*Annex 9*

# *REPORT OF THE SHARK WORKING GROUP WORKSHOP*

International Scientific Committee for Tuna and Tuna-like Species
in the North Pacific Ocean

28 May – June 4 2012
Shizuoka, Japan

## 1.0 INTRODUCTION

An intercessional workshop of the Shark Working Group (SHARKWG or WG) of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) was convened at the National Research Institute of Far Seas Fisheries (NRIFSF) in Shizuoka, Japan from 28 May through 4 June 2012. The primary goals of the workshop were to: 1) review blue shark fishery data including size data, catch estimates and estimation procedures; 2) review models for CPUE abundance indices; 3) make decisions regarding fishery data, life history assumptions, model type, structure and parameterization for the blue shark assessment; and 4) review fishery and biological information on mako sharks and other ISC species.

Dr. Yuji Uozumi, the Director of NRIFSF, welcomed SHARKWG participants from Canada, Chinese Taipei, Japan, and United States of America (USA), as well as the ISC Chairman, members of the STATWG and ISC peer reviewers (Attachment 1). In his address, Dr. Uozumi thanked members for their commitment to supporting this working group. He emphasized the importance of assessing the status of key shark species to support sustainable utilization. He acknowledged the challenges facing the group since catch, effort and even basic life history information are difficult to collect. Dr. Uozumi spoke of the destruction, due to the earthquake and tsunami last year, of the main shark fishing port in Japan, Kesennuma. He indicated that efforts have begun to reconstruct the port and processing plants. Since the bluefin assessment meeting was occurring concurrently at the NRIFSF, he also thanked participants who are working hard for both working groups.

## 2.0 DISTRIBUTION OF MEETING DOCUMENTS

Sixteen working papers were distributed and numbered, and an additional 4 oral presentations and 6 informational papers were discussed during the meeting (Attachment 2). Most authors who submitted a working paper agreed to have their papers posted on the ISC website where they will be available to the public. The authors of working papers ISC/12/SHARKWG-1/05, ISC/12/SHARKWG-1/13 and ISC/12/SHARKWG-1/16 declined posting on the ISC website due to either data confidentiality concerns or because the papers were being prepared for publication elsewhere. Two follow-up papers were presented at the July meeting in response to requests for further analyses and are also included in Attachment 2.

## 3.0 REVIEW AND APPROVAL OF AGENDA

The draft meeting agenda was reviewed and adopted with minor revisions (Attachment 3).

## 4.0 APPOINTMENT OF RAPPORTEURS

Rapporteuring duties were assigned to nearly all participating working group (WG) members. The approved agenda (Attachment 3) indicates the rapporteurs for each item in parentheses.

## 5.0 SUMMARY OF THE NOVEMBER 2011 SHARKWG MEETING AND AGE AND GROWTH WORKSHOP

### 5.1 Summary of the November 2011 SHARKWG meeting

Suzanne Kohin, Chair of the SHARKWG, provided a summary of the second workshop of the ISC SHARKWG, convened in La Jolla, California, 28 November – 3 December 2011. The primary goals of the workshop were to: 1) review operational details and data for fisheries catching blue and shortfin mako sharks in the North Pacific and discuss retained and total catch estimation methods; 2) review life history studies addressing stock structure, age, growth and maturity of blue and mako sharks; and 3) review details of the previous north Pacific blue shark assessment and begin to make decisions about inputs for the 2012 assessment. Nineteen participants from Chinese Taipei, Japan, Mexico, USA, Inter-American Tropical Tuna Commission (IATTC) and Secretariat of the Pacific Community (SPC) attended the meeting. Twelve working group papers, one information paper, and several oral presentations were discussed. Topics included shark life history studies (genetics, tagging, age and growth, reproduction), fishery catch data collection and analysis (Canada, Chinese Taipei, Japan, Mexico, US, IATTC, SPC), and assessment approaches and preliminary parameterization. Significant progress was made in compiling all available biological information on blue and shortfin mako sharks in the North Pacific and identifying areas of the greatest uncertainties for research prioritization. The WG will maintain a life history matrix containing summaries of key studies and will add to the matrix as new studies emerge. The group reviewed assumptions made for the last blue shark assessment (Kleiber et al. 2009) and made some preliminary decisions on assumptions for the upcoming WG assessment and on the data needs. Each nation identified their fisheries catching blue sharks and templates for catch tables were prepared for each nation in order to gather data for the upcoming assessments.

<u>Discussion</u>

The WG discussed the problem that the estimated shark catches determined by WG scientists are likely to differ from the National Statistics reported to the ISC. The WG discussed how to treat the estimated values and any other derived data needed for the assessments. The ISC Chair indicated that members of the STATWG are also meeting this week to discuss the official statistics and that the ISC Chair and STATWG Chair would bring up this topic later with the SHARKWG once some decisions have been made (see agenda item 6).

The WG also discussed missing data, i.e. catch data from member nations that may not be submitted, or catch from non-member nations. The ISC Chair recommended that the WG wait for the ISC STATWG meeting (July 11-12), when all submitted category I and II data received by 1 July, 2012 will have been compiled. The SHARKWG Chair indicated that efforts will be made to estimate unreported catch after the STATWG meeting (see agenda item 6).

### 5.2 Summary of the Age and Growth Workshop

Following the SHARKWG meeting, the ISC sponsored a Shark Age and Growth Workshop, December 5-6 in La Jolla, California. This workshop was conceived by WG members following the April 2011 meeting in Keelung, Chinese Taipei, when it was recognized that there are a lot of uncertainties regarding the aging of blue and shortfin mako sharks. Sixteen participants from Chile (on behalf of the IATTC), Chinese Taipei, Japan, Mexico, USA and IATTC attended. The goal of the workshop was to bring together specialists from the ISC member nations to discuss methodologies and regional studies on age and growth of north Pacific pelagic sharks caught in tuna and tuna-like species fisheries. A number of regional studies have been conducted, and at the workshop, current and past methodologies and results were examined. Methodologies and regional studies were discussed, and participants examined some prepared specimens and images during hands on demonstrations. Recommendations for sample collection, processing and analysis were developed and collaborations were established for inter-lab cross validations with the goal of combining studies and coming up with consensus growth curves. A work plan for developing reference collections and comparing some regional studies was developed. The Chair indicated that a large number of samples of blue shark vertebrae for the reference collection have already been collected by colleagues from Mexico and will be distributed to the national scientists in coming months. The report of the workshop is provided as Attachment 4.

Discussion

WG members asked about the size ranges of samples that may be obtained from the various countries. Mexico was recognized as particularly important because a wide size range of blue sharks is taken by its fisheries. The Chair subsequently provided a spreadsheet showing the sizes of sharks sampled by Mexico, and while there were some large sharks sampled, vertebrae from more large sharks may be needed in order to adequately represent the full size range. It was also noted that the sex of the sharks sampled was not identified, which may be a problem since there is some indication of different growth rates between male and female blue sharks. Japan has also collected blue shark vertebrae to contribute to the reference collection and the WG will be updated under agenda item 14.

The Chair indicated that the participants of the Age and Growth Workshop did not believe that the group could conduct cross lab validations and prepare new growth information for blue sharks in time for the winter blue shark assessment. However, after sharing samples and cross validating among labs, the age and growth specialists are hopeful to have new results for the blue shark assessment to be conducted 3 years later. Thus, attention should be focused on shortfin mako age and growth to provide the best available information in time for the first mako assessment. The Chair agreed to provide the WG with a work plan on age and growth studies at the July meeting.

## 6.0 REVIEW OF FISHERY DATA FOR BLUE SHARK STOCK ASSESSMENT

### 6.1 Canada

#### *6.1.1 Blue shark bycatch statistics in Canadian fisheries (1996-2011), oral presentation by Jackie King.*

This presentation provided updates to data presented in November 2011, with estimates for the 2011 fishing season. There are no targeted blue shark fisheries within Canadian waters, as such there are no landing statistics. All commercial fisheries in Canada are covered by a dockside monitoring program which provides validated landing statistics to verify zero landings of blue sharks. Blue shark are encountered as bycatch in a number of Canadian fisheries including groundfish trawl and longline fisheries, salmon (*Oncorhynchus* spp.) troll, gillnet and seine fisheries, albacore tuna (*Thunnus alalunga*) troll fisheries and recreational fisheries. Currently, only the groundfish trawl and longline fisheries have 100% observer coverage, with either at-sea observers or electronic monitoring. Blue shark bycatch data from other commercial fisheries are derived solely from fisher logbooks. All Canadian fisheries have low bycatch rates of blue sharks. From 1996-2011 there have been a total of 2.71 tonnes of blue sharks caught by the trawl fleet resulting in a mean of 0.17 tonnes annually. The total estimated bycatch by longline (1998-2011) is 83.14 tonnes, with a mean annual estimate of 5.94 tonnes. The mean annual bycatch estimate for years with the most reliable records (2006-2011) is 9.98 tonnes. The salmon fisheries estimates of bycatch are very low, with a mean of 0.24 tonnes annually. The logbook records for albacore tuna troll fisheries are unreliable and should be viewed as incomplete. Blue shark catch rates in similar U.S. tuna fisheries were examined to apply to Canadian tuna effort data; however, these data were not appropriate since it was not always possible to separate U.S. troll fisheries (similar to Canadian) from bait fisheries (which Canada does not have). Recreational fisheries are monitored by creel survey programs which collect limited information on blue shark bycatch and annual estimates cannot be made prior to 2007. From 2007-2011, 23 blue sharks were reported through creel interviews as captured and released off the west coast of Vancouver Island.

Discussion

The presenter indicated that all blue sharks caught are discarded. The WG asked if there is any information on the mortality of discarded/released blue sharks. It is believed that all sharks caught by the trawl fishery are discarded dead. As for the ones caught by bottom longlines that target halibut or sable fish, there may be some dead and live releases depending upon when during the operation the shark is captured. The mortality of sharks caught by the bottom longline could be estimated by video data recorded as part of the fishery observer program, but that detail has not yet been extracted from the video and thus estimates have not yet been made. The presenter recommended to assume that all discarded sharks are dead as a conservative estimate. The WG noted that the reliability of the estimates of the bottom longline catch in the period before 2007 was less certain since they are derived from logbook data. The Chair mentioned that the WG agreed in November to try to estimate annual catch data from 1971 for the assessment. Canadian groundfish fisheries have logbook data back to 1977. The rough estimates of the historical level of the bycatch of blue shark could be estimated using the annual effort data. **The WG requested that Canada prepare the best estimates for the total mortality of blue sharks caught by Canadian fisheries since 1971.**

The WG asked about the availability of size information. Limited information (i.e. average size) is available for some of the fisheries. It was pointed out that the average size information could be used to convert the reported catch weight into number if needed. The presenter further added that there are size/sex data available from blue shark pelagic longline research surveys conducted in 2007 and 2009, but the data are limited and may not be directly applicable to the fisheries.

6.2 USA

*6.2.1 Catches of blue and shortfin mako sharks from U.S. West Coast recreational fisheries 1980-2010, presented by Tim Sippel (ISC/12/SHARKWG-1/04).*

Recreational fishing is popular in the USA, and effort is directed at many of the same species targeted in commercial fisheries. Various fishing modes contribute to both targeted and non-targeted catch of mako and blue sharks, but the predominant method used by recreational anglers is rod and reel fishing with trolling lures. Recreational fishing activity is monitored and regulated at the state-level, but surveys, data collection, and catch and effort estimation are also coordinated at the Federal-level. Surveys are conducted across many species, fishing modes, locations and times. Current estimates of blue and shortfin mako shark catch along the U.S. West Coast between 1980-2010 indicate much higher catches in the 1980s with generally declining catch levels from 1990-present. For a number of reasons, including low survey coverage for the sectors targeting sharks, there are high standard errors and relatively high interannual variability in the catch estimates that should be taken into consideration when using these data in stock assessments. Examinations of these data to understand sampling changes over time, and implementation of the estimation procedures within the RECFIN database are ongoing, so the data may be revised further before the blue shark assessment.

Discussion

**The WG requested that estimates be extended back to 1971, and that if possible estimates for discard mortality be made.** The presenter mentioned that it is believed that post-release survival for the recreational fishery is reasonably high, and that anglers do not typically land blue sharks since they are not in demand for consumption in the USA. The reports by anglers do give some information on dead versus live discards, so it may be possible to apply post-release survival estimates to the live discards.

The WG asked about the possibility of converting numbers to weight. It was clarified that there are no reliable estimates of average size; any blue shark size data available from RECFIN for a given year are often of a sample size less than ten, and size data are not available for all years. It may be possible to use the average size of sharks caught during the NOAA juvenile shark survey as a proxy, however the survey is only conducted in the Southern California Bight area and recreational shark fishing may occur over a larger area. The drift gillnet fishery operates over a larger area, but the U.S. scientists caution against using data from the drift gillnet fishery that operates in the fall/winter since most recreational shark angling occurs in the summer. **It was requested that the U.S. scientists decide on an appropriate size conversion for this fishery by investigating the applicability of the NOAA survey and drift gillnet fishery data and report back at the next WG meeting.**

The author pointed out that there is some concern in the quality of intercept survey data recorded in the RECFIN database for the earlier part of the timeseries due a less statistically rigorous and comprehensive sampling design. This may have resulted in high catch estimates during 1985-1989 when only high use areas were opportunistically sampled. **It was suggested that an investigation of the intercept survey reliability could be done by comparing the charter boat logbook data to the charter boat data captured by interviews in RECFIN.** The ratio of blue shark catch in high use areas to low use areas from 2004-2006 could also be used to extrapolate from the high use only data available for 1985-1989. The author also indicated the estimated catch data may underestimate catch obtained aboard charter boats operating in the

Mexico EEZ because samplers preferentially interview captains from vessels fishing in U.S. waters.

The WG questioned if there could be issues with incorrect species identification of blue sharks. The presenter responded that it is believed that the identification of blue sharks is easy, as no other sharks encountered in southern California where this fishery operates have a similar appearance. Thus, the possibility of species misidentification is believed to be negligible. It was pointed out that it is possible that some anglers may have reported all the shark catch as blue shark, but this would be hard to check.

The WG asked about whether there are recreational fisheries that may catch blue sharks in other U.S. Pacific territories such as Hawaii and Guam. After consulting with the U.S. data correspondent it was answered that there is no known recreational catch of blue and mako sharks beyond the U.S. west coast and Mexico EEZs.

*6.2.2 Catch statistics, length data and standardized CPUE for blue shark (Prionace glauca) taken by longline fisheries based in Hawaii and California, presented by Bill Walsh (ISC/12/SHARKWG-1/02).*

This paper presents compilations of catches, length distributions, catch per unit effort (CPUE) standardizations and other information for blue shark *Prionace glauca* in U.S. Pacific longline fisheries. The objective of the paper is to provide inputs for the ISC SHARKWG blue shark stock assessment. The blue shark catch in waters near Hawaii from 1991 through 2011 was estimated by using fishery observer data and self-reported data from mandatory commercial logbooks. CPUE was standardized by the delta-lognormal method for both the deep-set (target: bigeye tuna) and shallow-set sectors (target: swordfish) of the Hawaii-based longline fishery. The haul year, haul quarter, and region of fishing were factor variables, and a cubic function of SST was a continuous explanatory variable in all models. The indices of relative abundance decreased over time in both sectors. Mean total lengths of both sexes in the two sectors of the Hawaii-based longline fishery varied by 9.7% (shallow-set sector males: 211.9 cm; shallow-set sector females: 207.5 cm; deep-set sector males: 227.7 cm; deep-set sector females: 211.8 cm). Blue shark sex ratios were characterized by predominance of males in tropical waters (0–10°N) and above 30°N in the deep-set sector and predominance of females at 20–30°N in the shallow-set sector. Other results from Hawaii include maps of observed catches and CPUE in 1996, 2001, 2006 and 2011, and a summary of the typical bias in self-reported blue shark catch data. Results of catch data estimation from two California-based longline fisheries are also provided: an experimental fishery that operated in the Southern California Bight between 1988-1991; and a combined deep and shallow set fishery that operates on the high seas. Total estimated blue shark catch averaged roughly 6600 mt annually throughout the time series, although the majority of sharks are discarded due to low market value, particularly since 2001 when the U.S. imposed a ban on shark finning.

