international working group to evaluate growth issues for tunas. Several participants endorsed this proposal. A new study on the reproductive biology of yellowfin tuna is being planned by the IATTC staff. Sex-ratio estimates for large yellowfin in the EPO have been based on very low sample sizes. A participant pointed out that yellowfin caught by longline also have skewed sex ratios.

A discussion of natural mortality ensued. It was noted by a participant that the IOTC and ICCAT stock assessments are now basing their assessments on an assumption of 0.3 annual M for adults, which is lower than their previous assumption that adult M equaled 0.4 on an annual basis. These lower M values have been estimated from recoveries in the Indian Ocean (Brownie method) and by the Lorenzen method in the Atlantic. Dr. Deriso mentioned that an annual natural mortality rate of 0.8 and a quarterly rate of 0.2 have been used for decades by the IATTC based on fitting catch curves, and estimating natural mortality from tagging data would require an extensive tagging program. Tagging experiments should be designed for estimating natural mortality. It was recommended that the natural mortality at age estimated by the Lorenzen method should be used in the sensitivity analysis of future stock assessments.

A participant requested a less-technical summary of the yellowfin stock assessment results. The Kobe phase plot shows that the EPO stock is healthy, and despite substantial uncertainty, the relative trends are fairly robust. It is important to consider the relationship between yield and fishing mortality. Fishing mortality can be reduced substantially with the expectation of getting similar long term yield compared to fishing heavier. The spawning biomass ratio increases with lower fishing with hardly any loss in yield.

ii. Proposal to add several years of data to the assessment of yellowfin tuna

Dr. Fonteneau examined the "shifting base-line syndrome" faced by the yellowfin stock assessment done by the IATTC staff. Historical stock assessments in the EPO were started in 1934, but the present stock assessments use data starting only in 1975. The analysis concludes that future yellowfin stock assessments should be conducted, at least on an experimental basis, starting at the beginning of the yellowfin fisheries, for instance in 1920 or 1930. Such extended analysis should be based on a data mining effort to recover and incorporate in the IATTC data base all the historical data. The assessment model should also be modified in order to fully use all these new data and the major changes in stock and fisheries, for instance changes in catchabilities, size selectivities, and increasing fishing areas. Such extended analysis covering the early fishery should offer, in the medium term, an improved scientific understanding of the changes in the yellowfin stock and fisheries, and improved future stock assessments of the yellowfin in the EPO.

Dr. Maunder agreed that using older data for the assessments requires dealing with spatial aspects of the population dynamics, and pointed out that the same problem probably occurs for conducting spatial assessments using recent data. The information on yellowfin movements is lacking. A possible solution might be to model the fish in different areas as separate stocks, and not try to estimate movements. For example, basing the analyses on the IATTC's market-measurement areas, which were designed based on consistent length-frequency data for yellowfin tuna. Using the current data avoids difficult issues, while it might be valuable to use the older data for research efforts.

Dr. Deriso informed the meeting participants that a separate analysis using past data could be available next year. For the stock assessments, however, an argument can be made that the current data time series may be too long, not too short, because the current exploited stock should be evaluated using the current gear selectivities and growth, and under the current environmental regime.

A spatial analysis should take into account that fishing takes place within different major current systems north and south of the equator in the EPO. The fish in these different areas might have different growth and trophic characteristics, for example.

b. Stock assessment of bigeye

Dr. Alexandre Aires-da-Silva presented the current stock assessment of bigeye tuna in the EPO. This assessment was conducted using Stock Synthesis (Version 3). The assessment reported here is based on the assumption that there is a single stock of bigeye in the EPO, and that there is limited exchange of fish between the EPO and the western and central Pacific Ocean (WCPO).

Catch, CPUE, and length-frequency data for the surface fisheries have been updated to include new data

for 2008. New or updated longline catch data are available for Chinese Taipei (2005-2007), the Peoples Republic of China (2007), and Japan (2003-2007).

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 increased slightly. The increase in the fishing mortality of the younger fish was caused by the expansion of the fisheries that catch tuna in association with floating objects.

There are several important features in the estimated time series of bigeye recruitment. First, estimates of recruitment before 1993 are very uncertain, as the floating-object fisheries were not catching significant amounts of small bigeye. There was a period of above-average recruitment in 1994-1998, followed by a period of below-average recruitment in 1999-2000. The recruitments have been above average from 2001 to 2006, and were particularly large in 2005 and 2006. The 2007 recruitment was below average, but the recent recruitment in 2008 appears to be particularly high. However, this recent estimate is very uncertain and should be regarded with caution, due to the fact that recently-recruited bigeye are represented in only a few length-frequency samples.

The biomass of 3+-quarter-old bigeye increased during 1975-1986, and reached its peak level of about 630 thousand metric tons (t) in 1986, after which it decreased to an historic low of 287 thousand t at the beginning of 2009. Spawning biomass has generally followed a trend similar to that for the biomass of 3+-quarter-olds, but lagged by 1-2 years.

At the beginning of January 2009, the spawning biomass of bigeye tuna in the EPO was near the historic low level. At that time the spawning biomass ratio (the ratio of the spawning biomass at that time to that of the unfished stock; SBR) was about 0.17, which is about 11% less than the level corresponding to the maximum sustainable yield (MSY).

Recent catches are estimated to have been 19% higher than MSY levels. If fishing mortality (F) is proportional to fishing effort, and the current patterns of age-specific selectivity are maintained, the level of fishing effort corresponding to the MSY is about 81% of the current (2006-2008) level of effort. The MSY 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 15°N because it catches 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 less than F_{MSY}.

Recent spikes in recruitment are predicted to result in stabilized levels of SBR and increased longline catches for the next few years. However, high levels of fishing mortality are expected to subsequently reduce the SBR. Under current effort levels, the population is unlikely to remain at levels that support MSY unless fishing mortality levels are greatly reduced or recruitment is above average for several consecutive years.

