SCIENTIFIC COMMITTEE
NINTH REGULAR SESSION

6-14 August 2013
Pohnpei, Federated States of Micronesia

REPORT OF THE SHARK WORKING GROUP WORKSHOPS
May 2012, January and April 2013

WCPFC-SC9-2013/ SA-WP-11a
Associated with the NP Blue SharkStock Assessment Report

ISG Shark Working Group[1]

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

Annex 8

REPORT OF THE SHARK WORKING GROUP WORKSHOP

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

16-24 April , 2013
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 16 - 24 April, 2013. The primary goal of the workshop was to complete a Bayesian Surplus Production (BSP) stock assessment for blue sharks in the North Pacific and develop tentative conservation information for the ISC Plenary. Other goals included 1) developing plans for a preliminary age-structured assessment of blue sharks in the North Pacific that will be completed by the next SHARKWG meeting in July and 2) gathering information and discussing assessment plans for shortfin mako shark.

Dr. Hitoshi Honda, the Deputy Director of NRIFSF, welcomed SHARKWG participants. Meeting participants included Canada, Chinese Taipei, Japan, Secretariat of the Pacific Community (SPC), United States of America (USA) and the ISC Chairman (Attachment 1). In his address, Dr. Honda announced that the NRIFSF has a new Director, and that research on tuna and tuna-like species continues to be a focus of the Shimizu lab. He thanked the participants for their continued dedication to the ISC and this working group. Sharks are important in the fisheries of Japan, in particular in Miyagi prefecture where Kesennuma fishing port has historically been the major unloading and processing port for sharks. The port was mostly destroyed during the Great East Japan Earthquake, but the fisheries operating out of that port are beginning to recover. Dr. Honda wished the group success in completing the blue shark assessment and the other planned work. He acknowledged the need for the working group to work hard through the weekend in order to achieve the meeting goals, but he also said he hoped participants will have some time to enjoy the spring in Shizuoka. Now is the time for the first harvest of green tea which is considered very special in this region.

2.0 DISTRIBUTION OF MEETING DOCUMENTS

Seven working papers and one information paper were distributed and numbered (Attachment 2) as well as a number of background papers. Several oral presentations were also made during the meeting. 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 paper ISC/13/SHARKWG-2/03 declined posting on the ISC website because the paper is being prepared for publication elsewhere.

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 WG members. The approved agenda (Attachment 3) indicates the rapporteurs for each item in parentheses.

5.0 SUMMARY OF THE JANUARY 2013 WORKSHOP

Suzanne Kohin, Chair of the SHARKWG, provided a summary of the January 2013 workshop held in La Jolla, California USA. The workshop was the final data preparatory meeting for the BSP assessment of blue shark in the North Pacific. Goals of the workshop were to agree to the data to be used in the north Pacific blue shark assessment, finalize all time series provisionally, establish an assessment data submission deadline, estimate catch of fleets that have not provided data, and conduct some exploratory Bayesian Surplus Production (BSP) runs with the provisional data. Participants included WG members from Japan, Chinese Taipei, IATTC and USA, and a scientist from Mexico. Nine Working Papers and one Information Paper were submitted.

The WG reviewed all the previously submitted catch data as well as some updates to several fishery time series for the USA and Chinese Taipei. Catch time series were developed for the longline fisheries of Korea and China, members that were not in attendance. Two time series of catch for the Mexico fisheries were reviewed and the WG agreed upon a method to estimate Mexico's catch based on research provided by the USA and the scientist from Mexico. The WG established a table of criteria to use for evaluating abundance indices being considered for use in the assessment. After examining the candidate indices and their diagnostics, the WG decided to use the two Japan Kinkai shallow longline indices (early and late) in the base case assessment and to use the Hawaii deep-set longline fishery index in place of the Japan late index as a sensitivity run. Other input parameters were discussed and values for the base case assessment were established. The WG finalized plans for the blue shark assessment to be completed at the April meeting.

The SHARKWG Chair also noted that since the January meeting, several members of the WG have decided to move forward with a collaborative preliminary age-structured assessment of blue shark in the North Pacific Ocean with efforts being led by Joel Rice of SPC and Kevin Piner of NOAA Southwest Fisheries Science Center (SWFSC). The preliminary assessment will be a collaborative ISC SHARKWG product and presented to the SHARKWG in July.

6.0 BAYESIAN SURPLUS PRODUCTION MODELING OF NORTH PACIFIC BLUE SHARK

6.0.a Outstanding issues with catch time series

At the January 2013 SHARKWG workshop, the north Pacific blue shark catch for Korea and China were estimated and were reported in the Workshop Report. The BSP assessment report will use text from the January 2013 Workshop Report summarizing the methods since Working Papers were not produced. An information paper was received describing the methods used to estimate Mexican blue shark catch.

Unofficial blue shark catches estimations for the Mexican Pacific (1976-2011) (ISC/13/SHARKWG-2/INFO-01)

<u>Summary</u>

This document presents estimates for the blue shark catches landed at ports or fishing camps in the coasts of five Mexican states, located in the Pacific, for the period of 1976 to 2011. Mexican shark catch statistics by species were not available until 2006, so past blue shark catches have to be estimated. Here an unofficial estimation using different sources of information is suggested. This estimation assumes that blue shark has been represented in total catches with different proportions through time and those proportions are based on species composition data obtained from the scientific literature or by using more detailed local statistics. In Mexico, blue sharks are caught mainly by the artisanal and middle size long-line fisheries, which target pelagic sharks or swordfish. Catches that were landed in the past by the former large size vessel longline fisheries and the drift gill net fisheries were taken into consideration to construct the historical series. Historically, blue shark was not an important species in past catches; however, catches have increased from levels of less than 500 t in the 1970s to around 1,000 t in the 1990s, and to around 4,000 t recently. Estimates indicate that blue sharks are caught mainly off the western coast of the Peninsula of Baja California. Also, in order to facilitate the assessment by the SHARKWG, information from blue shark size frequencies in the catches is added, from information of studies analyzing, mainly, the artisanal fisheries in the region. The results of these studies suggest that a large proportion of the catch is represented by juvenile sharks.

<u>Discussion</u>

At the January 2013 SHARKWG workshop, preliminary estimates of blue shark catch by Mexico based on analyses similar to those in this Information Paper were reviewed and provisionally accepted. Shark aggregated landings data were provided by INAPESCA but further work was needed to derive blue shark catch. Catches estimated in January and for this revised time series were not official submissions, and were not collated by INAPESCA scientists; however, they were considered to represent the best available estimates. The data presented in January 2013 was further amended to include estimated discards from midsize vessel driftnet fisheries and catch from Joint Venture foreign longline fleets. The discard data and Joint Venture longline data were sourced from published documents and confirmed with O. Sosa-Nishizaki as reasonable estimates.

The SHARKWG received the revised landing estimates in the Information Paper provided for this meeting. Although past the deadline for data submission, the WG agreed to consider them for use in the assessment. These revised estimates result in lower landings from 1996 onwards, although the differences are minimal. The revised landings estimates are well documented in the Information Paper, while the preliminary estimates were only presented orally at the January 2013 workshop. **In order to have documented, best estimates, the SHARKWG agreed to**

use the new revised landings estimates along with the additional drift net discard data and Joint Venture longline catch derived from the published documents. It is important to note that these independent estimates are unofficial, but are considered the most complete and current estimates. Updating the Mexico catch based on these estimates for the BSP model will not dramatically change the assessment results since the difference between preliminary and revised landings are minimal, and the Mexico catch represents only 4.8% of the total north Pacific blue shark estimated catch.

The SHARKWG Chair noted that some blue shark data were received from INAPESCA and that they hoped to have a scientist in attendance at the current meeting, although his travel fell through at the last minute. INAPESCA has indicated that they are working on estimating blue shark catch for all fleets and ports, and are also collating shortfin mako catch, so the WG should have improved data for the next stock assessments. **The SHARKWG appreciates the efforts of Mexico to join the WG meetings and provide shark data and endorsed continued collation of Mexico blue and shortfin mako shark data.**

WCPFC non-ISC Member Longline Catch

<u>Summary</u>

The Chair raised the issue about potential double counting between longline data provided to the WCPFC for non-ISC members and Taiwan's reported small longline fishery catch. This is because Taiwan has reported landings into their ports that include some from foreign flagged longline vessels, which may have also been reported to the WCPFC by the foreign fleets directly. At present there is no evidence to suggest significant double counting, although this issue is largely intractable given the current information regarding landings by vessel.

<u>Discussion</u>

It was clarified that the WCPFC catch data provided, which includes discards, are specifically only catch in the north Pacific and likely only for the Federated States of Micronesia, Kiribati, Marshall Islands, Papua New Guinea and Vanuatu. There was concern that these data might be included in the Taiwan catch, either from Taiwanese vessels fishing under the non-member nation flags and landing catch in Taiwan or from non-member nation vessels landing in Taiwan. There is not information on what flags the Taiwanese vessels are using, so filtering of the WCPFC data is not possible. There is also no information on the relative effort on foreign flag landings compared to Taiwan flag landings in Taiwan. The WCPFC data are not port-specific so these data cannot be filtered to address the concern of Taiwan landings.

It was noted that even if all the catch provided by WCPFC is double-counted, it in most years would be less than 15% of the catch provided by Taiwan. The SPC representative, based on his knowledge of the non-ISC member nation's fisheries, believes that very little of the WCPFC data is likely to come from Taiwan landings and it was suggested that both the submitted Taiwan and WCPFC data be used in the BSP base case. **The SHARKWG agreed to use both the WCPFC and Taiwan data in the BSP base case, and to continue to investigate the problem of teasing out foreign fleet landings from the Taiwan data for future assessments.**

Catches of blue sharks from U.S. West Coast recreational fisheries during 1971-2011 (ISC/13/SHARKWG-2/01)

Summary

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 shortfin mako and blue sharks, but the predominant method used by recreational anglers to target sharks 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. This is an update to preliminary estimates of blue shark catches from recreational fisheries on the US West Coast provided in 2012 to the SHARKWG to provide a US recreational catch time series for the ISC North Pacific blue shark assessment.

Discussion

The SHARKWG acknowledged that the methods presented in this Working Paper were agreed to at the January 2013 workshop. This paper provides documentation for the additional methods used to expand the time series to the early years and to include estimates of additional mortality of discarded sharks. **The SHARKWG reiterated that it accepted these data for use in the BSP base case.**

6.0.b Outstanding issues with CPUE time series

Analysis of North Pacific Shark Data from Japanese Commercial Longline and Research/Training Vessel Records (Clarke et al. 2011)

Summary

The SPC representative presented an overview of the methods and results of this WCPFC Working Paper. The presentation and discussion focused on the standardized CPUE time series developed from Japanese Research Training Vessel (RTV) records, since the index for WCPFC Region 2 was put forward to the SHARKWG for consideration for the blue shark assessment. The North Pacific longline operational data from research and training vessel surveys (1992-2009) were provided by Japan for onsite analysis in Shimizu in early 2011. Both sets required filtering to remove records believed to under-report actual shark catches. The analysis was based on 7,974 sets representing 10 vessels in the research and training vessel surveys. Application of different filtering methods could result in larger sample sizes, but this benefit would need to be weighed against the probability of increasing the presence of under-reported catches in the filtered database. When considering the selection and application of data filters it is important to recall that if vessels began releasing/discarding (and not reporting) sharks in recent years, filtering may not fully correct for this effect, and declining catch rate trends would thus potentially be exaggerated. On the other hand, if reporting practices do not change but shark stock abundance actually does diminish over time, declining catch rates would be expected. The challenge is to apply a filter which removes those catch records which are under-reported, but retains those which are low but accurate. Filtered data were examined in terms of five potential indicators of fishing pressure: distribution, catch composition, catch rate, targeting and size. Blue sharks showed declining standardized catch rates (in Region 2) using RTV data.

Discussion

The RTV data (1993-2009) are from WCPFC Regions 2 and 4, and have previously been reviewed by the SHARKWG (Takahashi et al. 2012; ISC/12/SHARKWG-1/06) and not considered for use as an index to be included in the BSP. The majority of observed RTV sets are in Region 4, but in the later part of the time series there are increased observations in Region 2. There is a seasonality to Region 2 data, with most sets occurring August-November. The SHARKWG was concerned that despite having the majority of observed RTV sets in Region 4 and indication that there are substantial effort and catch in that Region in all years, that the standardized CPUE based on filtered data show that the model did not adequately fit the data. This result casts serious doubt on the filtering and standardization methods, and based on this the SHARKWG expressed reservations about accepting the results in Region 2 for interpretation since it is based on the comparable analyses. The SHARKWG noted that Clarke et al. (2011) acknowledge that the filtering and standardization models presented here should be considered a starting point for further analysis, implying that these are preliminary results only and should not be used as an abundance index in any assessment. The document outlined that additional improvements (i.e. alternate definitions of covariates and combinations) need to be are explored.

The SHARKWG discussed problems with interpreting and analyzing RTV data. The RTV have different behavior than the commercial fishing fleets; the RTV avoid commercial vessels and fish either before or after the commercial vessels. Also based on the Gulland Index, where values well below 1.0 are typical when avoidance of a species is occurring, the fleet appears to avoid sharks. The RTV have unique strategies to deal with safety concerns for high school students, and the target destination is often Hawaii. These elements suggest that the RTV data cannot be viewed analogous to a survey, or fishery-independent survey. Another issue is that the RTV data come from an area that is a mixing area, where in one season the area is occupied by sub-adults and in another season it is occupied by adults. The treatment of this index will be difficult in a size-based model. Overall, the utility of the RTV sets as abundance indices in these Regions is questionable, and they should not be used for this purpose.

The SHARKWG discussed the implications of the declining trend in the standardized CPUE time series in Region 2. The RTV sets in both Region 2 and 4 are deep sets. The SHARKWG has already reviewed standardized CPUE time series from the Hawaiian longline fisheries for these Regions. The Hawaiian deep set longline fleet operates in Region 4, while the Hawaiian shallow set longline fleet operates in Region 2. Both standardized CPUE time series show decreases, so the decrease in the RTV data for Region 2, if it were representative, could reflect a central Pacific trend. The Hawaiian deep set CPUE time series has been selected by the SHARKWG to include in the BSP as a sensitivity run. So this regional trend is already captured, which also suggests that there is no need to utilize the RTV data given the concerns regarding the methods of filtering and standardization.

The SHARKWG noted that the WCPFC background document itself notes that if changes in data recording and/or discard rates changed in recent years, then the declining trend would be an exaggeration. Japan confirmed that there have been changes in the pattern of recording, including reporting of discards with species identification and in the number of discards. In the 1990s the catch by species would have been more reliable than it is now. The precision of identification of species has deteriorated since 2000, mainly because discards (mostly live releases) without species identification, increased. In addition, due to national regulations relating to finning bans, fewer sharks are now brought on board. All of these changes in behavior and practices would result in a decline in reported catch, and would account for the apparent decline in CPUE.

The diagnostics reported in the background document were not comprehensive, and elements such as deviance tables and CVs were not provided. For the diagnostics that were provided, the SHARKWG expressed concerns of the lack of linearity in the q-q plots, residual patterns, which coupled with small sample sizes, all suggest that these should be treated as preliminary analyses only and not used in any assessment models. The SPC noted that in an age-structured model (specifically SS3 model), the Region 2 RTV index could still be useful in an alternative run since it indexes a somewhat different area from the Hawaiian deep set index, and it can be down weighted. The SHARKWG noted that a fully integrated model would require the catch and size data from the RTV fishery as well. Some RTV size data have already been compiled by the SHARKWG, and it was further suggested that the selectivity could be assumed to be similar to the Hawaiian deep set data for the same region.

The SHARKWG decided to examine the RTV CPUE index using the same criteria as established at the January workshop, and thus tabulated information about the index along with the other 6 indices that had been considered (Table 1). **Based on the selection criteria, and the lack of time to properly evaluate the index, the WG rejected the RTV indices for use in the BSP model. It was also noted that indices for consideration should have been provided in time for the final data prep meeting.**

Table 1. Characteristics of candidate abundance indices proposed to represent relative abundance of north Pacific blue shark and criteria used to evaluate the indices. This table was created during the January 2013 meeting and updated at this meeting to include the proposed RTV index.