<u>Discussion</u>

A number of questions were raised about some of the details of the data collected and the presenter provided the following clarifications. The size data and ratio of discards of blue shark caught by Hawaii is available since 1991 when the observer program started. The protocol for measuring the catch was consistent until five years ago when observers were instructed to measure every third fish rather than every fish. It was reported that finning of sharks was prohibited in the U.S. in 2001, and that resulted in reduced landings of blue shark as its carcass has no market value in Hawaii. This may have largely decreased the motivation to catch blue sharks and may have contributed to the trend in the estimated abundance index which shows a continuous decline even 10 years after the finning prohibition. **The U.S. scientists are considering evaluating the effect of the finning prohibition on blue shark CPUE by including a time period factor for before and after the introduction of the finning ban. The WG encouraged that analysis. The WG suggested that analyses similar to that conducted for the Japan longline fishery which may help capture changes in fishing operation be attempted.**

Discussion on under-reporting focused on the deep-set fishery where the number of discards recorded by the observers was consistently higher than discards recorded in logbooks for the observed trips. It is possible to correct for this under-reporting by using predicted catches on a set-level basis based on a regression relating actual logbook records to the predicted catch. Records with large residuals could be replaced by the predicted catch estimates on the premise that they are either logbook recording errors or falsification. This correction would likely increase the discard estimates by 10-20%.

The presenter's expertise with these fisheries suggested that these fisheries handle discarded blue sharks with a reasonable degree of care, and that the survival rate may be near 90%. It would be unreasonable to estimate discard mortality as 100%, but a conservative estimate could be 25-50%. **The WG recommended all national scientists to report the live discard rate by fishery as reported by observers when available.** Estimates of blue shark release mortality since 2001 are very low and discussion was made about studies such as Musyl et al. (2011) and Campana et al. (2009) and their findings of post-release mortality. **It was suggested that it may be good for the WG to come up with some general post-release mortality estimates, recognizing that rates may differ by region, water temperature and fishery**.

The WG asked if there were any interaction effects in the models. The main factors were year, quarter, region of fishing, and a continuous cubic function of sea surface temperature. The sea surface temperature used in the analyses came from satellite data. The only interaction that could be tested was year and quarter due to missing information for many factors. The year effect was not so important after scaled by the degrees of freedom, and both region and quarter became important.

There was little discussion of the California-based longline fishery estimates; however, **the WG recommended that the authors decide if the California and Hawaii data should be combined into a single time series. The WG would like to hear back from the U.S. about any updates to the CA longline fishery information.**

### *6.2.3 Preliminary time series for north Pacific blue and shortfin mako sharks from the U.S. West Coast drift gillnet fishery, presented by Tim Sippel (ISC/12/SHARKWG-1/03).*

Blue and mako sharks are not the primary target species of the U.S. West Coast drift gillnet fishery but are caught in non-negligible numbers. In this paper, the data sources and methods used to develop preliminary time series (catch including retained catch and dead discards, size composition, and standardized abundance indices) spanning 1971-2010 for upcoming stock assessments are described. Commercial landings and logbook records of mako sharks are representative of the fishery impact on the stock but not for blue sharks, due to the large difference in economic value. Catch time series for mako sharks were therefore developed primarily from landing records but blue shark catch estimates were developed from several data sources using different algorithms for different periods. Catch estimates for blue sharks were reliable for 1990-2010 but earlier estimates were highly uncertain. Catch estimates for mako sharks were relatively reliable for the entire time series (1971-2010). Length compositions for both species were derived from observer (1990-2010) and market survey (1981-1990) data. Since blue shark is typically not landed by this fishery, market survey length composition data for blue shark were very sparse and not used. Standardized abundance indices for both species were developed from observer data (1990-2010). However, the small spatial scale of this fishery relative to the ranges of both mako and blue shark stocks suggest that these two abundance indices are not likely to be representative of the population trends of the entire stocks. It is therefore recommended that these abundance indices should not be used in the upcoming assessments, but catch and length composition time series should be used. It is also recommended that the units of catch for this fishery be thousands of fish and sensitivity runs be performed to account for the uncertainty in catch.

Discussion

It was noted that several nations use ratios between blue shark and target species catch to estimate blue shark catch for time periods when target species catch was recorded but blue shark catch was not recorded. This requires the assumption that the ratio is relatively constant over time, or that any declines (or increases) in the target species also correspond to declines (or increases) in blue shark. This assumption may not always be correct; however, for this fishery the ratios of blue shark to swordfish and mako shark to swordfish from 1990-2010 were relatively stable. Nevertheless, this does not address the assumption of consistency between 1981-1990 to which the ratio was applied to estimate blue shark catch, and for 1971-1980 for which the authors plan to apply the ratio to estimate blue shark catch.

In the previous meeting, the WG decided to set as the stock assessment boundary the entire North Pacific, thus to include data for U.S., Canada and Mexico fisheries. Despite this, the authors recommend that the CPUE time series for this fishery not be used for the assessment because the limited geographic range of the fishery means the index is not representative of a significant portion of the population. A declining amount of effort over time also contributes to higher variability of the CPUE over time. After 2000, vessels participating declined from over 1000 to about 40 boats and regions of fishing changed, again support for questioning the use of the CPUE time series. The authors suggest that the catch in numbers may be most useful for the assessment; however, whether numbers or mt can be used may depend upon the assessment model and the consensus of the WG regarding the input data.

Though the information contained in the recent catch and effort data of this fishery is rather limited, considering that little fishery information for blue sharks is available for the EPO, **the WG recommended further analysis of the data to help clarify which part of the stock this fishery represents.** For example, introduction of some additional oceanographic factors such as the position of currents may provide a better understanding of the representativeness. **In the EPO, there are a variety of small scale fisheries, such as artisanal fleets in Mexico and Central American countries and efforts should be made to fully understand the available**

**fishery and biological data.**

6.3 Japan

*6.3.1* Recent catch pattern of blue shark by Japanese offshore surface longliners in the northwest Pacific*, presented by Kotaro Yokawa (ISC/12/SHARKWG-1/05).*

The size category-specific catch and effort data as well as sex-specific size data of blue sharks caught by Japanese surface longliners in 2009 and 2010 are reviewed. Japanese surface longliners supposedly targeted blue sharks during late spring to late autumn, but the size category composition of the catch and size category specific monthly CPUE pattern changed between the two years. These observed changes may be attributed to the opportunistic change of the target species between blue shark and swordfish, a change of fishing grounds, as well as sex and growth stage specific migration patterns of blue shark. Blue sharks in the extra small and small size categories tended to be caught in the lower temperature and salinity side of the fishing grounds during summer. The monthly CPUE patterns by size category demonstrate that smaller individuals tend to distribute in higher latitudes and suggest size-specific north-south seasonal migrations. It is also suggested that size-specific migration patterns may change by area. The quarterly length frequency of blue sharks caught by Japanese surface longliners seems to be affected by the complex migration pattern of blue sharks as well as the complex operation patterns of the longliners. In both years, the sex ratio was biased toward males of all size classes during the 1$^{st}$ to 3$^{rd}$ quarters but nearly equal sex ratios obtained in all size classes during the 4$^{th}$ quarter. In total, more than 75 % of blue sharks caught by Japanese surface longliners in 2009 and 2010 were male. The results of this study demonstrate the need for further study on the sex- and growth stage-specific migration patterns of blue sharks and their relationship with oceanographic conditions.

Discussion

Clarification was made that the CPUE time series shown represents nominal data and that these data represent some of the best available blue shark data sets. Catch of blue shark recorded in both skipper notes and official logbooks are almost identical, and the situation has been the same for 10 years. Smaller values of CPUE may be related to salinity, and perhaps box plots would show the relationships better; a request was made to re-do the maps in order to better examine the data.

The WG asked if the skipper notes were consistent with the log books, so that more data can be derived using log books from the past, but the answer was no because the logbook has only 1 x 1 degree resolution. An observation was made that the surface longline fishery primarily caught males, but no reliable explanation could be made other than that the pattern is highly consistent with the sex and age specific patterns observed by Nakano’s previous research. Only 2-3 years of size data exist for the surface fishery.

*6.3.2 Review of size data of blue shark caught by Japanese training vessels in the central Pacific, presented by Kotaro Yokawa (ISC/12/SHARKWG-1/12).*

The sexed size data of blue sharks caught by Japanese training and research longliners primarily targeting tunas by deep set is analyzed from the view point of its use in the stock assessment of blue shark in the North Pacific. The amount of size data seems to be high enough for the period between 1992 and 2000 to represent the length frequency of the fishing grounds of the training fleet analyzed. The amount of data starts to decrease rapidly in 2001, and its level becomes almost negligible since 2006. Because most of the size data are collected from a limited area and season, it likely only represents a small portion of the blue sharks caught by Japanese deep set longliners in the North Pacific. During the 1st half of the period analyzed, the sex ratio by size classes is changed by subarea, by season and by year. This is consistent with the reported sex- and growth stage-specific distribution patterns of blue shark in the North Pacific, and also demonstrates that patterns change inter-annually. Thus, extensive size sampling is necessary to construct reliable catch at size by sex.

Discussion

The WG discussed the complex pattern of seasonal distribution of blue shark depending on sex and size, and the need for sex and size specific models for abundance indices. Moreover, the estimates of sex specific catch time series may be necessary, particularly in some major fisheries if unbalanced sex ratios are observed.

The WG also discussed why the presented sex ratio in the fourth quarter at subarea 4 was different from the previous WP (ISC/12/SHARKWG-1/05) despite their regional similarity. It was answered that the previous WP only used data of catch by size category and no information about sex were considered. The data used in this study were primarily obtained by port sampling while the data in the previous study was obtained by skipper's notes. **The WG suggested the necessity of additional research to reveal the distributional pattern of blue shark such as electronic tagging research and life history for future stock assessment with consideration for the sex and size specific model.**

Support clearly shows differences in sex and size with respect to area, but given the limited data sets for blue sharks, addressing differences may be too difficult. It may be very difficult to incorporate such detailed information in a model. We would also need very good data to generate spatial selectivity. The WG noted that the IATTC silky shark assessment is planning to use selectivity functions from the fisheries with good sex and length data to apply to other fisheries, so perhaps similar assumptions could be made for blue sharks.

*6.3.3 Historical catch amount of blue shark caught by the Japanese coastal fisheries, presented by Ai Kimoto (ISC/12/SHARKWG-1/11).*

This document provides the estimation of historical catch of blue shark by coastal fisheries since 1951. Most of the Japanese shark catch data were reported as species aggregated "sharks", thus the ratio of the catch of blue sharks among all sharks by fishing gear was calculated using available species specific landing data, and used to estimate the catch of blue shark. The estimated catches for the coastal longline varied between 200 and 1800 tons, while the catches for other longline were between 70 and 750 tons. The estimated catches for the other fisheries were substantially smaller than longline catches, and were below 60 tons. Although the catch was tentatively estimated in this document, the detailed species compositions of catch of sharks for coastal fisheries was very limited. This indicates the necessity of further investigations, and the uncertainty should be taken into account when conducting the stock assessment.

Discussion

The transition year of 1979 was arbitrarily selected based on known changes in the shark composition of the majority of the coastal fisheries. For example, other fisheries (mainly harpoon) had operated mainly in the southern and western part of Japan to target blue, black and striped marlin prior to the 1980s, but they were replaced by operations in the northern part of Japan to target swordfish. This change caused the increase of the catch of blue shark. The data are landings only, which is believed to be identical to the total catch for the coastal fisheries other than the coastal longline. The coastal fisheries retain most blue shark caught. **The coastal longline fisheries do have a lot of blue shark discards, and these will be estimated by July.**

*6.3.4 Extraction of blue shark catches from species-combined catches of sharks in the log-book data of Japanese offshore and distant-water longliners operated in the North Pacific in the period between 1975 and 1993, presented by Minoru Kanaiwa (ISC/12/SHARKWG-1/07).*

An extraction method of blue shark only catch is developed because the logbook data of Japanese longliners possessed only the species aggregated shark catch data for the period between 1975 and 1993, and blue shark specific catch data have only been available since 1994. The extractions of the blue shark only catch data are conducted for the logbooks of the Kinkai and Enyo fleets separately. In both cases, the model created with the explanatory variables only available for the data set before 1994 had similar robustness to the one using explanatory variables available not only for the data set before 1994, but for the data set after 1994, and also it was apparently more robust than the model created by the single explanatory variable of the reporting ratio. Thus, the model created by explanatory variables only available for the data set before 1994 is recognized to produce a reliable extraction of blue shark only catch from the species aggregated shark catch in the logbooks of 1975-1993. The results of this study also indicated that the extraction method used in the previous assessment results in an overestimation of the blue shark catch as they only used data obtained from high blue shark CPUE areas.

<u>Discussion</u>

It was clarified that the catch data are estimated as number not weight. Concern was raised that the formulas used in the estimation were highly parameterized, particularly when two way interactions were included. In general, a simpler model structure is believed to preferable for this kind of analysis, and too many variables would cause over parameterization resulting in less accurate predictions. Thus, the WG asked if model validation using subsets of data to assess performance of prediction were done. The WG members suggested that sensitivity analyses need to be done, such as comparison between the simple and advanced models. It was answered that the authors have already tried a variety of models including simpler ones, which are not presented in the working paper, and they concluded that the model presented in the working paper was best. For example, the authors changed the resolution of latitude and longitude from 1 degree to 5 degree but it produced unrealistic outcomes. It was also clarified that the SST was a fixed factor, but input as a continuous variable. The presenter noted that this working paper introduced a method of estimating landings, and the estimation of total removals is explained in ISC/12/SHARKWG-1/08.

*6.3.5 Comparison of CPUEs of blue shark reported by logbook of Japanese commercial longliners with Japanese research and training longline data, presented by Norio Takahashi (ISC/12/SHARKWG-1/06).*

Some portion of blue shark catch by Japanese commercial longliners is known to be often unreported. This paper is our attempt to compare blue shark catch recorded in logbooks from Japanese commercial longliners with "reference" catch. The "reference" catch is based on catch and effort data recorded by research and/or "fisheries high school" training vessels for which all of their catch were observed and reported. For the commercial longline fishery, the same catch and effort data as in ISC/12/SHARKWG-1/08 were used, subsetted to include only the data where the spatio-temporal coverage overlapped, and the same values of hooks per basket as the "reference" data were extracted. To compare differences between blue shark catch of the Japanese longline fishery with the "reference", the ratio of the two catch rates was calculated. The ratio was computed for each of the combinations of vessel types ("Kinkai" or "Enyo") and longline set categories (deep or shallow set) as defined in ISC/12/SHARKWG-1/08, except for "Kinkai"-deep set combination. All catch rates were standardized by GLM. The ratios varied year to year for the analysis period. There was no particular systematic pattern (neither increasing nor decreasing) observed in any of the year trends of the ratios for the three vessel type/set category combinations. For "Kinkai"- and "Enyo"-shallow set fleets, the ratios fluctuated between 0.6 and 1.5. There were several reasons which caused higher catch rates of the research vessels and consequently produced the ratios less than 1.0. Considering these reasons, it may be valid to assume that both "Kinkai"- and "Enyo"-shallow set fleets have properly reported their blue shark catch. In contrast, the ratios for "Enyo"-deep set fleet fluctuated between 0.04 and 0.10, suggesting that an unignorable portion of blue shark catch by this fleet has been unreported. It was difficult to draw a decisive conclusion on the unreported issue because available information was truly limited. Given large uncertainties about the unreported portion in total blue shark catch, final conclusions should be synthetically drawn from multiple results from this paper and other analyses.

Discussion

It was asked why this study used aggregated latitude and longitude data for the model, while ISC/12/SHARKWG-1/07 used continuous latitude and longitude. This was mainly because the author tried to overlap the reference training vessel data with the commercial log book. The goal of this study was to determine whether utilization of the log books is appropriate before estimating catch. **It was also noted that data of shallow sets appear representative but deep set data should not be used for CPUE estimation.** Reference training vessels are actually captained by experienced fishermen, not by students, thus searching ability of the training vessels for fishing ground is almost identical to that of the commercial longliners.

