INTER-AMERICAN TROPICAL TUNA COMMISSION

3RD TECHNICAL MEETING ON SHARKS

Stock Assessment of Silky Shark in the Eastern Pacific Ocean

La Jolla, California, USA
7-9 December 2011

REPORT OF THE MEETING

AGENDA

1. Silky shark stock synthesis model: review of data and assumptions
   a. Biology
      - Length-weight
      - Growth
      - Natural mortality
      - Reproduction (maturity, fecundity, frequency)
      - Stock structure
      - Tagging
      - Genetics
   b. Catch
      - Expand to total catch
      - By gear type, region, country
   c. Effort
      - Total or index
      - By gear type, region, country
   d. Indices of abundance
      - Catch per unit effort
   e. Composition
      - Age
      - Length
      - Weight
      - Length/weight categories
      - Stage/sex
2. Model results
3. Modeling discussion
4. Future work
5. Report writing

SUMMARY

A third IATTC technical meeting on sharks was held in La Jolla on 7-9 December 2011. The meeting was chaired by Alexandre Aires-da-Silva, of the IATTC staff, and aimed at achieving progress on the stock assessment of silky shark (*Carcharhinus falciformis*) in the eastern Pacific Ocean (EPO) (see agenda). This report summarizes the discussions and progress made on different data components needed for the Stock Synthesis 3 assessment model for the silky shark (see data table, Appendix 1). Because of the need for further work to develop more accurate estimates of silky shark catches and bycatches for some fisher-

ies, it was not possible to implement a stock assessment model during this meeting. However, it is anticipated that further work on estimation of catches and bycatches for the silky shark will be conducted during 2012 and an assessment for the silky shark has been scheduled for 2013. A set of recommendations was identified that should be implemented in order to improve the quality of the assessment (see recommendation list, Appendix 2). A list of participants is provided in Appendix 3.

1. STOCK STRUCTURE

Alexandre Aires-da-Silva described the current assumption about stock structure used to separate the northern and southern stocks at the equator for the two planned independent assessments and the data supporting this choice. Genetic data support two stocks separated at around the equator, but the sample size is small and most of the data in the southern area come from the central Pacific. Oceanographic data show that the equatorial waters of the EPO are typically cooler than other offshore waters of the EPO, and this might be a deterrent to cross-equatorial movement of species with an affinity for warmer waters. However, there is considerable temporal variability in sea-surface temperature (SST) within the EPO, such as seasonal cooling offshore of Ecuador and Peru and warming near the equator in the western EPO. These seasonal fluctuations in temperature might possibly lead to east-west movement of silky shark in the southern part of the EPO as well as north-south movement across the equator throughout the EPO. Tagging data are limited, and not very informative. Catch-per-unit-effort (CPUE) trends from the floating-object purse-seine fishery differ north and south of the equator, but there are also differences in trends within the northern region. The catch by size category in the floating-object purse-seine fishery also shows differences between north and south of the equator, with proportionally greater numbers of smaller sharks caught north of the equator. However, catches by longline fisheries suggest that the area around the Galapagos Islands is more similar to the northern area. Based on this information, the workshop recommended that, as a provisional hypothesis, the area around the Galapagos Islands be included in the northern region stock assessment, and that additional research be conducted to define the stock structure of the silky shark, including detailed analyses of both longline and purse-seine fisheries data to elucidate seasonal pattern. Additional genetic samples have already been collected or are in the process of being collected. Further studies should look into identifying nursery, pupping, and mating grounds.

2. BIOLOGY

Alexandre Aires-da-Silva described the biological data available for silky shark in the EPO, and how they would be used in the stock assessment. Empirical data from multiple sources are available on growth, the length-weight relationship, maturity, fecundity, and sex ratio at birth. There may be differences among countries and/or regions in the methodologies (maturity scales) used in different studies to identify maturity, and it is important that these methodologies are standardized. The relationship between fecundity and length should be investigated, and included in the assessment. Relationships to convert among the various measures of length are available from empirical data. Natural mortality was calculated from various methods based on life history theory and empirical relationships with maximum age. The biological parameters may differ between the northern and southern areas, or between males and females, and this should be taken into consideration when constructing the assessment. The assumptions about biological parameters, and the data on which the assumptions are based, are described in the summary data table in Appendix 1.