	Hawaii Deep-set Longline	**Hawaii Shallow-set Longline**	**Taiwan Large-scale Longline**	**Taiwan Small-scale Longline**	**Japan Early Offshore Shallow (Hokkaido & Tohoku)**	**Japan Late Offshore & Distant Water (Hokkaido & Tohoku)**	**Japan Research Training Vessel Region 2 Index**
Quality of Observations	Good because observer data is used with ~5-20% observer coverage and discards are recorded	Good because observer data is used with ~5-100% observer coverage and discards are recorded	Good because observer data is used but recorded discard data may not be representative	Catch data are representative but effort data were estimated	Relatively reliable because 94.6% filtered data applied, logbook data more reliable by filtering	Relatively reliable because 94.6% filtered data applied and logbook were validated by training vessel and observer data	Species ID believed good until 2000, quality declining since, after 2005-2006 discarding may be underreported and data quality considered bad
Spatial distribution	Relatively small (Areas 4 & 5)	Relatively small (Areas 2 & 5)	Large (Areas 1-5)	Large (Areas 1-5)	Medium (Area 1 & 3)	Large (Area 1, 2, 3 & 4)	ISC area 2, and some area 4
Size/age distribution	90% of catch from females: 175-275 cm TL; males: 175-300 cm TL	90% of catch from females: 100-275 cm TL; males: 100-300 cm TL	60 to 340 cm TL	90 cm to 320 cm TL	no information	90-170 cm PCL	120-200 PCL, median 160
Statistical soundness	Yes. Delta-lognormal model was used and model diagnostics were good	Yes. Delta-lognormal model was used and model diagnostics were good	Some diagnostics provided	Diagnostics provided	Yes	Yes	No. Strong patterns in residuals and departure from normality in qq plot; not enough information provided (e.g. deviance table,

							CV's)
Temporal coverage	1995-2011	1995-2001; 2004-2011	2004-2010	2001-2003; 2005-2010	1976-1993	1994-2010	1993-2008
Catchability Changes (due to management, fishing practices, etc.)	Finning ban from 2000 (probably limited effect on Q)	Ban in shark finning from 2000 (probably limited effect on Q); Shallow-set longline ban from 2001-2004 (likely affects Q); hooks and bait requirements after 2004; limits on turtle bycatch	Ban in finning from 2005 (probably limited effect on Q)	Ban in finning from 2005 (probably limited effect on Q)	No regulation, gear or targeting change	No regulation, gear or targeting change	Opportunistic fishing effort, so changes in catchability are hard to determine
Relative catch contribution	~1500 to 2000 mt annually	~1500 to 2000 mt annually	<500 tons from 2003	>10,000 tons from 2004	19,000-55,000 mt	13,000-24,000 mt	~50mt annually
Decision	Use in sensitivity run	Not used	Not used	Not used	Used in base-case model	Used in base-case model	Not to use in BSP modeling; not to use for SS3 reference case
Decision reason	Use in sensitivity run because it has some desirable characteristics and has different trend from others, but area too small to be primary index	Multiple management changes likely affected catchability	Time-series is relatively short and some questions remain about the representativeness of recorded number of discards	Time-series is relatively short, especially since the index in the early period (2001-2003) should not be used due to incomplete sampling of effort	Large spatial and temporal coverage	Large spatial coverage	Too late to evaluate properly; overlapping in area and operation with HI index that shows similar trend; very small proportion of overall catch

Working papers need to include the following elements:

Fishery description	ISC/11/SHARKWG-1/05, ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/11/SHARKWG-1/05, ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/11/SHARKWG-1/06, ISC/13/SHARKWG-1/07	ISC/12/SHARKWG-1/15, ISC/13/SHARKWG-1/08	ISC/11/SHARKWG-2/10	ISC/11/SHARKWG-2/11	SC7 Clarke et al. paper
Analysis description	ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/13/SHARKWG-1/07	ISC/13/SHARKWG-1/08	ISC/12/SHARKWG-1/07, 08, 09 ISC/12/SHARKWG-2/02 ISC/13/SHARKWG-1/03	ISC/12/SHARKWG-1/08, 09 ISC/12/SHARKWG-2/02 ISC/13/SHARKWG-1/03	SC7 Clarke et al paper
Treatment of outliers or data filtering	ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/13/SHARKWG-1/07	ISC/13/SHARKWG-1/08			SC7 Clarke et al paper
Remarks			Discard rate is suggested to be higher than recorded by observers because CPUE is unexpectedly low	Negligible discard rate; more confidence in late compared to early time series due to higher coverage of effort sampling in the late period			Region 4 CPUE index seems unreasonable, so concern was raised about the methods as applied to region 2; Gulland index seems to indicate the vessels were avoiding the high CPUE areas for blue sharks

Population Trends in Pacific Oceanic Sharks and the Utility of Regulations on Shark Finning (Clarke et al. 2012)

Summary

This scientific paper was tabled as a background document for discussion by the SHARKWG. A long-term record of species-specific catches, sizes, and sexes of sharks collected by onboard observers in the western and central Pacific Ocean from 1995 to 2010 was analyzed. Relative to blue shark, the authors used generalized linear models to estimate population-status indicators on the basis of catch rate and biological indicators of fishing pressure on the basis of median size to identify trends. Standardized catch rates of longline fleets declined significantly for blue sharks in the North Pacific (by 5% per year [CI 2% to 8]). Combined, these results and evidence of targeted fishing for sharks in some regional fisheries heighten concerns for sustainable utilization. Regional regulations that prohibit shark finning (removal of fins and discarding of the carcass) were enacted in 2007 and are in many cases the only form of control on shark catches. The authors found little evidence of a reduction of finning in longline fisheries. The authors argue that finning prohibitions divert attention from assessing whether catch levels are sustainable and that the need for management of sharks should not be addressed by measures that are simple to implement but complex to enforce and evaluate.

Discussion

The WG recognized that the blue shark index for the north Pacific developed in this paper is delineated at the equator and is largely based on US longline data from Hawaii. The results presented in this paper are not inconsistent with the results that the SHARKWG has observed in the Hawaiian longline data. There is overlap with the data that the SHARKWG has used to develop one of the indices used in the BSP model, so it would be redundant to include more than one index based on the same data in any model runs. The other data contained in this paper are blue shark length data. From 1995-2010 there has been a decrease in size in some of the fisheries. However, the change in size cannot be interpreted without consideration of changes in catchability or selectivity.

Estimation Process of Abundance Indices for Blue Shark in the North Pacific (ISC/13/SHARKWG-2/02)

Summary

In this working paper (WP), we summarized previous WG papers (ISC/11/SHARKWG-2/09, ISC/12/SHARKWG-1/08, ISC/12/SHARKWG-1/07, ISC/12/SHARKWG-1/09, ISC/12/SHARKWG-2/02, and ISC/13/SHARKWG-1/03) relating to the estimation of abundance indices of blue shark in the North Pacific because there were many discussions under the ISC SHARKWG before agreement on the final indicies. The last WP which described the accepted abundance indices for stock assessment cited many WPs of studies conducted before the final one. The objective of this WP is to provide the estimation process of the time series of abundance indices including data preparation and standardized CPUE. The detail of each analysis was described in the original papers.

The abundance indices of blue shark were estimated for the period between 1976 and 2010 using logbook data of shallow sets of Japanese longliners registered to Hokkaido and Tohoku prefectures, which actively target blue sharks. Because only species aggregated shark catch data is available for the period before 1994, blue shark specific catch data is estimated for this period by the species specific catch data after 1993. In this estimation, season-area specific ratio of blue shark catch to the total shark catch is assumed to be the same for the period before 1994 and after 1993. The standardizations of CPUE were conducted separately for the period before 1994 and after 1993 as the quality of data are different between two periods. Japanese shallow longline operations target both swordfish and blue shark using the same gear configuration (hooks per basket), thus the annual percentile of swordfish CPUE of each set is incorporated into the model of CPUE standardization as an explanatory variable. Although the annual trend of the estimated abundance index was decreasing during the period of 1980 to 1989, a continuous increasing trend was observed during the subsequent period except in 2007 and 2008.

Discussion

The SHARKWG had already accepted the analyses outlined in this document and the derived indices for use in the BSP base case model. The WP paper had been requested in order to have a document that contained all the necessary details about developing the indices in order to support the assessment report. As an additional request, the WG asked that the nominal CPUE time series be added to Figure 4 in the WP. The SHARKWG also requested an additional figure with step-plots of the nominal and final standardized CPUE time series and all intermediary series, produced with sequential inclusion of predictor variables. The WP was updated and finalized by the end of the meeting.

Updated historical catches and standardized CPUE series of blue shark by Taiwanese tuna longline fisheries in the North Pacific Ocean (ISC/13/SHARKWG-2/05)

Summary

In the present study, the blue shark catch and effort data from observers' records of Taiwanese large longline fishing vessels operating in the North Pacific Ocean from 2004-2011 were analyzed. Due to the large percentage of zero shark catch, the catch per unit effort (CPUE) of blue shark, as the number of fish caught per 1,000 hooks, was standardized by a zero inflated negative binomial model. The best model for CPUE standardization included the predictors: year, quarter and area. The analysis of standardized CPUE showed a stable increasing trend for blue sharks. The standardized CPUE is multiplied by logbook effort to estimate historical catch prior to 2004.

Discussion

Based on presentations and papers describing methods for estimating the Taiwan's large longline catch at prior meetings, the calculated estimated catch had already been accepted by the WG. However, some suggestions were made that should be explored to improve the index and catch estimation for future assessments. The histogram of residuals for 2005 and 2011 had a bimodal distribution which might reflect area or season differences. An annual interaction term with area might remove this but it is not a critical or required improvement. Future research could investigate the dramatic spike in the catch per set that occurs in 2011. The SHARKWG requested histograms of residuals in addition to box plots for each predictor in Figure 5 of the Working Paper and a revised version was provided by the end of the meeting. The WG concluded the WP was good for describing the catch estimation procedures in support of the stock assessment.

6.0.c Parameterization issues

Priors for r and n in the BSP model: food for thought (Powerpoint presentation)

<u>Summary</u>

The priors for *r* (intrinsic rate of population growth) and *n* (shape parameter, which is directly related to B_{msy}/K) are highly influential in the BSP model and, in the preliminary base case model, were identical to the priors used in Kleiber et al. (2009). However, the WG should document that these priors are derived from Atlantic blue shark demographic analyses by Cortés (2002). If demographic analysis on north Pacific blue shark were available, the WG could review and consider using these as the priors instead of using values from Atlantic blue shark. Similarly, the current assumption that B_{msy}/K = 0.5, in the Schaefer model is a strong assumption that the WG should review, discuss, and document. Fowler (1988) presented a relationship between B_{msy}/K and *r* and *T* (generation time), which can be used to provide an initial parameterization for B_{msy}/K, albeit with uncertainty. Based on the values for *r* and *T* presented in Cortés (2002), the B_{msy}/K for blue shark in this assessment might be better represented by 0.47 instead of 0.5. However, since these values are relatively close, the WG would not be amiss to use 0.5 as the base case value but should document that demographic analysis suggests a highly similar value (0.47).

Estimate of the intrinsic rate population increase for the blue shark in the North Pacific (ISC/13/SHARKWG-1/04)

<u>Summary</u>

The intrinsic rate of increase (*r*) is an important and crucial parameter in fish stock assessment especially using the production model. In this study, the *r* of the blue shark in the North Pacific Ocean was estimated using a demography approach. The input parameters, collected from 3 studies, include the growth coefficient, longevity, fecundity, age at maturity, reproduction cycle, and natural mortality. The results of demographic analysis indicated that the *r* of blue shark ranges from 0.162 to 0.356 with standard error from 0.038 to 0.103. The results derived from this study can be used as the prior of Bayesian surplus production model of blue shark in the North Pacific Ocean.

<u>Discussion</u>

Using the Euler-Lotka model to estimate *r* for Pacific blue shark using biological parameter estimates and growth curve parameters for different regions of the north Pacific, the values of *r* were 0.35 (Northwest Pacific) to 0.162 (Northeast Pacific) and 0.356 (central North Pacific) if assuming a 2 year reproductive cycle. These estimates change to 0.453, 0.245 and 0.468, respectively, if a 1 year reproductive cycle is assumed. The California and central north Pacific growth curves are published, and the northwest Pacific growth curve was presented at the SHARKWG Age and Growth Workshop (Hsu et al. 2011, ISC/11/SHARKWG-2/INFO-02) and is being prepared for publication. These estimates of *r* fall within the range of inputs chosen for the base case and sensitivity runs. **The SHARKWG recommends that future research should investigate *r* estimations specific to the North Pacific once the northwest Pacific blue shark growth curve estimation is finalized and also include a range of methods to estimate natural mortality (*M*) and encompass the range of uncertainty in the biological parameters.**

Reliable growth curve estimates are required for estimating *M* and *r*, both of which are important parameters required for stock assessment models. **As such, the SHARKWG recommends continued research into resolving differences between growth curve estimates in the north**

Pacific and developing reliable growth curve estimates, particularly in the eastern Pacific region. In addition, given the differences in *r* estimates depending on the assumed reproductive cycle (i.e. 1 year vs. 2 years), **the SHARKWG recommends that future research focuses on collecting monthly samples of adult females to address this knowledge gap**. One source of samples might be the Hawaiian fishery observer program since that fishery typically encounters larger females.

At the January 2013 workshop the SHARKWG decided that $r = 0.34$ would be used in the BSP model to be consistent with the previous north Pacific production model assessment. This value is based on Cortés (2002) and is derived for north Atlantic blue shark. Use of this value in the north Pacific BSP model assumes that our north Pacific blue shark has similar demographics to the Atlantic blue shark. This assumption needs to be explicitly stated in the BSP model assessment document. Preliminary research with north Pacific blue shark life parameters (ISC/13/SHARKWG-1/04) confirms that 0.34 is a reasonable value. There is inadequate time to investigate the full range of growth curve estimates and life history parameter estimates in the north Pacific for calculating *r* using Euler-Lotka method or alternates (e.g. McAllister et al. 2001). **The SHARKWG recommends that future research should attempt to investigate alternate approaches using north Pacific life history parameter for *r* estimation. The SHARKWG confirms the use of 0.34 (SD 0.3) as the *r* priors for the BSP model since it is published in Cortés (2002); *r* sensitivity runs should use the range of uncertainty provided in Cortés (2002) and Babcock and Cortés (2009) which are from 0.14 to 0.43.**

Currently the BSP model is using $B_{msy}/K = 0.5$ as a Schaefer model to be consistent with the previous assessment. The SHARKWG agreed that using a shape parameter derived from a demographic analysis was an improvement, and decided that the base case of the BSP model will assume $B_{msy}/K = 0.47$ (derived from $r = 0.34$ and T). **Using the range for *r* in Cortés (2002) results in a calculated range of B_{msy}/K of 0.39 to 0.56, therefore the SHARKWG recommended that BSP sensitivity runs should use $B_{msy}/K = 0.3$ and 0.6.** In addition, a matrix comparison with B_{msy}/K and *r* varying concurrently was included in the sensitivity runs.

6.0.d Examination of model diagnostics and suggested further analysis

<u>Summary</u>

Results of the BSP stock assessment modeling conducted during the intercession were presented. Base case and all sensitivity runs were based on specifications in the January 2013 meeting report. The results indicated that the north Pacific blue shark stock decreased between the mid 1970's and the beginning of 1990s, turned to increasing afterwards, and recovered by the early 2000s to a level similar to that of the mid-1970s. Current stock level is well above B_{msy}, and current fishing mortality rate is less than F_{msy}. The results were relatively or modestly sensitive to some alternative assumptions: shape parameter (less than 2); low *r*; maximum and minimum catch scenarios; and Hawaii longline CPUE. All other sensitivity runs resulted in similar stock status to the base case. Future median projected blue shark biomass is above B_{msy} under status quo, +20% and -20% harvest policies.

