INTER-AMERICAN TROPICAL TUNA COMMISSION

WORKING GROUP ON STOCK ASSESSMENT

6TH MEETING

REVIEW OF 2004 STOCK ASSESSMENTS

La Jolla, California (USA)
2-6 May 2005

MEETING REPORT

Chairman: Dr. Robin Allen

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The 6th Meeting of the Working Group on Stock Assessments was held in La Jolla, California, USA, on 2-6 May, 2005. The attendees are listed in Appendix A.

1. Welcome, introductions, meeting arrangements

The meeting was called to order on May 2, 2005, by the Chairman, Dr. Allen, who thanked the attendees for coming to the meeting, and then asked them to introduce themselves. Drs. Arenas and DiNardo were appointed Rapporteurs.

2. Consideration of agenda

After a brief discussion, the provisional agenda was approved, with the addition of a new agenda item 11: *Issues to be considered in an ecosystem approach to management for the eastern Pacific Tuna fisheries.*

3. Report of the Data Working Group

Dr. Hinton presented the report of the 1st Meeting of Data Correspondents, held in La Jolla on April 29-30, 2005 (Appendix B). This *ad hoc* meeting to review data and standards was held in response to the recommendation of the 5th Meeting of the Stock Assessment Working Group to review data collected and compiled by the IATTC that are used in the staff's stock assessments. Information on the Commission's logbook, observer, biological sampling, and landings data systems were presented by IATTC staff. In addition, to provide further details on data which are provided to the Commission by parties and cooperating non-parties, presentations were made on fisheries and data systems by representatives of Japan, Canada, the USA, Spain, Korea, Chinese Taipei, and China. Dr. Allen reviewed, and sought advice on, the specifications for data provision under IATTC Resolution C-03-05. The status of data received by the Commission prior to June 30 each year, in accordance with the Resolution, was also reviewed. The Group expressed concern that some of the reported longline catches were not verified by landings data. The Group encouraged the posting of total and detailed data to the IATTC website as soon as possible.

4. Report of the meeting on developing indices of abundance

Dr. Maunder presented the report of the *Workshop on developing indices of abundance from purse-seine catch and effort data*, held in La Jolla on November 3-5, 2004 (Appendix C). The objective of the workshop was to develop indices of abundance for tuna fisheries associated with floating objects. The workshop also assessed the need to uniquely mark fish-aggregating devices (FADs) in an effort to provide information on the relationship between catch per unit of effort (CPUE) and abundance. A report from the workshop is available on the Commission's web site.

The discussion centered on technical issues that may be affecting the indices, such as the improvement of searching and brailing, the age of vessels, and changes in fishing gear and fishing techniques. It was mentioned that the distance covered by each vessel has increased considerably over the last 20 years in the Indian Ocean. The Group agreed that it was appropriate to update CPUE standardization analyses on the dolphin and unassociated fisheries in the eastern Pacific Ocean (EPO), using search time. The last time standardization analyses were conducted was in the mid-1990s. When conducting these analyses, a careful interpretation of search time is necessary, as this will affect the results.

Another important topic discussed was the use of FADs in surface fisheries. The Group agreed that FADs are a unique fishing gear that attracts and retains fish for collection at a later time. Uniquely identifying FADs would be beneficial from a scientific perspective, but there may be logistical issues that need to be solved before implementing. The Group did not reach consensus on this issue, but agreed that future efforts should focus on identification and resolution of any logistical issues and preparing a research plan that would demonstrate the potential benefits of marking all FADs.

5. Review of contributed papers

Dr. Chi-Lu Sun made available to the meeting the paper *Sex-specific yield per recruit and spawning stock* *biomass per recruit for the swordfish, Xiphias gladius, in the waters around Taiwan*, published in 2005 (Document SAR-6-05a).

Dr. Miyabe presented an update on the CPUE of the Japanese longline fishery in the EPO. These data showed a recovery in CPUE for 2004, especially in the southwestern and southeastern areas, where CPUEs are similar to the average level of the 1990s. CPUE in the other areas remains below the 1990s level. Catch data in weight shows less of a recovery, perhaps indicating that recruitment of small individuals to the longline fishery is occurring. The CPUE data for the fourth quarter of 2004 were based on a small number of observations and are subject to revision.

Dr. Fonteneau made a presentation on several topics, including Pacific-wide trends in longline catch, Japanese longline target shifting off Peru, and monthly catch by numbers in various subareas during recent years.

Both of the latter presentations indicated that the Japanese longline fleet might have been directing more effort towards yellowfin in the area off Peru during 2003, thereby possibly reducing the CPUE of bigeye independent of their abundance.

6. The fishery in 2004

Mr. Everett and Ms. Suter reviewed the information on the fishery for tunas in the EPO in 2004 (Document SAR-6-09 SEC A). This report, in contrast to those of previous years, which were based on reported catches, provides the best scientific information available, used in the stock assessments.

Mr. Everett discussed EPO tuna catch statistics for 2004; total catches by species and by flag, purse-seine catch distributions for yellowfin, skipjack and bigeye, as well as sampling protocols and size compositions of the three species. Participants suggested a variety of edits, formatting changes, and additions to the report. Many of the suggestions will integrated into the report before it is submitted to the Commission in June; any substantive changes will be incorporated into future versions of the document.

Ms. Suter provided a review of the species composition sampling program the Commission has conducted since 2000, in conjunction with its length-frequency sampling program. More detail regarding the collection of samples was provided at the 1st meeting of Data Correspondents, and the program is described in detail in the IATTC Annual Report for 2000. Basically, the sampling scheme is a two-stage stratified sampling program. The first stage is selecting wells to be sampled, by determining that the fish in the well were all caught in the same type of set, in the same calendar month, and in the same IATTC sampling area. The second stage is selecting fish in the well. A select number of fish are counted and identified for the species composition sample, and 25-50 fish of each species are measured, independently from the species composition sample.

This information has been used to obtain estimates of the species composition of the total reported catch of yellowfin, skipjack, and bigeye tunas. Beginning this year, these estimates will be used in reporting total catches of these species in the IATTC Fishery Status Report. The motivation for this change is that there are now five full years of sampling data available. In those five years, the species composition estimates of bigeye have been greater than any of the other available estimates (unloadings from canneries, observer, or logbook estimates), similar to results found in other oceans. Some of these comparisons were presented.

Species composition estimates were also calculated by flag for 2000-2004. This was done by raising the stratified observer or logbook data by flag to the total catch by flag, then summing the catches of all flags together, and calculating the proportion of total catch taken by each flag in each stratum, by species. The proportions were then multiplied by the total species composition estimates by stratum and species. The result provided a species composition estimate by month, gear, area, and flag.

The average proportion by flag for 2000-2004 was calculated and applied to the data prior to 2000. There were some problems with this procedure, since a species estimate for a given flag may vary in direction for the five years of data. Also, the sample sizes for some flags were too small to give reasonable results.

The sampling program is not designed to sample at a certain coverage rate per flag and stratum. In the future, new methods to estimate species composition by flag will be explored, including the possibility of using a multivariate modelling approach.

The Group discussed identification problems and misreporting when most of the catch is of one species. The relative importance of stratifying data by flag (about 1000 wells are sampled each year), and seasonality were also discussed. The Group agreed that the IATTC staff should explore the use of multivariate analyses and report on progress at a later date.

7. Review of staff stock assessments

Yellowfin, bigeye, and albacore tuna assessments were presented by IATTC staff. The assessments of yellowfin and bigeye were conducted by IATTC using A-SCALA (*Age-Structured Statistical Catch-at-Length Analysis*). The assessment of North Pacific albacore was conducted by the Albacore Working Group, now under the auspices of the International Scientific Committee of the North Pacific (ISC), using VPA-2BOX.

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. Yellowfin

Mr. Hoyle reviewed the yellowfin assessment presented in Document SAR-6-07a. An age-structured, catch-at-length analysis (A-SCALA) was used to assess yellowfin tuna in the EPO. The assessment for 2004 differs from that carried out in 2003 in the following ways:

Catch and length-frequency data for the surface fisheries have been updated to include new data for 2004 and revised data for 2000-2003. Effort data for the surface fisheries have been updated to include new data for 2004 and revised data for 1975-2003. Catch data for the Japanese longline fisheries have been updated for 1999-2002, and new data for 2003 have been added. Catch data for the longline fisheries of Chinese Taipei have been updated to include new data for 2002. Catch data for the longline fisheries of the People's Republic of China have been updated to include new data for 2003 and revised data for 2001 and 2002. Longline catch-at-length data for 2001-2002 have been updated, and new data for 2003 added. Longline effort data based on standardization of CPUE with a generalized linear model, rather than a neural network model, have been developed, using data for 1975-2003. Otolith data have been integrated into the growth model using a different form of the likelihood function that takes better account of the sampling method.

The results are similar to those of the previous five assessments, except that the spawning biomass ratio (SBR) at AMSY is higher than estimated previously. The biomass is estimated to have declined slightly in 2004. There is uncertainty about recent and future recruitment and biomass levels. The estimate of current SBR is less than that required to produce AMSY but its confidence intervals encompass the AMSY. The current fishing mortality rates are above those required to produce AMSY. The average weight of a yellowfin in the catch is much less than the critical weight, and increasing the average weight of the fish caught would substantially increase AMSY. There have been two different productivity regimes, and the levels of AMSY and the biomass required to produce AMSY may differ between the regimes. The results are sensitive to the assumption about the stock-recruitment relationship.

Participants suggested a suite of formatting changes and additions to some of the tables and figures. Many of the suggestions will be integrated into the report. The IATTC staff will review the other suggestions and, if appropriate, incorporate them into the current documents as time allows. If the changes are substantive, they will be incorporated into future documents. The participants also 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.

Samples of large sized yellowfin tuna contain few females. Two hypotheses have been forwarded to explain this observation, an increasing female mortality with increasing size, or differing growth patterns between males and females. In the assessment model, an increasing female mortality has been assumed. Data that support this decision are that no differences in growth were detected between males and females, and that there is no intermediate age at which there is a preponderance of females.