### *6.3.6 Blue shark catch of Japanese surface longliners registered in Kesennuma fishing port, presented by Kotaro Yokawa (ISC/12/SHARKWG-1/14).*

The information on discards of blue shark recorded in the skipper's notes of Japanese surface longliners targeting swordfish and blue shark in the North Pacific was reviewed. The ratios of discards to retained catch were less than 1% in 2008 and 2009, and increased to 2.6% in 2010. The highest ratio of 3.3% was observed in 2011, but it was believed to not reflect the normal situation as the processing factories of blue shark meat were destroyed by the earthquake disaster. The skipper discard records of the cruise of Shoryo-maru No. 7 during January to February 2010 were compared with the ones collected by onboard observers. The results of the comparison suggest the possibility of 20 – 30% underestimation of the discard rate in the skipper's note. Even if this underestimation is accounted for, the discard ratio of blue sharks of

Japanese surface longliners is recognized to be a negligible level for the analysis of their catch and effort data.

Discussion

The skipper notes have been collected separately from the logbook, and from a large portion of the shallow set sector of the offshore and distant longline fisheries. In the period analyzed, the skippers notes used in this study cover most offshore and distant-water longline boats conducting shallow sets. The WG recognizes that fishery discard data could be estimated using these skipper notes for Japanese shallow set fisheries, although it is noted that it will only add approximately 2% or less to their total catch.

*6.3.7 Estimation of total blue shark catches including releases and discards in Japanese longline fisheries during 1975 and 2010 in the North Pacific, presented by Yuko Hiraoka (ISC/12/SHARKWG-1/08).*

Total catch number including all live releases and dead discards is estimated in this study using fishery category specific standardized CPUE values as well as the results of comparisons of catch rates of blue sharks between commercial and non commercial operations. The targeting effects are investigated for each fishery category used for the CPUE standardization and based on the results of this, an additional variable is incorporated into the estimating models of the shallow sets of Hokkaido and Tohoku fleets both in 1975-1993 and 1994-2010 periods to adjust for the effect of blue shark target sets. The results of estimated total catch of blue shark by Japanese offshore and distant-water longliners peaked in 1980 at around 1,400,000 individuals, then decreased to around 800,000 in 1990 and leveled off until 2006. Because we improved the method to estimate total catch from the previous study, the estimates in this study are considered more realistic than before and are provided as the best available information for input to the stock assessment.

*6.3.8 Estimation of abundance indices for blue shark in the North Pacific, presented by Yuko Hiraoka (ISC/12/SHARKWG-1/09).*

Due to the recent analysis under the ISC SHARKWG, the abundance index of the north Pacific blue shark is estimated for 1975 – 1993 and 1994 - 2010 using a newly developed GLM model to standardize CPUE as well as estimate the blue shark catch and effort data of Japanese longliners. Following these results, abundance indices are estimated using methods developed in this study. The blue shark only catch data estimated by the new method are used for the period between 1975 and 1993. Set by set data of shallow sets registered to vessels of Hokkaido and Tohoku prefectures are directly used for the CPUE analysis with targeting effect for all periods. We recommend that the standardized CPUEs in this study are suitable as the abundance indices in the next stock assessment at the present stage, because they seem to be well developed.

Discussion of papers 08 and 09

The WG asked for clarification and presentation of GLM model diagnostics. Diagnostic specifics were provided in the appendix to the document. It was noted that there were no estimates of post release mortality in this study, and it was commented that a conservative mortality of 100% can be assumed. The authors pointed out in Figure 4 of working paper 08 that a shift from 1975-1993 to 1994-2010 was a function of a shift in effort with a focus on shallow rather than deep sets.

The WG members expressed some concerns over the Q-Q plots. The authors explained that they had difficulty fitting models to this large and complicated data set. The authors fit negative binomial models and did some data mining within several models. It was also commented that most residuals lied around 0, but a few outliers were still apparent.

Given the discussions, the WG requested additional calculations of the abundance indices for both early and late periods, and checked how the model fittings were changed under the following two sensitivity analysis:1) indices calculated by removing the outliers with high residuals, and 2) indices calculated by reducing the factors from the current models.

The abundance indices were recalculated with the data sets after removing the 5%, 10%, and 20% tails of high residuals on both positive and negative sides. The indices with simplified models were also shown by authors. With the partially-removed data, the fittings were improved but the patterns and trends of the abundance indices did not change much for both 1975-1993 and 1994-2010. Removal of outliers at the tails (5, 10, 20%) improved leverage plot diagnostics (leverage data fell between 3 SD range instead of 15-20 SD range of full data set), but the residuals were still skewed. With the simplified models, the patterns and trends of the abundance indices also did not change much. In both cases, most residuals were centered around 0, but a few outliers still remained. The WG clarified that all available data were used without any filtering, that the indices were for the target fisheries for blue sharks assuming a 100% reporting ratio. The authors noted that the "target effect" is one of the important factors, and the trends and fittings changed without the factor. It was felt that most of the outliers had been identified and removed, but the model was still missing some explanatory factor(s). With this in mind, it was suggested to use the full data set since the resultant CPUE was similar to that of the filtered indices.

The WG also explored the possibility of comparing the indices derived from this study and the last assessment. Comparisons were difficult to make because data selection and model configurations, such as spatial strata and other factors were different. The authors recommended using all available data for the indices in the original document, because results were robust and the removal of outliers could not be objectively justified. The authors also noted that it would be easy to compare these results to future analyses when they are completed.

The WG asked the authors to present their residual patterns as a function of year in order to help determine whether the unusual residual pattern could be explained by a year effect. The results showed that there may still be some year effect, but the residuals were very small and the residual patterns did not appear to show any specific bias. The WG asked that further analyses for the selection of a best model be carried out, including a delta-lognormal analysis for comparison. **Given all the discussions, the WG agreed that these indices appear robust, but that decisions on the acceptance of all indices for the blue shark assessment will be finalized at the July meeting.**

The presenter provided an updated paper with the requested analyses at the July meeting (see ISC/12/SHARKWG-2/02 in list of papers). After review, the WG asked that the targeting ratio be calculated with respect to swordfish catch rather than blue sharks. The results showed little change in the pattern of the indices however it was felt that using swordfish provides a more independent factor for calculating blue shark CPUE. **The WG endorsed the use of swordfish rather than blue shark for the targeting ratio calculation and tentatively accepted the procedures to recalculate the abundance indices and to use the CPUE for catch estimation.** The Japanese scientists agreed to carry out further research on these indices in the future.

At the July meeting, Japan provided additional updates to estimates of catch for coastal longline and (EEZ) driftnet fisheries based on some gaps identified at the May meeting (see ISC/12/SHARKWG-2/02 in list of papers). The annual catches of blue shark were estimated for the Japanese coastal longline (1994-2011) and EEZ driftnet fisheries (1993-2011). The total blue shark catch including discards was estimated using logbook and some recent observer data for the longline fishery. **The WG expressed some concern about applying the results from 2 years of observer data to the fishery time series, but given no other information is available, agreed to the procedures presented to estimate the coastal longline catch.** For the driftnet fishery, blue shark specific catch was estimated using the species aggregated sharks catch data in the year book and species specific data of wholesale auction records. **The WG suggested that it may be more appropriate to apply an average ratio of blue sharks to total catch obtained from the earlier auction records (e.g. 2005 through 2008) since there is some indication that the fishery switched from targeting marlin to salmon shark with a resultant decrease in blue shark catch ratio.** These suggestions will be adequately incorporated into the procedures when final time series for base-case and sensitivity runs are developed. The WG hopes to use the data from Kleiber et al. (2009) for Japan driftnet catch prior to 1993.

*6.3.9 Blue sharks caught by Japanese large mesh drift net fishery in the north Pacific in 1981 – 1993, presented by Kotaro Yokawa (ISC/12/SHARKWG-1/10).*

Catch and effort data for blue shark caught by Japanese high seas large mesh drift net fishery in the period between 1981 and 1993 was reviewed and its CPUE standardized. The distribution pattern of the catch and CPUE of blue shark shows a more or less similar pattern to those of effort, with relatively higher CPUE observed in the offshore area of the northeastern side of Honshu, in the area between 160E – 180E as well as in the area around 170W. The nominal CPUE (number/km net length) of blue shark in the areas 1 and 2 shows generally the same trend over the period analyzed, but the level of the nominal CPUE is about 2 times higher in the area west of dateline than in the area east of dateline. The trend of the annual standardized CPUE was generally similar to that of the nominal CPUE, and they started to increase in the middle of the 1980s. The residual pattern was bimodal and this suggests, however, the necessity of the introduction of other factors to the model for CPUE standardization. The standardized CPUE obtained by this study could be used for the stock assessment of the north Pacific blue shark as the general trend of the standardized CPUE does not different from the nominal CPUE and this tendency would not change largely when other factors are introduced to the model.

Discussion

It was clarified that the CPUE in Fig. 13 of the working paper was averaged over the time series with year effect removed. The WG asked if there were many zeros in the catch, suggesting that a delta lognormal model would be best. The author indicated there were not many zero catch sets since the nets used were very long (10 km) and were fished with overnight soaks. The WG asked if mis-reporting was a concern since these data are logbook records. Almost all of the catch was landed, so the logbooks would already be corrected based on verified landings. In addition, this means that there were virtually no discards in this fishery.

Other high seas drift net fisheries (e.g. by Korea and other nations) were estimated and compiled for input in the last assessment. Those estimates appear to be reasonable, with enough documented explanation. **Estimates from the Kleiber et al (2009) assessment (catch and CPUE) could be used directly for this assessment if no better estimation procedures are identified**. The previous assessment did not use the CPUE by Japan high seas drift net fisheries, so this WP adds to the previous input by providing another CPUE series. The author also commented that a simpler model is better than adding too many variables.

**The presenter suggested the tentative area stratification should be reassessed.** The 30 degree north latitude line cuts directly through prime fishing regions. In addition, the size of the stratified area tentatively selected by the WG in the last meeting is too large to assume uniform density within it. The Chair responded that indices could cover any region in the entire north Pacific at least for its use in the production model, and thus CPUE standardization can be done with different area stratification from the one previously decided by the WG.

## 6.4 Chinese Taipei

### *6.4.1 The catch of shark caught by Taiwanese offshore longline fisheries in 2001-2010, presented by Chien-Pang Jin (ISC/12/SHARKWG-1/10).*

Sharks caught by Taiwanese offshore longline fishery were landed in Nanfanao, Chengkung and Tungkang fishing ports in Taiwan and blue sharks dominated the shark landings in 2001-2010. The blue shark occupied 57.6% of total shark landings and 89.3% of them were frozen in Nanfanao. Annual blue shark landings at Chengkung ranged from 268 mt to 689 mt with an average of 391 mt, which comprised 3.9% of total blue shark landings. The estimated blue shark landings at Tungkang increased from 1368 mt in 2001 to 1762 mt in 2006, but decreased thereafter to 394 tons in 2011. The ratio of frozen blue shark (processed) weight to whole body weight was estimated to be 0.413. After conversion, annual yield of blue sharks caught by Taiwanese offshore longline fisheries was estimated to range from 7898 mt to 11,777 mt in 2001-2010.

<u>Discussion</u>

The catch data from Tungkang appears to decline after 2006 likely because that fleet began to operate in the Indian Ocean, with less effort in the North Pacific. The vessels operating in the Indian Ocean are verified using the IOTC vessel list. The data presented in this paper are landings only and do not include discards, however in the offshore fishery (which is unobserved) all blue sharks are retained and landed. **The WG recommends that if fishery-independent data become available, that the information collected be verified. The WG also requests that CPUE be calculated for this fishery in order to compare it with other similar overlapping fisheries.** The amount of discards by the far seas longliners are being estimated using observer data and it will be reported in the July meeting.

It was pointed out that the catches described in this working paper contained catches obtained by foreign-based Taiwanese flag longliners. It was noted that the offshore fishing ground is different from and closer to Taiwan than those of distant-water fleets, and the coastal longliners are only operating within the Taiwanese EEZ. Offshore longlining trips last more than one week, but coastal longline trips last 2-3 days. The majority of frozen blue sharks (irrespective of fishery or landed as fresh or frozen) are processed at sea, i.e. headed, gutted and finned. Some size data (length) for fresh blue sharks caught by offshore and coastal longline were available from port samplers, but no size data are available for the frozen blue sharks. Some size data were measured on distant-water longline vessels by observers. The author was asked if sex identification could be possible on frozen sharks if copulatory organs remained attached to the body. The response was that sex identification was not possible because carcasses were processed in two pieces. However, it may be possible to obtain size and sex information from now on by fishing port observers where sharks are landed whole.

It should be noted that the 'restored' catch has been estimated to round weight from frozen weight using the conversion factor obtained by the authors. **Research on improving the conversion equations is needed due to low sample sizes for current conversion equations.** These catch data are reported in weight (mt), however they can be converted to number using average weight data from the observed far seas fishery. A question was raised regarding the similarity of length frequency between offshore and fisheries, but that information is not known because the observers measure only on the far seas fishery.

The WG asked about Taiwan's foreign based chartered vessels. It was reported that many small longline vessels are operating and obtain much catch. The WCPFC observers reported there are many discards and finnings. The authors pointed out that is not the case for the domestic registered vessels; all blue sharks are retained. It is not clear what is happening aboard foreign based Taiwanese-flag vessels.

*6.4.2 The sex-specified length frequency distribution of blue sharks collected by observers on the Taiwanese far seas longline vessels in the North Pacific, oral presentation by Chien-Pang Jin.*

Total lengths of 1707 blue sharks were measured by observers on Taiwanese far sea vessels in the North Pacific from 2002 to 2010. The mean total lengths are 219 cm (n=861) and 221 cm (n=846) for males and females, respectively. Most samples were collected between latitude 0-10° N and higher than 30° N (31.2% and 51.3%, respectively). The mean total lengths of blue sharks were 217 cm and 211 cm TL for latitudes between 0-10° N for males and females, respectively. The mean lengths were 222 cm and 227 cm TL for males and females for latitudes higher than 30° N. The samples collected between 10-30° N comprised only 17.5% of the blue shark samples. The mean total lengths of blue sharks in that area were 214 cm and 214 cm for males and females, respectively. Overall, the mean length of blue sharks was a little higher in the latitude >30 °N than those in 0-10°N, however the difference is not significant.

Discussion

The WG clarified that the measurement agreed to at the last WG meeting for the stock assessment data was total length. The question was raised about the practicality of measuring total length in the field. Though measuring total length is common among researchers studying shark biology, its measurement in the field seems difficult and laborious at least in some member countries. **Thus, the WG agreed to revisit the selection of the standard length for the stock assessment.**

The measured blue sharks for the Taiwanese far seas longliners seems to have roughly equal sex-ratio. In contrast, there was an observed shift of sex-ratio for the Japanese research and training vessels when the data were analyzed by year and season. For the Taiwanese far seas longliners, the number of samples of is not large enough to conduct a seasonal analysis.

**The WG requested that the Taiwanese size data be provided by quarter and area, especially for the distant-water longliners due to a substantial difference of the operational patterns between seasons and fishing grounds. The WG recommended authors prepare a working paper about the size data of blue shark caught by each Taiwanese fishery.** The historical and areal coverage of size data should be clarified to investigate the representativeness of the size data. The time period and area of size data collection have been mentioned above in the report summary, but details about the quarterly and smaller strata for the fishery are not provided.

6.5 Estimation of Unreported Catch

The Chair showed WG members some catch data received from China before the meeting. The number of hooks fished in the China longline fishery and the catch of blue and mako sharks for 2008 through 2010 were provided for the EPO, WCPO and Kiribati. It is unclear whether the data represent total landings, total catch or some subset of total catch based on sampling. It is also unclear whether the data represent only the north Pacific catch, which is what the WG would need for assessment purposes. **The Chair will work with the China data correspondent through the STATWG to verify the submitted data.**

The Chair also received some blue shark catch data from IATTC and SPC. In the case of IATTC, catch of blue sharks in the EPO north of the equator by large purse seine vessels was estimated based on EPO observer data. Estimated blue shark catch by large purse seiners ranged from 18 to 578 sharks, so was relatively insignificant. Nevertheless, the WG would like to be able to account for all blue shark removals in the upcoming assessment. The tables established at the November meeting did not specify submission of national effort data with the understanding that each nation would derive catch estimates based on their fishery catch and effort data for their respective table. But in the case of the IATTC, the SHARKWG working in collaboration with the IATTC, will have to come up with appropriate catch estimates for non-member countries or member countries that do not report their catch. Since the IATTC data have so far been aggregated by all nations for the northern EPO, **the Chair will work with the IATTC SHARKWG contact, to parse out catch and/or effort data for purse seine and longline fisheries in order to estimate catch for nations not contributing data** to the WG in advance of the July meeting. The Chair will also ask the IATTC if they have catch or effort data for coastal gillnets in the EPO as well.