<u>Discussion</u>

The WG thanked the lead modelers and Dr. McAllister for all their work conducted in advance of the workshop. It was noted that these preliminary results were based on an early base case definition, which has changed after the discussion in **Section 6.0.c** (priors for *r* and *n*). **The WG agreed to use an *r* prior with mean of 0.34 and SD = 0.3, and B_{msy}/K fixed at 0.47.**

Several improvements to the documentation were suggested. For example:

1) Tables of projection results for 5, 10, and 20 years should be produced in the report in addition to the figures shown;
2) The initial input CVs (CV = 0.2) of the indices before reweighting should be noted in the document;
3) The bounds on the uniform prior for log(K) should be noted;
4) There should be a comparison of the model fit between the base case model and the sensitivity run using the Hawaii LL index.

In addition, the WG suggested several additional sensitivity runs to do:

1) A grid of sensitivity runs that vary both *r* and B_{msy}/K at the same time should be performed using the following values: mean r = 0.34 (base), 0.14, and 0.43; and B_{msy}/K at 0.47 (base), 0.3 and 0.6, for a total of 8 sensitivity runs (excluding the base case run). These runs would replace the Fletch1, Fletch2, Fletch3, R1, and R1b sensitivity runs;
2) There should be a sensitivity run that only uses the priors and catch (i.e., not fit to the indices) in order to show the effect of using only the priors;
3) More runs were conducted and presented in subsequent days.

Some members of the WG proposed that a fishery impact analysis be performed. However, after some discussion, **the WG agreed not to perform a fishery impact analysis because it was difficult to separate the catch data into useful fishery components**. It was possible to separate the catch into Longline, Drift Gillnet, and Other fisheries. But since **it was obvious that the longline fisheries dominated the catch, the fishery impact would obviously be dominated by the longline fisheries.**

6.0.e Finalize model results, sensitivities and projections

<u>Discussion</u>

The WG reviewed and discussed the preliminary model results, sensitivities, and projections. After some discussion, three additional analyses were suggested: 1) provide statistical evidence on whether model fits degrade when using the Hawaii longline index instead of the Japanese longline late index; 2) retrospective analysis; and 3) model runs that are not fit to abundance indices (i.e., a priors only run).

It was suggested that a comparison of the root mean square error (rmse) of the fit to indices could be used as an indicator of model fit and estimated process error. However, the base case and the Hawaii sensitivity runs had different input CVs due to the reweighting process. Therefore, additional model runs using input CVs of 0.2 for all indices were performed on the base case and Hawaii sensitivity runs. For these additional runs, the rmse of both indices in the Hawaii sensitivity run were substantially larger than the base case run. This indicates that model fit was degraded, given the model structure, when the Hawaii longline index was used instead of the Japanese longline late index. **The WG therefore agreed that the Japanese longline late index is more statistically consistent than the Hawaii index.**

The WG suggested that a retrospective analysis be performed to investigate possible biases resulting from the terminal data and to support the choice of years to average for catch and F in the projections. Five retrospective model runs were performed, using the same model structure as the base case. For each run, an additional terminal year of data was removed prior to the model run, resulting in 1 to 5 years of data being removed. The retrospective analysis indicated that there was a slight overestimation of terminal biomass, but it was not substantial.

The WG discussed the referenced current year (2011) and whether that should be the starting year for projections because catch and effort during 2011 should be lower than normal due to the Great East Japan Earthquake. The BSP can technically only output the CV of parameters for the last year. The retrospective analysis results did not show substantial differences. In addition, the WG expects the influence of the earthquake to affect catch and effort for several years and that should be considered in the projection. **The WG agreed to use the average of years 2006-2010 for projections of status quo catch and F.**

The WG also recommended that a model run be performed using only the input priors and catch, without fitting to the abundance indices. This will allow the WG to evaluate the influence of priors by estimating the biomass trajectory of the model given only the priors and catch data. However, technical difficulties were encountered that would need the help of Dr. McAllister in order to overcome. **The WG recommended that the main modelers consult with Dr. McAllister to do this and complete this analysis before the ISC Plenary in July 2013.**

The WG drafted the assessment executive summary and all members agreed to the content provisionally. The conservation information may be modified based on the age structured model runs. The WG also reviewed several versions of the draft assessment report and agreed to the content. Some sections still need minor work, but the report will be completed by June 29, 2013.

7.0 AGE STRUCTURED MODELING OF NORTH PACIFIC BLUE SHARK

7.0.a Review of fishery data

The WG had previously reviewed 6 candidate indices for use in the BSP model and produced a table that compared the pros and cons of each index. This table was used to make the decision on which indices to use for the BSP base case and sensitivity runs. The WG revisited the table to discuss the indices to use in the age structured modeling (Table 1).

A**fter much discussion, the WG recommended that for the sensitivity runs, the SS model should use the entire range of candidate indices for various runs (not in the same run), so as to incorporate the entire range of uncertainty in the indices.** Care should be taken to not use indices together that have overlapping data.

The WG recommended that the SS model only use the Japan LL early and Japan LL late indices in the reference case run. These are the indices considered to be the most representative indices for the north Pacific blue shark stock and would maintain consistency with the BSP model, thus making it easier to compare the results of both models.

7.0.b Review of size data

The WG reviewed the size and sex data by fishery. The WG considered whether there were size and sex data for each fishery, and if not, which fishery was most similar to the fishery without size and sex data. **Based on this review, the WG assembled a table (Table 2) that provided the SS model with the representative size composition data to use for each fishery.**

Table 2. Size composition data available for the age structured modeling.

Fisheries	Size Data? (Y/N)	Fishery To Mirror
Mexico	some	
Canada: groundfish LL	N	avg size 21 kg applied
Canada: groundfish Trawl	N	avg size 21 kg applied
Canada: Salmon troll, Gillnet and Seine	N	avg size 21 kg applied
China	Y (some WCPFC data)	
Japan: Kinkai shallow (offshore; smaller boats)	Y	
Japan: Kinkai deep (offshore; smaller boats)	N	Enyo Deep
Japan: Enyo shallow (distant water; larger boats)	N	Kinkai Shallow
Japan: Enyo deep (distant water; larger boats)	Y	
Japan: large mesh driftnet EEZ	Y	
Japan: coastal longline	N	Kinkai Shallow
Japan: other longline	N	Kinkai Shallow
Japan: bait fish	N	Kinkai Shallow
Japan: trap net	N	Kinkai Shallow
Japan: other	N	Kinkai Shallow
Japan: squid driftnet	N	Kleiber Squid
IATTC	N	average wt by year provided
Korea	Y	
SPC non-ISC longline	Y	
USA: drift gillnet	Y	
USA: sport total	N	USA Drift Gillnet
USA: longline	Y	
Taiwan: large longline	Y (+ some WCPFC Data)	
Taiwan: offshore small longline	Y	
Driftnet (Kleiber): DF large mesh (Japan and Taiwan)	Y (no sex data)	
Driftnet (Kleiber): DF small mesh (Japan and Taiwan)	Y (no sex data)	(same as Japan Squid Driftnet)

It was reported that there was a source of blue shark size composition data from Japanese experimental longline cruises targeting salmon shark and driftnet cruises targeting pomfrets. Preliminary size compositions from this data source were presented to the WG. This presentation showed that there might be unrepresentative size data included in this data source. In addition, since the operations of these experimental cruises are likely different from commercial operations, and that there was not enough time for review and quality control of these data, **the WG recommended that these size data should only be used for sensitivity runs if they can be provided, after some examination by the Japan scientists, and should not be used for the reference case run.** Sex is not available in the Kleiber data for the high seas squid driftnet fishery, so these experimental data could be useful.

Size composition data from WCPFC members (e.g., China, South Korea) were reported to the WG and examined. **After some discussion, the WG recommended that the SS modelers use any additional size and sex data that the WCPFC observer program holds and that those data should be distributed with all the other input data to WG members interested in helping with the SS modeling. The WG also requests regular updates of relevant progress**

from the SS modelers. Correspondence should include WG members Takahashi, Kai, Sippel, Kanaiwa, Tsai, Chin, Liu, King, Rice and Piner.

7.0.c Reference case parameterization

The WG reviewed and discussed the parameterization to be used in the age-structured model, especially the life history parameters. Because the BSP model used a productivity assumption based on the previous assessment that was shown to be consistent with the current state of knowledge of blue sharks in the North Pacific, the WG had not decided on specific values for some of the life history parameters needed for the age structured modeling. The WG acknowledged there is still uncertainty in many of the life history parameters.

The WG reviewed an analysis of the length-weight, and total length-alternate length conversion models, that takes into account seasonal and gender effects. The analysis showed that there were statistically significant seasonal and gender effects but the resulting models were not biologically significantly different with the previously agreed models. **The WG therefore agreed to use the current length-weight and length-length conversion models for the SS model**.

The WG also reexamined the growth curves to be used in the SS model. After reviewing multiple available growth models, **the WG agreed to use either growth model by Nakano (1994) or Hsu et al. (2011) for the reference case, and in addition choose alternative L_{inf} values for sensitivity runs.**

Table 3. Recommended blue shark life history parameters to use in the SS3 reference case and for sensitivities.

Blue Shark Life History Characteristics	SS3 input assumption	SHARKWG most/more plausible	Cortés (2002) – to mimic BSP model reference case
Gestation	1 yr		
Breeding frequency	1 or 2		biennial
Sex ratio at birth	1 to 1		
Litter size	1 to 54	25-30, with no relationship between number of pups and female size	37 (SD 14.6) range 4-75 pups per litter
Length at birth	40 to 50 cm FL		
Length at 50% maturity	F: 185-212 TL	193 cm TL	
Age at 50% maturity	F: 5-7 years		5 (triangular distribution 4-6; age at maturity)
Maximum length	380 cm TL		327 cm TL
Longevity	20		16 (empirical); 21 (empirical +30%)
Length conversions	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, R2=0.98		

Length-weight relationship	$Wt=4.2x10^{-6}*PCL^{3.1635}$, where weight is in kg and PCL in cm		
Growth models	Nakano 1994 and Joung, Hsu, Liu and Wu 2011 (use one with a lower L_{inf} for sensitivity)		
Natural mortality (M)	0.06 to 0.39	0.2	1-(0.76 to 0.85); survivorship calculated based on 4 methods - age specific survivorship range 0.61-0.94

The WG reviewed the map showing the spatial extent of fisheries to determine their accuracy. Some discrepancies were noted and **the Chair agreed to provide a revised version for the assessment report that has some boundary changes for Taiwan small longline, Hawaii longline and Japan Kinkai longline fisheries.**

While reviewing information for the age structured modeling, it was apparent that there remain many uncertainties regarding blue shark life history characteristics. The WG identified the following high priority research needs.

Blue Shark Research Recommendations

- Continue research on temporal, spatial and environmental effects on historic and current blue shark catch rates in order to improve CPUE and catch estimation procedures.
- Improve documentation of catch for foreign flagged vessels landing in member nation ports to ensure accurate accounting of all catch.
- Determine post-release survival for different fleets, seasons and areas based on available information and prioritize new studies if needed in order to accurately estimate dead removals.
- Continue age and growth studies to resolve apparent regional differences.
- Continue research on female reproductive maturity to resolve uncertainty in breeding frequency.
- Prioritize monthly collections of adult females that represent the greatest gap in data needed for age and growth and maturity studies.
- Investigate *r* estimations specific to the North Pacific; include a range of methods to estimate *M* and encompass the range of uncertainty in biological parameters.

7.0.d Potential sensitivity runs and projections

The WG agreed that the SS modeling team should include and document any additional sensitivity runs and information that is important.

7.0.e Plan for use of SS3 model and WG paper

There was much discussion about the appropriate use of the WG data for a fully integrated stock assessment model of north Pacific blue shark. The WG had not prepared the assessment data with the intent of using them for a fully integrated model, thus the definition of fisheries and a careful examination of the size and sex specific catch has not been conducted. Similarly, all potential abundance indices were not evaluated for use in a more complex model. Results of the SS modeling should be treated as preliminary and exploratory until the group has a chance to carefully review the size and sex compositions of the catch by fishery, area and season with a plan to define fisheries for use in a future age structured model.

Some members of the WG expressed concern that the possible inconsistency in the assessment results between the BSP and the SS model. If there are large differences in the results, the WG may find it difficult to explain the results. **As was previously agreed, the WG reiterated that it is important to base the conservation advice primarily upon the BSP model. Results of the SS3 model will be reviewed in July and the conservation information developed can take into account any new information based on the SS modeling. In addition, the WG also agreed that the Chair and WG participants of the ISC Plenary and SC meetings will make their best effort to ensure that the results of stock assessments complement each other with respect to conservation information.**

There is the possibility of use of the output data from the assessment in projections to evaluate harvest strategies, but **the WG agreed that the SS input data are not to be used for further analysis outside the ISC SHARKWG.**

The SPC representative stated his understanding of the process around the development and finalization of the SS3 assessment for North Pacific blue shark. The reference case model would include CPUE and catch inputs chosen so that the SS model is comparable to the BSP model. The life history parameters chosen would aim to approximate the shape parameter of the base BSP model. SPC would also undertake a range of sensitivity analyses, in particular, several model runs relating to alternative CPUE abundance series and life history parameters reviewed by the ISC SHARKWG. The reference case model would be used for the purpose of presenting results and diagnostics. SPC noted that the WCPFC Scientific Committee would likely take its own decision as to which model(s) and run(s) to use to develop its management advice (referred to as base case model(s)) as it has done with other assessments. Finally SPC will work within the ISC SHARKWG to have a single paper describing the SS3 assessment to be submitted as both an ISC SHARKWG document and for the WCPFC SC meeting.

8.0 SHORTFIN MAKO SHARK INFORMATION GATHERING

8.0.a Review life history matrix, identify information gaps and high priority work assignments

The WG life history specialists updated the latest version of the Life History Matrix for shortfin mako sharks and presented the findings to the WG. Although the WG is not aware of any new papers on shortfin mako shark life history, additional information was reported about the validation of growth band pair deposition.

The progress of age and growth studies in the North Pacific was introduced and discussed. Wells et al. (2013), which was previously reviewed by the WG (ISC/11/SHARKWG-2/06), provided the information of the age validation of juvenile shortfin mako tagged and marked with OTC off southern California and supportive information from analysis length frequency and tag-recapture data. In comparison with the study from central and western North Pacific, the difference in the interpretation of growth band pair potentially due to different enhancement techniques was discussed. There are discrepancies in the interpretation of the periodicity of growth band pair deposition i.e. 1 vs. 2 bands annually. Studies that previously validated 1 annual band pair deposition (Natanson et al. 2006; Ardizzone et al. 2006) included larger size sharks, hypothesizing ontogenetic changes in the deposition of bands. **It was ascertained that progress of cross-reading using samples from USA and Japan is urgent for clarification of this problem.** Cross validation is occurring in these age studies, and the results will hopefully be presented in July.

Several shortfin mako shark growth curve problems were discussed. The growth curves cited from each existing paper were put into one figure after being standardized to PCL. It was suggested that the original data would be needed and should be converted to PCL to develop directly comparable error distributions. Problems arising from converting existing growth curves to PCL were acknowledged as well as complications due to the use of various enhancing methods. **The SHARKWG endorsed a shortfin mako ageing workshop to address outstanding issues. The Chair will follow up with the national age and growth specialists regarding participation, prioritization and scheduling.**

Other discussion revolved around the priorities for determining the reproductive cycle and other life history characteristics.

The WG asked that if the most important thing was the collection of larger sharks, and large females in particular, would each nation be able to request samples through existing observer and research programs. It was agreed that **a sampling collection protocol for shortfin mako shark gonads and vertebrae should be developed in order to insure standardization across fleets**.

Discussion of the length-length and length-weight relationships are very close based on the data presented. A data exchange and comparison will take place and the conclusions will be distributed within 30 days.