3. STOCK-RECRUITMENT RELATIONSHIP

Mark Maunder described the new survival-based stock-recruitment model for species of low fecundity that is available in Stock Synthesis 3. This model is more appropriate for sharks because it takes the number of pups per female into consideration when calculating recruitment. The underlying concept is that the survival of pups is relatively constant until the population density gets close to the carrying capacity of the area, and then declines. The resulting stock-recruitment curve is often dome-shaped, like a Ricker stock-recruitment relationship, which differs from the asymptotic shape of the Beverton-Holt

stock-recruitment relationship that is commonly used for teleost fish. However, neither the Ricker nor Beverton-Holt relationships have the convex decreasing survival expected for sharks. This new stock-recruitment curve will be used for the silky shark assessment. Survival as a function of density is based on the generalized logistic (or Pella-Tomlinson) model, which has three parameters: the logarithm of the average recruitment, a parameter representing the difference in survival between that at carrying capacity and that at very low stock size, and a parameter representing the shape of the survival curve. It is expected that the shape parameter will be fixed at a reasonable value for the silky shark assessment.

4. CATCH

Cleridy Lennert-Cody described the catch data available for the tuna purse-seine fisheries. Silky shark bycatch data for large vessels (greater than 363 metric tons fish-carrying capacity; IATTC size class 6) have been collected since 1993, and are available in the IATTC observer database. Bycatches of sharks are recorded by size category (< 90cm TL (total length) ; 90-150cm TL; > 150cm TL). For those years for which observer coverage of large vessels was less than 100%, the total bycatch of sharks, by size category, was estimated as the product of bycatch per set and total sets. Bycatch data for smaller vessels (IATTC size classes 1-5) are not available, and total bycatch had to be constructed by multiplying the total number of sets by smaller vessels (obtained from logbooks) by the bycatch per set of size class 6 vessels, assuming the bycatch rates of larger vessels are representative of those of smaller vessels.

Cleridy Lennert-Cody also described the catch information available for the distant-water longline fisheries. Total catches of U.S. longliners were provided by the NMFS/NOAA Southwest Region, but in general catch data were not available for other fleets fishing in the EPO. Catches for a subset of the Japanese fleet in the EPO were computed (Semba 2011), but did not fully reflect the total catch and bycatch of silky sharks for that fleet during the 1993-2010 time period. Therefore, hypothetical time series of catches had to be constructed for fleets other than the United States by multiplying effort in the EPO by various catch rate time series. EPO catch rates were available for only a limited number of years and fisheries, so several scenarios of catch rates were developed, based on the available data and assumptions about trends in catch rates. Catch rate data for the EPO during 2005-2010 were provided by Jiangfeng Zhu, of Shanghai Ocean University, for the Chinese observer program, and by Sung Il Lee, of the National Fisheries Research and Development Institute, for the Korean observer program. Trends in catch rates were inferred from Japanese catch-rate time series for the central Pacific during 1993-2008 (Clarke 2011), and from the standardized bycatch-per-set trend for the floating-object purse-seine fishery in the EPO. An added complication is that catch rates may vary with depth of the fishing gear, which changes with target species. Information from Spanish longliners (García-Cortés *et al*. 2001) and observer data in the Western and Central Pacific Ocean (WCPO) (Rice pers. comm.) suggest that catch rates in shallow sets are an order of magnitude higher than those in deep sets. Hooks-per-basket data in the IATTC longline database are available only for the Japanese fleet. Published data (Wang *et al*. 2009) show that vessels of Chinese Taipei changed from shallow to deep sets around 2000. This was associated with a decline in albacore catch and an increase in bigeye catch. The catches of albacore, yellowfin, and bigeye tunas were used to investigate the depth of sets in the Chinese and Korean longline fisheries. This analysis suggests that since 1993 most of the sets in those fisheries were deep sets. Further evaluation of the spatial distribution of the fishing effort of Chinese Taipei may be needed before adjusting catch rates for the depth of the sets. In addition, research on estimation of catch rate trends with Japanese research and training vessel data for the EPO will be conducted by Dr. Yasuko Semba and other scientists at the National Research Institute of Far Seas Fisheries of Japan, in collaboration with the IATTC. Fernando Márquez Farias, from the Universidad Autónoma de Sinaloa (UAS), described the methodology used to obtain preliminary estimates of silky shark landings in the Pacific waters of Mexico. Total shark landings (in total weight, called live weight) are reported in Mexican fisheries statistics yearbooks (Anuario Estadístico de Pesca). These estimates are available for two shark groups: “Tiburón” (>150 cm) and “Cazón” (<150 cm). The latter may include some silky sharks, but the amount is thought to be small. Estimates of total shark (Tiburón) landings for each Pacific Mexican state were compiled. These