Next there was some discussion about the portion of the EPO in which the fishery for yellowfin by purse seiners and pole-and-line vessels has taken place. Until the late 1960s the fishery took place relatively close to the coast and to a few offshore islands and banks. At that time it began to expand, reaching waters as far as about 150°W by the early 1970s. After that it did not expand further until the 1990s, when vessels began to fish on tunas associated with FADs along the equator west of the Galapagos Islands (catching relatively few yellowfin) and south of the equator on fish associated with dolphins. As the fisheries expanded in the late 1960s and early 1970s, estimates of recruitment and AMSY increased and there was some discussion that a similar increase might be expected as a result of the expansion and changes of the fishery in the 1990s. Some participants thought carrying out the assessments with data prior to 1975 would be useful, while others thought a better approach would be to compare current assessments with assessments prior to 1975. In either case, detailed spatial information would need to be included. The Group did not reach a consensus on this issue. Such analyses would take advantage of the substantial database held by the IATTC.

Next there was some discussion about the two regimes that have been observed (lesser biomasses during 1975-1983 and greater biomasses during 1984-2004). During the 1970s the biomass of yellowfin was estimated to be low, due to at least some extent to catching of small yellowfin and low recruitment. This, plus a strong El Niño event during 1983-1984, caused many vessels to transfer their operations to the western Pacific Ocean. After the El Niño event was over, about half of these vessels returned to the EPO, where fishing conditions were greatly improved: as expected, reduced fishing mortality during the early 1980s increased the biomass of yellowfin shortly thereafter. It was estimated that about half of the increase was due to a greater yield per recruit, and the other half to increased recruitment. It was pointed out that the phenomenon of regime shifts is not uncommon for other species of organisms, not all of which are exploited by man. It was also pointed out that the staff must make its recommendations in accordance with the current regime, rather than in accordance with some other regime that has occurred in the past or may occur in the future.

The Group discussed how periodic changes in oceanic conditions affect yellowfin tuna dynamics. Participants agreed that available data do not allow determination of causal mechanisms, and that analyses assessing the impact of environmental conditions on catch should be continued. These analyses could prove useful in explaining how environmental conditions affect recruitment, which in turn would help in the interpretation of forward projection analyses.

While standardized effort time series are critical input vectors to this assessment model, the methods and results employed to develop the series were not presented to the Group. The Group recommends that any changes of standardization methods and results be provided at future meetings.

The Group noted reductions in discards after 1999 coincident with the period of regulations prohibiting discards.

b. Bigeye

Dr. Maunder reviewed the bigeye assessment by first discussing the new biological parameters in the model (Document SAR-6-07b SUP). New results from recent age and growth and reproduction studies have been incorporated, and used to update the other biological parameters. Dr. Maunder explained that, in recent years, several new biological data sets for bigeye tuna in the EPO have been provided by

Messrs. Schaefer and Fuller of the IATTC staff and Dr. Miyabe. These data sets are reported and analyzed in two manuscripts that have been submitted for consideration for publication as IATTC Bulletins and made available to the Group.

The data collected provide important information about growth and reproduction (fecundity, maturity, and sex ratio) for the bigeye tuna stock assessment. The information is also used to develop the age-specific natural mortality rates for both sexes combined used in the assessment. In addition to the data from the staff research, sex ratio data from the National Research Institute of Far Seas Fisheries (NRIFSF) of Japan (pers. com. Dr. Miyabe), and estimates of natural mortality based on tagging data from the Secretariat of the Pacific Community (SPC) are used to develop the natural mortality rates used in the EPO bigeye tuna assessment. Dr Maunder described how these data are used in the assessment, using the A-SCALA method. Because the von Bertalanffy growth curve estimated by Schaefer and Fuller has an asymptotic length that is much greater than any recorded bigeye tuna, asymptotic length was constrained and refitted to a Richards growth model. This also influenced the age-specific values of the other biological parameters. Based on results from the 2004 assessment, the new biological parameters had a moderate influence on the assessment results, and incorporating them results in a more pessimistic assessment of the status of the population. The Group generally endorsed the use of the new biological parameters, but was concerned that the recently studied phenomenon of shrinkage of frozen fish might affect the growth curve, and length and age estimates as well. Some participants suggested that, depending on the extent of the shrinkage, this could be a major problem and indicated that length data might need to be adjusted. Published estimates show that shrinkage is less than 3 cm and hence not a problem in this context. Participants agreed that additional shrinkage studies on bigeye tuna, as well as other tuna species, may be needed determine its impact.

Dr. Maunder reviewed then the bigeye assessment in Document SAR-6-07b. Catch and length-frequency data for the surface fisheries have been updated to include new data for 2004 and revised data for 2000-2003. Effort data for the surface fisheries have been updated to include new data for 2004 and revised data for 1975-2003. Monthly reports of catch data for the longline fishery provided at the time of the assessment were incorporated. Catch data for the Japanese longline fisheries have been updated for 1999-2002 and new data for 2003 added. Catch data for the longline fisheries of Chinese Taipei have been updated to include new data for 2002. Catch data for the longline fisheries of the People's Republic of China have been updated to include new data for 2003 and revised data for 2001 and 2002. Longline catch-at-length data for 2001-2002 have been updated and new data for 2003 added. Longline effort data based on statistical habitat-based standardization of CPUE have been updated to include data for 2002, and raw catch and effort data were used to extend the time series to the second quarter of 2004.

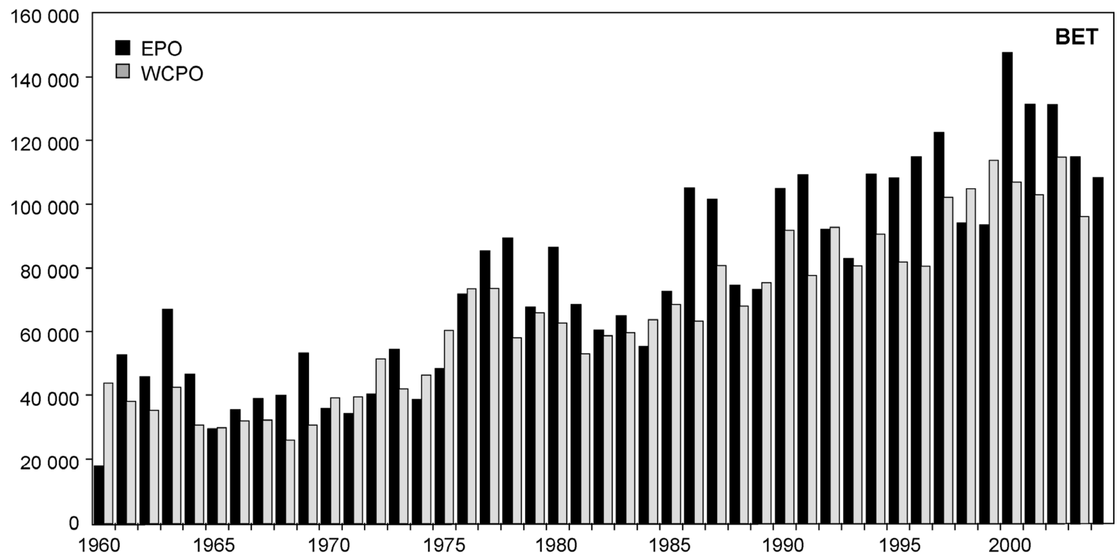
Biomass trends are similar to those estimated (and predicted) in previous assessments. Both total and spawning biomass is estimated to have declined substantially since 2000. Current biomass level is low compared to average unexploited conditions. Current SBR is estimated to be below the level corresponding to AMSY, and the fishing mortality is estimated to be greater than that corresponding to the AMSY. The current effort restrictions are not enough to allow the population to reach a level that will support AMSY. The results are more pessimistic with the inclusion of a stock-recruitment relationship. The assessment results are highly dependent on the assumption that the longline CPUE is proportional to exploitable biomass.

Dr. Maunder concluded the review of bigeye assessment by presenting the main results of a recent Pacific-wide bigeye assessment, in which the IATTC collaborates with the SPC, the NMFS Pacific Islands Fisheries Science Center, and the NRIFSF. Drs. Adam Langley and John Hampton of the SPC supplied results from the latest preliminary Pacific-wide assessment.

Historically, according the Pacific-wide assessment, the EPO accounted for about 65% of the total estimated biomass of bigeye tuna in the Pacific Ocean, but in recent years this proportion has fallen to about 45%. The IATTC assessment and the Pacific-wide assessments show similar trends for the spawning biomass of bigeye in the EPO up to mid-2002, after which the Pacific-wide assessment through 2003 shows an increase while the IATTC assessment shows a decrease. The IATTC assessment follows the longline CPUE more closely than the Pacific-wide assessment. The differences in the assessments may be due to the weighting of length-frequency data in the two analyses and the greater stratification of the FAD fishery in the IATTC assessment.

The general discussion of the bigeye assessment included suggestions on data input display, especially showing the actual catch used in the analysis, and maps showing the spatial and seasonal distribution of catches for both purse-seine and longline fisheries. The inclusion of an appendix was also suggested to include (1) an update of model equations and a summary of changes; (2) a table of parameter estimates, standard errors, and their bounds; and (3) a full description of the CPUE analysis (as described in the yellowfin tuna section above).

The Group noted the comparison of catches in the western and central Pacific and eastern Pacific since 1950 shown in the figure.



Catches of bigeye tuna in the central and western Pacific and eastern Pacific Ocean (t)

Stock structure and tagging were discussed at length. The Group recognized that the available tagging data are insufficient to allow for the estimation of movement and to define more clearly the stock structure patterns suggested by spatial catch distributions. However, the Group considered that a bigeye assessment for the EPO is appropriate and that its results are consistent with the Pacific-wide study, and suggested further consideration and cooperation on this topic. The Group discussed the need for a Pacific-wide bigeye tuna tagging program to address stock structure issues.

Sensitivity analyses were recommended for both purse-seine and longline input data. Especially, the Group recommended that the IATTC staff examine the assumption of catchability for the southern longline fishery, which is strongly influencing the model. The Group discussed the importance of natural mortality rate (M) in the assessment and recommended that the staff continue sensitivity analyses on this parameter. Tables showing the impact of varying M on AMSY, biomass, etc. should be continued. It was also recommended that variances associated with priors on bigeye growth be relaxed in the future assessments.

The Group noted reductions in discards by purse-seine vessels after 1999, and discussed whether this resulted from low recruitment or the effect of regulations prohibiting discards. During 2000 and the first part of 2001 it was thought that the reduction could be explained by low recruitment, but since then, the effect of regulations was seen to be the more likely cause.