Table 4. Key life history parameters for shortfin mako sharks in the North Pacific. The information below represents what was identified by WG participants as of April 24, 2013 as the best available information, although uncertainties and omissions were highlighted for further work. More comprehensive tables including references, regions, and sample sizes among other details of the studies will be maintained by the SHARKWG Chair for use by WG members.

Shortfin Mako Shark Life History Characteristics	A: Known with high confidence	B: Known with moderate confidence	C: Highly uncertain
Reproduction	Aplacental viviparity with oophagy - A mother gives birth to live young that initially develop in a yolk sac then feed on a continuous supply of uterine eggs after yolk is depleted.		
Gestation			9-25 months
Breeding frequency			2 or 3 years
Sex ratio at birth	1 to 1		
Litter size	range 4-25; average 12 (there's some evidence of increasing number with female size)		
Length at birth	70-74 cm TL		
Length at 50% maturity		Males: 180-210 cm TL	Females: 278-307 cm TL
Age at 50% maturity			Males: 5-9 years, Females: 17-21 years; depends upon band deposition periodicity
Maximum length	378 cm TL		
Longevity			Males 9-31 years, Females 18-41 years; depends on band deposition periodicity
Length conversions	TL=(FL+0.397)/0.913 AL=(FL-9.996)/2.402 TL=(PCL-0.784)/0.816 TL=(FL-0.952)/0.89		
Length-weight relationship *	All: $Wt(kg)=1.103 \times 10^{-5}\ FL^{3.009}$ All: $Wt(kg)=1.1 \times 10^{-5}\ TL^{2.95}$ M: $Wt(kg)=2.8 \times 10^{-5}\ TL^{2.771}$ F: $Wt(kg)=1.9 \times 10^{-5}\ TL^{2.847}$		
Growth models *			All: $FL_t= 292.8[1-e^{-0.072(t+3.75)}]$ All: $FL_t = 375.4[1-e^{-0.05(t+4.7)}]$ M: $FL_t= 321.8[1-e^{-0.049(t+6.07)}]$ F: $FL_t= 403.62[1-e^{-0.040(t+5.27)}]$ M: $TL_t= 332.1[1-e^{-0.056(t+6.08)}]$ F: $TL_t= 413.8-[(413.8-74)e^{-0.05t}]$ M: $PCL_t=231.3[1-e^{-0.156t}]$ F: $PCL_t=308.6[1-e^{-0.090t}]$

* a number of studies have been conducted in the North Pacific and these will be compared to choose the appropriate ones for use by the SHARKWG

Global genetic population structure and demographic history of shortfin mako (Isurus oxyrinchus) inferred from mitochondrial DNA. (ISC/13/SHARKWG-2/03)

Summary

Global genetic population structure of shortfin mako was examined using a total of 649 whole sequences in mitochondrial cytochrome b region of shortfin mako to contribute the decision of management unit of this species in the North Pacific Ocean. Five population genetic analyses, SAMOVA, AMOVA, pairwise conventional F_{st} and Φ_{st} estimates, and an exact test of haplotype frequency, indicated the genetic structure of shortfin mako with a maximum genetic differentiation between the North Atlantic, and the Indian and Pacific Ocean. These analyses also showed at least two sub-stocks, the Indian Ocean and the Pacific Ocean, within the Indian and Pacific Ocean group. Additionally, pairwise conventional F_{st} and an exact test of haplotype frequency suggested a weak genetic structuring of this species within the Pacific Ocean with at least three genetic stocks, the western and eastern South Pacific and North Pacific Ocean. Furthermore, three phylogeographic analyses, parsimony network of haplotypes, neutrality tests and mismatch distribution analysis, inferred the range expansion of shortfin mako from the Pacific to the North Atlantic Ocean through the Indian Ocean with sudden population growth in the past. Overall results suggested that the population history of this species should be one of the factors which had an influence on their genetic population structure as well as other marine taxa.

Discussion

These preliminary results confirm previous studies that suggest that there is a single north Pacific stock. The stock structure in the south Pacific may be defined as two stocks, east and west. The results presented based on mtDNA (which reflects maternal lineage) confirm previous studies that suggest an east-west delineation in the south Pacific. However, preliminary results presented here based on nuclear DNA did not detect this same delineation. Taken together these suggest that males might move more widely throughout the Pacific than females. The SHARKWG concluded that stock management of shortfin mako in the Pacific could benefit from a 3 area management perspective. **The SHARKWG recommends using a stock boundary between the north and south Pacific and that the assessment would be conducted on the NPO stock. This is most consistent with the genetics and tagging information and reflects appropriate stock units for management.** One issue that may be difficult is that there is significant shortfin mako shark catch around the equator in the EPO, which may not have a clear definition of a north-south boundary.

8.0.b Review fishery metadata table

After review, the SHARKWG noted that the majority of the fisheries will have similar data to those used for blue shark. The SHARKWG discussed the potential movement of fishery effort from west to east due to changing the target from swordfish (winter) to blue shark (summer).

8.0.c Discuss fishery and size data availability

Preliminary review of catch and effort data of shortfin mako shark caught by Japanese offshore and distant-water longliners in the period between 1994 and 2012. (ISC/13/SHARKWG-2/06)

Summary

Japan mandated a new logbook system for Japanese offshore and distant-water longliners in 1994 which requires reporting of shortfin mako shark landings. Though this information does not contain information on discards, some useful information about this species could be extracted. This study summarized the information of shortfin mako shark in this logbook data. The results of analysis in this study suggest that continuous data are available in the subtropical/temperate region in the northwest Pacific and some better coverage of data exists in the central North Pacific. The quality and quantity of catch and effort data are better in the earlier years, but it is not as good as those of blue shark.

Discussion

The most consistent catch has been in the north off of Japan, although the effort distribution has changed. Catch and effort data differs by area with the majority of the catch occurring in the Eastern Tropical Pacific. The effort has declined over twenty years. In the north, the majority of the catch is by surface fisheries (3-4 hooks between floats; HBF) while previously it was a bit deeper (7 HBF), but further south most of the catch is deeper. Some catch and effort data exists but operational changes in space overtime may complicate the utility of this data.

The SHARKWG wondered if there was a high level of retention of shortfin mako, and if so was the logbook data in need of filtering due to poor record keeping. Japan replied that the shortfin mako is mostly a bycatch species, not a target species, and most are retained because of high market value. The data in this Working Paper only contains information on unloaded fish, so just landings and not discards. The coverage rate is quite high, almost 100%. In 2013 the logbook catch includes landings and discards, and skipper notes describing the catch and discards also began in recent years.

Distribution pattern of shortfin mako (Isurus oxyrinchus) caught by Kesennuma offshore longline fleets (ISC/13/SHARKWG-2/07)

Summary

The distribution pattern of shortfin mako was examined in relation to the environmental factors, on the basis of the size data collected by the Kesennuma offshore longline fleet. Size and sex data, with location and date, were collected between 2005 and January 2013 and data from 60,769 individuals were used. It was suggested that the main component of catch was individuals smaller than 200 cm (PCL) and these individuals were extensively distributed in the Kuroshio Current, Kuroshio Extension and the Transition area. An ontogenetic shift of distribution was suggested to occur - from waters off Japan (<100 cm) to western or southern areas (≥100 cm). Strong evidence of a sexual difference in the distribution pattern and environmental preference was not found within the size range used here. However, considering that the number of records of adult females was very small, segregation of this component outside the fishing ground of this fleet and/or an ontogenetic change of catchability may occur. Further investigation is necessary to clarify the distribution pattern of this species throughout its life span.

Discussion

The SHARKWG considers these very valuable size and sex data for shortfin mako shark. The SHARKWG wondered if there was adequate information to relate to the hypothesized size and sex distribution model with regards to identifying pupping and mating grounds and pregnancy areas. Japan clarified that these data are limited to 20°N and higher, and are based on skipper notes. Combining this information with data from the Taiwan fisheries that operate in the lower latitudes will be valuable. Hypotheses on shortfin mako shark size and sex distribution could be addressed through ongoing tagging studies and further collections of catch by size and sex in lower latitudes. A Pacific-wide size and sex distribution study would also be useful.

The WG recognized that previous WG papers describe fishery information on shortfin mako sharks but that once the focus shifted to completing the blue shark assessment, the WG did not routinely carry out further shortfin mako shark data compilation. **The Chair agreed to prepare a metadata table regarding the working papers for shortfin mako sharks to help the group review the information previously provided and minimize requests to submit redundant information.**

8.0.f Develop shortfin mako shark assessment workplan

The Chair introduced a draft workplan for completion of a north Pacific shortfin mako assessment prior to the 2014 ISC Plenary.

Some WG members questioned the 'ambitious schedule' given the fact that the BSH SS model is not yet complete and the priority in July is now to finalize the BSH conservation information for the Plenary after reviewing the SS model. After much discussion about the scheduling, the WG decided to focus on the spatial pattern of shortfin makos by size and sex at the July meeting. This will help the WG see the amount of size data available and whether there are strong patterns that may need to be taken in account. The WG could then make a decision about the potential modeling approach to be used and establish data submission needs. The draft workplan was amended to reflect this.

Shortfin Mako Shark Assessment Work Plan (April 24, 2013)

In advance of the July 2013 meeting:

1. Compare prior L-L and L-Wt conversions with raw data submitted. *(Tsai)*
2. Each nation compile summarized size and sex data in PCL for review at July meeting *(all WG members and observers)*
3. Life history specialists continue to update life history matrix based on prior studies and continue work on high priority biological studies including cross validation of vertebrae from the Wells et al. (2013) and Semba et al. (2009) studies (*Semba, Liu, Kohin*)
4. Chair works with SPC and IATTC, other national delegation leads, and other species WG Chairs to come up with effort, catch and/or size data for fisheries with non-reported catch (*Kohin*).
5. Chair to contact national age and growth specialists about progress on collecting reference vertebrae for blue and shortfin mako sharks and interest in follow-up Age and Growth Workshop (*Kohin*).
6. Chair to review prior WG papers and prepare a meta-data spreadsheet identifying papers that contain fishery information on shortfin mako sharks *(Kohin)*

July 6-8 and 11, 2013 meeting (Busan, Korea)

1. Review information on the size and sex composition of shortfin mako sharks
2. Review progress on biological studies and prioritize studies based on assessment needs and greatest uncertainty
3. Tentatively decide on modeling approach given information on stock structure

4. Decide on area stratification to use for submission and compilation of catch and size data.
5. Develop data submission templates and establish submission deadlines
6. Develop plans and assignments for Second Age and Growth Workshop
7. Revise assessment workplan if needed

ISC SHARKWG Second Age and Growth Workshop (tentative objectives)
1. Compare results of cross validation for shortfin mako vertebral counts (*Semba, Wells*)
2. Compare results of reference vertebrae collection readings for shortfin mako and blue shark (prioritizing shortfin mako work for upcoming assessment)
3. Develop process for combining raw data given the results of the reference collection comparisons
4. Combine raw data based on regional and/or sex-specific growth hypotheses
5. Propose candidate growth curve(s) for shortfin makos for use in the stock assessment

Winter 2013/2014: final data prep meeting (tentatively in Mexico or the US)
1. Review and agree upon all data and procedures to estimate catch and abundance indices.
2. Review and accept catch estimation procedures for non-reporting fleets.
3. Finalize life history parameters to use for assessment.
4. Review and accept size data and definition of fisheries.
5. WG modelers provide proposal(s) for base case run, sensitivities, and projections.
6. Conduct and review preliminary runs.

Late April 2014: shortfin mako shark assessment meeting (location TBD)
1. Conduct and review base case assessment modeling (subgroup meeting in advance of WG meeting if needed).
2. Conduct and review sensitivity results.
3. Conduct and review future projections.
4. Develop stock status conclusions and conservation information.
5. Prepare assessment report.

The WG also discussed ongoing research priorities in the context of the shortfin mako shark life history data gaps and stock assessment needs and came up with the following list of research recommendations.

Shortfin Mako Shark Research Recommendations
- Conduct/continue research on the temporal and spatial distribution of shortfin makos by size and sex.
- Conduct tagging studies to help determine the movements and distribution of mature individuals since few are caught.
- To address differences in age and growth studies, conduct cross-reading of vertebrae samples from USA and Japan.
- Convene the second ISC sponsored shark age and growth workshop.
- Continue research on female reproductive maturity to resolve uncertainty in breeding frequency.
- Develop a sampling collection protocol for shortfin mako shark gonads and vertebrae in order to insure standardization across fleets.

- Prioritize monthly collections of adult females that represent the greatest gap in data needed for age and growth and maturity studies, particulary from lower latitudes.
- Continue genetics studies.
- Continue studies on size conversions.

9.0 FUTURE SHARKWG MEETINGS

The next WG meeting will be held July 6-8, and 11 in Busan, Korea during which the blue shark SS3 model will be reviewed and the conservation information finalized for the Plenary. Additional goals are to finish other work for the Plenary and to review shortfin mako shark size and sex composition information to help plan for the shortfin mako shark assessment. The WG has tentatively agreed to a winter meeting for shortfin mako shark data prep and a spring meeting to complete the shortfin mako shark assessment. The meeting schedule will be revisited at the July meeting after plans for the shortfin mako shark assessment are further developed.

10.0 OTHER MATTERS

10.0.a Data submission

The Chair expressed frustration regarding the failure in many cases of WG members to submit data and other requested information by the deadlines agreed to and within the templates provided. While delays in submitting data may be unforeseeable given the challenges associated with the need to recreate catch due to the lack of reliable shark data, she requested that members make every effort to respond to WG requests using the templates provided and make every effort to adhere to the deadlines. Complications associated with some of the delays and the short decision to conduct the SS modeling have resulted in an extraordinary schedule this year including the need to meet for many days in July. The WG does not want to continue with such a scheduling situation in coming years.

11.0 CLEARING OF REPORT

The Report was reviewed and the content provisionally approved by all present. The Chair will make minor non-substantive editorial revisions including adding some research recommendations. The revised version will be circulated to all WG members within 2 weeks. The report will be finalized within 30 days.

12.0 ADJOURNMENT

The Chair thanked all participants for attending and contributing to a very productive meeting. She also thanked the NRIFSF hosts their generous hospitality and for assisting with logistics throughout the meeting.

The meeting was adjourned at 14:50, April 24, 2013.

13.0 LITERATURE CITED

Ardizzone, D., G.M. Cailliet, L.J. Natanson, A.H. Andrews, L.A. Kerr, and T.A. Brown. 2006. Application of bomb radiocarbon chronologies to shortfin mako (*Isurus oxyrinchus*) age validation. Envir. Biol. Fish. 77: 355-366.

Babcock, E.A. and E. Cortés. 2009. Updated Bayesian surplus production model applied to blue and mako shark catch, CPUE and effort data. Collect. Vol. Sci. Pap. ICCAT, 64(5): 1568-1577.

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

Clarke, S.C., S.J. Harley, S.D. Hoyle, and J.S. Rice. 2012. Population trends in Pacific oceanic sharks and the utility of regulations on shark finning. Conservation Biology 27(1):197-209.

Cortés, E. 2002. Incorporating uncertainty into demographic modeling: application to shark populations and their conservation. Conservation Biology 16:1048–1062.

Fowler, C.W. 1988. Population dynamics as related to rate of increase per generation. Evol Ecol 2:197–204.

Hsu, H., S. Joung, G. Lu, K. Liu, and C. Huang. 2011. Age and growth of the blue shark, *Prionace glauca*, in the northwest and central south Pacific. ISC Shark Working Group paper submitted for the ISC Shark Ageing Workshop, 5-6 December 2011, La Jolla CA, USA. ISC/11/SHARKWG-2/INFO-02.

Kleiber, P., S. Clarke, K. Bigelow, H. Nakano, M. McAllister, and Y. Takeuchi. 2009. North Pacific blue shark stock assessment. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-17, 74 p.

McAllister, M.K., E.K. Pikitch, and E.A. Babcock. 2001. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding. Canadian Journal of Fisheries and Aquatic Sciences 58: 1871-1890.

Nakano, H. 1994. Age, reproduction and migration of blue shark in the North Pacific Ocean. Bulletin National Research Institute of Far Seas Fisheries. 31:141-256.