estimates were prorated to silky shark catches by Mexican state for the 1976-2006 period using species composition ratios based on information about the silky shark fisheries for each state available from recent studies and from observer programs. It was discussed that the silky shark species composition ratios were likely not stationary over time due to several reasons (different species abundance trends, changes of operational/targeting practices, and changes of fleet spatial distribution over time). Obtaining silky shark species composition estimates over time could reduce biases and improve the methodology used to estimate silky shark catches by Mexico. The adjustments could be made based on available CPUE time series for key shark species.

José Carvajal (INCOPESCA) described the shark landing statistics available from Costa Rican sources. Estimates of "total shark" landings are available for the 1969-2010 period. Species composition data are available for the most recent years (2006-2010). However, silky shark landings are contained in a pooled group of "gray sharks" ("Tiburón gris"), and there is uncertainty about its proportion within the larger species group. This catch information represents local and foreign fishing vessels that unload in Costa Rica, and fleet composition estimates are available for 2009 and 2010 only. In recent years, around half the catch data from Costa Rica comes from foreign longliners unloading in Costa Rica. It is not known if these data on unloadings by foreign vessels is duplicated in the IATTC effort database used to construct the longline fishery catch, which could cause an overestimation of catch. It is also not known if the catch comes from the southern or northern stocks.

Manuel Pérez (OSPESCA) described the catch data available for the coastal states of Central America. Total shark landing estimates are available from various national sources, but the temporal coverage varies by country and does not fully cover the historic period of the assessment. Silky shark species composition estimates are available by country from a pilot shark sampling program conducted by OSPESCA, but these cover 2009-2010 only. Assumptions about species composition and landings in missing early years have to be made for the historic data based on recent estimates. However, the species composition may not have remained constant over time due to changes in targeting (market value) and differential changes in abundance of the different species. Historical information on species composition from the Mexican longline fleets and the Ecuadorian coastal fleets might be useful for improving the species composition estimates for the other fleets.

While the catch statistics from Central American countries are available in "dressed" (headed and gutted) weight, all other countries report catch in total weight. Unfortunately, conversion factors between either type of dressed weight and total weight are not available, and obtaining such conversion factors is critical.

Information about catches in Peru and Colombia is needed. The World Wildlife Fund (WWF) has data on catch rates by hook type, which could be used to further improve the catch estimates. The WWF database includes several types of data that would be useful for the assessment. WWF is encouraged to provide the data and collaborate in the stock assessment process.

Mexico has constructed catch estimates prior to 1993, the starting year for the stock assessment. If catch data for years prior to 1993 can be constructed for all fisheries, and indices of abundance are available for the Mexican longline fleet prior to 1993, it may be beneficial to extend the start time of the stock assessment back before 1993.

Jimmy Martinez (SRP) presented the silky shark catch statistics available from Ecuador. An extensive sampling program of artisanal fisheries has been ongoing in Ecuador since September 2007. The program provides detailed catch statistics for smaller longliners ("tipo fibra") and gillneters, with the former dominating the silky shark catches. Some observer data are also available. Prior to 2007, estimates are available for "sharks, total or by family" landings from various Ecuadorian sources, but the historic period of the assessment going back to 1993 is not fully covered, and assumptions and/or interpolations need to be made for missing years. Some silky shark species composition data are available to separate silky shark landings from total sharks in the years before 2007, when the species composition sampling program began.