Analyses were carried out to assess the sensitivity of results to: 1) a stock-recruitment relationship; 2) use of a Richards growth curve fit to age at length data derived from otolith data; 3) extending the assumed western limit of the bigeye stock distribution from 150°W to 170°E.

The base case and sensitivity analyses all indicate that, at the beginning of 2009, the spawning biomass (S) was below S_{MSY}. MSY and the F multiplier are sensitive to how the assessment model is parameterized, the data that are included in the assessment, and the periods assumed to represent average fishing mortality, but under all scenarios considered, fishing mortality is well above F_{MSY}. The management quantities derived from the base case model were the less pessimistic among all scenarios.

The MSY calculations indicate that, theoretically, at least, catches could be increased if the longline fishing effort was increased and purse seine effort decreased.

Discussion: One participant asked if the bigeye assessment would benefit from inclusion of data from the

western Pacific. Dr. Aires-da-Silva noted that the bigeye tagging information that is available to date does not support high mixing rates of bigeye between the western and eastern Pacific. In fact, it supports high degrees of site fidelity of bigeye in the EPO. Considering a single stock of bigeye in the EPO is the most reasonable assumptions, not only in terms of stock structure, but also for management purposes. The same participant also questioned whether the assumption of a stock-recruitment relationship is important in the analysis. Dr. Aires-da-Silva indicated that it is difficult to estimate steepness due to the lack of contrast in spawning biomass. There is no evidence that recruitment is related to spawning stock size for bigeye in the EPO. If steepness is estimated as a free parameter in the model, it is estimated to be close to 1.

There was some discussion about the southern longline fishing area for bigeye. It was described as a warm, core feeding area for bigeye, an area both heterogeneous and large. There was a request made for better stratification of this area in the bigeye assessment. Recent results from SPC bigeye tagging were discussed, since this analysis indicated very fast movements of bigeye between the western and eastern Pacific. One participant questioned the assumption of little to no mixing of bigeye between these regions in the assessment. Dr. Deriso responded that in a later presentation, the staff would present some problems and potential inaccuracies in tag location data from conventional tags. He indicated that it is sometimes difficult to separate large-scale movements of tunas from movements of tuna fishing vessels. Dr. Aires-da-Silva also addressed the importance of investigating other models such as the Pacific-wide assessment which the staff conducted previously with the SPC. The participant also commented on the use of the Richards growth curve and questioned whether this function accurately describes bigeye growth. It was suggested that the Richards curve is estimated outside rather than inside the stock assessment model (uses tagging data in addition to otolith data).

Another participant reiterated the importance of inter-decadal changes in oceanographic conditions when considering changes in the longevity of time periods in the assessments. Biological parameters such as availability and growth of fishes change under different physical conditions in the ocean. It was suggested that inter-decadal periods of warmer and colder ocean conditions can be very important in assessing the stocks. Dr. Aires-da-Silva pointed out that the staff has begun some analyses of environmental variables and recruitment and has also conducted similar analyses in the past. This year's analysis indicated some correlations between environmental indices and recruitment, but other time series of recruitment are disconnected from environmental variables. The staff will continue to work with physical variables in their stock assessments.

7. Assessment of skipjack tuna

Dr. Maunder presented the indicators of stock assessment for skipjack tuna in the EPO. Skipjack tuna is a notoriously difficult species to assess. Due to its high and variable productivity, it is difficult to detect the effect of fishing on the population with standard fisheries data and stock assessment methods. Since the stock assessments and reference points for skipjack in the EPO are so uncertain, developing alternative methods to assess and manage the species that are robust to these uncertainties would be beneficial. Maunder and Deriso (2007) investigated some simple indicators of 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. They also developed a simple stock assessment model to generate indicators for biomass, recruitment, and exploitation rate. We update their results to include data for 2007. To evaluate the current values of the indicators in comparison to historical values, we use reference levels based on the 5^{th} and 95^{th} percentiles, as the distributions of the indicators are somewhat asymmetric. The purse-seine catch has been increasing since 1985, and is currently above the upper reference level. Except for a large peak in 1999, the floating-object CPUE has generally fluctuated around an average level since 1990. The unassociated CPUE has been higher than average since about 2003 and was at its highest level in 2008. The standardized effort indicator of exploitation rate has been increasing since about 1991, but declined in recent years. The average weight of skipjack has been declining since 2000, and in 2008 was at the lower reference level. The biomass, recruitment, and

exploitation rate have been increasing over the past 20 years.

The main concern with the skipjack stock is the constantly increasing exploitation rate. However, the data- and model-based indicators have yet to detect any adverse consequence of this increase. The average weight is near its lower reference level, which can be a consequence of overexploitation, but it can also be caused by recent recruitments being greater than past recruitments.

A participant noted that the catches of skipjack in 2008 were very high in certain 1-degree areas of the EPO, and that this concentration of skipjack catches was unusual compared to past years. It was requested that in the future the IATTC analyze the high concentration of catches to determine if environmental factors could be influencing a concentration of spawning biomass or food resources for skipjack.

There was some discussion about factors that might have contributed to the increased catch of skipjack during 2008. A participant asked if higher retention rates of smaller fish might influence the higher catches. Dr. Compeán noted that the market was buying more small fish. Dr. Hall suggested that the estimates of size of fish made by observers aboard the vessels could be used to assess the relative influences of recruitment or economics on the increased catches of skipjack.

A participant noted that the assessments of skipjack are difficult, and asked if work will be done on management measures for skipjack. Dr. Compeán explained that to date the staff has not made recommendations for management measures for skipjack because there have been no indicators that management measures are needed. The staff has not undertaken any enactment of management measures on a resource that fluctuates as much as skipjack. The IATTC will continue to monitor the stock to identify potential indicators of over-exploitation.

It was also noted by a participant that the average size of skipjack is variable and presents practical issues in processing. When the average size of skipjack is around 2 kg, there are problems in processing and cleaning the fish. The average size of skipjack can vary among and within years, contributing further to the variable nature of the stock.