Similarly, some catch data for blue and mako sharks caught in longline fisheries north of the equator in the WCPO area were provided by SPC. The data are aggregated by all nations and **the WG Chair will work with SPC to parse out data for nations not reporting to the SHARKWG as well as investigate whether there are any blue sharks caught in the other WCPO fisheries north of the equator.**

Mexico has been an active member of the SHARKWG at past meetings and several of their fisheries target and catch large numbers of blue sharks within the Mexico EEZ. In advance of this meeting, the Chair received a message from the Mexico scientists indicating that due to other domestic fisheries priorities, they were unable to provide all their blue catch data in time for this meeting; however, at the November meeting the Mexican correspondent identified the main Mexico fisheries catching blue and mako sharks and provided some preliminary estimates of their catch in recent years. **The Chair will follow up with the Mexican scientists** and is hopeful that they will be able to provide catch estimates for the upcoming blue shark assessment. If data are not provided, perhaps catches can be estimated based on an assumed ratio of blue shark to swordfish catch.

The ISC Chair indicated that a reminder was sent out to all data correspondents and delegation leads of the July 1, 2012 data submission deadline. The reminder specifically indicated the need to submit shark catch and discard data as well as category 2 catch/effort data, and category 3 size and sex data by species by fleet. At the July 13 SHARKWG meeting, all submitted data will be reviewed and at that time, if there are fleets with unreported catch, the WG will develop catch estimates based on one or more of the following:

1. the analyses conducted for the last blue shark stock assessment
2. effort data multiplied by CPUE estimated from a member fleet operating in a comparable manner, time and space.

**The Chair will request effort data from IATTC, SPC and the other ISC Working Group Chairs that may have archived catch and effort data for the other ISC species.**

<u>General Discussion Regarding Agenda Item 6.0 - Fishery Data:</u>

The WG reviewed the Tables 1 provided by each member and discussed the data needed for the assessment. Based on confusion regarding interpretation and use of the terms “total catch”, “catch”, “retained catch”, “landings”, “discards”, “dead discards” and “live discards”, among other descriptive terms, the WG came up with some specific definitions and terminology to describe requested and submitted WG data. The WG defined terminology was compared with the types of data requested by the ISC STATWG for the official ISC data, in order to understand what data must be prepared for the ISC plenary and what data will be needed and archived by the WG for the shark assessments. **The terms and definitions agreed upon by WG members are provided below.**

| **Plenary and published SHARKWG data** | **Data for SHARKWG use only** | | |
|---|---|---|---|
| *Retained Catch* | *Total Catch* | *Discards* | *Total Dead Removals* |
| Official reported national catch, likely equal to official landings data | Every shark estimated caught during the fishing operation | Estimated dead plus live sharks discarded | Total catch minus those estimated to be discarded alive or to survive post-release |

Total dead removals will be the input catch data for the stock assessments. **All member countries are requested to improve their estimates of total catch, discards and total dead removals in both number and weight by fishery. Members are also requested to provide**

**quantitative (or at least qualitative) indicators for the reliability of their estimates so that the information can be incorporated into the stock assessment model for sensitivity analyses if necessary. Each member nation is requested to provide further information about the representation of size data for each fishery with respect to the total catch in terms of the time period covered, seasonality and areas sampled. All member countries are requested to estimate blue shark specific data from 1971 through 2010 for the blue shark assessment, even for their fisheries that historically had only shark species aggregated data.**

## 7.0 REVIEW OF BIOLOGICAL PARAMETERS FOR THE BLUE SHARK ASSESSMENT

The WG had tentatively agreed to certain biological inputs for the blue shark assessment at the November meeting. Some had been agreed upon because they were considered the best available information at the time that Kleiber et al. (2009) conducted the last blue shark assessment and there was no new information. The WG revisited the November tentative decisions and agreed that the **status quo for assumptions would be to use the inputs from the Kleiber et al. (2009) assessment unless new information is available.** The WG members specializing in shark biology and life history had no new information to share; no new published studies have emerged since November. Growth rates of blue sharks are still considered uncertain with various studies estimating slightly different growth parameters, and variation between female and male growth.

There was much discussion regarding the best measurement to use for reporting shark sizes. Kleiber et al. (2009) converted all size data to precaudal length (PCL) for use in the assessment. The WG had agreed to use standard total length (TL) in November because several nations collect shark sizes in TL, and converting from TL to anything shorter than TL means losing resolution in the size data. However, it was acknowledged that measuring TL is also the most difficult to measure consistently because of the possibility of measuring some variable degree of "stretch" of the tail when attempting to measure either natural TL or stretched TL. Generally scientists prefer to record straight fork length (FL) because it is the greatest measurement short of TL that can be consistently measured because of the stiffness of the body from snout to fork. The WG searched for appropriate equations with adequate sample sizes to convert between dorsal to dorsal, PCL, FL and TL and found that only conversions to PCL from any of the others are available. Thus **the WG decided that all size data for the blue shark assessment should be converted to and reported in PCL, and information regarding the original type of size measurement should be provided.** It was clarified that it is not the intent of the WG to request that all nations begin to collect shark size data in PCL from this time forward. Because of the degree of processing that may occur onboard, or based on established protocols, it may be impractical for all nations to collect the same type of size data, thus the decision of what measurements to take should be made at the national level. **The WG strongly encouraged research addressing length conversion factors since equations for all size conversions are not available and in many cases sample sizes are low. The equations for both sexes combined to be used for all size conversions are below.**

PCL=0.748*TL+1.063, n=497, $R^2$=0.94, size range = 98-243 cm PCL

PCL=0.894*FL+2.547, n=497, $R^2$=0.98

Tentatively the U.S. and Japan scientists will use their own conversion equations for DL to PCL until the WG adopts a consensus conversion equation.

Past studies were similarly reviewed to obtain the most appropriate PCL to weight conversions so that catch in numbers could be converted to catch in weight for the assessment based on the size compositions or average size of the catch. **All total dead removals for the assessment will need to be provided in metric tons, whole weight. The agreed upon length-weight relationship for both sexes combined is:**

$Wt=4.2x10^{-6}*PCL^{3.1635}$, where weight is in kg and PCL in cm.

The WG agreed on other biological parameters for input in the base case assessment. The base case assessment model and sensitivities are described below.

## 8.0 & 9.0 MODEL CONFIGURATION FOR THE BASE CASE AND TENTATIVE SENSITIVITY RUNS

In order to help make decisions about the type of modeling that can be conducted, the Chair created a metadata table containing information regarding the fisheries known to catch blue sharks in the North Pacific. The metadata table contains such information as the type of fishery, the years and seasons of operation, the approximate average annual catch, the geographic area of operation, whether size data are available, and if an abundance index can be calculated. The WG reviewed the available information to decide on appropriate and feasible models as well as the base case. The WG summarized the condition of available data as follows:

1) The reported or estimated landings are available for most major fleets, but some data gaps still exist, such as the ones by fleets belonging to countries not attended this meeting. Several new time series of annual landings were reported during the meeting.

2) The estimates of discards are also available for major fleets, which seem to be greatly improved in terms of quality and quantity from those in the last stock assessment. Some information does not have verifications by fishery-independent data, which necessitates further research on this topic.

3) The amount of discards are reported to be large in some fisheries, especially for cases where shark conservation regulations have been introduced. There seems to be some information through observer programs, at least for the recent years, to identify the ratio of live release among discards, but the quantity and quality of this information diminishes back through time. In the 1970s and 1980s, the quality of data relating to this topic is not as reliable as in recent years and is only available from a limited number of fleets.

4) On the other hand, there is only qualitative information about the mortality of released blue sharks in some fisheries, especially during the period when the finning was not prohibited. The actual mortality is reported to vary by gear, soaking time of gear, water temperature, as well as the treatment of sharks at the time of release.

5) Some new abundance indices were reported on during the meeting and selected for incorporation into the stock assessment. The reliability of indices is likely improved by the new estimation methods.

6) Size data are available for many fisheries, and the coverage of size data appears to have increased in recent years due to increased observer coverage. Because of the sex and growth specific distribution and migration patterns of blue shark, the possibility that these patterns change by year with environmental conditions as well as the sex specific growth, the WG recognizes the need for a north Pacific wide review of available size data to incorporate them into the stock analysis process. In general, the coverage of size information in the earlier periods is poor.

Under the conditions summarized above, the WG agreed to start with production models, such as Bayesian surplus production models or ASPIC for the base case scenario, mainly due the fact that some important work remains to obtain total catch, which will be covered in the next WG meeting in July. **The WG agreed to qualify how reliable their catch data are for different fisheries. For the catch estimated using statistical methods, SD or confidence interval should be submitted, and the corresponding information should be supplied by national scientists for the catch estimated using complex and simpler methods in order to decide on sensitivity runs.** These information will be used to quantify the reliability of catch in the dynamic pool production types of analysis. The WG recognized that the estimations of total removals have been much improved compared to the previous assessment (Kleiber et al., 2009), although the estimations of discards have still many uncertainties. It was pointed out that the quality and quantity of catch, indices and size data of blue sharks should be better than other shark species among the three Oceans. The WG agreed to consider improvement of the assessment model to a more complex one as a next step, because many informative life history parameters and sex-size data are available for the north Pacific blue shark.

The WG discussed pros and cons of conducting simple versus more complex assessment models. The spatial distribution of blue sharks is uncertain, especially regarding seasonal and spatial segregation by sex and size. In addition there is evidence of sex varying growth rates. The complex dynamics of the population suggest that a complex model is needed to reliably account for total mortality and population growth of all sex and age classes and adequately assess the stock. Fishery data by size and sex and biological information are, however, extremely limited.

Decisions regarding inputs for the base case production modeling and some proposed sensitivity runs are shown in the table below. Some decisions can't be made until the actual assessment data are examined, particularly for alternative models that may be run after the base case run is completed.

| Parameter or Model Structure | Base case and possible sensitivity runs |
|---|---|
| Model type | A production model as base case with some level of complexity depending upon the available data. In minimum expect to have reasonable catch estimates, and a couple of abundance indices. An alternative model that may include age structure if size and other data are considered adequate will be conducted for potential validation after the production modeling is completed. |
| Absolute stock boundary for assessment | Entire North Pacific |
| Time span | 1971-2010; try full time series vs. 1994+ (or alternative weighting for early vs. late based on reliability of catch or CPUE time series) |

| | |
|---|---|
| Seasonality for production modeling | Annual catch and individual size data (in PCL), annual CPUE indices (for production model, size and sex are not an issue, so WG request annual data be submitted by July meeting; tentatively the WG requests that members prepare catch, size and sex data by quarter in time for the winter meeting in order to inform decision making regarding alternative modeling approaches) |
| Sex structure | single combined sex for base case |
| Age structure | Tentatively annual up to 20+ (refer to Kleiber's study) |
| Growth | Not needed for production model; need to revisit for the alternative modeling |
| Reproductive cycle | Current evidence suggests once every 1 or 2 years – not necessary for production model. Will decide in the winter for alternative modeling. |
| Length measurement | PCL in cm (individual size data requested) |
| Weight measurement | Whole weight in kg |
| Stock recruitment relationship | Not needed for production model. For alternative modeling, potential options include estimating within model or use Brodziak method; new Taylor et al. paper describes how to use a relationship more realistic for sharks in SS3. |
| Recruitment season | Season 2 (Apr-Jun) |
| Natural mortality | Not needed for production model. For alternative modeling, may use 0.2 with 0.15 and 0.3 in sensitivity runs. |
| Spatial structure for estimating unreported catch | Depends upon the spatial coverage of the data provided. Need to revisit the original strata from the November meeting once we see all fishery data. |
| Catch time series | Fisheries as identified in metadata table. Weighting of fisheries based on reliabilty of data and estimation procedures, including for discard mortality. Possible sensitivities on catch time series. |
| CPUE time series | Japan longline – early and late, US longline, maybe others. To be finalized in July. |

## 10.0 FUTURE PROJECTIONS AND BIOLOGICAL REFERENCE POINTS

Decisions regarding future projections will be made only after deciding on the production model to be run and what code will be used. Regarding determination of stock status with respect to reference points, it was noted that MSY will be estimated for a production model.

## 11.0 WORK PLAN FOR BLUE SHARK STOCK ASSESSMENT

Note that a revised work plan for the blue shark stock assessment was developed at the July meeting and is provided as Attachment 5.

<u>Work Plan for Base Case Blue Shark Stock Assessment</u>

**By July meeting:**

1. Each nation calculates catch (in mt whole weight) of blue sharks in North Pacific including:
    a. official retained catch (for Plenary Table 1)
    b. estimated total catch
    c. estimated discards
    d. total dead removals
    e. indication of reliability for each catch time series (e.g. CIs if multiple estimation procedures are used, or some explanation of uncertainty based on best available information)

* minor updates to assessment data will be accepted up to August 31, 2012

2. Each nation should bring assessment CPUE indices with confidence intervals, CV or SE
3. Each nation should prepare individual size data by fishery, by year, by sex in PCL
4. Chair should work with SPC and IATTC, other national delegation leads, and other species WG Chairs to come up with proposal for estimates of non-reported catch. Procedures for estimation of non-reported catch will be approved at the July meeting.
5. Obtain executable file sets including input data and parameters and code from Drs. Kleiber and Clarke for base case from both MFCL and Surplus Production models of last assessment.

**Fall/Winter Assessment Meeting: Location and dates TBD**

1. Conduct base case assessment modeling (subgroup meeting in advance of WG meeting not needed; assessment will be conducted in advance by e-mail correspondence)
2. Conduct future projections
3. Results with respect to MSY and potentially other BRPs will be prepared
4. Review alternative modeling ideas and revisit the requests for the type of information needed for the alternative modeling
5. Agree upon biological inputs for alternative modeling including growth curve to use

Work Plan for Alternative Blue Shark Modeling

1. Examine catch selectivities by various fisheries – will have a better idea after catch by fishery data are prepared for the July meeting.
2. Examine sex ratio differences in catch patterns by fishery – will have a better idea after catch by fishery data are prepared for the July meeting.
3. Participants should consider using any other available data or information for alternative modeling.

## 12.0 REVIEW OF PRELIMINARY CATCH TABLES FOR MAKO SHARKS

Several of the WG papers provided estimates of catch for mako sharks as well as blue sharks. In addition, some members and cooperating non-members provided Tables 1 specific for mako shark catch, but most nations have not yet provided complete mako data. All data provided will be consolidated into the WG master version of the mako Tables 1, but **it was agreed that a Table 1 of official retained catch for mako sharks will not be finalized at the July meeting** since the work of the WG has been to develop blue shark catch tables for the upcoming assessment and not focus on mako sharks. It was recognized that there will be many gaps in the first round of Table 1 development because this is a new working group and almost no data exist in the ISC database on sharks.

## 13.0 UPDATE LIFE HISTORY TABLES

The abbreviated life history tables published in the November workshop report remain unchanged. The WG Chair maintains more detailed Excel versions of the life history matrix for use by the WG.

### 13.1 Blue Sharks

David Wells provided an update on the life history tables developed for blue sharks at the November meeting. As a work assignment, the life history specialists were to provide greater detail regarding the size range and sample sizes and methodologies pertaining to growth, length-weight and size conversion models. The presenter indicated that the details had been added to the matrix. Since November, a few L-L conversions, L-Wt conversions and growth models were added to the life history matrix for blue sharks. Blue shark growth was identified in the tables as being the parameter with the greatest uncertainty. The presenter showed a figure of all the estimate growth curves from various studies overlaid to help the WG understand the variations and decide on the appropriate curve to use for the upcoming assessment.

<u>Discussion</u>

Several blue shark growth curve problems were discussed. The growth curves cited from each existing paper were put into one figure after being standardized to TL. It was suggested that the original data would be needed and should be converted to TL to develop directly comparable error distributions. Problems arising from converting existing growth curves to TL were acknowledged as well as complications due to the use of various enhancing methods.