Joel Rice (SPC) presented research conducted on the longline observer data from the Western and Central Pacific Ocean (WCPO). Catch rates of silky shark were significantly higher for shallow gear, and catches were generally limited to a specific temperature range. This information could be used to improve the estimates of longline catch in the EPO. Spatial differences between males and females and juveniles and adults suggest some segregation by size and sex.

5. INDICES OF ABUNDANCE

Cleridy Lennert-Cody described the indices of relative abundance calculated from purse-seine CPUE data. Standardized trends were computed for the floating-object purse-seine fishery based on a zero-inflated negative binomial regression model for bycatch per set. This model was not applied to the bycatch data of dolphin and unassociated sets due to the very limited numbers of sets with positive catches and the extreme skewness of the positive bycatch values of those set types. Instead, standardized presence/absence trends were computed for dolphin and unassociated sets based on a logistic regression model. The analyses were conducted separately for the northern and southern stocks. There were not enough positive catches for the dolphin-associated fishery in the southern region to construct a reliable index. Indices from the floating-object fishery for the northern stock were estimated separately for each of the three size categories of sharks (<90cm TL; 90-150cm TL; >150cm TL), while indices for the northern stock from dolphin and unassociated sets were only estimated for large sharks (> 150cm TL). Similar size-specific indices were estimated for the southern stock, with the exception that no index for small sharks in floating-object sets was computed, due to a paucity of positive bycatch values.

There are CPUE data available for two longline fleets in Mexico that might provide additional indices of abundance for the northern stock. This information may be available in the future and could be particularly useful for improving the assumed estimates of the Mexican species composition over time (Fernando Márquez-Farias, UAS, Mexico).

6. SIZE COMPOSITION

Alexandre Aires da Silva described the size-composition data available for the different fisheries. Length-composition data are available for the purse-seine fisheries, longline fisheries, and coastal fisheries of Mexico, Central American countries, and Ecuador. Other sources of size-composition data exist for Mexico (*e.g.*, Chiapas artisanal fishery) and, if available, could help to better model the Mexican fisheries in the assessment (*e.g.* to separate fisheries which catch different sizes of the population). Size-composition data from Ecuador are available for two fishing gears (longline and gillnets); the latter seem to catch smaller sharks. The sample size for some of the fisheries (*e.g.* high-seas longline) is limited. Additional length-composition data for the longline fisheries might be available from Japanese training and research vessels.

7. OTHER DATA

Fernando Marquez-Farias presented the data available for the Mexican longline fisheries. Catch, effort, and length-composition data are available for large and medium Mexican longline vessels. The data is available starting from the 1980s, prior to the start of the stock assessment model. The catches of silky sharks vary seasonally. There has been some change in the spatial distribution of fishing effort that needs to be taken into consideration when using the data.

8. MODEL RESULTS

Mark Maunder presented preliminary results of the Stock Synthesis stock assessment model. The stock assessment is preliminary because the workshop recommended a change in the stock structure definition and there are additional data available that will help clarify some assumptions made in the catch reconstruction (*e.g.* species composition for the coastal fisheries and shallow longline catches, weight conversion relationship). Only the northern stock assessment was presented, and an attempt was made to approximate the new stock structure definitions. A preliminary stock assessment has also been conducted

for the southern stock, but the results were not presented due to time constraints and changes in the stock structure definitions. Some interesting aspects of the stock assessment included the use of cubic splines to model selectivity and sex-specific selectivity (which allowed the model to fit the unusual shape of the length compositions), the new survival-based stock-recruitment relationship, and fitting to weight category data. The model generally fit the size composition data well, but the fit to the CPUE-based indices of relative abundance was not as satisfactory. Refining the reconstruction of the historical catch data might improve the fit to the indices of abundance. The modes in the length-composition data show a large variation of length-at-age, which is probably due to the annual time step of the model and the fast growth of silky sharks. Future models should probably consider a shorter time step (*e.g.* quarterly).