8. Assessment of striped marlin

Dr. Hinton presented the stock assessment for striped marlin in the EPO. Studies and analyses of stock structure of striped marlin using fisheries data suggest that in the north Pacific there appear to be at least two stocks, distributed principally east and west of about 145º-150ºW, with the distribution of the stock in the east extending as far south as 10°-15°S. Genetic studies also provide indications of stock structure. One study identified separate stocks in the northern, north- and southeastern, and the southwestern Pacific. The most recent and well designed genetic study for this species indicates that the striped marlin in the EPO off Mexico, Central America, and Ecuador are of a single stock. This study also identified stocks related to known spawning grounds off Australia, Hawaii, Japan/Taiwan, and New Zealand.

The most recent stock dynamics modeling indicated that striped marlin in the EPO were at or above the level expected to provide landings at the maximum sustainable yield (MSY), which was conservatively estimated to be about 3300 to 3800 t. Annual catch last exceeded the MSY in 1988 (5300 t) and 1997 (4500 t). A declining trend in catch has been observed since 1997, with annual catch of about 1500 t in recent years. A new record low estimated catch of about 1,400 t was seen in 2007. There is no indication of increasing fishing effort or catches in the EPO stock area. Considering the catch and fishing effort history observed, which are less than those which will provide catch at MSY levels, it is considered that the striped marlin stocks in the EPO are in good condition. Fishing effort, anticipated and current, is less than that required to produce MSY catch, but effort and catch should be closely monitored.

A participant noted that in the past there was an issue of the existence of northern and southern stocks of striped marlin. The Billfish Foundation has contributed over $1 million in support of genetic studies addressing this question. It was pointed out that the striped marlin fishery is a very valuable fishery in

Mexico. In Los Cabos, the fishery produced $635 million in revenues to Mexico in 2007. The IATTC was encouraged to further develop an assessment of striped marlin. Dr. Compeán noted that these comments are important to the IATTC and that the staff recognizes the economic importance of the sport fishery in Mexico. However, he pointed out that the IATTC Commissioners decide on the focus of the staff's research.

A discussion ensued about the limited amount of information available on commercial catches of billfishes. In Mexico and Colombia there is no commercial fishing directed at billfishes. Some information on incidental catches of billfishes from small longline fisheries is available from Mexico and Colombia and can be shared with the IATTC. Dr. Compeán noted that the IATTC has its own data collection structure, but he welcomed the contribution of additional data on incidental catches of billfish.

During the discussion of status of striped marlin, it was noted that there may continue to be catches from some fisheries which have gone unreported to the Commission. All parties are encouraged to provide details of catch of bycatch and non-tuna species by all fisheries, in order that resource and stock assessments are as accurate and precise as possible, and of optimal value to the parties.

9. Evaluation of aspects of the IATTC sampling design for purse-seine tuna catches

Dr. Lennert-Cody presented an analysis that explored the degree that the IATTC port sampling data, collected for purse seiners, is representative of the entire fishery, the relative magnitudes of within-well and among-well variability of the port sampling data, and the estimation procedures for the catches using descriptive data analysis techniques and simulations. Analyses and simulations were based on port sampling data and fisheries observer data collected since 2000. The results of the descriptive analyses suggest that catches from purse-seine sets in wells sampled by the port sampling program tended to be greater than catches from sets in unsampled wells. The percentage of bigeye tuna in the catch from floating-object sets loaded into sampled wells was sometimes greater than that of sets loaded into unsampled wells, but the results were not strongly consistent across years nor across test statistics. Significant differences were mostly positive, suggesting a greater percentage of bigeye tuna from floating-object sets loaded into sampled wells. However, the magnitude of the differences were small. Variability in average fish length of simulated within-wells samples of purse-seine vessels was generally found to be much less than the variability in average length among wells. Similarly, the variability among wells in the percentage of bigeye tuna catch from purse-seine sets on floating objects exceeded that of simulated samples from the same well. With regard to the estimation procedures for surface fishery catches, simulations for bigeye tuna catch indicate that the average bias of the estimated catch is approximately an order of magnitude less than the average standard deviation. A conclusion of the analyses is that, with a fixed budget for sampling personnel time, emphasis should be given to sampling more wells rather than increasing the sampling within wells.

Dr. Lennert-Cody was congratulated on this analysis, and IATTC staff was encouraged to put the analysis into a "worldwide context." An analysis by SPC concluded that it is necessary to sample onboard the vessels at sea by observers to avoid biases of port sampling. There will be an international working group meeting in France next month to study this issue, and IATTC staff will participate. Dr. Deriso commented that the SPC study was a key motivation for this work. He recalled that the SPC results showed a bias in the estimated species composition of sets when obtained from on-board sampling by observers using the grab-sampling technique, while our results compared the variance to the bias of the estimation procedures for total bigeye catch as applied to the port sampling data. There are differences between oceans about how tuna are handled by purse seiner, loaded on board, etc. The current prices of tuna have an effect on what size fish are retained or discarded, and sampling of discards can only be done at sea. Another participants suggested that both port sampling and at-sea sampling are necessary. A participant related the results of another study by SPC, which compared onboard sampling of longline catch with port sampling. There were large differences between the results of the two methods, with very different species composition. However, the SPC observers sampled 10 fish per brailer, which makes it

difficult to obtain random samples.

Sampling in Japan has shown that, in general, larger purse-seine sets on unassociated schools produce smaller proportions of bigeye and larger proportions of skipjack. Dr. Lennert-Cody commented that in preliminary investigations of the fisheries observer data for floating object sets, there seemed to be a tendency for the catches of bigeye tuna to increase initially as the total catch increased, but the relationship was nonlinear, and at the largest total catches the amount of bigeye tuna in the catch was highly variable. She has not yet analyzed this pattern further. She also noted that this pattern is consistent with the weak indication of a greater percentage of bigeye tuna in sampled sets compared the strong indication of larger catches for sampled sets (see above).