The reported bigeye discard rate for the longline fisheries does not include fish that are removed or damaged by sharks and cetaceans after they have been hooked, a common occurrence which represents unreported catches. Data to estimate the magnitude of this loss should be provided and analyzed. Maps of spatial distribution of potential predators of the bigeye longline catch, especially pilot whales, were looked at. It was noted that this problem could be significant, especially in the southern areas of the EPO.

The current assessment model defines 13 fisheries, and assumes that the selectivity in each fishery is constant. Participants reviewed the data to support this assumption (residual patterns) and recommended that, particularly for the longline fisheries, additional diagnostics or sensitivity analyses should be employed to further examine the assumption that selectivity has been constant for the 1975-2004 period.

In the current assessment, environmental factors are not integrated into the model. Previous assessments did integrate an environmental index into the model, but recent hypothesis testing indicated that the index is no longer statistically significant. Participants discussed the lack of an environmental index in the model, and agreed that more analyses are necessary to fully assess the impact of environmental factors. It was recommended that IATTC staff perform further analyses of the influence of environmental factors on bigeye tuna.

c. North Pacific Albacore

Dr. Hoyle presented salient points from an assessment of North Pacific albacore that was conducted during the 19th North Pacific Albacore Workshop in 2004 (Document SAR-6-07c), based on the draft report available before this meeting. The results of the assessment were previously presented at the 5th meeting of the ISC in March 2005. The assessment was conducted using a statistical, age-structured virtual population analysis (VPA) model. Projections were conducted under the equally likely assumptions of low fishing mortality rate (F) (0.43) and high F (0.68) coupled with low and high productivity. Results indicated that the point estimate of the 2004 stock biomass is roughly 429,000 t, with 80% confidence limits ranging from roughly 329,000 to 563,000 t. The 2004 level of spawning stock biomass (SSB) of 165,000 t (24% less than SSB_{AMSY} relative to $F_{30\%}$) is largely reflective of a very strong 1999 year-class that eventually became a major contributor in 2004 as part of ‘mature’ (spawning) biomass. However, subsequent recruitment declined to levels more typical of the extended historical time series, which translated to reduced levels of forecast SSB, particularly if assuming ‘high F’ scenarios (F=0.68) within the overall uncertainty analysis. This, coupled with a current fishing mortality rate (F_{2003}) that is high relative to commonly-used reference points, may be cause for concern regarding the status of the North Pacific albacore stock. Future conditions are less well-known, but if F continues at assumed levels, it is unlikely that SSB will rebuild to SSB_{AMSY} levels within five years.

The 2005 meeting of the ISC gave the following advice:

> “Future SSB can be maintained at or above the minimum ‘observed’ SSB (43,000 t in 1977) with F’s slightly higher than the current F range. However, the lowest ‘observed’ SSB estimates all occurred in late 1970’s and may be the least reliable estimates of SSB. A more robust SSB threshold could be based on the lower 10th or 25th percentile of ‘observed’ SSB. If so done, current F should maintain SSB at or above the 10th percentile threshold but a modest reduction from current F may be needed to maintain SSB at or above the 25th percentile threshold.”

The IATTC staff considered the higher level for current fishing mortality (0.68) to be more likely, based on the methods used to calculate the estimates. Furthermore, even the high estimate may be too low, given the retrospective bias shown by the model. Current fishing mortality of 0.68 implies an equilibrium spawning stock biomass at 17% of unfished levels, and projections assuming fishing mortality of 0.68, under low and high scenarios of future recruitment, suggest that the biomass may decline if current levels of fishing mortality persist.

Regardless of whether low and high Fs are equally likely (Albacore Workshop view) or that the high F is more likely (IATTC staff view), it is unlikely that SSB would rebuild to SSB_{AMSY} within five years.

8. Review of 2004 management measures

Dr. Maunder reviewed Document SAR-6-08a, on the evaluation of the effect of the Resolution C-04-09 on the conservation of tuna in the EPO, which called for restrictions on purse-seine effort and longline catches for 2004: a 6-week closure during the third or fourth quarter of the year for purse-seine fisheries, and longline catches not to exceed 2001 levels. To assess the effects of these management actions, the population was projected forward 5 years, assuming that these conservation measures were not implemented.

The spawning biomass of bigeye tuna at the end of 2004 under the management restrictions is about 14% higher than if no restrictions had been implemented. However, the spawning biomass is significantly below the AMSY level and, assuming average recruitment, will remain below the level corresponding to the AMSY. The spawning biomass will decline even further if no restrictions were implemented.

If no restrictions were implemented the catch of bigeye tuna in 2004 would have been 12% higher for purse seine and 30% higher for longline. However, it is predicted that by 2007, the catches based on the lower effort due to the restrictions would be higher than under the unrestricted effort.

The spawning biomass of yellowfin tuna at the end of 2004 under the management restrictions is about 12% higher than if no restrictions had been implemented. However, the spawning biomass it is likely to be below the AMSY level and, assuming average recruitment, will remain below the level corresponding to the AMSY. The spawning biomass would decline even further if no restrictions were implemented.

If no restrictions had been implemented, the catch of yellowfin tuna in 2004 would have been 9% higher for purse-seine and 36% higher for longline. However, it is predicted that, by 2006, the purse-seine catches with restricted effort would be higher than without the restrictions. Catches in the longline fishery are predicted to remain lower with the restricted effort than would have been the case without the restrictions.

The Group discussed the impact of the restrictions of fishing effort, in particular whether total effort was actually reduced or merely redistributed as a result of the resolution. For this reason, the Group expressed the view that the impact estimated in Document SAR-6-08a was probably a best-case scenario. The Group examined the number of days at sea by purse-seine vessels, and noted that in 2004 this was about equal to the average of 2002 and 2003. However, this simple analysis does not necessarily reflect the impact of the measure on the stock in terms of fishing mortality.

Dr. Maunder then reviewed Document SAR-6-08b, on catch limits for individual purse-seine vessels to reduce fishing mortality on bigeye tuna in the EPO. He indicated that the analysis on this topic presented last year was updated using data for 2004 and additional information.

Results show that 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. Between 11 and 15 vessels captured 50% of the bigeye catch, but only about 5% of the yellowfin catch and 25% of the skipjack catch. Between 23 and 30 vessels captured 75% of the bigeye catch, but only about 10% of the yellowfin catch and 34-50% of the skipjack catch. Many of the same vessels frequently caught a large proportion of the total purse-seine catch of bigeye.

The vessel limits of bigeye catch required to reduce the purse-seine catch to 50% of the levels in each year were around 350-474 t, except for 2000, which would have required a much higher limit. Such vessel limits would have affected 30-40 vessels, and would have resulted in a 15-20% reduction of the total tuna catch if they had been implemented.

The Group noted that the analysis was based on observer estimates of bigeye catches rather than the species composition sample estimates, and observer estimates are probably underestimates. The Group also noted practical difficulties if such limits were to be monitored at sea by observers.

The Group discussed alternatives for restricting bigeye catches. Restrictions in the number of sets a vessel could make or the number of days it could fish were discussed, and it was tentatively concluded that restrictions in the number of days a vessel could fish would be better. The possibility that fishermen can reduce their catches of bigeye by estimating the proportion of bigeye in a school of tuna before setting, and not setting if that proportion was too high, was discussed. It was agreed that the presence of bigeye can be detected, but it is not certain that the fishermen can estimate the proportion of bigeye in the school. It was discussed that the results shown in Document SAR-6-08b seem to indicate that the captains of vessels with large bigeye catches might learn to reduce their catches of bigeye by adopting the fishing techniques used by the captains of the other vessels. Other measures for reducing bigeye catches could include systems of penalties, incentives, or taxes. Any of these would require more extensive examination of catches or landings.

9. Status of tuna and billfish in the EPO

The Group reviewed extensively Documents SAR-6-09 SEC A and SAR-6-09 under this agenda item, considering the text paragraph by paragraph, as well as all figures and tables individually. Dr. Allen said that this document 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 numerous suggestions for improving the format and graphical display of information, and suggested various changes to correct information and detected inconsistencies, as well as to balance the detail of information and conclusions from assessments, especially regarding yellowfin and bigeye.

10. Anticipation of Antigua Convention Article 11, Scientific Advisory Committee

Dr. Allen explained that this agenda item arose from suggestions by the European Union in anticipation of the entry into force of the Antigua Convention, and specifically Article 11 and Annex 4, which deal with the Scientific Advisory Committee. The Group reviewed the relevant provisions of the Antigua Convention, described in Document SAR-6-10, and felt that there was no need at this time to change the way in which the Stock Assessment Review meeting is structured or conducted.

However, should future assessments involve significant changes in modeling or key structural assumptions, it may not be practical to carry out a thorough review during the stock assessment meeting. In these circumstances, it may be preferable to convene a special workshop approximately six months prior to the stock assessment meeting. Further discussion focused on the feasibility of doing additional analyses during the assessment work, as in some previous years, and on ways to incorporate other types of assessments and "what if" scenarios into the meeting structure.

11. Issues to be considered in an ecosystem approach to management for the eastern Pacific tuna fisheries

This agenda item, consistent with the Reykjavik Declaration, was requested in a letter from the United States regarding its proposal for a resolution on the use of an ecosystem approach to fisheries management in the EPO. The US requested a list of key issues for such a resolution, and felt that this was an appropriate subject for the stock assessment meeting. Dr. Allen presented a list of issues as a basis for discussion. Participants agreed this is an important topic, and suggested several improvements to the list as well as the addition to of a provision for adequate information, given the lack of data on key components of the ecosystem (Appendix D). In general the Group felt that the lack of more detailed information from the longline fishery was a limiting factor in assessing ecosystem impacts from the fishery.

It was noted that future ecosystem studies should try to incorporate the environmental heterogeneity within the EPO.