Natanson, L.J., N.E. Kohler, D. Ardizzone, G. M. Cailliet, S. P. Wintner, and H. F. Mollet. 2006. Validated age and growth estimates for the shortfin mako, *Isurus oxyrinchus,* in the North Atlantic Ocean. Environ. Bio. Fish 77: 367-383.

Semba, Y., H. Nakano, and I. Aoki. 2009. Age and growth analysis of the shortfin mako shark, *Isurus oxyrinchus*, in the western and central North Pacific Ocean. Environ. Biol. Fishes. 84: 377-391.

Takahashi, N., Y. Hiraoka, A. Kimoto, K. Yokawa, and M. Kanaiwa. 2012. Comparison of CPUEs of blue shark reported by logbook of Japanese commercial longliners with Japanese research and training longline data. Working paper for the ISC SHARKWG meeting, 28 May-4 June 2012, Shizuoka, Japan. ISC/12/SHARKWG-1/06.

Wells, R.J.D., S.E. Smith, S. Kohin, E. Freund, N. Spear, and D.A. Ramon. 2013. Age validation of juvenile shortfin mako (*Isurus oxyrinchus*) tagged and marked with oxytetracycline off southern California. Fishery Bulletin 111:147-160.

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

Chien-Pang Chin
Institute of Oceanography
National Taiwan University
1, Sect. 4, Roosevelt Rd.
Taipei 106, Taiwan
886-2-2462-2192 ext 5018,
886-2-2462-0291 (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
886-2-2462-0291 (fax)
kmliu@mail.ntou.edu.tw

Wen-Pei Tsai
Institute of Oceanography
National Taiwan University
Taipei 106, Taiwan
886-2-2462-2192 ext 5018,
886-2-2462-0291 (fax)
d96241001@ntu.edu.tw

Japan

Yuko Hiraoka
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6039, 81-54-335-9642 (fax)
yhira415@fra.affrc.go.jp

Mikihiko Kai
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6045, 81-54-335-9642 (fax)
kaim@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
81-54-336-6036, 81-54-335-9642 (fax)
aikimoto@affrc.go.jp

Yasuko Semba
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6011, 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
81-54-336-6045, 81-54-335-9642 (fax)

Mioko Taguchi
Natl. Res. Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633
81-54-336-6011, 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
81-54-336-6016, 81-54-335-9642 (fax)
Yokawa@fra.affrc.go.jp

United States

Gerard DiNardo
NOAA/NMFS PIFSC
2570 Dole St.
Honolulu, HI 96822-2396
808-983-5397, 808-983-2902 (fax)
Gerard.DiNardo@noaa.gov

Suzanne Kohin
NMFS/SWFSC
8901 La Jolla Shores Drive
La Jolla, CA 92037
858-546-7104, 858-546-7003 (fax)
Suzanne.Kohin@noaa.gov

Tim Sippel
NMFS/SWFSC
8901 La Jolla Shores Drive
La Jolla, CA 92037
858-546-7070, 858-546-7003 (fax)
Tim.Sippel@noaa.gov

Steven Teo
NMFS/SWFSC
8901 La Jolla Shores Drive
La Jolla, CA 92037
858-546-7179, 858-546-7003 (fax)
Steve.Teo@noaa.gov

Secretariat of the Pacific Community

Joel Rice
Secretariat of the Pacific Community
BP D5
98848 NOUMEA Cedex
+687 26 20 00
joelr@spc.int

Attachment 2. Meeting Documents

WORKING PAPERS

ISC/13/SHARKWG-2/01	Catches of blue sharks from U.S. West Coast recreational fisheries during 1971-2011. Tim Sippel and Suzy Kohin (tim.sippel@noaa.gov)
ISC/13/SHARKWG-2/02	Summary of estimation process of abundance indices for blue shark in the North Pacific. Yuko Hiraoka, Minoru Kanaiwa and Kotaro Yokawa (yhira@affrc.go.jp)
ISC/13/SHARKWG-2/03	Global genetic population structure and demographic history of shortfin mako (*Isurus oxyrinchus*) inferred from mitochondrial DNA. Mioko Taguchi and Kotaro Yokawa (tagu305@affrc.go.jp)
ISC/13/SHARKWG-2/04	Estimate of the intrinsic rate population increase for the blue shark in the North Pacific. Chien-Pang Chin and Kwang-Ming Liu (kmliu@mail.ntou.edu.tw)
ISC/13/SHARKWG-2/05	Updated historical catches and standardized CPUE series of blue shark by Taiwanese tuna longline fisheries in the North Pacific Ocean. Wen-Pei Tsai and Kwang-Ming Liu (kmliu@mail.ntou.edu.tw)
ISC/13/SHARKWG-2/06	Preliminary review of catch and effort data of shortfin mako shark caught by Japanese offshore and distant-water longliners in the period between 1994 and 2012. Kotaro Yokawa (Yokawa@fra.affrc.go.jp)
ISC/13/SHARKWG-2/07	Distribution pattern of shortfin mako (*Isurus oxyrinchus*) caught by Kesennuma offshore longline fleets. Ko Shiozaki, Yasuko Semba and Kotaro Yokawa (senbamak@affrc.go.jp)

INFORMATION PAPERS

ISC/13/SHARKWG-2/INFO-1	Unofficial blue shark catches estimations for the Mexican Pacific (1976-2011). Oscar Sosa-Nishizaki (ososa@cicese.mx)

Attachment 3. Meeting Agenda

16-24 April, 2013
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu-Ku
Shizuoka 424-8633 JAPAN

Meeting will start at 10:00am on April 16 and at 9:00am everyday thereafter unless otherwise arranged.

1. Opening of SHARKWG Workshop
   a. Welcoming remarks
   b. Introductions
   c. 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 January 2013 Workshop (*Kohin*)
6. Bayesian Surplus Production Modeling of north Pacific blue shark
   a. Outstanding issues with catch time series (*King*, *Semba*)
      - Review of Mexico catch time series paper
   b. Outstanding issues with CPUE time series (*King, Semba*)
      - Review of Clarke et al. abundance index
      - Review of Clarke et al. Cons. Bio. paper
   c. Parameterization issues (*King, Kai*)
   d. Examine model diagnostics and conduct further analyses if needed (*Teo, Hiraoka*)
   e. Finalize model results, sensitivities and projections (*Teo, Hiraoka*)
   f. Formulate conservation information considering model uncertainty
   g. Develop/finalize assignments to complete assessment report
   h. Finalize all supporting WG papers for assessment time series
7. Age-structured modeling of north Pacific blue shark (*Semba, Kai*, *Teo*)
   a. Review fishery data
   b. Review size data
   c. Discuss base case parameterization
   d. Discuss potential sensitivity runs and projections
   e. Develop plan for use of SS3 model and WG Report
8. Shortfin mako shark information gathering (*Rice*, *Tsai*, *Chin*)
   a. Review life history matrix, identify information gaps and high priority work assignments
   b. Review fishery metadata table
   c. Discuss fishery and size data availability

   d. Discuss preliminary model choices
   e. Establish data submission templates and deadlines
   f. Develop shortfin mako shark assessment workplan
   g. Age and growth progress, planning

9. Future SHARKWG meetings (*Kohin*)

10. Other matters (*Kohin*)
   a. Data submission

11. Clearing of report

12. Adjournment

Annex 6

REPORT OF THE SHARK WORKING GROUP WORKSHOP

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

7-14 January, 2013
La Jolla, California USA

1.0 INTRODUCTION

An intercessional workshop of the Shark Working Group (SHARKWG) of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) was convened at the Southwest Fisheries Science Center (SWFSC) in La Jolla, California, USA from 7 – 14 January, 2013. The primary goal of the workshop was to agree to the data to be used in the north Pacific blue shark assessment data, finalize all time series provisionally, establish an assessment data submission deadline, estimate catch of fleets that have not provided data, and conduct some exploratory Bayesian Surplus Production (BSP) runs with the provisional data.

Kristen Koch, the Deputy Director of SWFSC, welcomed SHARKWG participants. Meeting participants included Chinese Taipei, IATTC, Japan, Mexico and United States of America (USA) (Attachment 1). Kristen extended her greeting and apologies on behalf of SWFSC Science Director Dr. Cisco Werner who was out of the country. In her address, she thanked members for their commitment to supporting this working group. She emphasized the importance of assessing the status of blue sharks, which is an important commercial species in many nations. In the USA, blue shark is not utilized; however, they are a significant portion of the catch in several US fisheries and there is a blue shark nursery area in southern California waters. She acknowledged the challenges facing the group since catch, effort and even basic life history information are difficult to collect and wished the group a successful meeting.

2.0 DISTRIBUTION OF MEETING DOCUMENTS

Nine working papers and one information paper were distributed and numbered (Attachment 2). Several oral presentations were also made during the meeting. 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/13/SHARKWG-1/09 and ISC/13/SHARKWG-1/INFO 1 declined posting on the ISC website due to either data confidentiality concerns and the preliminary nature of the results, or because the paper was being prepared for publication elsewhere.

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 MAY 2012 AND JULY 2012 WORKSHOPS

Suzanne Kohin, Chair of the SHARKWG, provided a summary of the May 2012 and July 2012 workshops. The May 2012 meeting was a blue shark data preparatory meeting held in Shizuoka, Japan May 28 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. 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 attended. Significant progress was made on reviewing the CPUE indices, developing plans for a base case production model assessment, and discussing blue shark biological parameters. A work plan for completing the blue shark assessment before the 2013 Plenary was developed.

The SHARKWG also met in advance of the 2012 Plenary in Sapporo, Japan for one day to finalize some unresolved work from the May meeting and to conduct work for the Plenary. During the short meeting, two papers provided updates to some Japan fishery catch data and the Japan longline abundance indices. Further work on finalizing the blue shark data was hindered by lack of participation from many member scientists and a lack of species-specific shark data for many member and non-member fleets. Consequently, a revised assessment work plan was developed that included holding another data preparatory meeting with the assessment to be completed in spring 2013. A very preliminary catch table was developed for the Plenary based on blue shark retained landings data provided by several members and derived from National Reports.

6.0 SUMMARY OF BAYESIAN SURPLUS PRODUCTION MODEL WORKSHOP

Report from the Bayesian Surplus Production model (BSP) workshop: Yokohama, Japan Nov. 2012 (ISC/13/SHARKWG-1/01), Tim Sippel

Summary:

The ISC Shark Working Group decided a Surplus Production (SP) model would be constructed as the base-case for its initial North Pacific blue shark assessment. Given the variable quality of fishery and biological data available for the assessment, it was decided this would be an appropriate starting point from which supplemental analyses and future assessments could be constructed. A state-space Bayesian Surplus Production (BSP) model has been developed by Prof. Murdoch McAllister at University of British Columbia and colleagues. The software is referred to as BSP2 and is considered an appropriate application for this assessment. BSP2 fits either a Schaefer or Fletcher/Schaefer model to time-series of catch and indices of abundance (CPUE), with CVs if available. The parameters that can be fit include carrying capacity (K), intrinsic rate of increase (r), biomass in the first modeled year defined as a ratio of K (alpha.b0), the shape parameter for the surplus production function for the Fletcher/Schaefer fit (n), the average annual catch for years prior to recorded catch data (cat0), and catchability for each

CPUE series (q). Priors can be used for all parameters. The biomass trajectory can be projected under any catch or harvest policy, with confidence bounds. Decision tables with policy performance at given time horizons, such as stock rebuilding are included in the outputs. A key aspect of BSP2 is assessing different model scenarios and determining criteria for objectively selecting and rejecting different models. The primary diagnostic for comparing model fits is calculating and comparing Bayes factors amongst different model likelihoods. The workshop covered a lot of ground, ranging from theory of Sampling Importance Resampling (SIR) algorithm which underpins how parameter space is estimated in BSP2, to running SP models in spreadsheets, to developing a provisional model of BSP2 using sample blue shark data. An important outcome was learning that the provisional, but representative blue shark data was of good quality relative to other assessments Prof. McAllister has conducted.

Discussion:

The WG asked if the BSP model could incorporate the uncertainty in total catch in the estimation of the population dynamics. The authors clarified that catch is assumed known but uncertainty in the catch levels could be addressed through sensitivity analysis. The authors further reported that uncertainty in CPUE is included in the likelihood function, including both observation error for the simplified and state-space models and process error when using the state-space model. It was also noted that the BSP model is a generalized model with an estimable shape parameter, and that Dr. McAllister offered support for the assessment modeling efforts. A manual describing the methods of the BSP model which was prepared for ICCAT in 2006 was provided to this WG.

7.0 REVIEW OF FISHERY DATA FOR BLUE SHARK STOCK ASSESSMENT

In this section, several WG papers addressed both CPUE models and catch estimation procedures since estimating catch depended upon applying CPUE to a time series of effort. In those cases, the summary and discussion addressing both are included in section 7.1 below.

7.1 Catch and discard data and total catch estimation procedures

7.1.1 Chinese Taipei

Catch and abundance index of the blue shark by Taiwanese small-scale longline fishery in the North Pacific Ocean (ISC/13/SHARKWG-1/08), Kwang-Ming Liu

Summary:

This study estimated the blue shark catch and abundance index of the small-scale Taiwanese longline fishery from 2001 to 2010. Almost all sharks caught by these fleets landed in Nanfanao, Chengkung and Tungkang fishing ports located at eastern and southwestern Taiwan. The landing data indicated that the shark landings of offshore fisheries were dominated by blue sharks comprising 62.2% of landed sharks. All blue sharks landed at Chengkung were whole fish, but 89.5% of those landed at Nanfanao were frozen (processed). The mean conversion factor (0.41) between processed and whole weight was used to convert frozen landings to catch in whole weight. Annual blue shark catch by Taiwanese small-scale longline fisheries ranged from 8847 mt to 16081 mt, with an average of 12314 mt in 2001-2010. Fishing effort was estimated by the multiplication of fishing days of each trip and numbers of hooks per day. The standardized CPUE of blue shark ranged from 20.75 (kg/1000 hooks) to 63.57 (kg/1000 hooks) from 2001 to 2003, and increased to 40.63 (kg/1000 hooks) to 64.67 (kg/1000 hooks) from 2005-2010.

Discussion:

The WG asked why the standardized CPUE of the small-scale fleet which targeted blue shark was low in comparison to Japan and HI deepset longline CPUEs. One possible reason was that a seasonal effect was incorporated in the standardization model to account for targeting of the Taiwan coastal fleet. Because the fishery includes foreign-based vessels not targeting shark, the seasonal effect may not have adequately accounted for targeting in the model result. Similar to the large-scale fleet, there was a request for Taiwan to investigate a reason(s) why standardized CPUE of the Taiwanese small-scale fleet was much lower than that of Japanese training vessels which operated in the same seasons/area. The WG discussed whether the estimated catch and standardized CPUE of Taiwanese small-scale fleet should be used for the blue shark assessment. **The WG agreed the standardized CPUE is not to be used for the assessment. The WG agreed to use the estimates of catch as they are based on weighed landings information. The WG requested Taiwan provide information regarding the coefficients and the model diagnostics, including why several interaction terms showed too few degrees of freedom. The WG reviewed some diagnostics that were subsequently provided and requested that Taiwan prepare a new document describing the fishery including its operational coverage, and the standardization methods, and recommended further research to improve the index for the next assessment.**

The WG discussed how to deal with the low CPUE. If the values are for some reason biased, one possible way to deal with this is to introduce an inflation factor. However, there may be no way to determine the correct reference value.