10. Effect of stratification of the EPO stock into several isolated sub-stocks

Dr. Alexandre Aires-da-Silva presented the results of a preliminary evaluation of spatial structure in the stock assessment of bigeye in the EPO. Tagging studies indicate restricted movements and regional fidelity of bigeye within the EPO. Such restricted movements, combined with the spatial heterogeneity of the fleet distribution and the catch, suggest that localized depletion patters of bigeye sub-stocks may exist in the EPO. A preliminary evaluation of spatial structure in the stock assessment of bigeye in the EPO was made. The EPO was divided into four major geographical sub-areas - inshore, central, northern and southern – with no mixing of fish assumed between sub-areas. An independent stock assessment was conducted for each sub-area. The preliminary analyses show differences in the longline CPUE trends and in the depletion levels among sub-areas in the EPO. These results suggest that smaller spatial scales are important to consider. However, similar trends in recruitment indicate that sub-stocks may be connected through recruitment or similar recruitment processes.

11. Preliminary natural mortality estimates for bigeye tuna based on integrated analysis including tagging data

Dr. Maunder presented an analysis of tagging data to estimate age- and sex-specific natural mortality for bigeye tuna in the eastern Pacific Ocean. Cohort analysis was used to model the tagging data, and existing estimates of natural mortality and information on the proportion of females were used as auxiliary information to improve the estimates. The cohort analysis approach was used to account for the limited spatial distribution of tags. The cohort analysis approach treats the fishing mortality of tagged fish at age independent from the fishing mortality experienced by the stock as a whole. This accommodates any incomplete mixing of the tagged fish over the whole distribution of the stock. The estimates of natural mortality are consistent with the values assumed in the current stock assessment. However, the estimates are highly uncertain and dependent on the assumed reporting rate for the archival tags caught by the longline fishery. The apparent restricted movement of bigeye tuna inhibits mixing of the tagged fish over the whole eastern Pacific and limits the recaptures of large bigeye in the longline fishery. Therefore, a more comprehensive tagging program is needed with a wider spatial distribution of releases, releases of older bigeye tuna, improved reporting rates of conventional tags from the longline fisheries, and estimates of reporting rates.

It was noted that natural mortality is a key parameter, and asked for comment on the accuracy of the estimate of natural mortality for small fish. Not many young bigeye were tagged, less than 250 fish of age 3 quarters. Most of the information on small fish is from an estimate from Dr. Hampton, SPC for age 2 quarters. Previous stock assessments indicated low sensitivity to natural mortality of small fish.

A participant asked for clarification of why the increase in recruitment during the last three years was due to a reduction of catches by longline gear, which is contradictory with the analysis of spawning biomass. Dr. Maunder pointed out that the catch is not causing changes in recruitment, but changes in the estimate of recruitment due to the way the model operates.

12. Update on proposal for EPO tuna tagging project

Dr. Deriso gave a brief presentation of a proposal for a regional tuna tagging project. A steering committee of twelve scientists has worked to revise a tagging proposal originally presented at the 78th meeting of the IATTC. The project, estimated to cost $US 4.6 million, would consist of three years of tagging onboard two pole and line vessels. The objectives of the project include: obtain data that will contribute to EPO tuna stock assessments, obtain information on the rates of movement and mixing of tuna in the EPO, between this region and other adjacent regions of the Pacific basin, and obtain information on local exploitation rates and productivity of tuna.

A new analysis of tag seeding experiments conducted in 2000 and 2002 was made to estimate the accuracy the purse seine wells reported for tag recoveries. Incorrect wells were reported for about 30% of the tag recoveries. The accuracy can be improved by employing technicians to observe vessel unloadings, which is usually where tag recoveries occur. The tagging proposal will need to be revised to incorporate an increased budget for tag recovery technicians.

A participant noted that this is a good tagging program and was needed many years ago. It was pointed out that in the Indian Ocean many tag recoveries are done at sea by fishermen, so perhaps similar recoveries could be performed by observers in the EPO to ensure good recovery information. An inquiry was made as to the percentage of recoveries made at sea in the EPO. Dr. Deriso explained that the vast majority of tag recoveries are made in port, not at sea by observers. One problem is that the observers are not physically located near the fish on the boats. The second most frequent source of tag recoveries is the cutters in the canneries, and the third most frequent source is on board the boats. Dr. Deriso agreed that the ideal location for recovery is on board the boats, and suggested that the staff could discuss this proposal with the captains.

A discussion continued regarding methods for maximizing tag recoveries. It was pointed out that in the Indian Ocean there is active competition among crew members to recover tags at sea. Dr. Deriso agreed that this is a good idea. He indicated that in the EPO, there are vessels that fish inside and outside of 150W on the same trip, and he suggested that these vessels could be targeted for more precise data. This could be accomplished by ensuring that a program representative is present at unloading to verify the well information.

There was also some discussion regarding tag recovery rewards. In the Indian Ocean the reward is $5 or a t-shirt or cap and many tags are recovered each day. Dr. Deriso indicated that in the EPO the reward is $10 plus entry into a lottery for $1000. There are some issues with this system since some captains insist that the reward belongs to the boat. Some unloaders will put the tags in their pockets and report it later, often resulting in poor data.

A participant described the programs of the ISSF, an industry organization created to facilitate research and management of tunas. The ISSF board has agreed to do what it can to facilitate recovery of tags, and canneries that belong to the ISSF have offered to help. It was suggested that perhaps a cannery person ("tag coordinator") could be placed in each port to coordinate tag recoveries. This would require guidance from RFMOs to develop an educational system for the tag coordinators. This system could be a good option if funding for the EPO tagging program is less than desired.

A participant offered a different opinion that the majority of tag recoveries should be done at sea. It was pointed out that much information on location and date of capture are lost if the tag recovery is done at the cannery.