12. Recommendations

a. Review of staff recommendations

Dr. Allen reviewed the draft staff conservation recommendations in Document SAR-6-11. The Group considered the document paragraph by paragraph. During the discussion, some inconsistencies were noted and several suggestions for improving the language were made. Dr. Allen indicated that the revised conservation recommendations will be presented at the Commission meeting in June.

b. Recommendations from the meeting

Many general issues were discussed during the meeting, while some recurring themes were discussed in detail in various agenda items. These are the basis for the three following recommendations to the Commission:

1. On the issue of excess capacity of the tuna fleet in the EPO, the Group noted that the IATTC is the only regional fisheries organization with a capacity arrangement (Resolution C-02-03), and also noted that the draft *Plan for Regional Management of Fishing Capacity* is being considered by the Commission. The Group also noted the various initiatives worldwide on the topic of excess tuna fishing capacity involving several tuna agencies and programs, as well as governments, and suggested that the IATTC should provide input into those. On this basis the Group recommends that
    a. The IATTC hold a workshop to examine techniques for reducing the capacity of the fleet, including economic incentives, with the intention of facilitating conservation measures and improving the economics of fishing.
2. On the framework for cooperation between the IATTC and organizations in the Western and Central Pacific, the Group recommends cooperative ties with the Western and Central Pacific Fisheries Commission (WCPFC) on:
    a. the Pacific-wide assessment of bigeye tuna, currently being led by the SPC, and
    b. a joint WCPFC-IATTC Pacific-wide tagging program for tropical tunas.
3. The Group recommends that all countries whose longline catches are reported by radio or fax verify reported catches using landings documentation.

13. Other business

The Group discussed the topic for the mid-year technical meeting and considered the following: 1) sensitivity analyses, detailed examination of A-SCALA structure; 2) species composition, taking account of work in other oceans, especially for bigeye, and to consider ways of revising historical data, and 3) old and recent bigeye tuna tagging data, with a view to obtaining new quantitative estimates and for designing a Pacific-wide tagging program. It was decided that the selection could be made by correspondence.

14. Meeting report

The meeting report was adopted.

15. Time and place of next meeting

The next meeting will be held tentatively at the same place in 2006.

16. Adjournment

The meeting was adjourned at 4 p.m. on 6 May 2005.

Appendix A.

INTER-AMERICAN TROPICAL TUNA COMMISSION
COMISION INTERAMERICANA DEL ATUN TROPICAL

WORKING GROUP ON STOCK ASSESSMENT
GRUPO DE TRABAJO SOBRE LAS EVALUACIONES DE POBLACIONES

6th MEETING- 6a REUNION

La Jolla, California (USA)
May 2-6, 2005 – 2-6 de mayo de 2005

ATTENDEES – ASISTENTES

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ECUADOR

IVÁN CEDEÑO
Instituto Nacional de Pesca

ESPAÑA - SPAIN

JAVIER ARÍZ TELLERÍA
PILAR PALLARÉS
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JULIO MORÓN
OPAGAC

JAPAN - JAPON

NAOZUMI MIYABE
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National Research Institute of Far Seas Fisheries

PETER MIYAKE
Federation of Japan Tuna Fisheries Co-operative Associations

MEXICO

GUILLERMO COMPEÁN
MICHEL DREYFUS
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UNITED STATES OF AMERICA - ESTADOS UNIDOS DE AMERICA

WILLIAM FOX
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GERARD DINARDO
KEVIN PINER
RAMON CONSER
RAY CLARKE
ROBERT SKILLMAN
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NON-MEMBER COUNTRIES – PAISES NO MIEMBROS

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DAI XIAO-JIE
Shanghai Fisheries University

EUROPEAN COMMUNITY – COMUNIDAD EUROPEA

ALAIN FONTENEAU
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ULISES MUNAYLLA ALARCÓN
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WILLIAM CLARK
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EDWARD EVERETT
MICHAEL HINTON
SIMON HOYLE
MARK MAUNDER
ROBERT OLSON
JENNY SUTER
PATRICK TOMLINSON

Appendix B.

INTER-AMERICAN TROPICAL TUNA COMMISSION

DATA AND STANDARDS REVIEW MEETING

MINUTES

La Jolla, California (USA)
April 29 – 30, 2005

AGENDA

1. Review of IATTC data systems and processing:
   a. Logbook: Purse seine and longline
   b. Observer
   c. Length frequency and species composition sampling
   d. Landings
2. Review of data systems and processing for data received by IATTC from cooperating non-parties and members and others
3. Data requirements:
   a. IATTC Resolution C-03-05 on Data Provision
   b. Standards

DOCUMENTS

DC-1-02a	Documentation of Data Provision and Processing for the Japanese Tuna Fisheries in the Eastern Pacific Ocean
DC-1-02b	The 2004 Canadian North Pacific Albacore Troll Fishery
DC-1-02c	U.S. Fisheries for Tuna and Tuna-like Species in the Eastern Pacific Ocean
DC-1-02d	Documentación sobre el preparación de datos científicos de la pesquería española de pez espada (*Xiphias gladius*) en las regiones del Pacífico, con especial referencia a los años más recientes 2002 y 2003
DC-1-02e	Korea's Data Collection and Processing for Distant-Water Tuna Fisheries
DC-1-02f	Review of Taiwanese Data Collection and Processing System, and Plans of Improvements for the Taiwanese Tuna Longline Fleet in the Pacific Ocean
DC-1-02g	Review of Chinese tuna data collection and processing system in the eastern Pacific Ocean

APPENDICES

1. List of attendees

The meeting opened at 9:30 A.M. on April 29, 2005, at the Inter-American Tropical Tuna Commission (IATTC) Headquarters, Southwest Fisheries Science Center, La Jolla, California, USA. The meeting was chaired by Dr. Michael G. Hinton (IATTC); the participants are listed in Appendix 1. Following brief discussion, the meeting agenda was adopted.

1. Review of IATTC Data Systems and Processing

a. Logbook: Purse seine and longline

Ms. Jenny Suter presented a review of the IATTC logbook data systems and processing for longline, pole-and-line, and purse-seine vessels. A general discussion focused on the ability to identify the quality of longline logbook data. It was noted that in most instances landing data for individual trips are not available to compare to logbook data. This comparison would be complicated by the nature of the longline operation, particularly because vessels transship multiple times at sea while away from home ports for periods of time which may exceed a year.

b. Observer

Mr. Nick Vogel presented a review of the IATTC purse-seine observer data collection and processing program. There was a general discussion about the measurement of nets by observers. It was noted that the IATTC obtains details on the sonar systems of the vessels but that this is not entered into the observer data base, and thus the information is not readily available for use in standardization of fishing effort. It was noted that this has been important in the Atlantic and Indian Oceans. It was also noted that there has not been a comparison of observer measurements of net dimensions to those obtained from net-plans maintained by the vessels, and that this should be done.

c. Landings

Mr. Ed Everett presented a review of the IATTC landings data collection and processing system. In discussion, it was noted that statistics from recreational fisheries are generally good for fisheries of the USA, but not well documented from other regions.

d. Length frequency and species composition

Ms. Suter presented a review of the process used by the IATTC staff to sample pole-and-line and purse-seine wells to obtain size-frequency and species composition data. There was particular interest in, and discussion of, sampling of wells that are sorted for species or size prior to or during the unloading process. A different sampling scheme is used for these wells. It was noted that a similar process of size-sorted-sampling is used by the United States in American Samoa, but that there they occasionally see mixed "buckets" of small yellowfin and skipjack tunas set aside during the unloading process, which would be problematic if not noted. At the present time in the eastern Pacific Ocean (EPO) region, size sorting is only taking place at sampling locations in Mexico, and at these ports there is not significant landing of bigeye tunas. Thus species misidentification is not a significant issue presently at these locations, as it would likely be in more southern ports in landings coming from floating-object or non-associated sets made in areas from which produce bigeye catches. However, it was noted that if the unloading method changed in ports where bigeye tuna are unloaded, then the sampling program would need to be revised.

It was noted that the adjustment of catches resulting from information obtained from species-composition sampling was also being applied in the western Pacific. There was a short discussion of electronic data recording and reporting, and information may be presented in the future as it becomes available.

2. Review of data systems and processing for data received by the IATTC

Documents describing fisheries and data collection and processing were presented by various Members and Cooperating Non-Parties. Full text of documents may be found on the IATTC website at http://www.iattc.org/IATTCandAIDCPMeetingsApril29-30-05ENG.htm.

a. *Japan* (Document DC-1-02a)

Dr. Naozumi Miyabe presented a review of the fisheries and data systems of Japan. During discussion it was noted that personnel from the Fisheries Agency of Japan (FAJ) are stationed in Shimizu where more than 70% of the longline catch is landed annually. They have checked the reported catches with the landing data. It was also noted that the current data provision and processing system requires nearly two years after the end of a calendar year and therefore there was a need to shorten the time required for this. The National Research Institute of Far Seas Fisheries (NRIFSF) and FAJ are now making collaborative efforts to facilitate this process so that the complete annual statistics can be provided within a year or so. With regard to the precision of logbook data, catches for bycatch species such as sharks were generally less precise and probably under-reported.

b. *Canada* (Document DC-1-02b)

Dr. Max Stocker presented a review of the Canadian fisheries for albacore and the associated data system. During discussions it was noted that the length-frequency data for these fisheries were obtained by the United States when catches were landed at US ports. Detailed data for years prior to 1995 do not exist, but total catch data for north Pacific albacore are available.

c. *USA* (Document DC-1-02c)

Mr. Al Coan presented a review of the fisheries (purse seine, baitboat, troll, longline, gill net, harpoon and recreational) and data systems of the United States of America. During discussions it was noted that catch and effort data provided to others are not raised, but the coverage factor (percentage of catch) is provided so that the data may be raised by others if desired. There was some discussion concerning whether raising is best done by those collecting the data or those to whom the data is provided (length-frequency data are also unraised; coverage rates are provided). In general for the USA, the commercial landings data are covered at 100% by receipts. Logbook coverage is 100% for all fisheries except the albacore troll fishery, but this will change in 2005 to 100% coverage. Length-frequency coverage rates are low, at 1% to 2 % of the total catch.

d. *Spain* (Document DC-1-02d)

Dr. Javier Ariz presented a review of the fisheries and data systems of Spain. The presentation focused on the data systems, while the written document focused on the swordfish fishery. During discussion it was noted that the logbook system of the European Union (EU) is obligatory and used for all fisheries, but that it requires reporting only of catch retained by set. The Instituto Español de Oceanografía (IEO) logbook is voluntary, but it does record fishing effort in number of hooks as well as catch, and it requests information on discards. In general, the catches of the Spanish longline fishery in the EPO are covered at 100%, and effort at about 40%, by the logbook programs. The Spanish longline fishery has about 10% observer coverage in the EPO. Information on size of fish or discards are available from observers and from onboard sampling.