The WG noted that there were no estimates for past catch (prior to 1980). **Taiwan scientists agreed to estimate past catch based on effort information.**

The WG discussed how the whole weight of landings was calculated. Sixty-two fresh sharks were measured before and after being dressed and frozen to calculate whole weight from frozen trunks. It was noted that the dressed to whole weight ratio presented is comparable to those found in the Indian and Atlantic Oceans, although the ratio is much higher for blue sharks landed in California. **The WG requested ongoing investigations of weight-weight conversion factors for dressed sharks by different size categories.**

Catch and standardized CPUE of the blue shark by Taiwanese large-scale longline fishery in the North Pacific Ocean (ISC/13/SHARKWG-1/07), Kwang-Ming Liu

Summary:

In the present study, the blue shark catch and effort data from observer records of the Taiwanese large-scale longline fleets operating in the North Pacific Ocean from 2004-2010 were analyzed. Due to the large percentage of zero shark catch, the catch per unit effort (CPUE) in number of sharks caught per 1,000 hooks, was standardized by the zero inflated negative binomial model. The standardized CPUE showed a stable increasing trend for blue sharks during the time period. The blue shark catches of 1991-2003 were back estimated by the multiplication of the mean standardized CPUE and annual fishing effort from logbooks. Blue shark bycatch by Taiwanese large-scale longline fleets ranged from 6 tons (1994) to 686 tons (2002) in the North Pacific Ocean.

Discussion:

In response to a question regarding the characteristics of this fleet, the author responded that the large-scale fishery (distant water) represents vessels more than 100 tons, targeting tunas and the small-scale one means offshore plus foreign-based vessels less than 100 tons. Observer coverage in the large-scale fleet is approximately 5% of the vessels. **The WG would like catch to be estimated pre-1991 (back to 1971).** Effort was small, but there was considerable swordfish catch, and therefore blue shark bycatch may not be insignificant. Two ways to estimate these data could be; 1) using a ratio of blue shark to swordfish catch, or 2) by applying the Japanese CPUE standardization model to Taiwan effort data. There is some negligible discard info from observers, but they do not distinguish between dead and live discards, and logbooks don't record discard information. It was estimated that 80% of shark bycatch is blue shark. The WG remarked that catch and CPUE seemed unexpectedly low compared to Japan and US longline CPUEs, but there is not enough information available to request additional analysis. Hooks-per-basket was not included as a factor in the standardization due to differences between fishing in the north and south regions. A targeting effect was accounted for in the standardization by an area term. Logbook nominal CPUE was lower than based on observer records, giving more reason to use observer data to reconstruct catch. The large-scale longline corresponds to the 'distant water' LL fishery in Billfish WG, and the small-scale longline corresponds to the 'offshore' LL fishery in Billfish WG.

The CPUE time-series is considered relatively short and not understood well enough to be used as an abundance index in the assessment. The WG requested further diagnostics be provided (i.e. residuals, model coefficients, trends in positive catch by 2 areas), and to consider including interaction terms. The WG requested that Taiwan investigate reasons why the nominal and standardized CPUEs were much lower (roughly 1/10) than that of the Japanese training vessel fleet which operated in the same time-area. Furthermore, the CPUE based on logbook data was even lower. The WG recommended further research to improve this index prior to the next assessment.

7.1.2 USA

Preliminary catch estimates of north Pacific blue shark from California experimental shark longline fisheries (ISC/13/SHARKWG-1/02), Steve Teo

Summary:

Two experimental longline fisheries targeting sharks were developed in California during two periods: 1979-1980 and 1988-1991. The first fishery from 1979-1980 (hereinafter called the SK fishery) consisted on a single vessel that was funded by a Saltonstall-Kennedy grant to investigate the development of a commercial fishery for north Pacific blue shark (*Prionace glauca*). The second fishery from 1988-1991 (hereinafter called the CFGC experimental permit fishery) developed after the California Fish and Game Commission (CFGC) issued permits for an experimental longline fishery targeting shortfin mako (*Isurus oxyrinchus*) and blue sharks starting in 1988. A report by the West Coast Fisheries Development Foundation provided direct records of number of blue sharks caught and landed weight by the SK fishery. Logbook data were used to estimate catch, dead discards, and total removals by the experimental permit fishery. The catch of this SK fishery in round weight was estimated to be 36.6 and 99.2 mt for 1979 and 1980, respectively. The estimated catch of the experimental permit fishery ranged from 35.18 mt in 1991 to 77.77 mt in 1988. However, due to the high discard rate and high proportion of discarded fish in good condition, the estimated total removals for this fishery ranged from 4.22 mt in 1991 to 37.91 mt in 1988.

Discussion:

The WG accepts these estimates.

Catch statistics, length data, and standardized CPUE for the blue shark taken by longline fisheries based in Hawaii and California (ISC/13/SHARKWG-1/02), Steve Teo

Summary:

This working paper presents an update to previously reported compilations of catches, length distributions, catch per unit effort (CPUE) standardizations and other information for blue shark *Prionace glauca* in US Pacific longline fisheries based in Hawaii and California. The blue shark catch in waters near Hawaii from 1975 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 a predominance of males in tropical waters (0–10°N) and above 30°N in the deep-set sector and a 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. In addition, catch data from the California pelagic longline fishery during 1991–2004 are included. The estimated catch from experimental longline fisheries in the Southern California Bight was reported in ISC/13/SHARKWG-1/02.

Discussion:

The WG recommended using the catch estimated for the assessment once the discard mortality is accounted for. Diagnostics of the indices were sound. However, the WG also noted that the area covered by the each fishery is small relative to those used for Japanese and Taiwanese indices, and may not be representative of the stock abundance as a whole. In addition, the WG noted that there were numerous regulations applied to the shallow set fleet and that would probably affect catchability. Noting that the HI deepset longline index was the only candidate index with a negative trend in recent years, the **WG recommended that the HI deepset index be used in a sensitivity run but not used in the base-case run**. The trend in this index differs from that for the other north Pacific longline fisheries, thus t**he WG would like the authors to continue to explore the effect of the regulatory changes on the CPUE trend.**

7.1.3 Japan

Re-estimation of abundance indices and catch amount for blue shark in the North Pacific (ISC/13/SHARKWG-1/02), Yuko Hiraoka

Summary:

The objective of this WP is to provide abundance indices by standardizing CPUE of blue shark caught by Japanese surface longliners registered in the Tohoku and Hokkaido areas and to estimate catch numbers using the standardized CPUE for use in the stock assessment of blue shark. In order to clarify the most appropriate model for the abundance index and the catch estimations, three types of formulae were compared. It is considered that the negative binomial model would be the best formula from the perspective of the estimation of blue shark catch because the delta-lognormal model resulted in under estimation. In addition, the filtering method, which was addressed by SPC and adopted by WCPFC SC in 2011, was introduced into this study to remove data for operations with unrealistically high zero catches, which was pointed out in the last ISC SHARKWG meeting in July 2012. The newly introduced filtering method succeeded in reducing the number of unexpected data with zero catch.

Discussion:

The WG requested that the fishery and methods for these abundance indices be well described as they are the most important indices used for the assessment. The WG Chair will determine if previously submitted WG papers adequately contain all the needed information including showing the effect of data filtering on proportion of zero catch that ends up in the standardization, diagnostics, observed & predicted CPUE, and the description of area coverage and catch composition.

7.1.4 Mexico

Estimates of Mexico's blue shark catch from 1976 – 2010 (ISC/13/SHARKWG-1/04), Tim Sippel

Summary:

The purpose of this document is to detail how blue shark catches have been estimated for Mexico from 1976-2010, using a combination of catch statistics from INAPESCA (Mexico) and publicly available information. Catch is estimated for three vessel size classes: small (artisanal: shark target); medium (drift gillnet and longline: swordfish and shark target); and large (longline: tuna and swordfish target). While there are many assumptions and uncertainties about these data, these estimates are the only ones currently available to the SHARKWG about the amount of blue shark catch from Mexico's fisheries.

Discussion:

The WG discussed the GLM methods used to estimate catch, noting that some additional explanation of the model used may be necessary to be sure it is appropriate for estimating catch for years with missing data since year was a factor. It was noted that the trends in estimates for the small and medium fleets were highly correlated due to the fact that they were both estimated based on a ratio of the total aggregated shark catch. The WG noted that the recent catch trend is due to increasing catches in the Tiburon shark category. It was explained that the increase is due to spatial expansion of the fishing grounds and increased targeting of blue shark.

Unofficial estimates of Mexico's blue shark catch from 1976 – 2010 (oral presentation), Oscar Sosa-Nishizaki

Summary:

Estimates of Mexico's blue shark catch in artisanal, mid-size drift and longline, and large longline fisheries were presented to the SHARKWG. It was noted that these estimates had not been reviewed or agreed upon by Mexico's national fisheries scientists of INAPESCA, thus they are considered unofficial. Estimates were made based on the national total shark landings statistics for 1976-2010 and the distribution in effort of the fisheries which changed during the time series from relatively greater shark catch in the Gulf of California early in the time series to relatively higher shark catch in Pacific waters off Baja California later in the time series. Blue shark catch is considered significant in 5 Mexican Pacific states: Baja California, Baja California Sur, Sinaloa, Nayarit and Colima. A number of factors contributed to changes in the fisheries over time including efforts to conduct joint venture longline fishing with Asian fleets in the 1970s and 1980s, and a switch from finning to total utilization in the 1980s. The estimates are considered to accurately include large longline fishing catch for vessels based out of Colima (Manzanillo port), but may underrepresent catch from Ensenada-based large longliners in the 1980s conducted jointly with Japan. The derived estimates across all fisheries and states ranged from roughly 300 mt through the late 1980s increasing to nearly 5000 mt in recent years.

Discussion:

The WG noted that the estimates of blue shark catch from WP 04 are very close to the unofficial estimates presented here, particularly for the recent 20 years. The WG discussed the level of discarding in Mexican fisheries. The author indicated that prior to 1985, discard is likely negligible for the midsize vessel fleet because the fleet didn't fish in high density areas. However, the large fishing vessel joint venture operations may have taken significant numbers of blue sharks, and their catch and discard is not currently included in these estimates. The author further clarified, that between 1985-1992 the drift gillnet fleet increased effort, which may have resulted in some level of discard not included in the estimates of catch. After 1993, discard may again be negligible as markets changed to favor shark retention. To estimate discard of blue shark in the period 1985-1992, a ratio of blue shark to swordfish could be used. **The WG recommends using the catch estimates presented in this paper for small and medium vessels after adding an estimate of the unrecorded discard in 1985-1992 for Ensenada vessels. Furthermore, the WG recommends using the estimates of large vessel catch from this paper (representing the Colima fleet) after adding the Japan joint venture fleet data ~1971-1990 catch for Ensenada if they are not already included in Japan's catch. The SHARKWG Chair will follow up with Mexico scientists to help finalize the catch time series.**

The WG noted that Mexico appears to have a lot of fishery information for blue and mako sharks, including size information and life history studies. The WG encourages presentations of Mexico and US fishery and biological information at future WG meetings as little information is currently available for the EPO.

7.1.5 IATTC

Estimates of blue shark catch by EPO purse seine fleets (ISC/13/SHARKWG-1/INFO-01), Cleridy Lennert-Cody

Summary:

The number of blue sharks caught by purse seiners in the north EPO from 1971-2010 was estimated from observer bycatch data, and observer and logbook effort data, both archived by the

IATTC. Some assumptions regarding the relative bycatch rates of blue sharks were applied based on their temperate distribution and catch composition information. Estimates were calculated separately by set type, year and area. Small purse seine vessels, for which there are no observer data, were assumed to have the same blue shark bycatch rates by set type, year and area, as those of large vessels. Prior to 1993, when shark bycatch data were not available, blue shark bycatch rates assumed to be equal to the average of 1993-1995 rates were applied to the available effort information by set type, area and year. The estimated number of blue sharks caught annually ranged from 20 to 585 individuals.

Discussion:

The WG noted that the BSP model needs total removals in tons. **The WG asked that the catch in numbers be converted to weight using the observed lengths and the agreed upon length-weight relationship. The WG recommends that observed size data be aggregated to derive the average size of a fish to estimate total catch in tons**. Bias in estimated population dynamics resulting from this aggregation will be negligible because catch is small relative to total NPO catch.

7.1.6 SPC

Longline catch estimates for non-ISC members fishing in WCPO north Pacific waters

Summary:

The SHARKWG Chair showed 1994-2012 estimates provided by SPC of longline blue shark catch from non-ISC members in the WCPO. Catch estimates ranged from a low of 161 mt in 1994 to 5846 mt in 2004. A figure was also provided showing the range of the fisheries included in the catch. Size data aggregated across all years (n=1233 sharks) were also provided but it was cautioned that they may not be representative of all fleets.

Discussion:

The WG was concerned that these longline data may also be reported in Taiwan's small scale longline fishery data, which includes catch from foreign flagged vessels. **The SHARKWG Chair will follow up with the SPC data manager to find out if more information can be provided regarding the fleets. Effort will be made to compare the Taiwan data with the SPC data in order to minimize the chance of double counting foreign flagged longline catch.**

7.2 Estimation of catch of fleets without direct observations

7.2.1 China

Estimate of annual catch of blue sharks by China longliners

Summary:

The ISC data managers received China's catch and effort data in 5x5 blocks in the Pacific for high seas longline fisheries from 2001-2010. Catch and effort were tabulated for north Pacific waters as provided to WCPFC and IATTC. For 2009 and 2010 these data also included a small experimental fishery based in the EEZ of Kiribati. Along with effort (longline hooks), blue shark catch was provided for 2008-2010. This information was used to calculate an average CPUE for 2008- 2010. The average CPUE was multiplied by effort for 2001-2007 to estimate blue shark catch in these years.

Discussion:

The WG discussed the method proposed to estimate blue shark catches of the China longline fishery. The WG noted that this fishery started relatively recently, in about 2000, so the reported effort information is the best information available. After much discussion, **the WG agreed that the proposed method be used to estimate blue shark catches for this fishery, given the limited amount of information available.**

7.2.2 Korea

Estimate of annual blue shark catch weight for Korean longliners

Summary:

The ISC database contains the annual catch weight of species aggregated sharks as well as the amount of effort (number of hooks) by Korean longliners between 1973 and 2011. The Korean annual reports to the two past WCPFC SC meetings (Korea 2010, Korea 2011) indicated that the catch of major shark species includes only blue and porbeagle sharks based on logbooks, and 65% of the catches of major shark species was comprised of blue shark based on observer records for one year (Korea 2010). The Korean annual report in 2010 also reported that the average CPUE of blue shark caught by Korean longliners was 0.07 (number/100 hooks) based on the observer data. The main operational area of Korean longliners is 150E – 100W and 10N – 10S.

Based on these information, it was assumed that all Korean reported catch of species aggregated sharks are blue sharks, because porbeagle sharks are not distributed in the north Pacific. Estimated CPUE by year in number of blue sharks per 1000 hooks caught by Korean longliners was calculated using reported catch and an assumed average weight of blue shark of 30 kg. The estimated CPUE values ranged from 0.0 to 0.89 which is comparable to the average CPUE obtained by the Korean observer data.

Discussion:

The working group noted that reported aggregated shark catches in the ISC database should be used for estimation purposes. Korean National Reports to WCPFC seem to indicate that all NPO shark catch is likely blue shark. **Thus the WG decided to use reported annual catch of species aggregated sharks data by Korea as the total removals for the base case. The possible maximum and minimum catches were also estimated for sensitivity analyses.** The maximum values were obtained by assuming additional catch as dead discards using the same discard ratio as Japanese deepset longliners. The minimum values were obtained by reducing the base case catch by removing discards based on the Japanese discard ratio assuming all discards survive. **The working group recommends additional research to improve Korean catch estimates for future assessments**.

7.2.3 Costa Rica

Summary:

An ISC Shark WG member had a brief, informal discussion with a fishery scientist from Costa Rica (CR) who was visiting the IATTC in late 2012. The CR scientist had recently begun estimating shark catches, including blue sharks, in a collaborative effort with IATTC. From 2004-2011, longline catches ranged from 1000-1300 mt. However, CR scientist indicated the majority of this catch was from foreign flagged vessels, with CR accounting for only 10-20% of this and the rest being of uncertain flag or reporting source. CR is continuing efforts to expand on these very preliminary estimates. CR indicated Panama could be another source of Central American blue shark catch to account for in the future.