Dr. Compeán described a source of some funding (around $1 million) offered within the IATTC to start this proposed tagging project. This funding could possibly be available during 2010, and Dr. Compeán welcomed any additional assistance from the governments of the meeting participants.

13. Sharks: Review of information and ongoing activities

Dr. Alexandre Aires da Silva provided an overview of IATTC shark related activities. It was pointed out that an existing resolution (C-05-03) requires that the IATTC, in cooperation with scientists of CPCs and, if possible, the WCPFC, to provide preliminary advice on the stock status of key shark species and to propose a research plan for comprehensive assessment of these stocks. In addition, the new Antigua Convention, which should be in effect soon, requires IATTC to adopt, as necessary, conservation and management measures and recommendations for species belonging to the same ecosystem and that are affected by fishing for, or dependent on, or associated with, the fish stocks covered by the Convention.

IATTC will be hosting a stock assessment workshop for shark species on November, 2009, in La Jolla. The workshop objectives are to identify stock assessment methodologies for selected shark fisheries and develop preliminary applications.

Dr. Aires da Silva reviewed the fishery data on sharks collected by the IATTC. The dominant shark species caught in the EPO tuna fisheries are the silky shark, oceanic whitetip, and hammerhead sharks. Three main fisheries catch sharks in the EPO: 1) purse seine, pelagic longline, and artisanal. Only limited shark catch statistics are currently available to the IATTC from pelagic longline fisheries and data on shark catch of artisanal fisheries are very scarce. There is an ongoing concerted effort by Latin American countries to pool national datasets and build an artisanal shark fishery database.

A participant suggested that a regional database be developed for sharks. An inquiry was made as to the percentage of sharks caught as bycatch in the EPO. Dr. Aires da-Silva indicated that sharks comprised a low percentage of the bycatch by purse seiners, however in the artisanal fisheries, sharks are sometimes targeted for catch. The research to compile this information is just beginning and the staff is building the system to extract more data. An inquiry was made regarding the bycatch of shark in relation to type of fishing. Dr. Lennert-Cody indicated that the shark bycatch data is collected by observers for all three types of purse-seine sets of large vessels and is based on numbers of fish. Estimates of the total number of sharks in the purse-seine bycatch of large vessels, by species and shark size category, will be made for the November 2009 workshop. Dr. Compeán added that there are bycatch data reported in the Annual Reports of the IATTC. Dr. Compeán also indicated that a resolution is in force to members of the IATTC to provide these types of data. There is currently a voluntary program with member countries to report these types of data and the current resolution is applicable only for sharks caught in tuna and billfish fisheries under the purview of the IATTC. When the Antigua Convention comes into force, all catches will be reported.

It was suggested that in the November 2009 workshop there should be some focus on the economic aspects of shark catches and the use of the entire animal. This approach is being used in several Latin American countries where the entire shark is utilized and finning of sharks is banned.

A participant inquired about the source of bycatch data reported in Table a.2.c of the Fishery Status Report (FSR). Dr. Lennert-Cody explained that the data shown for the purse-seine fishery are an estimate of the aggregated bycatch from large purse seine vessels. An observation was made that most incidental catch of sharks is by longlining and that the longline component of incidental catch is crucial to any assessment. Dr. Hinton suggested that the developing data analysis of incidental catches of sharks is similar to that of other non-target species such as marlin; the developing analysis will not be perfect but it will be an improvement over information currently available.

14. Vertical distribution of 17 pelagic fish species in the longline fisheries in the eastern Pacific Ocean

Mr. Jiangfeng Zhu presented an analysis on the vertical distribution of pelagic fishes caught by longline. Pelagic deep longline gear is widely used for targeting tunas of high economic value, and other fish species caught incidentally as bycatch. Identifying the characteristic vertical distributions of fish species caught by longline can provide critical information needed for the development of effective measures to

mitigate bycatch species, and is essential for ecosystem conservation. Much work has been done to investigate the vertical distribution of pelagic species; however, most of the work was focused on single species. The objective of this study was to estimate the depth distribution of species captured in China's tuna longline fishery and to evaluate the differences in depth distribution among species. We estimated the depth distribution for 17 frequently captured species based on a Chinese longline fishing trip targeting bigeye tuna in the eastern Pacific Ocean during February-November 2006. The mean depth and depth distributions of 13 bycatch species were significantly different from those of the targeted bigeye tuna. Mean depth and depth distribution were found to be not different significantly between the females and males for 7 species. An analysis using a generalized linear model suggests that species, latitude, longitude, and month had significant influences on the hook depth at which a fish was captured, while individual length did not. The information derived from such a study can play an important role in avoiding and reducing bycatch in pelagic fisheries.

The attendees recommended that 1) measurements of dissolved oxygen at depth be acquired from oceanographic data bases, given that the O_2 content was not measured directly during the study, and 2) that actual fishing depths be measured with depth-temperature recorders located near the hooks. Dr. Ariz reported that pilot studies by the Spanish found that actual hook depths varied greatly, due to environmental changes (currents) and the stratification of the species caught during the night and day. Mr. Zhu agreed that the depth of capture was highly dependent on the time of day of longline deployment.

15. Effects of the tuna fisheries on the ecosystem of the EPO

Dr. Olson presented an overview of ecosystem considerations for tuna fishing in the EPO, focusing on trophodynamics studies and estimates of average trophic level of the catches. It is widely recognized that management measures can have implications for other components of the food web, in addition to the target species. Bottom-up forces caused by environmental variability and top-down effects of fisheries removals act in concert through the food web. A greater understanding of the trophic links and biomass flows in the food web are necessary.

The STAR Project of the SWFSC is instrumental in ecosystem studies of the EPO, and the STAR cruises have provided samples for studies of stable isotope ecology. Collaborations with researchers of other organizations and students have contributed much to our studies of trophodynamics.