e. *Korea* (Document DC-1-02e)

Dr. Jeong Rack Koh presented a review of the fisheries and data systems of Korea. During discussion it was noted that basic landings data are from radio reports which are summarized and provided annually by fishing companies. These serve as the basis for raising factors and total catch statistics of Korea.

f. *Chinese Taipei* (Document DC-1-02f)

Dr. Shui-Kai Chang presented a review of the fisheries and data systems of Chinese Taipei. Total catch of the fleet was estimated from several sources of commercial information. Catch and effort data were raised from logbooks by a constant raising factor to keep CPUE and species composition of the raised data consistent with the logbook data. In this regard, it was noted that the summed catches by species from the data are not necessarily the same as the total catch estimates. The revisions of total catches of albacore and sashimi species (such as bigeye) due to newly recovered information and adjustments on fishing year, respectively, were discussed. It was reported that the observer program is going to be expanded from 2 observers in 2004 to 7 in 2005. It was noted that vessels are given incentives to carry observers in the EPO. A project has been undertaken to incorporate additional logbooks collected by the US National Marine Fisheries Service and re-raise the data separately for three latitudinal zones, rather than for an entire ocean. It was suggested that consideration be given to including other strata as well. At present size-frequency sampling for Chinese Taipei is done by fishermen. It was noted that a pilot port sampling program at landing ports is being established. There has been a change in restrictions on change in fishing area, which will allow estimation of number of vessels fishing in an area. There were also discussions on recent changes in operational practices of some parts of the fleet which may impact on standardization of fishing effort data.

g. ***China*** **(Document DC-1-02g)**

Dr. Dai Xiao-jie presented a review of the fisheries and data systems of China. During discussions it was noted that the longline fishery of China began operating in the EPO in 1999 and began submitting data to the IATTC in 2001. Since 2004 all vessels operating in the EPO have carried logbooks, which is the basis of China's tuna data collection program. Revised logbooks, requesting more detailed data, were introduced in 2004, and will be provided to some vessels operating in the EPO in 2004. This logbook will request individual weight data for major species as well as bycatch information in the EPO. Total catch is being estimated from regular radio reports by the vessels received via the fishing companies.

3. Data requirements

Dr. Robin Allen reviewed the Commission's Resolution C-03-05 on data provision. There was a general discussion of the timing of data provision. The June 30 deadline was satisfactory for catch and effort data processing systems of distant water fishing nations. There was discussion of the "SPECIFICATIONS FOR DATA PROVISION" as forwarded by the Director. A general comment was made that sources of standard codes should be cited. Several specific recommendations were made to improve clarity and ensure that required information was obtained:

a. Add an explicit Category I data request for total catch in the EPO by species and gear.

b. Rephrase request for Pacific-wide reporting, anticipating data-sharing agreement with the Western and Central Pacific Fisheries Commission.

c. Reword length-frequency reporting to indicate, "Whenever possible submit set-by-set, …, if not, report at the smallest possible grid level." This is to be done in order to eliminate aggregation, which is what was intended. As well, edit text to incorporate reporting of sample and raised length-frequency data.

d. Edit Table 3. Vessel Types, to include all types. Also, check for most recent version of gear codes. Make recommendation to CWP concerning naming of "Tuna Longline" vis-à-vis "Hand longline."

Appendix 1.

INTER-AMERICAN TROPICAL TUNA COMMISSION

DATA AND STANDARDS REVIEW MEETING

La Jolla, California (USA)
April 29 – 30, 2005

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Appendix C.

WORKSHOP ON DEVELOPING INDICES OF ABUNDANCE FROM PURSE-SEINE CATCH AND EFFORT DATA

La Jolla, California (USA)
3-5 November 2004

REPORT

Compiled by Mark N. Maunder

AGENDA

1. Introduction
2. The EPO fisheries and data
    2.1 Summary of the fisheries (Everett)
    2.2 The EPO fisheries, from a fishing captain's perspective (Stephenson)
    2.3 The FAD fishery, from an observer's perspective (Román)
    2.4 Summary of the fishery data (Suter)
    2.5 Summary of observer data (Vogel)
    2.6 Summary of fish behavior and data (presented by Hoyle on behalf of Schaefer and Fuller)
3. Overview of the analysis of CPUE data
    3.1 Traditional CPUE approaches (Maunder)
    3.2 Past IATTC uses of CPUE data (Hoyle)
    3.3 Using catch and effort data in A-SCALA and model sensitivity (Maunder)
4. Research
    4.1. Incorporating oceanographic data (Langley)
    4.2. Modeling abundance of tuna at anchored floating objects in the tropical eastern Pacific Ocean (Harley and Maunder*)
    4.3. FADs as attractors (Maunder)
    4.4. Counting FADs (Hoyle, Lennert-Cody, and Maunder)
    4.5. Effects of communication among fishermen on CPUE as an index of abundance (Dreyfus)
    4.6. Abundance of bycatch derived from "known" bigeye tuna abundance. (Newman, Olson, and Maunder*).
    4.7. Japanese purse-seine fisheries in the north Pacific Ocean, considerations for bluefin tuna assessment (Yamada)
    4.8. Statistical habitat-based model for standardizing longline CPUE (Maunder and Hinton)
5. Discussion of methods to develop indices of abundance from purse-seine catch and effort data
    5.1. What is the basis for expecting that CPUE data provide information on abundance in 1) dolphin-associated, 2) unassociated, and 3) floating-object purse-seine fisheries?
    5.2. Is there an appropriate measure of effort for 1) dolphin-associated, 2) unassociated, and 3) floating-object purse-seine CPUE?
    5.3. Has the development in technology in 1) dolphin-associated, 2) unassociated, and 3) floating-object purse-seine fisheries increased catchability?
    5.4. Are our current techniques able to estimate increases in catchability for purse-seine fisheries?
    5.5. What data should be collected to develop indices of abundance from purse-seine catch and effort data?
    5.6. What are the most promising methods to develop indices of abundance from purse seine catch and effort data?
    5.7. Marking FADs

*presenter different from first author

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Captain, purse-seiner *Connie Jean*

1. Introduction

Robin Allen, Director of the IATTC, gave a brief introduction to the meeting after which Mark Maunder, the meeting chairman, gave a few additional comments. The IATTC holds an annual technical workshop on a topic that is of significant importance to the stock assessment of tunas and billfishes in the eastern Pacific Ocean (EPO). The topic of the meeting of November 2004 arose from research needs identified at the annual review of the staff's stock assessments held in May 2004.

Indices of abundance developed from catch and effort data are one of the most common types of information about biomass trends used in fisheries stock assessment. This is particularly true for tunas and billfishes, for which fisheries-independent surveys are not available. Tagging studies provide information about abundance, but comprehensive tagging studies are generally not available for these species, and none have been carried out in the EPO.

Indices of abundance are used in the stock assessment models to provide information to estimate the model parameters, which, in turn, are used to estimate the quantities for management advice (*e.g.* maximum sustainable yield). The current method used for stock assessments of tunas in the EPO (A-SCALA), uses catch and effort information from a number of fisheries to provide information on abundance. Each of these fisheries harvests a somewhat different subset of ages, so information from multiple fisheries is desirable for obtaining information on all ages of fish. The catch and effort data from the purse-seine fisheries currently used in A-SCALA is simply catch per day of fishing.

Recent focus has been on the development of indices of abundance from Japanese longline catch and effort data. In general this relates to the larger individuals of the population. The methods used include habitat-based standardization (HBS), statistical habitat standardization (statHBS), regression trees, and neural networks. These methods have been developed mainly to incorporate the increased depth of the longline over time as they have changed to increase the catches of bigeye tuna. Habitat-based models and the neural network approach match the depth of the longline with the environmental conditions and the habitat preference of the species.

Recent assessments for bigeye tuna in the EPO have shown weak recruitment and high fishing mortality for the younger individuals. Since purse-seine fisheries catch small bigeye, indices of abundance from purse-seine catch and effort data may improve the bigeye tuna assessment. Such indices of abundance may also improve the skipjack and yellowfin assessments, since longline indices of abundance are not available for skipjack, and longline catch comprises only a small portion of the catch of yellowfin tuna. There are three types of purse-seine sets in the EPO 1) sets on unassociated schools, 2) sets on tuna associated with floating objects, and 3) sets on tunas associated with dolphins. Each of these types may pose unique problems and require different approaches.

Historical indices of abundance developed from purse-seine catch and effort data for tunas in the EPO have included simple catch rates compared to a standard vessel class and linear modeling that measure effort in either days of fishing or hours of searching. However, there has been a large amount of technological development, and the introduction of fish-aggregating devices (FADs) with locator beacons has transformed the nature of searching time in the floating-object fishery. Therefore, novel approaches to the development of abundance indices are needed, particularly for the FAD fisheries. This workshop was organized to facilitate the development of methods to produce indices of abundance from purse-seine catch and effort data.

To focus the discussions, six questions were posed at the start of the meeting.

1. What is the basis for expecting that catch per unit of effort (CPUE) provides information on abundance in a) dolphin-associated, b) unassociated, and c) floating-object purse-seine fisheries?
2. Is there an appropriate measure of effort for a) dolphin-associated, b) unassociated, and c) floating-object purse-seine CPUE?

3. Has the development in technology in a) dolphin-associated, b) unassociated, and c) floating-object purse-seine fisheries increased catchability?
4. Are our current techniques able to estimate increases in catchability for purse-seine fisheries?
5. What data should be collected to develop indices of abundance from purse-seine catch and effort data?
6. What are the most promising methods to develop indices of abundance from purse-seine catch and effort data?

The Commission, at its 72nd Meeting, provided additional guidance to the during its discussion of Document IATTC-72-13, *Marking of Fish-Aggregating Devices,* which outlines a staff proposal for a system for marking FADs. The proposal was made within the context of measures to better understand and manage the use of FADs, and the marking of this type of gear is supported by FAO and other international agreements. The Commission discussed this topic and agreed to send it to the Working Group on Stock Assessment for consideration, as it falls under the data collection category. Some participants felt that the proposal was more appropriate for anchored FADs and that more research was needed on other gears as well, such as longlines, while others supported it because it would improve research on FADs, which could reduce the catch of small bigeye tuna.