9. FUTURE WORK

Substantial discussions were conducted on the availability of data, how to analyze the data, and the stock assessment model assumptions. A list of recommendations was developed (Appendix 2). These recommendations range from those that can be incorporated into the stock assessment to those that are more long-term projects.

REFERENCES

Clarke, S. 2011. Analysis of north Pacific shark data from Japanese commercial longline and research/training vessel records. WCPFC-SC7-2011/EB-WP-02.

García-Cortés, B., A. Ramos-Cartelle, J. Mejuto. 2011. Biological observations of silky shark (*Carcharhinus falciformis*) on Spanish surface longliners targeting swordfish in the Pacific Ocean over the period 1990-2011. Prepared for the IATTC Second Workshop on Sharks, May 13-14, 2011, La Jolla, California, USA.

Semba, Y. 2011. Estimate of catch for silky shark (*Carcharhinus falciformis*) caught by Japanese longline vessels in the EPO from 2000 and 2010. National Research Institute of Far Seas Fisheries, Japan. available on IATTC web page for this meeting.

Wang, S.-P., Maunder, M.N., Aires-da-Silva, A. 2009. Implications of model and data assumptions: An illustration including data for the Taiwanese longline fishery into the eastern Pacific Ocean bigeye tuna (*Thunnus obesus*) stock assessment. Fisheries Research 97: 118-126.

Appendix 1 - Data table

Data type	Source	Description
	BIOLOGY	
Maximum age	Convenient values for model	13 years (Oshitani *et al*. 2003), 16 years (Sánchez de Ita 2010); 30 years convenient values for model.
Growth	Sánchez de Ita 2010 Oshitani *et al.* 2003	Sánchez de Ita, 2010 used in mode. Provides better fit to size composition data.
Variation of length at age	Estimated in model	
Length-weight rela-tionship	Published: Oshitani *et al.* 2003 Data provided: Heriberto Santana, Sandra Soriano (INAPESCA, Mexico) Jimmy Martínez (SRP,	Length-weight relationship provided by Sandra Soriano (INAPESCA, Mexico) used for northern stock. Samples were the most representative. Length-weight relationship provided by Jimmy Martínez (SRP, Ecuador) used for southern stock.

Data type	Source	Description
	Ecuador)	
Maturity	Padilla (2003) Galván-Tirado (2007) Peraza (2008) Grupo Tiburón (2011)	Galván-Tirado (2007) for northern stock; Grupo Tiburón Ecuador (2011) for southern stock.
Fecundity	García-Cortés *et al*. (2011)	Average six pups per female
Sex ratio at birth	García-Cortés *et al*. (2011)	50:50
Natural mortality		Derived from indirect methods
DATA NORTH		
Catch		
Purse seine	IATTC observer and logbook database	Effort (numbers of sets) 1993-2010. Total bycatch (numbers of sharks), 1993-2010. For large vessels (class 6), from bycatch-per-set x total sets. For small vessels (class 1-5), from bycatch-per-set (large vessels) x total sets by small vessels.
Longline	IATTC longline database; various publications; Chinese and Korean observer program data; U.S. total catches	Effort 1993-2010. From: 1) sum of 5x5 effort data; or 2) totals prorated with 5x5 effort ; or 3) (total effort not available) raised using the total target species catch and hooks per ton. Catch = Effort*CPUE, plus reported total catches (where available). CPUE series from: 1) Clarke (2011) (nominal trend for central Pacific); and 2) purse-seine floating-object standardized trend (north and south). CPUE series scaled with observer data from Chinese and Korean observer programs (provided by Jiangfeng Zhu, Shanghai Ocean University, and Sung Il Lee, National Fisheries Research and Development Institute, respectively).
Mexico	Fernando Márquez-Farias	Annual landing statistics are available by Mexican state for total sharks (>150 cm) and cazón (<150 cm) since 1976 (CONAPESCA-SAGARPA). Silky shark species composition proportions are available from various sources, but cover mostly recent years.
Central America	Manuel Pérez (OSPESCA) José Carvajal (INCOPESCA, Costa Rica)	Annual landings statistics are available by country (various sources) for total sharks, but the temporal coverage varies by country and does not fully cover the historic period of the assessment. Assumptions/interpolations need to be made, in particular for the 1990s. Silky shark species composition proportions are available from the "*Plan Piloto de Monitoreo de Desembarques Artesanales de Tiburones y Rayas en Centroamérica*", but for recent years only (2009-2010). For Costa Rica, annual landings statistics are available for total sharks (*Tiburón*) since 1969 (INCOPESCA). Species composition data are available since 2006, but silky sharks are contained in a pooled species group (grey sharks), with unknown proportions. Fleet composition data also exist for Costa Rica (Costa Rican and foreign vessels landing in Costa Rica), but for recent years only (2009-2010).