The approach used in the recent research on trophodynamics was to examine broad-scale spatial relationships among copepods and yellowfin tuna, using stable isotope and stomach-contents analyses, to infer information about the trophic position of yellowfin tuna in the food web. Using a generalized additive model fitted to abundance-weighted average $\delta^{15}N$ values of several omnivore copepod species, isotopic spatial relationships among the yellowfin and the copepods were examined. We found a broad-scale, uniform gradient in $\delta^{15}N$ values of the copepods increasing from south to north in a region encompassing the eastern Pacific warm pool and parts of several current systems. Over the same region, a similar trend was observed for the $\delta^{15}N$ values in the white muscle of yellowfin tuna caught by the purse-seine fishery, implying limited movement behavior. Assuming the omnivore copepods, primary-secondary consumers, represent a proxy for variations in $\delta^{15}N$ values at the base of the food web, the isotopic difference between these two taxa was interpreted as a trophic-position offset. An onshore-offshore increasing gradient in yellowfin trophic position amounting to about 1 trophic level, was concluded and substantiated by compound-specific isotope analysis of amino acids.

Trophic levels (TLs) are used in food-web ecology to characterize the functional role of organisms, to facilitate estimates of energy or mass flow through communities, and for elucidating trophodynamics aspects of ecosystem functioning. The mean TL of the organisms taken by a fishery is a useful metric of ecosystem change and sustainability because it integrates an array of biological information about the components of the system. TLs were estimated for a time series of annual catches and discards by species from 1993 to 2007 for three purse-seine fishing modes and the pole-and-line fishery in the EPO. The estimates were made by applying the nominal TL values from the EPO ecosystem model, weighted by the

catch data by fishery and year for all model groups from the IATTC tuna, bycatch, and discard data bases. The TLs of the summed catches of all purse-seine and pole-and-line fisheries were fairly constant from year to year, varying by less than 0.1 TL, and there was no indication of declining trends over the 15-year period.

Following the presentation, a discussion ensued over the TLs estimated for tunas in the EPO. A participant expressed surprise that bigeye tuna feed so heavily on squid resulting in a TL >5. Dr. Olson confirmed that the diet of bigeye is comprised heavily of squid and that the estimates of TL are based on the diet data. He also indicated that this characterization of the food web is a bit different from others in that two producer and two zooplankton groups were used, and that the TL estimated for large zooplankton (2.7) was higher than that estimated in other food web models. This would contribute to the high TL of bigeye.

Dr. Hall commented on the importance of ecological information derived from the STAR cruises and pointed out that there has been a tradeoff between dolphin abundance estimates and other ecological data collected during the cruises. Although a large amount of useful ecological data were collected through ancillary sampling, the estimates of dolphin abundances may have become less precise as a result of the additional sampling.

A comment was directed to Dr. Compeán regarding preservation of the ecosystem. It was noted that there was an IATTC resolution from 2008 mentioning full retention of tunas that was discussed in the tuna assessments of this meeting. A recommendation was made to retain this resolution again this year. Dr. Compeán agreed that the staff should recommend the continuation of that resolution.

a. Other ecosystem considerations

Dr. Hall covered some additional aspects of the ecosystem related work of IATTC, including some observations about the ecological effects of FADs, sorting grids, and bycatches in the EPO.

The fishery has experienced a switch in its geographical distribution after 1992. From a fishery on floating objects centered in the Panama Bight, and mostly seasonal, it has changed into a fishery on Fish Aggregating Devices (FADs) deployed along the equator, west of Galapagos. These FADs drift in northwestern and southwestern directions at a fairly fast rate.

The impacts of the fishery in the Panama Bight have been reduced, while the impacts in the offshore regions has increased. The impacts of the drift of FADs to the west cannot be assessed, but they highlight the need of tagging experiments of species associated with FADs, and of the identification of FADs.

The list of species taken in the sets was reviewed. For some (*e.g.* billfishes), the impacts of the fishery are very small in relative terms. Two shark species are a source of concern. For sea turtles, only the webbing hanging under the FADs is a source of mortality that needs to be addressed. Bycatches of small tunas may be addressed with acoustics. Sorting grids have potential for small tunas, and also for dorado (mahi-mahi) and other large pelagics. Some fishing skippers believe that small bigeye tuna come to the surface after encirclement, and if that assessment is correct, then it would open a door for releasing the bigeye while keeping the skipjack. Experiments to test selective attractors, that can bring the sharks out of the area to be encircled without also carrying the tunas, were discussed.

A matrix outlining potential approaches to address the purse seine bycatch issues was discussed, indicating which are activities already under way, and which are priorities for future research.

Finally, 2008 was another year with low dolphin mortality, and the NOAA surveys have shown that the point estimates of abundance for the most important stocks (eastern spinner and offshore spotted) are at the highest levels in many decades. The evidence for their recovery will be the subject of future research.

The concept that FADs, even without fishing, effect the ecosystem by moving fish to the west, was intriguing to several participants. FADs can potentially be made safer by experimenting with different materials hanging below the FADs that are tangle-proof. Spanish experiments have shown zero

mortalities of sea turtles. There was skepticism that bigeye would survive release from the net because of problems with their swim bladders.

A participant underscored the common opinion that sorting grids could not be a recommended measure at this time, and without research. Another participant suggested the chairman should emphasize the need for research on these issues.

Clarification about the notion that different species of tunas stratify vertically, which may facilitate the removal of bigeye from a set on skipjack, was requested. This idea is based on descriptions by some fishing captains, and is not confirmed by scientific observation or research.

16. Assessments by working groups of other international organizations

a. International Scientific Committee: Swordfish (preliminary)

Dr. Hinton presented a summary of swordfish-related activities of the Billfish Working Group of the International Scientific Committee for Tunas and Tuna-like Species in the North Pacific (ISC). It was noted that decisions on data and protocols for an assessment of swordfish were finalized at the most recent meeting (Feb 2009). The assessment is to be conducted at a meeting in May 2009, and results are to be reported to the ISC Plenary in July 2009.