2. The EPO fisheries and data

2.1. Summary of the fisheries (E. Everett)

Ed Everett gave an overview of the purse-seine fisheries in the EPO. During the early years of the fishery most of the catches were taken by pole-and-line gear, but by the mid-1960s most of these boats had been converted to purse seiners. At that time most of the catch was taken by US-flag vessels. The catch of tunas increased, peaking in the late 1970s, declining in the early 1980s, and increasing substantially starting in the mid-1990s due to an apparent increase in the abundance of yellowfin tuna and the expansion of the FAD fishery. By this time the fleet was multinational, and there were essentially no US-flag vessels left in the fishery. There have been substantial changes over time in the sizes of the vessels and the technology used.

As mentioned previously, there are three types of purse-seine sets in the EPO, sets on unassociated schools, sets on tunas associated with floating objects, and sets on tunas associated with dolphins. In general, vessels concentrate on either floating-object (mostly FAD) sets or dolphin-associated sets and set on unassociated schools when they are encountered.

2.2. The EPO fisheries, from a fishing captain's perspective (R. Stephenson)

Captain Dick Stephenson presented information on the operational aspects of fishing on tunas associated with FADs and tunas associated with dolphins. He described the methods used to search for tuna and set the net, and how these have changed over time and differ among vessels. These descriptions included, among others, the use of helicopters, speedboats, bird radar, powerblocks, de-ringers, the backdown procedure to release dolphins, problems that occur, such as net collapses, and the process of brailing.

Notable comments include:

a. The increased efficiency of brailing reduces the handling time and increases the amount of fish that can be caught in a single set. Brailing was originally carried out using the skiff, but now a boom attached to the vessel is used. Brails have evolved from those that can handle about 1.5 tons to those that can handle about 5 tons.
b. FADs have progressed from highly-detectable radio buoys, to cell-call buoys, to stealth global positioning systems (GPS) and echo-sounder buoys.
c. Individual skippers have their own systems. For example, Captain Stephenson uses colored lights

(green, red, white, and blue) on FADs to attract tuna. Red and white lights are thought to attract skipjack, and blue and red lights are thought to attract bigeye tuna.

d. Tuna species for large individuals can be identified by the echo-sounder signal and the behavior of the school. The boat-based echo-sounder can be used to determine if the fish are small or large, how densely packed the school is, and position relative to the FAD. It is difficult to distinguish small bigeye from skipjack, but large bigeye have a different signature.

e. The behavior of the tuna depends on the time of day. In the morning the tuna are in a tightly-packed ball around the FAD. By noon the tuna are spread out at the surface.

f. Bigeye behavior varies with moon phase. More bigeye are near the surface three days before and after a full moon.

g. Captain Stephenson generally has 30 FADs in the water and 8 on the boat. Larger boats may have 200 FADs. If a FAD is found with large amounts of tuna, the FADs on the boat are deployed in that area. The FADs are generally set 15 miles apart and 4 to a 'block.' They are set perpendicular to the current so that their paths do not overlap. Often the FADs are deployed on the way to port so that they are available for the next trip. FADs are deployed in areas away from the strong currents, and they tend to travel about 4.5 to 8 miles per day. He tends to leave them 30 days before checking them.

h. The area 4°S-4°N has a huge number of FADs and many vessels, Captain Stephenson generally does not fish there because his FADs, which are the beacon type, have a high rate of loss due to other vessels. In general, 2 or 3 FADs of 30 are lost per trip in the northern area, but 20 may be lost per trip around the equator.

i. Radio beacons can be found by bird radar and scanning devices, and GPS buoys can be found by locating the birds above the FAD. 'Beeper radar' can locate a FAD 15-20 miles away on a calm night.

j. The large fish usually go to the bottom of the purse seine and dominate that area.

2.3. The FAD fishery, from an observer's perspective (M. Román)

Marlon Román presented a summary of the FAD fishery in the EPO, based on his experience aboard vessels as an observer from 1989 to 1998, with additional updated information from current IATTC observers. The construction of FADs has varied over time and between vessels, but the current construction is fairly uniform. The FAD consists of a bamboo frame covered in netting with floats for buoyancy. Netting about 25m in length and weighted at the bottom is hung below the FAD. A bait bucket may be added to the FAD. FADs have been modified over time to reduce their detection by other vessels.

A locator beacon is attached to the FAD to aid in location. The types of location beacons have changed over time from simple radio buoys to GPS buoys. Radio buoys and GPS buoys are sometimes used together. The GPS buoys are used to find the general area of a group of FADs, and radio buoys to find the individual FADs. If flotsam is found, a locator beacon is often attached. Dead animals (*e.g.* whales) may be taken on board, wrapped in netting, and released elsewhere.

FAD sets generally occur shortly before or after sunrise. This is presumably because the tuna are tightly grouped around the FAD at this time and thus easier to capture.

The details of two trips were shown highlighting the wide variety of behaviors that occur in the FAD fishery. These behaviors included, setting on the FADs of other vessels, attaching radio beacons to flotsam, using dead marine mammals as FADs, deploying FADs, setting on FADs deployed on a previous trip, repeatedly deploying FADs in a good area and setting on them, and then moving them back to the initial deployment position.

2.4. Summary of the fishery data (J. Suter)

Jenny Suter gave an overview of the data available for the purse-seine fisheries in the EPO. The logbooks contain trip information, such as dates of departure and arrival, ports of departure and arrival, *etc*, along with some general vessel characteristics. The logbooks also contain the dates and times of vessel events, such as those for each set made, and the amount of catch by species taken in each set.

In addition to logbooks, catch estimates are available from observer records, unloading records provided by the canneries, and from a species-composition sampling program (done in conjunction with length-frequency sampling) that has been carried out since 2000, which provides independent estimates of the composition of the landed catches.

Effort data, such as number of days fished, searching time (length of day minus time spent setting and retrieving the net and landing the catch aboard the vessel), or number of sets made, is available from vessel logbooks and observer records.

The catch or effort data can be stratified by month, area, set type, *etc.,* by using the logbook or observer data. Total catch data are obtained from the cannery records, supplemented by observer or logbook data for trips for which cannery data are not provided. Total effort can be estimated by summing up the observer or logbook data and raising it to the total number of trips made during the time period in question.

Results of species composition sampling suggest that bigeye catches are underestimated by observers, and that canneries underestimate bigeye catches more than do the observers. Other summaries of the data were presented, including temporal trends in numbers of vessels, fish-carrying capacity, catch by species, spatial patterns, and lengths of sets.

Issues discussed included position validation via inferred speed; disparities in species-composition estimates among methods, and the way that the introduction of the AIDCP Tuna Tracking System in 2000 has affected the independence of logbook and observer records.

2.5. Summary of observer data (N. Vogel)

Nick Vogel summarized the history of the IATTC observer program, and collaboration of the IATTC with national observer programs. This was followed by a brief description of the data collected, editing procedures and amount of data collected through 2003. Information on equipment changes over the years, including net length and depth and use of helicopters, echo sounder and bird radar, was presented. The presentation closed with a description of the current *Flotsam Information Record* (FIR), used for collecting data on floating objects, a description of its limitations, and an introduction to the new form which will replace it in 2005.

Issues discussed included the equipment specification information available in the IATTC database; observer duty levels (95-99% of fishing time); and the introduction of the AIDCP Tuna Tracking System .

2.6. Summary of fish behavior and data (K. Schaefer and D. Fuller)

Simon Hoyle, on behalf of Kurt Schaefer and Dan Fuller, presented research on the behavior, vulnerability and acoustic discrimination of tunas. Archival tags have been deployed on 265 bigeye, 102 yellowfin, and 33 skipjack tuna. Archival tag recoveries to date are from 104 bigeye, 43 yellowfin, and 3 skipjack. Bigeye show regional fidelity to the EPO. They spend about 20% of their time in the equatorial EPO associated with floating objects, with a mean duration of 3 consecutive days per event. Yellowfin show seasonal movements in conjunction with latitudinal shifts of the 20°C surface isotherm. Yellowfin are not restricted in depth to the mixed layer, but spend considerable time in offshore areas off northern Mexico, 'bounce diving' throughout the day to depths of about 250 m, which appears to be a foraging strategy targeting prey organisms of the deep scattering layer (DSL). Skipjack tuna also exhibit bounce-diving behavior to depths of 250-350 m during the day in the equatorial EPO, also apparently targeting prey organisms of the DSL.

A comparative study of bigeye and skipjack behavior was carried out using ultrasonic telemetry, sonar, echosounders, and underwater video. Aggregations were observed upcurrent of moored buoys and downcurrent of drifting objects. When associated with an anchored moored buoy, bigeye were deeper than skipjack during both day and night. However, when associated with a drifting object, bigeye depth distributions were shallower than those of skipjack during both day and night. At night the aggregations were more diffuse, and the fish were feeding on organisms in the DSL near the surface. Skipjack schools associated with drifting FADs have been observed at dawn to separate from aggregations.

It is possible to discriminate bigeye, yellowfin, and skipjack tuna with commercial echo-sounders. The swimbladder can account for a majority of the acoustic target strength. Skipjack lack swim bladders, and bigeye swim bladders are larger than those of yellowfin. IATTC tagging cruises have verified the ability to discriminate among the species using echo-sounders and behavior. In addition, sonar provides estimates of the sizes of aggregations.

In addition to providing information useful for developing indices of abundance, these results may be useful in for management considerations in avoiding the capture of bigeye tuna associated with FADs.

3. Overview of the analysis of CPUE data

3.1. Traditional CPUE approaches (M. Maunder)

Mark Maunder described the traditional analyses used to develop indices of abundance from catch and effort data. He referred to the recent special issue of Fisheries Research (volume 70 issues 2-3) for reviews and applications.

The standard approach is to use a general linear model (GLM) with CPUE as the dependent variable. This is generally referred to as CPUE standardization. A multiplicative model with lognormal error structure is developed by log-transforming the CPUE. Year is included as a categorical variable, and used to represent the relative index of abundance. Multiple explanatory variables are tested for inclusion in the model (*e.g.* area or latitude/longitude, month/season, vessel or vessel characteristics). If there are significant zeros the delta-lognormal distribution is used. Interactions with the year effect are ignored.