Data type	Source	Description
Length composition		
Purse seine	IATTC observer database (large vessels only)	Size composition data: 1) size categories (< 90 cm TL; 90-150 cm TL; > 150 cm TL) for 1993-2010; 2) length frequencies (cm TL) for 2005-2010, by sex.
Longline	Chinese and Korean observer programs	Size- and sex-composition data available from Chinese and Korean observer programs for 2003-2010, provided by Jiangfeng Zhu and Sung Il Lee, respectively.
Mexico	Fernando Márquez-Farias	Length-frequency data from Mazatlán, 2006-2011, by sex, combined gears. Length-frequency data also exist for the artisanal fishery in Chiapas, 1996-2011, by sex (Sandra Soriano, INAPESCA-Mexico); these data may be available in the future.
Central America	Manuel Pérez (OSPECA); Salvador Siu, CENDEPESCA, El Salvador	Length-frequency data from *Plan Piloto de Monitoreo de Desembarques Artesanales de Tiburones y Rayas en Centroamérica* (2009-2010), and early years from El Salvador (2003, 2006, 2007, 2008), by sex.
Index of abundance		
Purse seine	IATTC observer database (large vessels only)	Standardized bycatch trends 1994-2010. From ZINB GAM for floating-object sets for small/medium/large/total sharks. For dolphin and unassociated sets, trends are for presence/absence of large sharks and total sharks.
DATA SOUTH		
Catch		
Purse seine	IATTC observer and log-book databases	Effort (numbers of sets) 1993-2010. Total bycatch (numbers of sharks), 1993-2010. For large vessels (class 6), from bycatch-per-set x total sets. For small vessels (class 1-5), from bycatch-per-set (large vessels) x total sets by small vessels.
Longline	IATTC longline database; various publications; Chinese and Korean observer program data; U.S. total catches.	Effort 1993-2010. From: 1) sum of 5x5 effort data; or 2) totals prorated with 5x5 effort; or 3) (total effort not available) raised using the total target species catch and hooks per ton. Catch = Effort*CPUE, plus reported total catches (where available). CPUE series from: 1) Clarke (2011) (nominal trend for central Pacific); and 2) purse-seine floating-object standardized trend (north and south). CPUE series scaled with observer data from Chinese and Korean observer programs (provided by Jiangfeng Zhu and Sung Il Lee, respectively).
Ecuador	Subsecretaría de Recursos Pesqueros (SRP)	Silky shark monthly landing statistics available from September 2007 to July 2011 (SRP), for longlines and gillnets. Annual shark landings available for total sharks (1991, 1994-1996, and 2002-2010) from various Ecuadorian sources, including the Instituto Nacional de Pesca. Assumptions/interpolations need to be made for the missing years in the assessment historic period. Silky shark species composition proportions are available and can be used to obtain silky shark from total shark landings.
Other		Information on silky sharks catches from Colombia, Peru and Chile is not available, but catches are thought to be low.
Length composition		
Purse seine	IATTC observer database	Size composition data: 1) size categories (< 90cm TL; 90-