<u>Discussion:</u>

There appears to be a lot of uncertainty regarding north Pacific blue shark catch landed in Costa Rica and other Central and South American nations. Information is not available on what proportion of the reported catch represents only Costa Rica catch or foreign flagged vessels. It was thought that some of the catch may already be included in foreign fleets catch accounted for in the other catch time series (i.e. in member fisheries, IATTC or SPC data). The WG discussed the need for additional catch information from other nations fishing in the EPO. It is unlikely that better estimates will be available by the data submission deadline. **Due to the expected lower catch rates of nations in the lower latitudes and the lack of good information, the WG agreed to not include estimates for other EPO non-member nations in this assessment. Research into the Central and South American shark catch should continue in order to provide improvements to the catch data time series for future assessments.**

7.3 Size Data

7.3.1 Chinese Taipei

Size and sex of blue sharks measured in the Taiwan longline fisheries (oral presentation), Kwang-Ming Liu

<u>Summary:</u>

Chinese Taipei presented the sex-specific length frequency distributions of blue sharks from the small-scale longline fishery in Taiwanese offshore waters, and from logbooks and observers for large-scale longline fishery. Sizes range from 90 cm to 320 cm TL with a mode of 200-210 cm TL for the small-scale fishery. Sizes reported by observers range from 60 to 340 cm TL with a mode of 220 cm TL for the large-scale longline fishery. These data were further separated by latitude at 30° N.

7.3.2 USA

Size and sex of blue sharks measured in the US fisheries (oral presentation), Tim Sippel

Summary:

US presented sex-specific blue shark size data from US West Coast drift gillnet fisheries (1990-2010), Hawaii longlines (deep and shallow set, 1995-2010), and juvenile shark longline survey (1993-2010) have been tabulated in 1 cm bins (PCL). For each year, the number of trips, number of sets, and number of fish measured are included to enable calculation of effective sample size for the 2013 blue shark assessment alternative model.

<u>Discussion of all size data:</u>

In response to a request from Japan, the basic plan for the use of size data in the alternative modeling was discussed. The alternative modelers responded that they will use the most detailed information provided to make the best assumptions for the simulation modeling. **The WG requested that member countries submit their size data in PCL by three areas (Areas 1&2**

combined, Areas 3&4 combined, and Area 5), quarter, sex and fisheries. A 1 cm bin is most desirable, but if the measured resolution is not as fine, then larger bins will still be useful.

The template of size data was reviewed and the deadline for all final data submission was set to February 8, 2013.

7.4 Abundance indices and CPUE estimation procedures

The WG reviewed 6 candidate abundance indices that were proposed to be used in the upcoming assessment to represent relative abundance of north Pacific blue shark. In order to determine which of the candidate abundance indices to use for the assessment, the WG evaluated the pros and cons of each index. It was suggested that the WG examine and discuss other RFMO's criteria and guidelines on evaluating abundance indices. A paper describing ICCAT guidelines for evaluating the quality of candidate abundance indices was reviewed (ICCAT 2010). After some discussion of ICCAT's and other criteria, the WG developed a table of criteria with which to evaluate the indices (Table 1). The characteristics of each candidate index with respect to each criterion was collated and used to populate the table. Several working papers were presented at this and previous meetings that documented the data and analysis used to derive these indices (Table 1 and see section 7.1 above).

Discussion:

After substantial discussion on each criteria and index, **the WG decided to use the Japanese early longline index from the offshore shallow-set longline fleet from Hokkaido and Tohoku (1976-1993) and the Japanese late longline index from the offshore and distant-water shallow-set longline fleet from Hokkaido and Tohoku (1994-2010) (Table 1) as the primary indices for the upcoming assessment.** The main reasons for using these as the primary indices are that the spatial and temporal coverage of these indices are large (covering most of the stock range), the relatively large catch of blue shark, the large range of sizes caught, no known changes in catchability, and sound statistical analysis using filtered data to remove data from trips that did not record blue shark data. In contrast, the longline indices from Hawaii were of relatively small spatial coverage and changes in regulations have likely affected the catchability of the Hawaii shallow-set index. The indices based on the Taiwan longline fisheries have good characteristics for many criteria (e.g., large spatial coverage and the use of observer data) but have relatively short time-series. For the Taiwan indices, there were questions about whether blue sharks discarded or total effort were consistently sampled throughout the time series, and the documentation did not have sufficient details addressing all necessary information. Since the Hawaii longline indices were the only indices that showed a negative trend in recent years, **the WG decided to use the Hawaii deep-set longline index as an alternative index to be used in sensitivity runs**. The Hawaii deep-set index was preferred to the Hawaii shallow-set index because of the likely impacts of regulations on the shallow-set index.

Table 1. Characteristics of candidate abundance indices proposed to represent relative abundance of north Pacific blue shark and criteria used to evaluate the indices.

	Hawaii Deep-set Longline	**Hawaii Shallow-set Longline**	**Taiwan Large-scale Longline**	**Taiwan Small-scale Longline**	**Japan Early Offshore Shallow (Hokkaido & Tohoku)**	**Japan Late Offshore & Distant Water (Hokkaido & Tohoku)**
Quality of Observations	Good because observer data is used with ~5-20% observer coverage and discards are recorded	Good because observer data is used with ~5-100% observer coverage and discards are recorded	Good because observer data is used but recorded discard data may not be representative	Catch data are representative but effort data were estimated	Relatively reliable because 94.6% filtered data applied, logbook data more reliable by filtering	Relatively reliable because 94.6% filtered data applied and logbook were validated by training vessel and observer data
Spatial distribution	Relatively small (Areas 4 & 5)	Relatively small (Areas 2 & 5)	Large (Areas 1-5)	Large (Areas 1-5)	Medium (Area 1 & 3)	Large (Area 1, 2, 3 & 4)
Size/age distribution	90% of catch from females: 175-275 cm TL; males: 175-300 cm TL	90% of catch from females: 100-275 cm TL; males: 100-300 cm TL	60 to 340 cm TL	90 cm to 320 cm TL	no information	90-170 cm PCL
Statistical soundness	Yes. Delta-lognormal model was used and model diagnostics were good	Yes. Delta-lognormal model was used and model diagnostics were good	Some diagnostics provided	Diagnostics provided	Yes	Yes
Temporal coverage	1995-2011	1995-2001; 2004-2011	2004-2010	2001-2003; 2005-2010	1976-1993	1994-2010

Catchability Changes (due to management, fishing practices, etc.)	Finning ban from 2000 (probably limited effect on Q)	Ban in shark finning from 2000 (probably limited effect on Q); Shallow-set longline ban from 2001-2004 (likely affects Q); hooks and bait requirements after 2004; limits on turtle bycatch	Ban in finning from 2005 (probably limited effect on Q)	Ban in finning from 2005 (probably limited effect on Q)	No regulation, gear or targeting change	No regulation, gear or targeting change
Relative catch contribution	~1500 to 2000 mt annually	~1500 to 2000 mt annually	<500 tons from 2003	>10,000 tons from 2004	19,000-55,000 mt	13,000-24,000 mt
Decision	Use in sensitivity run	Not used	Not used	Not used	Used in base-case model	Used in base-case model
Decision reason	Use in sensitivity run because it has some desirable characteristics and has different trend from others, but area too small to be primary index	Multiple management changes likely affected catchability	Time-series is relatively short and some questions remain about the representativeness of recorded number of discards	Time-series is relatively short, especially since the index in the early period (2001-2003) should not be used due to incomplete sampling of effort	Large spatial and temporal coverage	Large spatial coverage
			Working papers need to include the following elements:			
Fishery description	ISC/11/SHARKWG-1/05, ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/11/SHARKWG-1/05, ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/11/SHARKWG-1/06, ISC/13/SHARKWG-1/07	ISC/12/SHARKWG-1/15, ISC/13/SHARKWG-1/08	ISC/11/SHARKWG-2/10	ISC/11/SHARKWG-2/11

Analysis description	ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/13/SHARKWG-1/07	ISC/13/SHARKWG-1/08	ISC/12/SHARKWG-1/07, 08, 09 ISC/12/SHARKWG-2/02 ISC/13/SHARKWG-1/03	ISC/12/SHARKWG-1/08, 09 ISC/12/SHARKWG-2/02 ISC/13/SHARKWG-1/03
Treatment of outliers or data filtering	ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/11/SHARKWG-2/02, ISC/12/SHARKWG-1/02	ISC/13/SHARKWG-1/07	ISC/13/SHARKWG-1/08		
Remarks			Discard rate is suggested to be higher than recorded by observers because CPUE is unexpectedly low	Negligible discard rate; more confidence in late compared to early time series due to higher coverage of effort sampling in the late period		

8.0 REVIEW BIOLOGICAL PARAMETERS FOR BLUE SHARKS

Genetic population structure of blue sharks in the Pacific Ocean inferred from the microsatellite DNA marker (ISC/13/SHARKWG-1/9), Kotaro Yokawa

Summary:

To investigate the genetic population structure of blue shark (*Prionace glauca*) in the Pacific Ocean, a total of 471 individuals from 10 fishing grounds were genotyped at twelve microsatellite loci. Two loci were excluded from data analysis because of the evidence of deviation from Hardy-Weinberg equilibrium and/or linkage disequilibrium, although all microsatellite loci genotyped in the present study were polymorphic. An exact test of population differentiation based on allele frequencies indicated no genetic divergence across the Pacific Ocean. A Bayesian clustering analysis also inferred that the blue sharks in the Pacific Ocean assigned to one population. In contrast, hierarchical cluster analysis based on pairwise F_{st} estimates and AMOVA showed a weak genetic structuring of blue shark in the western Pacific Ocean. Taking together prior mtDNA results with these microsatellite results, the Pacific blue shark appears to have a weak genetic structure in the western Pacific Ocean. Additionally, the difference of genetic structure between the present microsatellite and the previous mitochondrial analyses would come from different aspects which both markers reflect, i.e., maternal population history for mitochondria, and more recent population dynamics of both sexes for microsatellites.

Discussion:

A comment was made this study was not designed to examine fine scale genetic differentiation, and that genetics studies in general are known to be of limited value in identifying stock structure. **However, the WG believes that evidence in the paper should be taken in combination with other evidence (e.g. CPUE patterns, tagging data, etc.). Ongoing sample collection and analysis are encouraged as larger sample sizes may help understand genetic structure.**

9.0 DISCUSS PRIORS FOR THE BSP MODEL

Summary:

The WG discussed BSP modeling parameters including priors, base case configuration, tentative sensitivity analyses and future projection scenarios. Once a draft catch table was prepared based on all the estimates reviewed in section 7.1, and the abundance indices selected, the WG conducted some trial runs to make sure the code was behaving correctly and that priors were appropriately specified. Some of the runs were conducted to identify how influential the priors were and the interplay between r and B_{init}/K. Refinements to the initial choices were made based on the outcomes of preliminary runs and the best scientific information available.

Discussion:

The WG requested clarification on how the proposed priors were developed and if the priors represented the final priors for the base case modeling. In particular, the WG noted that the prior on the ratio of initial biomass to carrying capacity assumes the stock was unfished prior to 1971. Catch of blue shark had been reported in some fleets prior to 1971. The authors clarified that the proposed priors (Table 2) were the starting points but were subject to change with new information. The authors also noted that the proposed prior on *r*, 0.34, is the same as the prior used by Kleiber et al. 2009. Runs conducted with the provisional data during this meeting demonstrated that the data appear to be driving the results which were relatively stable across a wide range of priors.

10.0 DECIDE ON MODEL CONFIGURATION FOR BASE CASE

The WG had tentatively agreed in previous meetings to use the Bayesian Surplus Production model software that was used in the previous assessment by Kleiber et al. (2009). In order to develop the base-case model for the upcoming assessment, the WG conducted several preliminary model runs based on specifications and parameterizations from Kleiber et al. (2009) as well as alternative parameterizations. In particular, emphasis was put on investigating the effect of using different priors (more diffuse priors and priors with different means; see Section 9) and understanding the relative influence of the data and priors on model results. **Based on these preliminary runs, the WG tentatively agreed to use the following specifications and parameterization for the base case model (Table 2). However, it should be noted that these specifications and parameterizations may be subject to change with further analysis by the WG.**

The WG agreed to investigate the best model to use to describe the shape of the production model function: the Schaefer model or the Fletcher/Schaefer model. The WG agreed to estimate K with a uniform prior of log(K) and *r* with a lognormal prior with a mean of 0.34 and SD of 0.3, which were used in Kleiber et al. (2009). Taiwan scientists provided preliminary analysis of the life histories and growth rates of several sharks and *r* was estimated to be approximately 0.35 for northwestern Pacific blue. The WG requested that Taiwan prepare a working paper on their study at the April assessment meeting. The B_{init}/K sets the relative proportion of initial biomass to K and was previously set with a normal prior with a mean of 1 and SD of 0.2 (bounds at 0 and 1) by Kleiber et al. (2009). However, preliminary runs suggest that the data tend to pull the mean of the B_{init}/K posterior towards the region between 0.5 and 1.0. Therefore, the WG recommended using a prior with a mean of 0.8 and SD of 0.5 for the B_{init}/K parameter in order to reduce the influence of this prior on model results.

Based on the analysis and review by the WG, the WG recommended that the catch data to be used in the base case model are the total dead removal estimates provided by WG members or estimated by the WG if these estimates were not provided (see Sections 7.1 and 7.2). The WG also recommended using the Japan early and late longline indices as the indicators of stock relative abundance (see 7.4).

Table 2. Tentative base case model specifications and parameterizations.

Specifications and Parameters	Mean	Uncertainty	Comments
K			Uniform on log(K)
r	0.34	SD=0.3	From Kleiber et al. 2009
B_{init}/K	0.8	SD=0.5	Lower mean and more diffuse prior than Kleiber et al. 2009, based on preliminary runs
Catch			Total dead removals estimated by WG members (see section 7.1 & 7.2)
Abundance Indices		CVs (TBD)	Japan early and late indices

11.0 DECIDE ON TENTATIVE SENSITIVITY ANALYSES

The WG discussed the sensitivity analyses to be performed for the upcoming stock assessment. Based on these discussions and the results from several preliminary runs, **the WG tentatively agreed to perform sensitivity runs based on the following scenarios:**

1) Maximum catch. This scenario assumes that the total dead removals estimated by the WG are underestimates due to extremely high discard mortality. Therefore, for this scenario, discard mortality is assumed to be 100% for fisheries with estimated discards (e.g., Japan longline, US longline, US gillnet). For fisheries without information on discard rates or mortality, the WG will assume that these fisheries have similar discard rates to similar fisheries (e.g., inflate the China longline catch based on the Japanese longline discard ratio).

2) Minimum catch. This scenario assumes that the total dead removals estimated by the WG are overestimates due to negligible discard mortality. Therefore, for this scenario, discard mortality is assumed to be 0% for all fisheries and only landed or finned fish are assumed to be removed from the population. In the case of Korea, the low catch time series would be decreased relative to the base case by the Japan discard ratio assuming that the Korea reported catch includes discarded fish.

3) Priors for r. The WG recommended that sensitivity runs be performed using biologically plausible maximum and minimum values (e.g., 0.15 and 0.5), as well as using less informative (more diffuse) priors with higher SDs. Since the number of sensitivity runs is relatively small and to check for possible interactions with other priors, the WG also recommended doing the runs for this scenario in conjunction with Scenario #4 (Priors for B_{init}/K) so that a matrix of sensitivity runs with a range of priors can be developed.

4) Priors for B_{init}/K. The WG recommended that sensitivity runs be performed using biologically plausible maximum and minimum values (e.g., 0.5 and 1.0), as well as using less informative (more diffuse) priors with higher SDs. Since the number of sensitivity runs is relatively small and to check for possible interactions with other priors, the WG also recommended doing the runs for this scenario in conjunction with Scenario #3 so that a matrix of sensitivity runs with a range of priors can be developed.

5) Abundance indices. The WG recommended performing a sensitivity run with the Hawaii deep-set longline index (1995-2011) replacing the Japan late longline index (1994-2010).

12.0 DISCUSS FUTURE PROJECTION SCENARIOS AND BRPS

The WG discussed the projections to be performed for the upcoming stock assessment. Based on these discussions and the results from several preliminary runs, **the WG tentatively agreed to perform projections based on the following scenarios:**

1) Base case catch. The WG recommended performing projections using the base case model, with future catches at status quo, +20% and -20%.