The necessary considerations required to standardize CPUE data include 1) deciding on a method (*e.g.* GLM, general additive model (GAM), regression tree, neural network, general linear mixed model (GLMM), HBS, statHBS, integrated), 2) choosing explanatory variables (which ones, categorical or continuous, interactions, polynomials, transformations), 3) deciding on the dependent variable (CPUE, catch, grouping data, subset of data, which measure of effort: include multiple measures of effort as explanatory variables), 4) choosing an error structure (*e.g.* least squares, log-normal, Poisson, negative binomial, delta methods to cope with zeros), 5) choosing a model selection technique (using r^2, F test, AIC, cross validation, score, stepwise regression) 6) selecting diagnostics (are the assumptions met, outliers), and 7) determining how to include the CPUE-based index in the stock assessment model.

Two major problems with standardizing CPUE data are dealing with large numbers of zero catches and interactions with the year effect. Large numbers of zeros can occur with non-target or rare species, or species that aggregate. Methods to deal with zeros include adding a constant, using zero-inflated distributions, or using the delta distribution to model the probability of a positive outcome and the distribution of positive outcomes. Interactions between area and year are very common. These can be dealt with by using a habitat-weighted average of the indices for each area, using a spatially-structured population dynamics model, or using a mixed-effect analysis of the CPUE data.

3.2. Past IATTC uses of CPUE data (S. Hoyle)

Simon Hoyle described the historical use of catch and effort data as indices of abundance. CPUE data have been used by the IATTC in population models since the early 1950s. As emphasis moved from surplus production to cohort models, CPUE received less attention, but the introduction of integrated analysis using an age-structured statistical catch-at-length analysis (ASCALA) has raised its profile once again. Early *ad-hoc* standardization was by vessel class, with catch rates compared to a standard vessel class. Linear modeling was introduced in the late 1960s. Analyses that separated search time and handling time were developed from the mid-1970s to the mid-1980s. These aspects of fishing effort are affected by different components of abundance (distance between 'fishable' schools and school size, respectively) and vessel characteristics. However, these CPUE standardization methods were used only for comparison with the 'raw' catch rates that are currently used in the ASCALA models.

3.3. Using catch and effort data in A-SCALA and model sensitivity (M. Maunder)

Mark Maunder described how purse seine catch and effort data are currently used in the IATTC tuna stock assessments. A-SCALA is used to assess the tuna stocks in the EPO. The stock assessment model fits to catch data conditioned on effort, and this extracts the information about abundance from the catch and effort data.

Only catch by set is available, separated into the three purse-seine fishing methods. However, catch per set is not an appropriate measure of stock size, it is probably more related to school size and school size is not necessarily related to stock size. Therefore, the number of days fished is regressed against the three set types to determine the number of days attributed to each of the set types (the coefficients in the regression). This is then used to convert catch per set by method into catch per day fished by method.

Sensitivity analyses were carried out to determine the influence of the purse-seine catch and effort data on the yellowfin and bigeye tuna stock assessments. First the assessments were run with the emphasis on the purse-seine catch and effort data at a low level (the standard deviation for the effort deviate penalty was set to 2); then the emphasis on each of the purse-seine set types was increased (the standard deviation for the effort deviate penalty was set to 0.2). Additional analyses were carried out for bigeye tuna with 1) the catch-at-length sample size divided by 10 to give more emphasis to the CPUE data, 2) a 2% per year increase in purse-seine catchability, and 3) hyperstability incorporated into the CPUE of the floating-object fishery. The results showed that for bigeye tuna the floating-object CPUE had very little influence on the results unless the length-frequency sample size was greatly reduced, and in this case the confidence intervals were very wide and the difference was not significant. The CPUE for the dolphin-associated fishery was more influential for yellowfin, and determining an index of abundance from this fishery for yellowfin tuna shows the most promise for improving the assessment. No analysis was carried out for skipjack tuna; it is possible that purse-seine CPUE is more important for skipjack because the assessment does not include data from the longline fisheries.

The trends in catchability from the assessments when the catch and effort data for the purse-seine fisheries were de-emphasized were described. The floating-object fisheries for bigeye tuna showed a general increase since the fishery expanded in 1993, but there were also periods of sharp decline. No remarkable trends were seen in the purse-seine fisheries for yellowfin tuna, except for some gradual declines.

4. Research

4.1. Incorporating oceanographic data (A. Langley)

Adam Langley presented results of an analysis highlighting the effect of oceanographic conditions on the purse-seine fishery. Data from oceanographic models and remote sensing are readily available, and can be easily incorporated in to the analysis of CPUE data from purse-seine fisheries. Two examples were presented from the purse-seine fishery of the western and central Pacific Ocean (WCPO). A qualitative analysis of purse-seine CPUE data from the Papua New Guinea anchored-FAD fishery revealed skipjack catches are strongly influenced by the prevailing current flows in the preceding month. A separate analysis used a clustering approach to define areas of intensive purse-seine fishing activity on unassociated fish. A GLM approach was then applied to investigate the influence of oceanographic features on the amount of skipjack taken from these monthly "clusters.” The oceanographic data explained a significant proportion of the variation in catch. Catch rates were influenced by the temperature at depth, chlorophyll-a concentration, meridional and zonal current flow, and the degree of convergence of currents. The model was applied to explain recent trends in the performances of several different fleets operating in the fishery. The inclusion of oceanographic data is likely to be informative in the development of a CPUE model to predict catch rates from the drifting FAD fishery.

4.2. Modeling abundance of tuna at anchored floating objects in the tropical eastern Pacific Ocean (S. Harley and M. Maunder*)

Mark Maunder presented a framework for modeling the tuna dynamics around floating objects. The population of tuna around a FAD increases due to immigration and decreases due to natural mortality, fishing mortality, and emigration. These processes can be represented by mathematical equations, and the catch taken from the FAD predicted and compared to the observed catch to estimate the model parameters. The basic underlying concept is that the accumulation rate of fish at a FAD is indicative of the local abundance of tuna. This will be moderated by FAD density, local fishing effort, and other factors.

To carry out this type of analysis the catch must be associated with a FAD. At present this is possible only with 1) the anchored TAO buoys, by matching GPS coordinates of the catch with TAO buoy coordinates or 2) within a trip if the observer can uniquely identify the FAD after the first set on that FAD or if the FAD was deployed on that trip. However, if drifting FADs had identification numbers the catch from any vessel could be associated with a FAD.

Modifications to the simple model described above could include

a. Information on when a FAD is checked but not set on

b. Effects of neighboring FADs

c. Effects of fishing in the local area

d. Inclusion of information from conventional and archival tagging data

e. FAD movement that accumulates fish

f. FAD age to accumulate the fish community

g. Random effects to integrate multiple FADs into a single analysis

4.3. FADs as attractors (M. Maunder)

Mark Maunder described how FADs could be modeled as attractors, while allowing for fish movement and habitat effects. This description was based on the presentation “Modeling Animal Movement, Resource Selection, and Home Range Simultaneously” by Dale Zimmerman, Department of Statistics and Actuarial Science, University of Iowa, Aaron Christ and Jay Ver Hoef, Alaska Department of Fish and Game, presented at the fifth Winemiller Symposium (see Christ, A., Ver Hoef, J.M., and Zimmerman, D. 2004. An Animal Movement Model Incorporating Resource Selection and Home Range. Proceedings of the American Statistical Association, Section on Statistics and the Environment [CDROM] Alexandria, VA: American Statistical Association: in press.). The calculations are simplified by assuming normal distributions for the FAD attraction and the movement of fish. However, a more complex estimation method similar to that used by the Pelagic Fisheries Research Program of the University of Hawaii at Manoa group would probably be needed for application to FADs and tuna. The method could be applied to archival tag data for tunas in the EPO.

4.4. Counting FADs (S. Hoyle, C. Lennert-Cody, and M. Maunder)

Simon Hoyle described methods that could be used to estimate the number of FADs in an area. Information about the distribution of FADs in space and time is needed to help determine the relationships between tuna population dynamics and purse-seine catch rates. He outlined a framework for modeling FAD population dynamics, taking into account issues such as type, ownership, detectability, movement, deployment, removal, and stealing of FADs. He considered the types of data currently collected in the EPO, and presented maps (1990-2002) of 1) average distance traveled between floating object visits, and 2) average number of unique floating-object visits per vessel.

He considered the utility of collecting additional data. Currently planned observer data collection on FAD deployment and removal is essential, and a mark-recapture experiment has potential benefits.

4.5. Effects of communication among fishermen on CPUE as an index of abundance (M. Dreyfus)

Michel Dreyfus described an individual-based neural network model of decisions by fishermen to allocate fishing effort employing a spatial model, considering the fact that fishermen cooperate in the tuna fishery, forming code-groups. It is shown in the simulations that this characteristic of the fishery generates an overestimation of abundance with CPUE or hyperstability. An option to adjust CPUE is considered that seems to correct this problem: calculation of CPUE is based only on vessels fishing in different areas.

4.6. Abundance of bycatch derived from "known" bigeye tuna abundance. (M. Newman, R. Olson, and M. Maunder*)

Mark Maunder presented a method to develop indices of abundance for bycatch species based on the ratio of the catch of bycatch species to the catch of bigeye tuna in a FAD set, under the assumption that the total bigeye tuna abundance is known. The bigeye tuna abundance is taken from the stock assessment for bigeye tuna. If the behavior of the bycatch species is similar to that of bigeye tuna then the ratio of the bycatch to the bigeye catch rates may not be influenced by the many unknown factors, such as FAD density or FAD age. Additional explanatory variables such as area or month can be added in a GLM context to remove additional variability not related to total abundance. The model parameters are estimated by fitting the predicted catch to the observed catch for the bycatch species. This approach may be useful for developing abundance indices for skipjack tuna from the catch and effort data for the FAD fishery.

4.7. Japanese purse-seine fisheries in the north Pacific Ocean: considerations for bluefin tuna assessment (H. Yamada)

Harumi Yamada reported on the Japanese purse-seine fishery in the Pacific north of 20° N, which is quite different from the fisheries in the tropical oceans, and discussed the estimation of abundance indices for Pacific bluefin tuna (PBF). The Japanese purse-seine fishery in the North Pacific operates in groups containing one fishing vessel (80-135 gross registered tons), one or two scouting boats, and two carrying boats. The fishing vessel has no fish wells. The fishing vessels target unassociated schools, regardless of target species, and sometimes set on schools associated with flotsam, but never use FADs. The scouting boats play an important role in finding the fish schools.