The WG recognized the high uncertainty of L infinity of blue sharks reported in previous studies because of continuous growth of the oldest group (around 16) and a large uncertainty envelope around estimates for older individuals. This will probably lead to failure to accurately estimate sizes for the plus group**, thus collection of additional vertebrae for aging large animals is needed.** Model estimation of L infinity could also be affected by the male-to-female ratio, **and the importance of confirming the size range and spatial coverage of samples was reiterated**. **Assessment model sensitivity analysis was recommended in order to determine the best choice of a plus group and the associated size.**

Regarding the selection for the best growth model, meta-analysis using all the original data from the existing study was discussed. For this purpose, differences in the enhancement methods and models fit between studies should be carefully considered. **Considering the time schedule for this stock assessment, it is recommended to utilize the growth model used in the Kleiber et al. (2009) assessment until a more precise model is developed.**

Due to the high uncertainty of the growth models available for blue sharks, **a high priority should be placed on blue shark age and growth research for subsequent assessments. Establishment of a small working group to facilitate cooperative research among ISC members, including coordinated sampling efforts and sample exchanges was suggested. The initial priority for the ISC shark age and growth specialists is cross-reading and cross-validation of aging techniques.**

### 13.2 Shortfin Mako Sharks

The life history tables for shortfin makos were revisited. Although no new papers were published on shortfin mako shark life history, additional information was reported about the validity of growth curves. The information on the area, sample size, size range of specimen used were compared and discussed for each study. In the North Pacific, 3 published and 2 upublished growth studies exist. Within 3 published studies, one was from the western and central North Pacific and two were from the eastern Pacific. Sex-specific growth trajectories were only reported for the western and central Pacific, while the other two equations were sex-combined. **For the eastern Pacific, the need for sex-specific growth curves was noted**. The paucity of vertebrae for large individuals was of concern in both areas and the **further examination of the periodicity of the growth band pair formation was regarded as an urgent issue. In addition, cross-reading and/or the determination of improved methods are also necessary.**

Discussion

The WG discussed the status of ongoing growth studies of this species and collaboration plans stemming from the ISC sponsored Shark Age and Growth Workshop in case age-structured models are needed for the stock assessment. The primary problems are paucity of samples and data from large individuals, poor understanding of vertebral band pair deposition rates, and consensus on the best enhancement methods. **Cross-reading of the same vertebrae or good images was suggested**.

The results in the Eastern Pacific from OTC validation, indicate two band pair deposition rates for juveniles, but whether there is a change to a single band pair deposition rate and when that may occur remains unknown. In the western Pacific, mako shark growth studies based on indirect methods suggest a single band pair deposition rate. A potential regional and/or ontogenetic change of banding pattern may occur because in some species, it is suggested that banding pattern has less to do with the environmental periodicity and more to do with the structural support. Regarding resolving the periodicity of band pair formation between areas, the application of markers like OTC, alizarin and radiocarbon signatures was discussed. It was agreed that **stock structure should be treated independently from the possible regional difference in growth at present**.

The WG assigned the age and growth specialists to report on the result of cross-reading in an upcoming WG meeting.

## 14.0 REVIEW OF ONGOING RESEARCH

### 14.1 Genetics

#### *14.1.1 Update on North Pacific Blue shark (Prionace glauca) Population Structure Based on Microsatellite Polymorphic Loci, oral presentation by Jackie King.*

Collaboration between Canada, United States, Mexico, and Japan began in 2011 to investigate the stock structure of blue shark (*Prionace glauca*) in the North Pacific based on microsatellite polymorphic loci. We update results presented in November 2011 using all available samples from the north North Pacific. Samples (n=921) from five locations of the northern Pacific (British Columbia, California, Mexico, Central Pacific and Hawaii Japan) and a single southern Pacific location (Chile) were obtained for this analyses. The microsatellites of this study were found to be moderately to highly polymorphic, having between seven to forty-eight alleles per locus. None of the pairwise $F_{st}$ comparisons (AMOVA) between locations (with samples pooled over years) were statistically significant. Comparisons between northern hemisphere locations ranged from -0.0001 to 0.0016. In contrast, all but one (Japan) of the pairwise comparisons of the northern hemisphere samples and the single southern hemisphere sample tended to be large (0.0023-0.0033). The exception is the Japan sample which is essentially indistinguishable from the Chile sample. This likely reflects the small sample size of Chile, and future analyses will focus on stratifying the Japan location samples (which cover a wide range of latitudes), within location variation and bootstrapping to examine individual loci influence. Alternate statistical analyses, such as SAMOVA, will be used to look for inferred structure from the data rather than assumed structure constrained by location. Previously we expected that an additional six microsatellite loci would be published soon and samples could be genotyped with these loci to measure allele frequency and heterozygosity. These loci are not yet available, but could be included in our analyses as late as September 2012. Additional samples from Oregon (n=21) collected in 2003 have been obtained and will be added to the analyses in the summer 2012. Samples from New Zealand, Russia and possibly Chile will be collected in the summer of 2012 and added to these analyses in the fall of 2012. It is still anticipated that a final version of a manuscript will be completed by December 2012.

Discussion

There was a lot of discussion about the preliminary results and whether subsetting the data into different groups may provide different results. One suggestion was to break down the Japan grouping into north and south because the samples appear to be separated by a relatively large gap and there may be differences within the larger group that mask differences between groups. This may help discern the connection between Japan and Chile. The WG commented that in genetics studies it is valuable to look at variation with groups before looking among groups. Another suggestion was to look only at groups at the extremes, i.e. with the greatest geographic separation, rather than many subgroups across a broad continuum. A comment about insufficient sample sizes not providing enough power to differentiate between Japan and Chile was made, and if the loci are highly polymorphic it was agreed that higher samples sizes might help. Perhaps the Chile sample should be excluded due to insufficient sample sizes. Another question was asked about the relative influence of any single locus with very high polymorphism on the results regarding stock structure, and this will be examined again. A suggestion was made about using statistical techniques such as SAMOVA to improve analytical results, and perhaps a presentation on statistical techniques could be helpful. Finally it was acknowledged that using several different genetic techniques may be useful. The WG discussed the idea of sponsoring an ISC Shark Genetics workshop in the future, similar to the Age and Growth workshop, time permitting.

The goal will be every 3$^{rd}$ year to assess blue sharks, every 3$^{rd}$ year assess makos, and possibly during the final 3$^{rd}$ year, the WG could focus on research such as stock structure or begin work on another species.

Canada has recently initiated a salmon shark genetics study and a map of ongoing salmon shark sampling efforts was presented. Japan and several other nations are providing samples, and it was pointed out that samples on both sides of the Pacific (W and E of the dateline) are needed. A question about the need for the WG to endorse participation from member and non-member nations in salmon shark genetics research was asked, and the Chair indicated this research is important and she encouraged participation by members; salmon sharks are one of the species of interest to the WG, along with the higher priority shortfin mako, blue and thresher sharks. PIs and genetics specialists within the WG can coordinate and should update the WG periodically on progress. Given the challenge in interpreting genetics data alone, it was suggested that all available information relating to migration should be combined to clarify general migration patterns before delving into details of stock structure based only on genetics studies.

*14.1.2 Genetic population structure and demographic history of blue shark (Prionace glauca) in the Pacific Ocean: a lack of genetic divergence of pelagic cosmopolitan species, presented by Mioko Taguchi (ISC/12/SHARKWG-1/13)*

Pelagic cosmopolitan species often show no or weak genetic population structure across their range in relation to their large population size and high mobility, which are also influenced by the population history. Little is known about the genetic population structure of pelagic sharks which are among of most common species in the global open ocean, although it is expected to be different from the pelagic bony fishes due to their unique reproductive properties such as vivipary, a lack of larval stage and philopatry to particular nursery ground. Genetic population structure and phylogeography of blue shark (*Prionace glauca*), which is one such pelagic shark in the Pacific Ocean, were thus examined using the entire mitochondrial cytochrome b region. The observed genetic diversities were not different among the sampling sites. Pairwise $\Phi_{st}$ estimates indicated a lack of genetic differentiation across the Pacific Ocean, whereas AMOVA showed a low level but significant genetic divergence between the southeastern Pacific Ocean and other regions. These results indicate a high gene flow of blue shark in the Pacific Ocean as well as other pelagic cosmopolitan species, despite their particular reproductive system. Furthermore, three of four haplotype groups inferred in phylogenetic analysis for the observed haplotypes were found across the Pacific Ocean, but the other one was absent in the eastern South Pacific. The mismatch distribution analysis and neutrality tests in each haplotype groups indicated at least two demographic expansions of blue shark in the Pacific Ocean at different times. These phylogeographic analyses also suggest the initial expansion derived from a small population and the invasion of blue shark into the southern South Pacific at a second demographic expansion. Overall, temporal genetic diversity and population structure of blue shark appears to have been influenced by a series of historical events.

Discussion

It was noted that the large sample size (N=400) across the Pacific is good, and that the preliminary findings regarding samples from Chile are somewhat similar to the Canada study.

A question was asked if the authors thought that the preliminary results could be used to separate Pacific blue sharks into two stocks, north versus south. The WG suggested caution in using only genetics, but to consider other corroborative studies (tagging, etc.) that all in concert may support two stocks. The usefulness of these genetic data was acknowledged and further work was encouraged. The Chair indicated the WG should decide what stock assumptions and conclusions should be made. When genetics, tagging and fishery data are taken together, it may suggest northern versus southern stocks, though results from genetics alone are not yet conclusive. It was noted that peak areas of abundance are very different in the north and south Pacific, and life history patterns based on seasonal reproduction events may also differ, suggesting possibility of two stocks. In addition, the time frame associated with movements based on genetics and tagging varies greatly. Genetics may tell you about movements over hundreds of generations or millennia whereas tagging tells you about movements on the order of months and years. Current assessment efforts of the SPC treat the south Pacific stock as separate from the north. The WG agreed that management units do not need to coincide with genetic sub-structure, especially when considering different genetic sampling time-scales. **The WG recommends assuming north and south Pacific stocks are separate based on all currently available information and encourages ongoing genetics work.**

## 14.2 Age and Growth

### *14.2.1 Age and growth of the blue shark, Prionace glauca, in the central and south Pacific, presented by Kwang-Ming Liu (ISC/12/SHARKWG-1/16).*

The blue shark, *Prionace glauca*, an oceanic migratory elasmobranchii species, is one of the most common bycatch species caught by longliners. A total of 87 female and 180 male specimens captured by Taiwanese far seas longliners in the central and south Pacific (178°40´W-179°55´E, 41°22´S-1°28´S) between March 2009 and May 2011 were collected for age and growth analysis. The vertebrae from the caudal peduncle region sampled by observers were used for aging. Growth band pairs were read via images photographed from X-ray films. Marginal increment ratio and edge analysis indicated that the growth band pair (including translucent and opaque bands) on vertebral centra was formed once a year. The Akaike's Information Criterion indicated that the von Bertalanffy growth function (VBGF) best fit the observed total length (TL) at age data. The VBGFs were significantly different between sexes using the likelihood ratio test ($P < 0.05$). Growth parameters were estimated to be $L_\infty = 330.4$ cm TL, $k = 0.164$ yr$^{-1}$, and $t_0 = -1.294$ yr for females; $L_\infty = 376.6$ cm TL, $k = 0.128$ yr$^{-1}$, and $t_0 = -1.482$ yr for males, respectively. The longevities were estimated to be 27.0 and 21.1 years for males and females, respectively.

Discussion

The pupping ground in the South Pacific and the reproductive status of the specimens collected in the tropical area was questioned, but these are largely unknown because of a lack of information. The possibility of a population around the equator was indicated, especially for males, but additional genetics, tagging, and fishery data analyses are required to address this. The WG asked about female distribution, and it was noted that they are found primarily in southern latitudes compared to males, but better understanding of the distribution of pregnant females is needed. The presenter assumes that large females around the tropical (more equatorial) areas were sexually mature, though it is not certain because observers do not record maturity. Some discussion occurred regarding the similarity of their life history to the Nakano model in the North Pacific with males more equatorial, females more temperate, and potential mating grounds in between. **The WG recommended that collection vertebrae throughout the Pacific, in both the North and South, continue to advance Pacific-wide age and growth studies.**

### *14.2.2 Preliminary age validation of the blue shark (Prionace glauca) in the eastern Pacific Ocean, presented by David Wells (ISC/12/SHARKWG-1/01)*

Accurate age and growth models are some of the most important biological parameters needed for stock assessment and fishery management. The blue shark (*Prionace glauca*) is subjected to one of the highest levels of fishery bycatch in the world and is the shark species caught in the greatest number in the California/Oregon drift gillnet fishery where most are discarded at sea due to a lack of market value. Despite their numerical importance, the stock status of blue shark in the North Pacific is uncertain. Assumptions regarding band pair deposition rates used for age and growth models are being made without validation studies in the Pacific Ocean. As such, the purpose of this study is to validate vertebral band counts of blue sharks tagged and recaptured in the eastern Pacific Ocean. Oxytetracycline (OTC) labeled vertebrae of 13 blue sharks have been obtained from tag-recapture activities and processed to determine timing of centrum growth band deposition. Several methodologies were used to examine blue shark vertebrae and digital images of the whole vertebrae centrum were determined to be the best. OTC tagging of the recaptured sharks occurred off southern California from 2007 to 2009, with time at liberty ranging from 22 to 473 days. For vertebrae samples used in this study, shark size at release ranged from 90 to 276 cm total length (TL). OTC marked vertebrae from at least 20 more sharks have been returned and will be processed to build upon this study. Results from band counts of vertebrae distal to OTC marks thus far indicate a single band pair (1 translucent and 1 opaque) is formed per year for blue sharks of the size range examined. These preliminary results corroborate annual deposition rates found in the only other OTC validation study for blue sharks and will aid in future blue shark age and growth studies in the Pacific Ocean.

Discussion

The WG discussed the comparisons conducted of the different aging methods. The author mentioned that x-ray images were very bad for discerning growth bands and that alternating band pairs were observed only in the outer part of section (arms of bow-tie) rather than in the intermedialia. The author remarked that the best enhancement methods seem to differ among species and that using bow-tie sections with x-rays, which they have used effectively for shortfin mako, was not effective for blue sharks. The differences in reading and aging methods between research groups confounds the comparison of results. **It was suggested that cross-reading among research groups using good photographs and a reference collection should help resolve this problem.** The WG asked whether the blue shark x-rays and photographs could be compared with those obtained for mako sharks from previous work. In response, no band pair counts could be obtained from blue shark x-rays for the present study because the images were of poor quality, so this was not possible. However, Taiwanese scientists have produced clear blue shark images of whole vertebrae using soft x-rays. **The highest quality methods can be agreed upon by sharing the best images generated by individual labs for the reference collection of vertebrae.**

## 14.3 Other Studies

### *14.3.1 Ongoing research for understanding biology for sharks (Japan), oral presentation by Yasuko Semba and Mioko Taguchi.*

Japan presented an update of ongoing research since the last meeting in November 2011. This consists of biological sampling, tagging research and genetic studies. Biological sampling included recording the fate, condition and size of retained and released individuals, and detailed measurements of lengths for developing more reliable conversion equations. Blue shark vertebrae were collected from 109 specimens and some already have been prepared for distribution to each country as a part of the reference collection. Pop-up satellite archival tags (PSATs) were attached to a male and a female shortfin mako in the central North Pacific, and a plan for genetic analysis of shortfin mako using mitochondrial DNA and using microsatellite DNA for blue and shortfin makos was introduced.

Discussion

Progress since the 2011 Age and Growth Workshop was acknowledged, as was the difficulty in obtaining large sharks for age and growth, reproductive studies and tagging. Examination of USA observer data has suggested that large mako sharks are available, but they are difficult to handle, leading to lower motivation to sample and work with them. However, records of large mako sharks are useful for determining where to focus sampling and tagging efforts for these sizes.

In response to a question about using microchemistry analyses of vertebrae to help study stock structure and movements, the response was that this is challenging due to shark metabolic processes diminishing signatures and masking the ability to differentiate physiological vs. environmental effects.