Data type	Source	Description
	(large vessels only)	150cm TL; > 150cm TL) for 1993-2010; 2) length-frequencies (cm TL) for 2005-2010, by sex.
Longline	Chinese and Korean observer programs	Size and sex composition data available from Chinese and Korean observer programs for 2003-2010, provided by Jiangfeng Zhu and Sung Il Lee, respectively.
Ecuador	SRP	Length-frequency data are available for 2004-2010, by sex and gear type (longlines and gillnets).
Index of abundance		
Purse seine	IATTC observer database (large vessels only)	Standardized bycatch trends 1994-2010. From ZINB GAM for floating-object sets for medium/large/total sharks. For dolphin and unassociated sets, trends are for presence/absence of large sharks and total sharks.
MODEL STRUCTURE		
Initial conditions		Estimate OBJ[1] initial *F* No fit to initial catch data Estimate initial recruitment offset No initial conditions age-class deviates
Selectivity		OBJ: Dome with male and female same NOA: Asymptotic, with male and female the same DEL: Asymptotic, with male and female different after 150cm Mexican: Asymptotic, with male and female different after 150cm Central America: Asymptotic, with male and female the same Longline: mirror NOA?
Stock-recruitment curve		Maunder-Taylor-Methot survival-based stock-recruitment curve for low-fecundity species available in Stock Synthesis.

[1] Purse-seine set types: OBJ: floating object; NOA: unassociated; DEL: dolphin

Appendix 2. Recommendations

1. STOCK STRUCTURE:

a. Conduct a study to compare silky shark morphometrics north *versus* south <need to have boundary defined in advance>.

b. Develop an EPO-wide tagging program.

2. GENETIC SAMPLING (species identification and stock structure):

a. Collect samples throughout the EPO, including the western boundary. IATTC will continue collecting samples from this area for purse-seine catches. Samples from Mexican fisheries may be collected from the Gulf of Tehuantepec.

b. Collect samples from Central American fisheries. Tissue samples from landings have already been collected and are being analyzed.

c. Analyze the samples already collected by Ecuador from the equatorial coastal area, and encourage continued collaboration between the U.S. and Ecuador on genetic studies.

3. SIZE CONVERSION AND WEIGHT CONVERSION RELATIONSHIPS:

a. Obtain a statistical model to convert between headed and gutted (trunk) weight to live (total) weight. Ecuador is working on this task.

b. Conduct a statistical analysis of sex-specific size-conversion and size-weight relationships by regions, before the end of 2012.

4. AGE AND GROWTH:

Obtain sex-specific growth estimates (vertebral samples of large sharks are a priority). Mexico is presently analyzing vertebral samples collected from purse-seine catches (Felipe Galván, CICIMAR). IATTC will continue its sampling program.

5. MATURITY:

Standardize methods of collection of reproductive data across regions. Collection of female maturity data (including pregnancy rates) is critical.

6. NURSERY/MATING GROUNDS:

a. Collect samples for:

- smaller sizes of sharks (juveniles), particularly in the southern EPO;
- pregnant females on both sides of the equator;
- evidence of mating behavior (mating scars).

7. CATCH/EFFORT (preferably completed before the end of 2012):

a. Pelagic longline:

- Obtain information on changes in fishing operational practices since the 1990s.
- Investigate availability of a CPUE series for the EPO from 1993-2010 based on Japanese research and training vessel data.

b. Mexico:

- Obtain information on species composition of historical “cazón” catches. Some relevant data may already exist. Data collection in the Gulf of California may be useful.
- Disaggregate the catch into coastal artisanal (mainly Chiapas) and offshore fisheries.

c. Central America:

- Obtain spatial information about landings (particularly for foreign fleets landing in Costa Rica and Panama). Captain interviews may be useful.
- Determine if longline catch and effort data reported to the IATTC by foreign fleets include unloadings in Costa Rica and Panama.

d. Colombia and Peru:
   - Obtain catch and effort information to confirm assumption that catches of silky sharks are low in fisheries of these countries.

e. General:
   - Develop data sets and methods appropriate for prorating historical species-aggregated catches. In particular, it is important to:
     - Estimate historical indices of abundance of the main shark species and use these indices to adjust species composition ratios over time.
     - Conduct an analysis of effects of target species, season and area on nominal indices (*i.e.* estimate standardized indices). Mexico has plans to conduct such a study for Mexican fisheries. Ecuador has data that are appropriate for such an analysis.