The Japanese purse seiners operate on two fishing grounds. One is the Pacific Ocean east of Japan, where the catch of PBF larger than 10 kg is observed in summer. The other is the western Sea of Japan to the Tsushima Strait, where the catch of PBF smaller than 10 kg is observed in the Strait through the year.

Purse seines are a major fishing gear catching PBF accounting for half the catch. Therefore, information on the purse seine fisheries should provide the most reliable abundance indices of PBF. The vessels usually target more abundant skipjack in the Pacific Ocean or small pelagic fishes in the western Sea of Japan, although they try to catch PBF if they are available.

The study estimated abundance indices, using catch and effort data. Records with no PBF catch were excluded. It was suggested that all effort should be considered directed toward PBF in the PBF area, as they are targeted if observed, and that operation data for scouting boats, in addition to the fishing vessel's data, should be collected.

4.8. Statistical habitat based model for standardizing longline CPUE (M. Maunder and M. Hinton)

Mark Maunder described the statistical habitat-based method (statHBS) that is used to develop abundance indices from longline catch and effort data. This method is an extension of the HBS method (IATTC Bull. 21(4)). The HBS model matches the depth of hooks with oceanographic data to determine the habitat where each hook is located. The effort is then calculated by summing the habitat preference related to the habitat of each hook to determine the effective effort for the entire longline. The habitat preference has traditionally been obtained from the time spent in each habitat, estimated from archival tag data. However, statistical tests applied to predicted catch from nominal and HBS standardized effort have produced results indicating that the habitat preference data may not be appropriate. The statHBS method extends these statistical tests to estimate the habitat preference by fitting the HBS predicted catch to the observed catch.

The habitat preference data from archival tags may not be appropriate because they include time when the fish are not feeding. There is also a mismatch between the spatial and temporal scales of the archival tag data and the oceanographic data, the wrong habitat variable may be used, and the archival tag data are limited in their spatial and temporal coverage.

It might be possible to apply the statHBS method (*e.g.* some modification of its current application) to purse-seine catch and effort data, in order to take oceanographic information into consideration.

5. Discussion of methods to develop indices of abundance from purse-seine catch and effort data

To focus the discussions, six questions were posed at the start of the meeting. In addition, the Commission gave the stock assessment working group guidance to evaluate the need for marking FADs. The discussion relating to these are presented below.

5.1. What is the basis for expecting that CPUE data provide information on abundance in 1) dolphin-associated, 2) unassociated, and 3) floating-object purse-seine fisheries?

CPUE data will provide information on relative abundance only if a measure of effective effort is available (*i.e.* either there is a valid measure of effort, and catchability does not change, or effort can be standardized for changes in catchability). Currently, it should be possible to determine measures of effective effort for the dolphin-associated and unassociated fisheries by determining the searching time. Due to the presence of locator beacons on FADs, measures of effective effort are not available for the FAD fisheries. The measure of effective effort for the FAD fishery may be related to the time the FAD is in the water "searching" for fish.

Cohort analyses carried out by the IATTC staff for yellowfin tuna have produced similar trends to catch per day fished, except in El Niño years, suggesting that catch per day fished is a reasonable measure of abundance for yellowfin, but catch per hour searched, or some other search measurement, should be somewhat better. However, the large changes in the spatial coverage of the effort are a concern.

5.2. Is there an appropriate measure of effort for 1) dolphin-associated, 2) unassociated, and 3) floating-object purse-seine CPUE?

An appropriate measure of effort for the dolphin-associated fisheries and unassociated school fisheries is search time/distance/area, but more work needs to be done to consider factors such as code groups, spatial shifts, and the use of helicopters. Code groups may cause hyperstability in the CPUE. Due to difficulties in defining searching time by set type, it may be appropriate to use only vessels that make most of their sets by one method.

No measure of effective effort is currently identified for the FAD fisheries.

5.3. Has the development in technology in 1) dolphin-associated, 2) unassociated, and 3) floating-object purse-seine fisheries increased catchability?

A comprehensive analysis has not been performed to determine how changes in technology have influenced catchability in the EPO purse-seine fisheries. It is expected that the introduction of bird radar and helicopters, and possibly the increased height of the observation towers, have increased catchability for the dolphin-associated and unassociated school fisheries. Several factors are thought to affect catchability in the FAD fishery, including FAD types, technology of the FAD, learning how to use FADs and where to put them, and the numbers of FADs (high density may reduce catchability). Handling ability has improved, reducing handling time, increasing catch, and reducing discards. This should have improved the apparent catchability. Large differences in catchability are apparent between vessels, related to crew skills, vessel age, and technology level.

To determine if the development in technology has changed catchability, a GLM or other statistical method could be used with abundance from the stock assessment as an offset.

5.4. Are our current techniques able to estimate increases in catchability for purse-seine fisheries?

The A-SCALA stock assessment can estimate increases in catchability for bigeye and yellowfin tuna if the indices of abundance from the longline catch and effort data are proportional to abundance. However, to calculate the changes in catchability, an appropriate measure of effort is required for the purse-seine fisheries.

5.5. What data should be collected to develop indices of abundance from purse-seine catch and effort data?

In general, for all fisheries, information should be collected on the equipment used and fishing strategy for each vessel. This information could be collected from skipper interviews. Some information on equipment used already exists in the IATTC vessel characteristic data base. Additional information should be collected on the use of code groups.

The FAD fishery is currently the most problematic for determining indices of abundance, and several different types of data should be collected. The new FAD form will collect vital information on the number of FADs deployed and removed. In addition it is important to uniquely identify individual FADs by trip and by vessel (*e.g.* number them). If this is not possible, a mark-recapture experiment on FADs should be carried out. Other information on the behavior and abundance of fish around FADs, for example with the use of archival, sonic, and conventional tags, should also be collected. Access to information from echo-sounder FADs from commercial vessels or a specific survey using echo-sounder FADs may be informative.

5.6. What are the most promising methods to develop indices of abundance from purse-seine catch and effort data?

There are several methods that have been identified as possible sources of abundance indices for tunas in the EPO. The first most basic method is to use a standard GLM approach on dolphin-associated and unassociated fisheries with search time/distance as the dependent variable. This may involve identifying vessels that predominantly use a single method and using the data from these vessels. However, the limited spatial coverage of unassociated fisheries for yellowfin tuna is a concern.

A GLM or similar approach with biomass estimated from the stock assessment as an offset might be promising for estimating the effects of technology on catchability. This could be used for bigeye or yellowfin tuna, and then the changes in catchability used in an assessment of skipjack to standardize the CPUE data. Alternatively, the abundance of bigeye or yellowfin estimated in the stock assessments could be used in a change-in-ratio method for skipjack or bycatch species.

Due to the changing spatial distribution of effort, methods that model the spatial and temporal correlation (*e.g.* random effects type models) might be promising. Cluster analysis of vessels might be useful to identify code groups so that this can be taken into account in the analyses.

The alternative approach for estimating indices of abundance by modeling the dynamics of tuna around FADs rather than using CPUE data may be the best method for the FAD fisheries. This would also require the estimation of local FAD density by modeling FAD dynamics or the distance between FADs or number of unique FAD sightings.

An alternative to using CPUE data to develop indices of abundance is to carry out large-scale tagging programs for tunas.

5.7. Marking FADs

Placing unique marks on all FADS so they can be identified between trips and between vessels is necessary for much of the work suggested to develop indices of abundance from the FAD fisheries. FADs are the searching component of effort in this fishery and information about the searching component is necessary for developing indices of abundance. A FAD is equivalent to a fishing vessel, so it is necessary to know where it is and how much catch is taken in association with it. Local FAD density is also important, as it may influence the accumulation rate of fish at the FADs. Information on FADs may provide insight into factors other than tuna abundance. For example, FADs attract organisms other than tuna, and thus affect the entire pelagic ecosystem. Such information may provide insights into bycatch mitigation and whether there is a relationship between the number of FADs and the catchability of tunas.

At present there is almost no information on the number of FADs that are deployed in the ocean, their movement, life span, and ultimate fate. Some of this information will be available from the new *Flotsam Information Record*, but much of it will require assigning unique identification to FADs.

5.7.1. Mark characteristics

Marks should be unique permanent identifiers (ocean wide) and attached before the FAD is first put in water. The identifier should be easily identified by an observer while the FAD is still in the water. The marking should include flotsam turned into FADs. The FAD characteristics should be recorded and the FAD linked to the originating vessel and any vessels that own locator beacons attached to the FAD.

5.7.2. Considerations

Marking of FADs requires several considerations including:

a. Who attaches the marks?

b. Confidentiality e.g. should the identification numbers be randomized so the vessel can be identified only in the database and by persons associated with the vessel that deployed the FAD?

c. Should the mark be linked to object or beacon?

d. Dealing with vessels without observers fishing on FADs;

e. Type of mark e.g. number, barcode, or short-range radio system.

5.7.3. Alternatives

An alternative to marking of all FADs is a comprehensive plan that includes 1) mandatory completion of the new *Flotsam Information Record* , including when a FAD is deployed and when it is removed and 2) mark only a proportion of all FADs deployed and recording subsequent observations of them from all vessels (*i.e.* a mark-recapture study). Therefore, they would still require unique identifiers. Other methods, such as using colors, with variations including changing the colors each week, are possible, but would provide less information.

Appendix D.

INTER-AMERICAN TROPICAL TUNA COMMISSION

WORKING GROUP ON STOCK ASSESSMENT

6TH MEETING

REVIEW OF 2004 STOCK ASSESSMENTS

La Jolla, California (USA)
2-6 May 2005

ISSUES TO BE CONSIDERED IN AN ECOSYSTEM APPROACH TO MANAGEMENT FOR THE EASTERN PACIFIC TUNA FISHERIES

1. Maintain stocks of tunas and billfish at or above levels that provide MSY and meet other relevant standards;
2. Ensure that populations of other fish and other species involved in the fishery are maintained or restored above levels at which their reproduction may become seriously threatened;
3. Minimize bycatches of endangered, threatened or protected species, and in particular,
    a. dolphins,
    b. sea turtles,
    c. vulnerable sharks
4. Monitor the average trophic level of the retained and discarded catches in the fishery, and ensure that any changes are not associated with ecosystem degradation.
5. Take account of changes in the physical environment and their effects on any other objective.
6. Take account of changes in the pelagic communities and their effects on any other objective.
7. Provision of data from all sectors of the fishery.