The length of PSAT deployments was discussed, and the need for coordination of tag programming and data binning schemes to simplify data analysis was emphasized. NOAA researchers offered to help with the tag programming and data analysis. Tag deployments lasting one year are most informative about seasonal movement patterns, although this decreases the likelihood of success due to tag failure, mortality, etc. The WG also discussed the possibility that observer programs could be useful for deploying PSAT tags. **The WG reiterated that examination of catch data by size and sex, dedicated research on stock structure, and continued satellite tagging studies are all high priorities.**

## 15.0 & 16.0 RESEARCH RECOMMENDATIONS AND FUTURE WORK PLAN

- Continue work on blue, shortfin mako and other relevant ISC shark species genetics including efforts to increase sample collection and sharing. Studies should prioritize determining stock structure within the Pacific first to determine if North and South Pacific can be treated separately. Second priority is to clarify stock structure within the North Pacific for the stock assessment stock structure. If feasible the WG should contribute to global studies.
- The WG would like to have detailed information on shark catch by species and sex in order to have background information for alternative modeling approaches, but recognizes that the collection of such data and biological samples puts a burden on the fishermen and observers. Recent domestic regulations prohibiting retention of sharks have resulted in greater levels of discards, thus less data being collected. Each nation should consider how to improve the collection of better data on sharks, even though retention has been discouraged. Examples include large scale pop-off tagging, or video methods to capture data on size, sex and condition without removing fish from the water, etc. The WG should also think about how to develop estimates of the condition of the stock when the group lacks such detailed information.

- Request increased collection of fishery-dependent information on sharks, with a priority for blue and shortfin mako sharks, through observer programs or comparable data collection programs. Data collected should include number of sharks caught including discards by species, size, sex, time and area. Some information on discards is not verified, which necessitates further research on this topic.
- In the EPO, there are a variety of small scale fisheries, such as artisanal fleets in Mexico and Central American countries and efforts should be made to fully understand the available fishery and biological data.
- Due to the paucity of fishery data on sharks, continue to examine distribution of blue and mako sharks by size and sex through the use of tagging studies. Encourage collaborative conventional and electronic tagging studies in order to gather information in areas where there is insufficient information.
- Continue research on age and growth and reproductive biology of blue and shortfin mako sharks through collaborations. In particular, collection of samples for aging large animals is necessary.
- All member countries should continue to collect necessary samples to enhance the collaborative genetics, age and growth and maturity studies.
- Although shark fishery data are poor in many areas, every effort should be made to include as much available information as possible in alternative stock assessment modeling.
- Research on species-specific and sex-specific length conversion factors should be conducted across all regions. Measurements of dorsal to dorsal, pre-caudal, fork and total stretched and natural length should be made from male and female sharks across all size classes in order to develop the best relationships. Each nation should also describe how the size measurements are taken so the appropriate conversion equations can be applied.

The next meeting of the SHARKWG will be on July 13, 2012 in Sapporo Japan. Full participation from all member nations and observers is encouraged. The winter blue shark assessment meeting dates and times are yet to be determined.

## 17.0 OTHER MATTERS

17.1 **One general concern that repeatedly surfaced is that the WG would like to point out the challenges in conducting their work because of the lack of good shark catch and biological data collection.**

17.2 Review of existing post-release mortality studies of blue sharks, oral summary provided by David Wells and Tim Sippel

The WG has identified the need to estimate post-release mortality in order to tabulate total dead removals for stock assessments. A number of published studies exist, but not for all areas and gear types. Some concern was expressed early in the SHARKWG meeting about the accuracy of mortality rates tabulated by Musyl et al. (2011). Both presenters discussed results from prior post-release mortality studies. Upon inspection, the presenters were able to confirm the data compiled by Musyl et al. (2011) and the estimates in the table by each of the studies. Also, they elaborated on some studies showing relatively high mortality estimates from observer data (35%) compared to some studies showing relatively low post-release mortality estimates (6-19%) based on electronic tagging. Factors such as boat type, soak time, animal handling, and fish size were important factors in survivorship. Many studies show that blue sharks are relatively tough, and can survive deep hooking and multiple catches. However, there is diminished post-release survivorship with poor handling, different hook and gear types, and longer soak times. Investigation of stress metabolites from blood chemistry revealed that both lethal and sub-lethal effects (mortality thresholds and recovery periods) were likely good indicators of survivorship.

The presenter showed results from his dissertation research on striped marlin, showing how tagging apparently affects their movement patterns and the potential behavior and longer term fitness of fish. Similarly southern bluefin studies showed biases in tag data with a lack of feeding for 3 weeks after tagging. For these reasons, there may be delayed mortality that is difficult to assess even with the current methods. **The WG recommended developing some model sensitivities under different post-release mortality assumptions and dead removal estimates.**

17.3 Application of a more realistic stock-recruitment relationship in a shark assessment, oral summary provided by Tim Sippel

A new stock-recruitment relationship (SRR) has been developed for low-fecundity species, like sharks. This new SRR should better represent the productive potential of sharks based on survival rates of age-0 animals, as opposed to density dependent recruitment from Beverton-Holt or Ricker functions used in broadcast spawners, like tunas. The new survival based SRR has been implemented in the latest versions of SS3, and has been used in an assessment of dogfish in the northeast Pacific Ocean. For details see Taylor et al. (2012) *ISC/12/SHARKWG-1/INFO-3.*

## 18.0 CLEARING OF REPORT

The Report was reviewed and the content approved by all present. The Chair will make minor non-substantive editorial revisions and circulate the revised version to all WG members shortly for finalization.

## 19.0 ADJOURNMENT

The Chair thanked all participants for attending and contributing to a very productive meeting. She also thanked the NRIFSF for excellent meeting support throughout the week.

The meeting was adjourned at 17:15, June 4, 2012.

# Attachment 1. List of Participants

**Canada**

Jacquelynne King
Department of Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC, V9T 6N7
1-250-756-7176, 1-250-756-7053 (fax)
jackie.king@dfo-mpo.gc.ca

**Chinese Taipei**

Hua-Hsun Hsu
Institute of Marine Affairs and Resource Management
National Taiwan Ocean University
2 Pei-Ning Road
Keelung 202, Taiwan
886-2-2462-2192 ext. 5039
886-2-24620291 (fax)
hsuhuahsun@yahoo.com.tw

Chien-Pang Jin
Institute of Oceanography
National Taiwan University
1, Sect. 4, Roosevelt Rd.
Taipei 106, Taiwan
886-2-24622192 ext 5018,
886-2-24620291 (fax)
d97241003@ntu.edu.tw

Kwang Ming Liu
Institute of Marine Affairs and Resource Management
National Taiwan Ocean University
2 Pei-Ning Road
Keelung 202, Taiwan
886-2-2462-2192 ext. 5018
886-2-24620291 (fax)
kmliu@mail.ntou.edu.tw

**Japan**

Yuko Hiraoka
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6044, 81-54-335-9642 (fax)
yhira415@fra.affrc.go.jp

Minoru Kanaiwa
Tokyo University of Agriculture
196 Yasaka, Abashiri
Hokkaido, Japan 099-2493
81-15-248-3906, 81-15-248-2940 (fax)
m3kanaiw@bioindustry.nodai.ac.jp

Ai Kimoto
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6035, 81-54-335-9642 (fax)
aikimoto@affrc.go.jp

Hideki Nakano
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6032, 81-54-335-9642 (fax)
hnakano@affrc.go.jp

Miki Ogura
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6042, 81-54-335-9642 (fax)
ogura@fra.affrc.go.jp

Yasuko Semba
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6043, 81-54-335-9642 (fax)
senbamak@affrc.go.jp

Ko Shiozaki
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6044, 81-54-335-9642 (fax)
airlines.sky@gmail.com
Mioko Taguchi
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6043, 81-54-335-9642 (fax)
tagu305@affrc.go.jp

Norio Takahashi
Natl. Res. Inst. of Far Seas Fisheries
81-45-788-7509,81-45-788-5004 (fax)
2-12-4 Fukuura, Kanazawa,
Yokohama, Kanagawa, Japan 236-8648
norio@affrc.go.jp

Kotaro Yokawa
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6044, 81-54-335-9642 (fax)
Yokawa@fra.affrc.go.jp

**United States**

Suzanne Kohin
NMFS/SWFSC
8604 La Jolla Shores Drive
La Jolla, CA 92037
858-546-7104, 858-546-7003 (fax)
Suzanne.Kohin@noaa.gov

Kevin Piner
NOAA NMFS PIFSC
2570 Dole St.
Honolulu, HI 96822
808-983-5705, 808-983-2902 (fax)
Kevin.Piner@noaa.gov

Tim Sippel
NMFS/SWFSC
8604 La Jolla Shores Drive
La Jolla, CA 92037
858-546-7070, 858-546-7003 (fax)
Tim.Sippel@noaa.gov

Steven Teo
NMFS/SWFSC
8604 La Jolla Shores Drive
La Jolla, CA 92037
858-546-7179, 858-546-7003 (fax)
Steve.Teo@noaa.gov

William Walsh
University of Hawaii Joint Inst. for Mar. and Atmos. Res.
2570 Dole St.
Honolulu, HI 96822
808-983-5346, 808-983-2902 (fax)
William.Walsh@noaa.gov

David Wells
NMFS/SWFSC
8604 La Jolla Shores Drive
La Jolla, CA 92037
858-546-5619, 858-546-5619 (fax)
David.Wells@noaa.gov

**ISC Reviewers**

Chang Ik Zhang
Faculty of Marine Production System Management, Pukyong National University
559-1, Daeyeon 3-dong, Nam-gu Busan
608-737 Korea
82-51-629-5892, 82-51-629-5886 (fax)
cizhang@pknu.ac.kr

Jerald S. Ault
Rosenstiel School of Marine and Atmospheric Science, University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149
305-421-4884, 305-421-4791 (fax)
jault@rsmas.miami.edu

# Attachment 2. Meeting Documents

## WORKING PAPERS

| | |
|---|---|
| ISC/12/SHARKWG-1/01 | Preliminary age validation of the blue shark (*Prionace glauca*) in the eastern Pacific Ocean. Natalie Spear, R. J. David Wells, and Suzanne Kohin (David.Wells@noaa.gov) |
| ISC/12/SHARKWG-1/02 | Catch Statistics, Length Data and Standardized CPUE for Blue Shark *Prionace glauca* taken by Longline Fisheries based in Hawaii and California. William A. Walsh, Steven L.H. Teo (William.Walsh@noaa.gov) |
| ISC/12/SHARKWG-1/03 | Preliminary time series for north Pacific blue and shortfin mako sharks from the U.S. West Coast drift gillnet fishery. Steven L. H. Teo, Tim Sippel, R. J. David Wells, and Suzanne Kohin (steve.teo@noaa.gov) |
| ISC/12/SHARKWG-1/04 | Catches of blue and shortfin mako sharks from U.S. West Coast recreational fisheries 1980-2010. Tim Sippel and Suzanne Kohin (tim.sippel@noaa.gov) |
| ISC/12/SHARKWG-1/05 | Recent catch pattern of blue shark by Japanese offshore surface longliners in the northwest Pacific. Ko Shiozaki, Mioko Taguchi and Kotaro Yokawa (yokawa@affrc.go.jp) |
| ISC/12/SHARKWG-1/06 | Comparison of CPUEs of Blue Shark Reported by Logbook of Japanese Commercial Longliners with Japanese Research and Training Longline Data. Norio Takahashi, Yuko Hiraoka, Ai Kimoto, Kotaro Yokawa and Minoru Kanaiwa (norio@affrc.go.jp) |
| ISC/12/SHARKWG-1/07 | Extraction of blue shark catches from species-combined catches of sharks in the log-book data of Japanese offshore and distant-water longliners operated in the North Pacific in the period between 1975 and 1993. Yuko Hiraoka, Minoru Kanaiwa and Kotaro Yokawa (yhira415@affrc.go.jp) |
| ISC/12/SHARKWG-1/08 | Estimation of total blue shark catches including releases and discards Japanese longline fisheries during 1975 and 2010 in the North Pacific. Yuko Hiraoka, Minoru Kanaiwa and Kotaro Yokawa (yhira415@affrc.go.jp) |

| | |
|---|---|
| ISC/12/SHARKWG-1/09 | Estimation of abundance indices for blue shark in the North Pacific. Yuko Hiraoka, Minoru Kanaiwa and Kotaro Yokawa (yhira415@affrc.go.jp) |
| ISC/12/SHARKWG-1/10 | Blue sharks caught by Japanese large mesh drift net fishery in the north Pacific in 1981 - 1993. Kotaro Yokawa (yokawa@affrc.go.jp) |
| ISC/12/SHARKWG-1/11 | Historical catch amount of blue shark caught by the Japanese coastal fisheries. Ai Kimoto, Toshikazu Yano, and Kotaro Yokawa (aikimoto@affrc.go.jp) |
| ISC/12/SHARKWG-1/12 | Review of size data of blue shark caught by Japanese training vessels in the central Pacific. Kotaro Yokawa (yokawa@affrc.go.jp) |
| ISC/12/SHARKWG-1/13 | Genetic population structure and demographic history of blue shark (*Prionace glauca*) in the Pacific Ocean: a lack of genetic divergence of pelagic cosmopolitan species. Mioko Taguchi, Jacquelynne King, and Kotaro Yokawa (tagu305@affrc.go.jp) |
| ISC/12/SHARKWG-1/14 | Blue shark catch of Japanese surface longliners based on Kesennuma fishing port. Kotaro Yokawa and Ai Kimoto (yokawa@affrc.go.jp) |
| ISC/12/SHARKWG-1/15 | The catch of shark caught by Taiwanese offshore longline fisheries in 2001-2010. Kwang-Ming Liu and Chien-pang Jin (kmliu@ntou.edu.tw) |
| ISC/12/SHARKWG-1/16 | Age and growth of the blue shark, *Prionace glauca*, in the central and south Pacific. Hua-Hsun Hsu, Guann-Tyng Lyu, Shoou-Jeng Joung, and Kwang-Ming Liu (hsuhuahsun@yahoo.com.tw) |

**WORKING PAPERS FROM JULY MEETING**

| | |
|---|---|
| ISC/12/SHARKWG-2/01 | Trials for the estimates of blue shark catches caught by Japanese longliners and drift netters in the north Pacific. Kotaro Yokawa, Ko Shiozaki and Ai Kimoto (yokawa@affrc.go.jp) |
| ISC/12/SHARKWG-2/02 | Estimation of historical catch amount and abundance indices for blue shark caught by the Japanese offshore and distant water longline. Yuko Hiraoka, Minoru Kanaiwa, Ai Kimoto, Momoko Ichinokawa and Kotaro Yokawa (yhira415@affrc.go.jp) |

**INFORMATION PAPERS**

| | |
|---|---|
| ISC/12/SHARKWG-1/INFO-1 | Gill net mesh selectivity for the blue shark. Nakano, H. and Shimazaki, K. 1989. Bulletin of the Faculty of Fisheries Hokkaido University, 40(1): 22-29 |
| ISC/12/SHARKWG-1/INFO-2 | A Status Snapshot of Key Shark Species in the Western and Central Pacific and Potential Management Options. Clarke, S. 2011. WCPFC-SC7-2011/EB-WP-04, 36. |
| ISC/12/SHARKWG-1/INFO-3 | A stock-recruitment relationship based on pre-recruit survival, illustrated with application to spiny dogfish shark. Taylor, I. G., Gertseva, V., Methot, Jr. R. D., and Maunder, M. N. 2012. Fish. Res. http://dx.doi.org/10.1016/j.fishres.2012.04.018 |
| ISC/12/SHARKWG-1/INFO-4 | Synopsis of Biological information on blue shark in the North Pacific. Nakano, H. and Seki, M. P. 2003. Bull. Fish. Res. Agen. No. 6, 18-55. |
| ISC/12/SHARKWG-1/INFO-5 | Age, reproduction and migration of blue shark in the North Pacific Ocean. Nakano, H. 1994. Bull. Nat. Res. Inst. Far Seas Fish., No. 31, 141-256. |
| ISC/12/SHARKWG-1/INFO-6 | Bycatch of high sea longline fisheries and measures taken by Taiwan: Actions and challenges. Hsiang-Wen Huang. 2011. Marine Policy, 35: 712–720. |

# Attachment 3: Agenda

## SHARK WORKING GROUP (SHARKWG)

***INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC***

## INTERCESSIONAL WORKSHOP AGENDA

**28 May to 4 June, 2012**
**National Research Institute of Far Seas Fisheries**
**Shizuoka, Japan**

**May 28 (Monday)**
**AM** (10:00 – 12:30)

1. Opening of SHARKWG Workshop: 28 May, 10:00
   - Welcoming remarks
   - Introductions
   - Meeting arrangements
2. Distribution of documents and numbering of Working Papers
3. Review and approval of agenda
4. Appointment of rapporteurs
5. Summary of the November 2011 Workshop and the Shark Age and Growth Workshop (Kimoto and Walsh)