8. SIZE COMPOSITION:

a. Pelagic longline:
   - Determine availability of Japanese longline size-frequency distribution data from the research and training vessel program for the EPO. These data could be used to reflect the commercial fishery or in a separate fishery that is treated like a survey.

b. Mexico
   - Determine availability of data from Chiapas for estimation of selectivity.

9. STOCK ASSESSMENT MODEL:

a. Implement seasonal fishery structure.

b. Conduct spatial estimation of total purse-seine catches for small vessels (Classes 1-5).

c. Conduct spatial analysis of catches of target species by pelagic longline vessels.

d. Adjust effort (catches) of pelagic longline fleets in the 1990s for shallow-set effects on catch.

e. Contact Korean colleagues regarding available information of hooks per basket from the 1990s.

f. Conduct spatial analysis of purse-seine data with respect to coincidence of the warm pool in EPO and increased catch rates.

g. Estimate confidence intervals for standardized purse-seine CPUE trends.

10. MISCELLANEOUS:

a. Artisanal fisheries:
   - Conduct analysis of hook selectivity for sharks (and possible bait effects).

b. Mexico and Ecuador:
   - Continue analysis of CPUE data.

c. General:
   - Investigate availability of other data sources for Central and South American silky shark catches, fishing effort, silky shark CPUE and effects of hook characteristics on shark catch rates.
   - Continue collaboration with SPC on movements and size composition, and the possibility of a Pacific-wide assessment.

Appendix 3 – List of participants

Acuña	Enzo	Universidad Católica del Norte	Chile	eacuna@ucn.cl
Castillo	José	Centro Regional de Investigación Pesquera de Ensenada	México	leonardo.castillo@inapesca.sagarpa.gob.mx
Carvajal	José	INCOPESCA/Instituto Costarricense de Pesca y Acuicultura	Costa Rica	carva77@gmail.com
Galván	Felipe	Centro Interdisciplinario de Ciencias Marinas, CICIMAR-INP.	México	galvan.felipe@gmail.com
Hiroaka	Yuko	National Research Institute of Far Seas Fisheries	Japan	yhira415@affrc.go.jp
Johnson	David	Vanuatu Monitoring and Management Services	Vanuatu	djonhson@vmmsl.com
Kohin	Suzanne	NOAA/National Marine Fisheries Service	USA	suzanne.kohin@noaa.gov
Martínez	Jimmy	Subsecretaría de Recursos Pesqueros	Ecuador	jimmy.martinez@pesca.gob.ec
Marquez-Farias	Fernando	Universidad Autónoma de Sinaloa	México	fermqz@yahoo.com
Namba	Takaya	Overseas Fisheries Cooperation Foundation	Japan	takayanamba@hotmail.com
Peréz	Manuel	OSPESCA (Organización del Sector Pesquero y Acuícola del Istmo Centroamericano)	Int. Org	infor.ospesca@sica.int
Rice	Joel	Secretariat of the Pacific Community	Int. Org	joelr@spc.int
Semba	Yasuko	National Research Institute of Far Seas Fisheries	Japan	senbamak@fra.affrc.go.jp
Sippel	Tim	NOAA/National Marine Fisheries Service	USA	tim.sippel@noaa.gov
Sosa	Oscar	CICESE	México	ososa@cicese.mx
Teo	Steven	NOAA/National Marine Fisheries Service	USA	steve.teo@noaa.gov

IATTC Staff –Personal de la CIAT

Compeán	Guillermo	gcompean@iattc.org
Belmontes	Ricardo	rbelmontes@iattc.org
Da-Silva	Alexandre	alexdasilva@iattc.org
Deriso	Richard	rderiso@iattc.org
Hall	Martin	mhall@iattc.org
Hinton	Michael	mhinton@iattc.org

Lennert-Cody	Cleridy	clennert@iattc.org
Maunder	Mark	mmaunder@iattc.org
Olson	Robert	rolson@iattc.org
Pulvenis	Jean-Francois	jpulvenis@iattc.org
Román	Marlon	mroman@iattc.org