To a question about direct measures of movements of swordfish in this large area, Dr. Hinton replied that there is very little tagging information. A swordfish tagged with an archival tag near Japan was captured in the same area one year later. Analysis of that tag indicated that the most likely migration routes were generally circular, with initial movement to the east or to the south. In the Atlantic Ocean, swordfish move toward the equator to spawn and to high latitudes to feed, and this is considered the case in the Pacific, as well. The ISC assumes that most of the swordfish biomass is north of 20ºN.

Dr. Fonteneau displayed a map of longline swordfish catches recorded by the SPC over 15 years in the Pacific, and most of the catch was between 5ºN and 15ºS. Dr. Hinton clarified that one genetics analysis showed stocks off Japan and Australia, with lack of differentiation among paired samples taken from along a horseshoe-shaped path to the east, thence along the Americas, and thence westerly to Australia, while a subsequent study identified stocks off Australia and Japan, but also in the north- and southeast Pacific, with an apparent mixing area in the central tropical Pacific.

b. International Scientific Committee: Pacific bluefin tuna

Dr. Aires-da-Silva presented an update on the ISC Pacific bluefin tuna (PBF) stock assessment. The bluefin stock status was evaluated by the ISC PBF Working Group on May 2008, in Shimizu, Japan. To date, the stock status remains uncertain. It remains to explain the large estimate obtained for the virgin spawning biomass (SSB_0=1.4 million tons), and the resulting low levels of SBR over the entire dynamic period of the assessment (<5%).

The WG is investigating the possibility of a model mis-specification. A PBF-WG workshop was held in November 2008, Ishigaki, Japan. One of the agenda items for the meeting was to overview the 2008 stock assessment, investigate the parameter estimates with "low plausibility," (e.g. unrealistically high estimate of B_0) and identify potential factors driving these results. Dr. da Silva reviewed the scientific process leading to the PBF natural mortality (M) schedule assumed for the 2008 PBF assessment. The group identified a few possible cause for this low plausibility. The most important factor was the uncertainty in natural mortality. Data misclassification of SS2 model was also noted. In the absence of direct estimates of M for PBF beyond age-0 (1+ years), the WG adopted a vector based on assumptions made for southern bluefin tuna (SBT). This choice does not seem appropriate considering the differences that exist between the life-history of PBF and SBT. The adoption for PBF of the SBT estimate of M=0.12 yr^{-1} for the 4+ year old adult fish seems the most problematic. The later is based on the long life-span of SBT (maximum age of 42) which does not seem to be the case for PBF (maximum observed age of 21 years). In addition, while the mean age at maturity for SBT varies from age 8-12 years, PBF begins to mature at age 3 and are

fully mature at age 5. It seems reasonable to assume that such an early investment on reproduction would result in higher natural mortality levels for mature PBF. A comparative analysis of reproductive output for different stocks of bluefin was conducted at the Ishigaki meeting. The analysis revealed that, under the 2008 PBF M assumptions, PBF is the most productive among the worldwide bluefin stocks and is very unlike the other bluefins. The group agreed on an alternative M schedule.

It was recommend at the Ishigaki meeting that a re-examination of all assumptions on PBF M should be initiated. A new analysis of the population dynamics using the current assessment model structure and a new mortality schedule reflecting higher adult mortality should be completed for presentation to the ISC plenary (July 2009) along with original assessment results.

Participants made the following comments. The natural mortality rate of juveniles is fundamentally important for the stock assessment (age 0 fish are taken in the Japanese fishery). The maximum age estimate of 20 years should be confirmed. Despite the historical data, the working group decided to start the analysis in 1950. The older fish are only in the west (15-20 years), and there are only 2-3 year old fish in the EPO. Age validation should be done.

The question was asked as to why the old data were not used in the assessments. Dr. Miyake reported that lots of studies have been done on growth and otolith validation. Data mining has been accomplished, showing that pre-war catches were as high as current catches. Current fishing grounds are completely different. A question and discussion ensued about comparisons between southern bluefin, Pacific bluefin, and Atlantic bluefin tuna. The older fish do not appear in the Atlantic catch either, and the natural mortality assumption about Atlantic bluefin was based on southern bluefin, which is probably too low. Dr. Dreyfus agreed that the M estimate needed more work, given a simple model gave him highly variable B_0 estimates.

Dr. Maunder made several observations about estimating natural mortality. Using longevity estimates and catch curves requires many simplifying assumptions. Less assumptions are required by using the same data inside the stock assessment model. Historical estimates of natural mortality were based on bad data or borrowed between studies. Dr. Deriso pointed out that the natural mortality rate used for southern bluefin was estimated from tagging of juveniles, and no direct estimate exists for older bluefin.

c. Southern albacore

Dr. Deriso informed the meeting about a request made last year to present a stock assessment for the southern stock of albacore. Dr. Hampton of SPC was invited to this SARM, but he had a conflicting meeting. The conclusion of the 2008 assessment reported to the WCPFC SC4 was that the stock was above MSY and fishing mortality was below the MSY level.

d. Update on FAO activities relevant to tunas

Dr. Majkowski reviewed some recent developments at, and activities of, the FAO Fisheries and Aquaculture Department, and its FAO Fisheries Management and Conservation Service. He referred to the May 2009 Meeting of the FAO Committee on Fisheries and its discussions on the Code of Conduct, IUU fishing, small scale fisheries, and climate changes. He gave an update about FAO's three catch data bases that include statistics for tuna (catches by (i) species, FAO statistical area and year, (ii) species, stock, gear, and year and (iii) by species, gear, 5x5 degree square, year and quarter). A methodological paper on the estimation of tuna fishing capacity has been accepted for publication by ICES, and the proceedings of the last workshop on the same subject will be available in a few months. Improvements to the website, including the incorporation of various global reviews on tunas, have been made.