**PM** (14:00 – 17:30)

6. Review fishery data for blue shark stock assessment
   - Catch and discard data and total catch estimation procedures (Kimoto, Yokawa and King)
   - Size data (Taguchi, Yokawa and Liu)
   - Abundance indices and CPUE estimation procedures (Kimoto, Yokawa and Wells)
   - Estimation of catch of fleets with no information (Taguchi, Yokawa and Jin)

**May 29 (Tuesday)**
**AM** (9:00 – 12:30) – **PM** (14:00 – 17:30)
Item 6 continued: Catch and discard data and total catch estimation procedures (Kimoto, Yokawa and King)
Update on blue shark genetics (from Item 14 moved forward; Semba, Hiraoka and Wells)
**PM** (19:00)
Reception for SHARKWG - around Shin-Shimizu Station

**May 30 (Wednesday)**
**AM** (9:00 – 12:30)
Item 6 continued: Size data (Taguchi, Yokawa and Liu)
**PM** (14:00 – 17:30)
Item 6 continued: Abundance indices and CPUE estimation procedures (Kimoto, Yokawa and Wells)

Estimation of catch of fleets with no information (Taguchi, Yokawa and Jin)

**May 31 (Thursday)**
**AM** (9:00 – 12:30)

7. Review biological parameters for blue shark stock assessment (Hiraoka, Yokawa and Jin)

**PM** (14:00 – 17:30)

8. Decide on model configuration for base case (Kimoto, Yokawa and Sippel)

**June 1 (Friday)**
**AM** (9:00 – 12:30)

9. Decide on tentative sensitivity analyses (Kanaiwa and Sippel)
10. Discuss future projection scenarios and BRPs (Kanaiwa, Yokawa and Sippel)

**PM** (14:00 – 17:30)

11. Work plan for blue shark stock assessment (Hiraoka, Kimoto and Kohin)
12. Review preliminary catch tables for mako sharks (Senba and Walsh)
13. Update Life History Tables (Senba, Wells and Hsu)

**PM** (17:30)

Reception for SHARKWG and PBFWG – at NRIFSF

**June 2 (Saturday)**

14. Review of ongoing research (Senba, Hiraoka and Wells)
15. Recommendations (Yokawa and Kohin)
16. Future work plan and SHARKWG meetings (Yokawa and Kohin)
17. Other matters (Jin and Kimoto)

**June 4 (Monday)**

18. Clearing of report
19. Adjournment

The above schedule is tentative and can be changed by the progress of discussions.

# Attachment 4: Age and Growth Workshop Report

**REPORT OF THE FIRST SHARK AGE AND GROWTH WORKSHOP SPONSORED BY**

***THE INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC***

**5-6 December, 2011**
**La Jolla, CA, USA**

## 1. Introduction

During the first meeting of the Shark Working Group (SHARKWG) of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), held April 19-21, 2011 in Keelung, Chinese-Taipei, Working Group members highlighted the need for better information on age and growth of the pelagic sharks of interest to the ISC. In particular, there is a high degree of uncertainty about key parameters associated with age and growth of many species including shortfin mako and blue sharks. The uncertainty stems largely from the range of methods used to assess shark ages, a lack of samples across all size classes, minimal interaction and cross-validation among shark ageing labs, and lack of standard protocols for sample collection and processing. Assumptions regarding age and growth for sharks, given their K-selected life history characteristics, can be highly influential in assessment modeling. Thus, the ISC SHARKWG organized a shark age and growth workshop to bring together specialists from ISC member nations to discuss methodologies and regional studies on age and growth of shortfin mako and blue sharks. A number of regional studies have been conducted and participants presented and discussed current and past methodologies for aging sharks. Recommendations on standards for collection and processing of vertebrae were developed and collaborations were established to collect and archive reference collections for cross validation in order to facilitate combining results of the various studies and coming up with consensus growth curves. A large number of references regarding age and growth studies on pelagic sharks and methods were compiled and many have been mentioned herein. A bibliography is available from the ISC SHARKWG Chair upon request.

## 2. Opening of Age and Growth Workshop

Dr. Russ Vetter, Director of the Fisheries Resources Division of the NOAA Southwest Fisheries Science Center welcomed workshop participants. He gratefully acknowledged the accomplishments of the SHARKWG during their meeting held the prior week and said he was encouraged by the collaborative nature of the new SHARKWG. He expects that efforts of the ISC SHARKWG to begin North Pacific-wide assessments on shortfin mako and blue sharks will greatly stimulate progress on life history studies, such as on age and growth.

Sixteen scientists from Chile (on behalf of the IATTC), Chinese Taipei, Japan, Mexico, USA and IATTC participated (Attachment 1). Suzy Kohin, Chair of the SHARKWG opened the meeting and described the workshop goals. A draft agenda was circulated (Attachment 2) that captured topics to be covered during the 2-day workshop, but in order to keep an open discussion, the sequence of presentations and discussions did not necessarily adhere to the sequence of topics on the agenda. In general, the group discussed methodologies early in the workshop, then heard from participants about regional age and growth studies on shortfin mako and blue sharks, spent several hours examining samples and demonstrating methods interactively, and finally developed recommendations and plans for collaborative studies.

Participants in the First ISC Sponsored Shark Age and Growth Workshop. Back row (L to R): Leonardo Castillo, Kwang-Ming Liu, Lisa Natanson, Hua Hsun Hsu, Suzy Kohin, Felipe Galván, Enzo Acuña, Yuko Hiraoka, Oscar Sosa. Front row (L to R): Kelsey James, Natalie Spear, Fernando Márquez, Yasuko Semba, Dave Wells.

**3. Presentations by Participants on Methodologies and Regional Studies**

A number of participants made presentations on methods they have used and lessons they have learned through experience. The presentations provided participants with an overview of various methods in order to formulate recommendations regarding sample collection, processing and analysis.

**Lisa Natanson (USA)** provided an overview of the age and growth research conducted on pelagic sharks at the NOAA Southeast Fisheries Science Center in Narragansett, Rhode Island. For several decades Lisa has been conducting shark age and growth studies. The work depends on cooperation with the recreational fishing community to tag sharks, return tags, and collect vertebral samples. The shark research program also collects samples opportunistically on research cruises, at tournaments and through cooperation with commercial fishers. Lisa has been involved with vertebral band count studies using x-rays, light microscopy, and silver and histochemical staining, OTC and bomb carbon age validation studies, tag recapture growth studies, and length frequency growth modeling. She has found that the best method to visualize vertebral bands varies between species. For blue sharks she prefers histochemical staining and for makos she prefers x-ray imaging or light microscopy of thin sections, although other methods may be adequate.

Lisa described the histochemical staining technique in detail since it is one of the preferred methods used in her lab and the methods are less known among the shark age and growth community.  The process involves extracting the water while paraffin is infused during a 12 step chemical process in an autotechnicon (an auto tissue processing machine).  Once embedded in paraffin, the samples are cut, stained with hematoxylin, and mounted on slides for imaging.  She also described the bomb carbon validation methods since she was the only participant who had worked on such a study.  For bomb carbon studies, participants were encouraged to search their archives for samples that may have been collected in the 1970s or 1980s.  It is important that samples used for individual bomb carbon studies within a study are from the same ocean.

Some of the pros and cons of the various methods were described.  For example, thin sectioning is very easy.  Adding a staining process may enhance bands, but adds work.  Specialized equipment, such as an X-ray is needed for some methods, and samples for bomb carbon validation (from the 1960s) are rare.  The histology methods Lisa employs are perhaps the most time consuming, and an autotechnicon is needed at a one time cost of roughly $10,000.  For the surface shadow method that Yasuko Semba and Hideki Nakano have used, sample processing is easy but requires treatment of vertebrae with NaOH.

Some of Lisa's general recommendations regarding sample processing include:
1) Try to have samples collected from the same part of the vertebral column for any given study. Ideally, vertebrae should be taken from behind the head, and historically Lisa's team has used vertebrae 15-20;
2) Freeze vertebrae (with neural arch intact, if possible) if not sectioning right away and preserve sections in 70% ethanol;
3) Extensive cleaning of the vertebrae prior to sectioning is not necessary;
4) For bow-tie sectioning, cut horizontally through vertebrae with the neural arch positioned at the top;
5) For precision - when reading vertebrae, have each reader work with only one species at a time viewing many until within reader variability is less than 10%, then compare between 2 readers by each reading at least 50 of the same samples; once agreement is achieved (CV less than 10%), then only one reader is needed for each sample.

**David Wells (USA)** described the NOAA Southwest Fisheries Science Center's shortfin mako sharks OTC validation study.  On research cruises off southern California, over 1000 sharks have been injected with OTC at a dosage of roughly 25 mg/kg.  Vertebrae from each recovered shark were sectioned, imaged under UV light, X-rayed using hard x-ray methods, and bands counted from high resolution images of X-rays.  Participants indicated that enhancing bands for mako sharks has consistently been challenging across labs and while the X-rays provided the best results in this study, others have used silver nitrate staining and surface shadow techniques.  The results for juvenile makos captured in southern California waters demonstrate a deposition rate of two band pairs per year.  This suggests a faster growth rate for juvenile mako sharks than has been found in studies elsewhere, including a bomb carbon validation study.  They also looked at growth estimated from size frequency data using both Multifan and MIXDIST and from tag-recapture data for 91 recaptured sharks using GROTAG; estimated growth rates were similar using the 3 different data sets. To identify differences among studies, it was emphasized that results of age (or bands) by size should be presented for all individual samples so that they can be compared with results from other studies. There was a lot of discussion about the potential for regional differences or perhaps an ontogenetic shift in banding patterns once sharks mature and devote more resources to reproduction rather than growth.

**Yasuko Semba (Japan)** described the surface shadow technique and its use in her studies of mako shark age and growth. Sample preparation is relatively simple. Bulk tissue is removed from individual vertebrae, then boiled and cleaned of surface connective tissue with NaOH for the centrum to be read. Longitudinal sections are made slightly offset from the focus such that banding on the flat surface of the corpus calcareum containing the focus could be used to further examine and verify banding patterns. The surface of the vertebrae is illuminated from two sides to create shadows and enhance surface ridges. Visible on the surface are alternating convex, corresponding to thin, and concave, thick bands. Edges are classified as either concave or convex for centrum edge analysis. In addition, based on measurements of the radius of the growth bands and centrum, marginal increment analysis (MIA) was performed for some vertebrae. In Yasuko's study, for some samples she compared results obtained from the shadow method to alizarin red stained thin sections, silver nitrate whole centra, and soft x-rays of half or whole centra. The bands are quite apparent, particularly for smaller sharks. There may be a tendency to under count for larger sharks as the alternating bands are narrower and more difficult to resolve.

**Alex da-Silva (IATTC)** described efforts to develop an integrated model to estimate fish growth using tag recapture and otolith (or any other hard parts) age data. Growth estimated independently from hard parts and tag recapture studies should not be compared because the error structures are different. The model fits direct age readings from hard parts simultaneously with the size-increment tag recapture data. Ages are estimated as parameters (A is age of each fish and is treated as a random variable). Tag recapture data needed are the sizes at tagging and recapture ($L_1$ at $t_1$ and $L_2$ at $t_2$). Only actual measured sizes should be used for the input data. The age at $t_1$ is first estimated and in later stages the model estimates an expected value for the size of the fish at $t_2$. Combining tag and hardpart age data in a single model overcomes some challenges if not all size classes are represented. For example, for bigeye tuna, the otolith samples collected by the IATTC are dominated by small fish with ages from larger (older) fish not being sampled. However, tag data exist for the larger fish so through the integrated modeling it is possible to obtain a better estimate of growth, in particular for the asymptotic size, $L_{inf}$. In all cases it is important to have sizes of some smaller fish in order to anchor the start of the growth curve ($L_0$). The AD Model Builder code can be made available to anyone interested. Computational time is very low with the bigeye data.

**Yasuko Semba (Japan)** described a new statistical method to validate growth band pair periodicity for shortfin mako sharks (see Okamura and Semba 2009). The model incorporates the circular characteristics of edge formation and can only be applied to the binary data obtained from centrum edge analysis (CEA). In general, MIA has been the most popular analysis for validation. MIA and CEA rely on the principle that a yearly sinusoidal cycle is exhibited when the density and/or width of the outermost increment of the vertebrae is plotted against month of capture if band pairs are deposited annually. However, for the indirect age verification methods of CEA and MIA, an appropriate statistical method had not been developed. In this study, three models were fitted to the CEA data and their goodness of fit was compared using AIC to determine whether the CEA demonstrated no cycle, an annual, or biannual pattern. A simulation based analysis was conducted to evaluate the performance of the new model.

The mako CEA looked sinusoidal in general, but there was a need to validate the pattern statistically. In a review of ageing methods, Cailliet et al. (2006) only identified 4 studies of many that used MIA methods and applied statistics to determine more rigorously if the seasonal or monthly variation observed was significant. However, the traditional statistical tests used only identified if a difference among months or seasons existed, and there was no confirmation of annual or biannual cycles. In Yasuko's study, the assumptions included: (*i*) discrimination between opaque and translucent growth bands is accurate; (*ii*) individual fish have identical and invariant growth band periodicities; (*iii)* the growth bands of each individual in the population are formed at similar times, even if multiple band pairs are formed within a year; and (*iv*) after a growth band pair has formed, the subsequent growth band pair forms within at least one year. The most influential control parameters in the model were $w_1$, which determines the timing of opaque band formation and $w_2$ which determines the duration of the opaque band formation within the year. AIC results indicated that the best model fit an annual cycle of band pair formation. The simulations demonstrated that the choice of the best model using AIC was robust, particularly for monthly sample sizes of 20 or more, and for lower values of $w_1$ and $w_2$. The authors produced the following code to assist with statistical verification based on edge analysis: https://sites.google.com/site/hiroshiokamura/program/agevalid.

The participants then discussed MIA methods in some detail. While there is some variation in methods used for enhancement among labs, all agreed that the marginal increment ratio is defined as $(VR–R_n)/(R_n–R_{n–1})$ where VR is the vertebral radius, $R_n$ is the radius to the last completed band, and $R_{n–1}$ is the radius of the next to last complete band pair. For both CEA and MIA, it was suggested that one should break out the data into smaller age classes for the validations in case the periodicity changes depending upon the ontogenetic status. Marginal increments are easiest to discern on smaller (younger) sharks. It is also important to have year round sampling.

**Hua Hsun Hsu (Chinese Taipei)** presented results of an age and growth study of blue sharks in the northwestern Pacific off Taiwan. Vertebrae from the caudal peduncle region sampled by observers were used for aging. Growth band pairs were read via images photographed from X-ray films. Marginal increment ratio and edge analysis indicated that the growth band pair (including translucent and opaque bands) on vertebral centra was formed once a year. Sex specific growth differences were found and were consistent with many other studies of larger males than females. Three growth models were presented and all had very similar overall fits (AIC), but the von Bertalanffy model was best for both sexes. The study had few small sharks with only one fish around 80 cm TL and the remaining samples older than 4 years of age (>160 cm TL). It was encouraged that additions of smaller sharks from the eastern and western Pacific be integrated into this study to have a more complete growth model. Lastly, a gestation period of only six months was proposed, but the group discussed previous studies and agreed that 9-12 months was more realistic.

**Felipe Galván (Mexico)** described the study of Ribot-Carballal et al. (2005) that used silver nitrate stained vertebrae and CEA to determine that the band pair deposition rate of makos off Baja California Sur was one per year. The small sizes of length frequency modes found in Mexico off Baja are similar to the sizes of makos studied by NOAA Southwest Fisheries Science Center staff in the USA.

**Fernando Márquez (Mexico**) discussed studies on the biology of shortfin makos caught in longline fisheries in the Mexico EEZ. The majority of makos encountered were juveniles (less than 200 cm FL). They used the growth curve of Ribot-Carballal et al. (2005) to assign ages 0 and 1 to sharks based on length and identified a large area off Baja California Sur where neonates are relatively common suggesting a nursery area.

**Oscar Sosa-Nishizaki (Mexico)** described his ongoing length frequency and biological sampling of blue and mako sharks off northern Baja California. Some of his students are using surface and shadow techniques to read blue shark vertebrae. In his studies, the sampling is seasonal and focused to just a few months, and the catch of blue sharks in the artisanal fisheries tends to be sharks of the same size classes of relatively small fish each year. Makos are much less frequent in the catch than blue sharks, so his group is not likely to be able to conduct aging studies on makos.