2) Maximum and minimum catch. The WG recommended performing projections using the maximum and minimum catch models (sensitivity scenario #1 and #2), with future catches at status quo.

The projection period (number of years and starting year) and the years used to determine catch for future projections will be determined by the WG at the upcoming assessment meeting.

13.0 PLANS FOR ALTERNATIVE MODELING

Examining size-sex segregation among blue sharks (Prionace glauca) from the Eastern Pacific Ocean using drift gillnet fishery and satellite tagging data (ISC/13/SHARKWG-1/06), Laura Urbisci and Rosa Runcie

<ins>Summary:</ins>

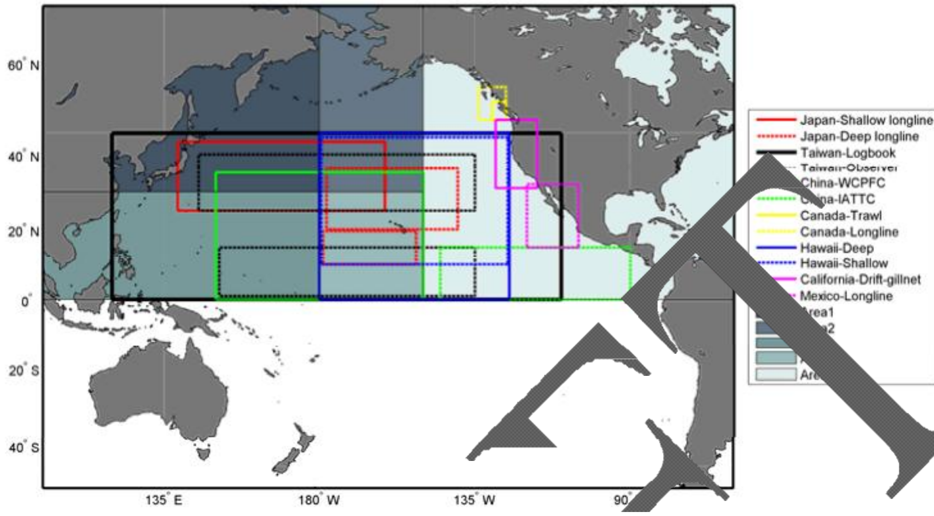
A study on the spatial distribution of blue sharks along the US West Coast was presented. Biomass dynamic (BD) models assume that fishery captures are taken from a temporally stationary distribution of age and sex classes. Nakano (1994) described a blue shark population in the North Pacific Ocean that showed significant size and sex structure that may violate the assumptions of a BD model. Fishery-dependent size composition for the US West Coast drift gillnet fleet and electronic tag data were used to validate the spatial model of Nakano (1994) which does not extend to coastal waters. Results support the conclusions of significant size-sex structure in the North Pacific Ocean and thus it is recommended that the SHARKWG consider this when assessing blue shark stock status.

<ins>Discussion:</ins>

There was much discussion about the results of this relatively small study and also evidence from other fisheries that show segregation by size and sex of blue sharks in the North Pacific. While Nakano's model was developed from sampled sharks in the central Pacific predominately, there may be different patterns in the coastal boundary areas. It was also noted that from a previous SHARKWG paper, an opposite pattern of segregation was observed with immature males predominating in the northern areas and immature females to the south of the immature males. In addition, in Mexico waters, pregnant females are captured in both the spring and fall, at latitudes that were not identified as parturition grounds in the Nakano model. It was acknowledged that the distribution of blue sharks by size and sex may be more complicated than can be described by a simple model, and that our knowledge is limited. For the planned alternative modeling, the most important thing will be to try to identify the characteristics of the majority of the catch for each of the fisheries. The first draft of a map outlining the extent of the known fisheries was reviewed (Figure 1) and, coupled with information on the size and sex composition of blue sharks in the catch, will be used to guide decision-making regarding the selectivity patterns of fisheries used in the alternative modeling. The authors were asked if seasonal movement was considered in this study and they responded that there are plans to incorporate seasonal movements in the future. **The WG recommended continued research on the spatial pattern of blue sharks in the North Pacific.**

The WG also discussed conducting alternative modeling efforts to investigate how changing biological catch composition (size and sex) may affect the BSP model results. The authors proposed using the information on size and sex structure of the fleets to construct a simulation model to evaluate the effect of changes in aggregate fishing location on BSP model results. These results would be used as validation and supporting evidence of the BSP results. It was further clarified that this effort would not be used as an alternative assessment but as part of the supporting documentation for the BSP assessment model.

Figure 1. First draft of map showing the extent of ISC member known fisheries catching blue shark in the North Pacific. The map will be updated to show all fisheries used in the stock assessment in order to develop hypotheses regarding spatial assumptions in the alternative modeling.



14.0 WORK PLAN FOR BLUE SHARK STOCK ASSESSMENT

<u>SHARKWG Members</u>

- All final assessment data are to be sent to the SHARKWG Chair and Tim Sippel by February 8, 2013. This includes total dead removal estimates, abundance indices and size and sex data by fishery.
- All time series data are to be to be prepared for 1971-2011. The 2010 value will be carried forward if 2011 is not available
- All members conduct updated analyses based on requests made during this meeting.
- Japanese modelers will take the lead on the BSP modeling. BSP correspondents are Norio Takahasi and Minoru Kanaiwa (Japan), Chien-Pang Chin and Kwang-Ming Liu (Chinese Taipei) and Tim Sippel (USA).
- Conduct base case and sensitivity runs in advance of assessment workshop.
- Conduct projections in advance of the assessment workshop.
- US modelers will take the lead on the alternative modeling.
- Conduct supporting alternative model runs in advance of the assessment workshop.
- All members ensure that working group reports describing any data used in the assessment adequately describe estimation methods with appropriate detail and diagnostics.

<u>SHARKWG Chair</u>

- Compile and distribute final assessment data within one week of the February 8 submission deadline.
- Distribute outline for assessment report based on the striped marlin assessment report.
- Contact SPC regarding cooperation on the ISC north Pacific blue shark assessment.

- Contact SPC regarding information on the longline fleets reporting blue shark catch in the north Pacific and compare with Taiwan's data in order to minimize the chance of double counting foreign flagged longline catch.
- Update metadata tables and draft map in advance of assessment workshop.
- Work with Mexico's scientists to derive their best estimates by the data submission deadline.
- Contact Korea and China correspondents for data updates by the data submission deadline.
- Review past working group reports to determine if they adequately describe methods and have appropriate detail and diagnostics. Follow up with WG members in advance of the assessment workshop if reports with greater detail are needed.

15.0 FUTURE SHARKWG MEETINGS

The WG discussed the need to keep on schedule to complete a shortfin mako assessment in 2014. In order to do so, up to 3 meetings may be needed to review shortfin mako biological and fishery information, finalize data and conduct the assessment. The WG felt that 3 meetings after completing the blue shark assessment and prior to the 2014 Plenary is too many meetings, thus came up with the tentative schedule below.

Dates (tentative location)	Objectives
April 16-24 2013 (Shimizu)	6 days blue shark assessment, develop conservation information and report writing, 2 days mako shark information gathering
July 11-14 2013 (Korea)	1 day finalize work for the Plenary on blue sharks, 3 days mako information gathering
Fall/Winter (Mexico or La Jolla)	mako shark data prep meeting
Spring 2014 (TBD)	mako shark assessment meeting

16.0 OTHER MATTERS

The WG discussed the WCPFC's SC work plan that includes conducting a Pacific-wide blue shark assessment this year. When asked by the SHARKWG Chair, SPC scientists indicated that they plan to conduct separate age structured assessments of the south and north Pacific stocks before the August 2013 SC meeting. The SHARKWG was surprised and does not agree with this decision given the understanding that there was agreement for ISC to focus on temperate north Pacific sharks and encourage collaboration with IATTC and SPC scientists on the assessments. Conducting two stock assessments for north Pacific blue sharks in the same year is not productive. ISC Chair Gerard DiNardo expressed his disagreement with this decision at the NC8 meeting. The SHARKWG welcomes participation by all members and observers in the stock assessment meeting to be held in April 2013, however detailed data will not be distributed beyond the SHARKWG for independent use by other organizations. The SHARKWG Chair will follow up with SPC to reiterate the invitation to work within the ISC SHARKWG on a north Pacific blue shark assessment.

Similarly, the WG does not agree with the decision of the SC to plan for a north Pacific shortfin mako shark assessment in 2014. The WG is moving forward with a north Pacific shortfin mako shark assessment expected to be completed in spring 2014 and encourages cooperation by all members and observers.

17.0 CLEARING OF REPORT

The Report was reviewed and the content provisionally approved by all present. The Chair will make minor non-substantive editorial revisions and circulate the revised version to all WG members within 2 weeks. Chinese Taipei delegates will be allowed to propose minor changes to content if there appear to be errors relevant to their fisheries or requests. The report will be finalized once agreed upon by all members in no more than 30 days.

18.0 ADJOURNMENT

The Chair thanked all participants for attending and contributing to a very productive meeting. She also thanked the SWFSC participants for assisting with meeting logistics throughout the week.

The meeting was adjourned at 12:47, January 14, 2013.

19.0 LITERATURE CITED

ICCAT 2010. Report of the 2009 ICCAT working group on stock assessment methods. Collect. Vol. Sci. Pap. ICCAT, 65(5): 1851-1908.

Kleiber, P., S. Clarke, K. Bigelow, H. Nakano, M. McAllister, and Y. Takeuchi. 2009. North Pacific blue shark stock assessment. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-17, 74 p.

Korea 2010. Annual report to the Commission, Part 1: Information on fisheries, research and statistics. WCPFC-SC6-AR/CCM-15, 17p.

Korea 2011. Annual report to the Commission, Part 1: Information on fisheries, research and statistics. WCPFC-SC7-AR/CCM-11, 15p.

Nakano, H. 1994. Age, reproduction and migration of blue shark in the North Pacific Ocean. Bulletin National Research Institute of Far Seas Fisheries. 31:141-256.

Attachment 1. List of Participants

Chinese Taipei

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

IATTC

Cleridy Lennert-Cody
IATTC
8604 La Jolla Shores Drive
La Jolla, CA 9203
858-546-7190
clennert@iattc.org

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

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

Mexico
(not a member of Mexico's delegation)

Oscar Sosa-Nishizaki
Laboratorio de Ecología Pesquera
Departamento de Oceanografía Biológica
CICESE
Carretera Ensenada-Tijuana No. 3918
Ensenada, Baja California,
C.P. 22860
52 (646) 1750500 ext. 24267
ososa@cicese.mx

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
NMFS/SWFSC
8604 La Jolla Shores Drive
La Jolla, CA 92037
858-546-5613
858-546-7003 (fax)
Kevin.Piner@noaa.gov

Rosa Runcie
NMFS/SWFSC
3333 North Torrey Pines Court
La Jolla, CA 92037
858-334-2847
858-546-7003 (fax)
Rosa.Runcie@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

Laura Urbisci
NMFS/SWFSC
8604 La Jolla Shores Drive
La Jolla, CA 92037
408-835-5718
lurbisci@gmail.com

Yi Xu
NMFS/SWFSC
8604 La Jolla Shores Drive
La Jolla, CA 92037
858-546-5619
858-546-7003 (fax)
yi.xu@noaa.gov

Attachment 2. Meeting Documents

WORKING PAPERS

ISC/13/SHARKWG-1/01	Report from the Bayesian Surplus Production model (BSP) workshop: Yokohama, Japan – November 2012. Tim Sippel and Norio Takahashi (tim.sippel@noaa.gov)
ISC/13/SHARKWG-1/02	Preliminary catch estimates of north Pacific blue shark from California experimental shark longline fisheries. Steven L. H. Teo (steve.teo@noaa.gov)
ISC/13/SHARKWG-1/03	Re-estimation of abundance indices and catch amount for blue shark in the North Pacific. Yuko Hiraoka (yhira415@affrc.go.jp)
ISC/13/SHARKWG-1/04	Estimates of Mexico's blue shark catch from 1976 - 2010. Tim Sippel (tim.sippel@noaa.gov)
ISC/13/SHARKWG-1/05	Catch Statistics, Length Data and Standardized CPUE for Blue Shark *Prionace glauca* taken by Longline Fisheries based in Hawaii and California. William A. Walsh and Steven L. H. Teo (william.walsh@noaa.gov)
ISC/13/SHARKWG-1/06	Examining size-sex segregation among blue sharks (*Prionace glauca*) from the Eastern Pacific Ocean using drift gillnet fishery and satellite tagging data. Laura Urbisci, Rosa Runcie, Tim Sippel, Kevin Piner, Heidi Dewar and Suzanne Kohin (lurbisci@gmail.com and suzanne.kohin@noaa.gov)
ISC/13/SHARKWG-1/07	Catch and standardized CPUE of the blue shark by Taiwanese large-scale longline fishery in the North Pacific Ocean. Wen-Pei Tsai and Kwang-Ming Liu (kmliu@mail.ntou.edu.tw)
ISC/13/SHARKWG-1/08	Catch and abundance index of the blue shark by Taiwanese small-scale longline fishery in the North Pacific Ocean. Chien-Pang Chin and Kwang-Ming Liu (kmliu@mail.ntou.edu.tw)
ISC/13/SHARKWG-1/09	Genetic population structure of blue sharks (*Prionace glauca*) in the Pacific Ocean inferred from the microsatellite DNA marker. Mioko Taguchi and Kotaro Yokawa (tagu305@affrc.go.jp)

INFORMATION PAPER

ISC/13/SHARKWG-1/INFO-1	IATTC Purse Seine estimates (clennert@iattc.org)

Attachment 3: Agenda

SHARK WORKING GROUP (SHARKWG)

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

INTERCESSIONAL WORKSHOP AGENDA

7 – 14 January, 2013
NOAA Southwest Fisheries Science Center
3333 North Torrey Pines Court
Large Conference Room
La Jolla, CA

1. Opening of SHARKWG Workshop
    - 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 May 2012 and July 2012 Workshops (Kohin)
6. Summary of Bayesian Surplus Production Model Workshop (Piner, Kanaiwa) **WP01**
7. Review fishery data for blue shark stock assessment
    - Catch and discard data and total catch estimation procedures (Sippel, Takahashi) **WP07, 08, 02, 05, 03, 04, INFO01**
    - Estimation of catch of fleets without direct observations (Piner, Teo)
    - Size data (Liu, Hiraoka)
    - Abundance indices and CPUE estimation procedures (Teo, Yokawa) **WP07, 08, 05, 03**

Goal is to have catch time series and abundance indices finalized by end of workshop

8. Review biological parameters for blue sharks (Liu, Sippel) **WP09**
9. Discuss priors for the BSP model (Piner)
10. Decide on model configuration for base case (Teo, Hiraoka)
    - Conduct some model runs
    - Discuss problems/parameterizations
11. Decide on tentative sensitivity analyses (Teo, Hiraoka) **WP06**
12. Discuss future projection scenarios and BRPs (Teo, Hiraoka)
13. Plans for alternative modeling (Piner)
14. Work plan for blue shark stock assessment (Kohin)
15. Future SHARKWG meetings (Kohin)

16. Other matters (Kohin)
17. Clearing of report
18. Adjournment

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.

<u>Discussion</u>

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 1st to 3rd quarters but nearly equal sex ratios obtained in all size classes during the 4th 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.

<u>Discussion</u>

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.

<u>Discussion</u>

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.

<u>Discussion</u>

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.

Discussion

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.

Work Plan for Base Case Blue Shark Stock Assessment

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.

Discussion

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.**

<u>Discussion</u>

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 3rd year to assess blue sharks, every 3rd year assess makos, and possibly during the final 3rd 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 Φ_{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.

Current methods in use (shortfin mako)

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.

Current methods in use (blue shark)

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.

Shortfin mako sampling

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

Blue shark sampling

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

Vertebrae enhancement:

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

Direct and indirect validation methods:

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

Analysis:

- 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.