17. Date and topics for October workshop

The proposed date for the fall workshop is 3-6 November 2009, and the topic will be "Modeling processes, including selectivity, growth, natural mortality, and recruitment. The technical workshop on shark assessment is scheduled for 2 November 2009.

18. Other business

There was no other business.

19. Recommendations

The following are recommendations made by individual participants at the Stock Assessment Review Meeting

1. Request to present the results of assessments by year instead of by quarter.

2. Give high priority to identifying the sex of large yellowfin tag recoveries.

3. Design tagging experiments for estimating natural mortality by age and sex.

4. Add several years of data to the assessment of yellowfin tuna, going back to the historical beginning of the fishery.

5. Consideration of inter-decadal changes in oceanographic conditions when considering changes in the longevity of time periods in the IATTC stock assessments.

6. Recommendation that the IATTC analyze the high concentration of skipjack catches in certain 1-degree areas of the EPO to determine if environmental factors could be influencing a concentration of spawning biomass or food resources for skipjack.

7. The IATTC is encouraged to further develop an assessment of striped marlin.

8. Recommendation for IATTC staff to put the analysis of sampling design into a "worldwide context."

9. Recommendation for more tag recoveries involving vessel crews at sea.

10. Locating "tagging coordinators" in each port to coordinate tag recoveries.

11. Development of a regional database for catches of sharks.

12. Recommendation to retain the IATTC resolution on full retention of tunas again this year.

13. Recommendation for a new analysis of the population dynamics of Pacific bluefin tuna using the current assessment model structure and a new mortality schedule reflecting high adult mortality.

14. Strongly urge all parties to provide details of catch of bycatch and non-tuna species by all fisheries, in order that resource and stock assessments are as accurate and precise as possible, and of optimal value to the parties.

15. Encourage cooperation and coordination of studies to estimate natural mortality of the various tuna species.

16. Strongly support the IATTC regional tuna tagging project and encourage parties to assist with necessary funding for this important work.

17. Encourage support of the efforts of GLOBEC-CLIOTOP in studying the dynamics of oceanic pelagic ecosystems and the effect of climate variability and fishing.

Dr. Compeán presented the staff recommendations listed in Appendix A.

20. Meeting report

The meeting report was adopted.

21. Adjournment

The meeting was adjourned at 12:30 pm on 15 May 2009.

Appendix A

Tentative IATTC Staff Recommendations to be presented at the 80th meeting of the IATTC:

A. Conservation of yellowfin and bigeye tuna: The staff recommends implementation during 2009-2011 of a conservation proposal similar to that proposed in Document IATTC-77-04:

1. **For the purse-seine fishery**, a 12-week closure in the entire EPO from 20 June through 11 September, and a closure of the offshore area (Figure A) from 12 September through 31 December. For 2009, due to the timing of the IATTC meeting, the recommended 12-week closure would be delayed by 25 days, and the offshore closure, which would begin at the end of the 12-week closure and terminate at the end of 2009, would be shortened.

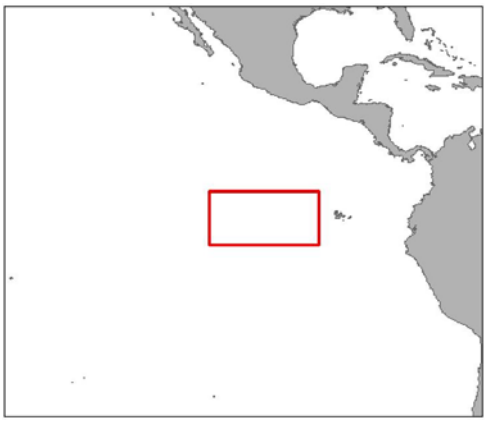

FIGURE A. Offshore closure area between 94° and 110°W and from 3°N to 5°S.

2. **For the longline fishery**:

   a. China, Japan, Korea, and Chinese Taipei shall take the measures necessary to ensure that their total annual longline catches of bigeye tuna in the EPO during 2009, 2010, and 2011 do not exceed the following levels:

China	2,190 t
Japan	28,283 t
Korea	10,438 t
Chinese Taipei	6,601 t

   b. Other CPCs shall take the measures necessary to ensure that their total annual longline catches of bigeye tuna in the EPO during 2009, 2010, and 2011 do not exceed the greater of 83% of 2001 catches or 500 t.

B. Marking and identification of FADs: The staff recommends that vessels that use FADs be required to mark the FADs in accordance with a program developed by the Commission, to include, inter alia, maintaining a record of the numbers of FADs on board each vessel at the beginning and end of each fishing trip, and recording the date, time, and position of deployment of each FAD. The information collected shall be held by the Commission staff, and shall be made available to CPCs, subject to any confidentiality rules or policies that the Commission may establish.

C. Conservation of Northern Pacific albacore: The most recent assessment of northern albacore, by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean in 2006, uses fishing mortality averaged for 2002-2004 as the "current" fishing mortality. **The staff recommends that** this definition be applied to paragraph 1 of Resolution C-05-02. Also, paragraph 3 calls upon all CPCs to report all catches of North Pacific albacore tuna every six months; however, since the limit in the resolution is in terms of effort, **the staff recommends that** the six-monthly

reports include information on effort as well as catch, in terms of the most relevant measures for a given gear type. The technical aspects of the effort data to be supplied could be established by the Director, in collaboration with scientists of the interested member countries.

Also, **the staff recommends that** the resolution be clarified to indicate that data provided should be for the EPO only, since that is the area covered by the IATTC. Currently, at least one country reports catches for the entire Pacific only. Finally, **the staff recommends that** the resolution contain a paragraph encouraging all CPCs to report annually to the IATTC all catches of albacore north of the equator and all fishing effort north of the equator in fisheries directed at albacore.

D. **The staff recommends that** RESOLUTION C-06-03 **(**the Resolution on full retention) be renewed for the next three years 2010-2012.

Appendix B.

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