**Leonardo Castillo (Mexico)** described ongoing conventional tagging efforts in the San Vizcaíno Bay area. For several years he has been tagging mostly juvenile blue and mako sharks, but so far few have been recovered. He would like to begin OTC tagging in the future. His program has been monitoring shark catch in the San Vizcaíno Bay for several years. He has developed a rapport with local fishermen and they have been instrumental in returning a number of tags and vertebrae for the NOAA Southwest Fisheries shark tagging program.

The NOAA researchers commented that OTC tagging is relatively inexpensive, provided you have access to a large number of sharks, but the rewards are costly. Currently they offer $100 for return of the vertebrae and recapture data, but the program needs good outreach in order to ensure high quality data and sample collection. In some cases they have found that vertebrae and data returned are not consistent with the data collected at the time of tagging (e.g. fishers report recapturing a blue shark and send a tag from a mako shark; returned vertebrae do not have OTC marks or are from sharks far larger or smaller than expected). They are working with their international colleagues to try to improve awareness of the studies to enhance the quality of information collected.

A general discussion that followed the presentations by Mexico concerned the different methods for length frequency analysis, and the majority of participants had experience with Multifan. Other methods were mentioned such as a multinomial model by Haddon which separates normal distributions. The main problem with this method is that one must enter the initial parameters and these may be subjective. In addition, there is no way to confirm that one is correctly separating the modes.

**Enzo Acuña (Chile)** presented objectives of biological research in pelagic sharks in the southeast Pacific. Since very little is known, his group has been attempting to learn about mako, blue, and porbeagle sharks throughout the region off Chile using several different fisheries. The Chilean swordfish fishery catches smaller mako sharks nearshore while China and Spain tuna longliners catch larger mako sharks offshore. Enzo presented a two-phase growth model by sex for both the mako and blue sharks. Blue sharks appear to reach sexual maturity at 5-6 years of age at which time the inflection point of the two-phase growth model appeared. The group considered the two phase growth models presented and concluded that more work needs to be done in order to demonstrate that the models are defensible biologically, compare between models, and identify the most parsimonious ones. All acknowledged that growth rates likely vary across life history stages. In particular, it is unlikely that growth of pups in utero follows the same pattern as after birth. In addition, calcium deposition rates may change depending upon life stage; pregnant females may allocate greater amounts of calcium to pups with less going into the skeleton. Examining alternative growth models is considered a high priority research objective.

**Lisa Natanson and Kelsey James (USA)** demonstrated use of a spreadsheet developed by Ken Goldman to assess within and between reader agreement using contingency tables. Quantitative documentation of the variability among readers is an important part of any aging study. The spreadsheet serves as a template for entering up to four independent age readings and for calculating percent agreement, and running the comparison tests of Bowker, McNemar, and Evans-Hoenig. Ken provided his spreadsheet and encouraged its use and distribution widely. The spreadsheet can be obtained from the ISC SHARKWG Chair upon request.

## 4. Recommendations or "Best Practices"

After hearing from the age and growth scientists on the various past and ongoing studies and sharing experiences, the following list of recommendations for blue and mako shark aging studies was developed.

*Sample Collection:*

- Plan collections to sample across all size classes and both sexes. Examine fishery data from other oceans and hemispheres for similarities in oceanographic and geographic features to guide where to look for certain life stages.
- Collect vertebrae from behind the head (roughly vertebrae 15-20) because this is where most groups have been collecting. The most important thing is to try to be consistent within a study.
- Freeze vertebrae rather than fix them if not processing right away, and if not sectioned, keep in freezer.

*Vertebral Aging Methods:*

- Optimal enhancement techniques vary across species. If possible, try several techniques to determine the best method.

*Processing Vertebrae:*

- Processing depends on the aging method. For surface reading, vertebrae need to be well cleaned; for sectioning, extensive cleaning is not necessary.

- If cutting vertebrae in half for bowtie sections, cut along the horizontal axis (neural arch at top).
- Store thin sections in 70% ethanol.

*Reading Vertebrae:*

- Use image enhancing software such as ImagePro and tweak contrast and emboss to optimize images.
- When reading vertebrae, only work with one species at a time and ground yourself first by viewing many.
- Validate reading internally (i.e. read twice or more).
- Validate a second reader with a first by each reading at least 50 samples. If CV < 10 %, can proceed with one reader.
- First band pair counting starts at the medial edge of the first narrow/more calcified band.
- Be consistent as to where the vertebral radius is measured (i.e. if you have a squished vertebrae, always measure consistently relative to the squished section).
- For all vertebrae include:
  - total radius and diameter for MIA;
  - radius from focus to medial edge of birth band;
  - radius to medial edge of last forming band pair (i.e. the last band pair starting with narrow/more calcified band but not complete to edge);
  - radius to medial edge of last fully formed band pair;
  - band pair counts;
  - edge readings for CEA;
  - confidence score.

*Analysis:*

- For all studies, back calculate for the catch and birth date rather than have fish assigned to rounded ages (see Goldman et al. 2006).
- Provide information on reading precision and biases determined through the use of contingency tables.
- Do not extrapolate growth curves beyond the size range sampled.
- Plot the actual size at age data for comparison with other studies.
- Estimate male and female growth separately, and combined.
- Compare different types of growth models and use statistical selection criteria (such as AIC) to choose the best model.
- Provide statistical verification for CEA and MIA.
- Conduct verification analyses separately for different size classes and sexes if possible.
- MIA and CEA require year round sampling.

*Tag-Recapture and Length Frequency Methods:*

- Use only data from sharks that have been reliably measured.
- Use appropriate statistical methods to combine growth curves from tag-recapture, length frequency analysis and vertebrae aging recognizing that the error structures are not the same.

## 5. Work Plan for Collaborations

Age and growth specialists from the ISC members present (Japan, Mexico, Taiwan, USA) agreed to collaborate to improve the information available for shortfin mako and blue shark stock assessments. The group identified priorities and came up with a general work plan that includes the following steps.

1. Compare all existing studies to determine the methods used and data gaps. Determine whether some studies can be combined to fill gaps in regional studies. Significant progress was made at this workshop in identifying past and ongoing work.

<u>Current methods in use (shortfin mako)</u>

Mexico and Japan are using the centrum-face shadow technique. Mexico is using thin sectioning techniques, with and without staining. Taiwan and USA are using x-ray techniques on section-bow ties and centrum-faces.

<u>Current methods in use (blue shark)</u>

Mexico is currently using thin sectioning techniques. Japan (Nakano) used whole stained vertebrae. Taiwan is using x-rays. USA (Natanson) is using thin sectioning techniques with histological processing.

2. Develop reference collections of blue and mako shark vertebrae to cross-validate band readings between labs. At least 50 vertebrae samples with a minimum of 4 vertebrae per sample from sharks of various sizes are needed. Each nation identified which samples they could potentially provide. Ideally 5 sharks of each sex by size range will be collected.

<u>Shortfin mako sampling</u>

70-100 cm TL: USA
100-150: USA, MX
150-200: Japan
200-250: Japan
250-300: Taiwan, Japan

<u>Blue shark sampling</u>

60-100 cm TL: USA
100-150: USA, MX
150-200: Japan
200-250+: Japan, Taiwan

3. Each lab should process each reference vertebra as they would for their ongoing studies. A template spreadsheet for data collection will be provided to ensure that all labs collect the recommended data (see recommendations above). High quality images and/or processed samples should be shared in order to help determine the best enhancing methods. Contingency tables will be used to compare readings between and within labs.

4. Once cross-validation has been completed, compare data from regional studies. Combine data when directly comparable to have better representation across sizes and sexes. To create combined growth curves, raw size and age data for each study are needed.

5. For future analysis, agree upon a single methodology that consistently provides the most reliable readings for each species given the resources available (i.e. equipment and expertise). Through the collaboration, individual labs could take on a different aspect of the studies (for

example, one lab could process all vertebrae with band reading being carried out in other labs). This would eliminate the need for all labs to have the same equipment and expertise. Some of the pros and cons of several of the techniques to consider are shown in the table below. Once the reference collections are analyzed and images shared and compared, it may be easier to decide upon a single method for each species.

| Technique | Pros | Cons | Equipment Needed | Notes |
|---|---|---|---|---|
| Thin (microtome) sectioning | Easy | | Microtome, Microscope | |
| Staining process added to thin sectioning | Improves upon thin sectioning | More labor intensive than simple thin sectioning | Microtome, Microscope | |
| Whole centrum with silver nitrate | | Chemical disposal issues | Microscope | See studies by Semba and Ribot-Carballal |
| X-ray (gross sectioning or whole centra) | Relatively easy | Chemical disposal issues | Microtome, X-ray and processor | See studies by Wells, Hsu, Acuña and Cailliet; consider performance of hard vs. soft x-ray |
| Histology | High quality images | Time consuming; resolves a lot of structure and may overestimate counts | Autotechnicon, Microtome, Microscope | See Natanson's studies; works well for blue sharks but not as reliable with mako vertebrae |
| Shadow technique | Easy | Requires some chemical treatment; may underestimate counts on large sharks as alternating bands are narrower | Light, Microscope | See Semba's studies |

6. Examine direct and indirect validation studies of mako sharks to resolve the band pair deposition rates discrepancy. Once comparing reference collections, are the band pair readings between labs the same or can differences explain the observed results? The SWFSC and NRIFSF will exchange samples used in their respective validation studies and verify readings between labs since their studies have sharks of similar sizes, but show conflicting results. If the two-bands per year hypothesis is true, at least for younger fish or in the eastern Pacific, or if there is two phase growth, it is important to indentify a biological explanation for the band deposition patterns and potential ontogenetic switch. If the pattern consistently changes at a specific point in development, the point of transition from two band pairs to one per year is important for modeling growth. Further research into the timing of formation of each band is necessary.

7. Validation studies were identified as a high priority. Participants encouraged OTC tagging whenever possible and bomb carbon dating if suitable samples are located. The SWFSC has vertebrae from OTC tagged sharks ready to process and they will begin analysis right away and report on findings at the May SHARKWG meeting.

**6. Proposed Timeline**

By May 2012 SHARKWG meeting – Interlab comparison of Japan and USA validation study samples
By May 2012 SHARKWG meeting - Analytical comparison of existing blue shark curves (original data if possible)
By end of May 2012 - Have reference collections for both mako and blue sharks
By end of August 2012 – Process reference samples and share readings and images

**7. Adjournment**

The ISC SHARKWG Chair thanked all participants for attending and contributing to a very productive meeting. The meeting was adjourned late afternoon, December 6, 2011.

# Attachment 1. List of Participants

**Chile**

Enzo Acuña
Universidad Catolica del Norte – Chile
eacuna@ucn.cl

**Chinese Taipei**

Hua Hsun Hsu
National Taiwan Ocean University
hsuhuahsun@yahoo.com.tw

Kwang-Ming Liu
National Taiwan Ocean University
kmliu@mail.ntou.edu.tw

**Japan**

Yuko Hiraoka
National Research Inst. of Far Seas Fisheries
yhira415@fra.affrc.go.jp

Yasuko Semba
National Research Inst. of Far Seas Fisheries
senbamak@affrc.go.jp

**Mexico**

José Leonardo Castillo-Géniz
Instituto Nacional de Pesca (INAPESCA)
Leonardo.castillo@inapesca.sagarpa.gob.mx
ptiburon@yahoo.com.mx

Felipe Galván-Magaña
Centro Interdisciplinario de Ciencias Marinas (CICIMAR)
galvan.felipe@gmail.com

Fernando Márquez-Farías
Universidad Autonoma de Sinaloa
fermqz@yahoo.com

Oscar Sosa-Nishizaki
Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE)
ososa@cicese.mx

**United States**

Ellen Freund
University of San Diego
ellen.freund@cox.net

Kelsey James
San Diego State University
kelsey.c.james@gmail.com

Suzanne Kohin
NOAA Southwest Fisheries Science Center
Suzanne.Kohin@noaa.gov

Lisa Natanson
NOAA Northeast Fisheries Science Center
Lisa.Natanson@noaa.gov

Natalie Spear
NOAA Southwest Fisheries Science Center
Natalie.Spear@noaa.gov

David Wells
NOAA Southwest Fisheries Science Center
David.Wells@noaa.gov

**Inter-American Tropical Tuna Commission**

Alex Aires-da-Silva
IATTC
alexdasilva@iattc.org

# Attachment 2. Provisional Agenda

**SHARK AGE AND GROWTH WORKSHOP**

**SPONSORED BY**

***INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC***

**5-6 December, 2011**
**SWFSC La Jolla Shores Drive Green Room**
**La Jolla, CA, USA**

Opening of Age and Growth Workshop: 5 December, 9:00

- Welcoming Remarks – Dr. Russ Vetter, Director of Fisheries Resources Division, NOAA Southwest Fisheries Science Center
- Introductions
- Meeting Arrangements

Overview of ISC SHARKWG and Meeting Objectives – Suzy Kohin

**Day 1 – Presentations and discussions**

<u>Vertebrae enhancement:</u>

- thin sectioning
- light microscopy
- histology
- silver staining
- x-ray imaging
- surface shadow method

<u>Direct and indirect validation methods:</u>

- OTC validation
- bomb carbon
- marginal increment analysis
- centrum edge analysis

<u>Analysis:</u>

- software for imaging
- software for growth model development
- modeling size frequency data
- growth from tag-recapture – see Simpfendorfer 2006
- Von Bertalanffy versus use of alternative growth curves
- addressing uncertainty - APE/D/CV bias graphs and contingency tables

- back calculation from vertebrae to age zero – see Goldman et al. 2006 for a description of several methods.

Regional age and growth studies of blue sharks:

Japan – Nakano's studies presented by Yasuko Semba
USA – Lisa Natanson
Chinese Taipei – Hua Hsun Hsu
Mexico – Felipe Galván
Chile – Enzo Acuña

Regional age and growth studies of shortfin mako sharks:

Japan – Yasuko Semba
USA – Lisa Natanson, David Wells
Chinese Taipei – Hua Hsun Hsu
Mexico – Felipe Galván

Others?

**Day 2**

Hands on demonstrations, methods sharing
Development of a "best practices" document
Develop a plan for collaborations on shortfin mako and blue sharks in the N. Pacific

# Attachment 5. Revised Workplan

**Blue Shark Assessment Work Plan as of July 13, 2012**

**By August 31 Data Deadline:**

1. For time series 1971-2010, each nation submits catch (in mt whole weight) of blue sharks in the North Pacific including:
    a. official retained catch (for Plenary Table 1)
    b. estimated total catch
    c. estimated discards
    d. total dead removals
    e. indication of reliability for each catch time series (e.g. CIs if multiple estimation procedures are used, or some explanation of uncertainty based on best available information).
2. Each nation submits individual size data by fishery, by year, by sex in PCL.
3. Chair works with SPC and IATTC, other national delegation leads, and other species WG Chairs to come up with effort data for fisheries with non-reported catch.
4. Chair contacts Dr. McAllister regarding potential collaboration on Bayesian Surplus Production modeling in Yokahama.
5. Chair contacts Dr. Kleiber to request nation specific drift net fishery data and original size data.

**Between August 31 and Winter Meeting:**

1. WG members will work to estimate catch for fleets with missing data. US will take the lead on estimating catch for Mexico and non-Asian fleets in the EPO. Japan will take the lead on estimating catch for the missing Asian fleets and WCPO fleets.
2. All nations update or revise submitted data to include data for 2011.
3. All nations prepare detailed working papers that describe the catch and CPUE estimation procedures.
4. All nations prepare detailed working papers that describe use of the size data.

**Mid to Late January: final data prep meeting (tentatively in the US)**

1. All data (1971-2011) and procedures reviewed and agreed upon.
2. WG modelers provide proposal for how to incorporate uncertainty in r and other input parameters in assessment.
3. Review and accept catch estimates for non-reporting fleets.
4. Finalize all data, and review preliminary runs for production model and any alternative models put forward.

**Late April: Blue shark assessment meeting (tentatively in Japan)**

1. Conduct base case assessment modeling (subgroup meeting in advance of WG meeting not needed; assessment will be conducted in advance by e-mail correspondence).
2. Review alternative modeling results.
3. Conduct future projections.
4. Results with respect to MSY and potentially other BRPs will be prepared.