FINAL

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ANNEX 6

18th Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Yeosu, Republic of Korea
July 11-16, 2018

REPORT OF THE SHARK WORKING GROUP WORKSHOP

28 November– 4 December 2017

July 2018

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Annex 06

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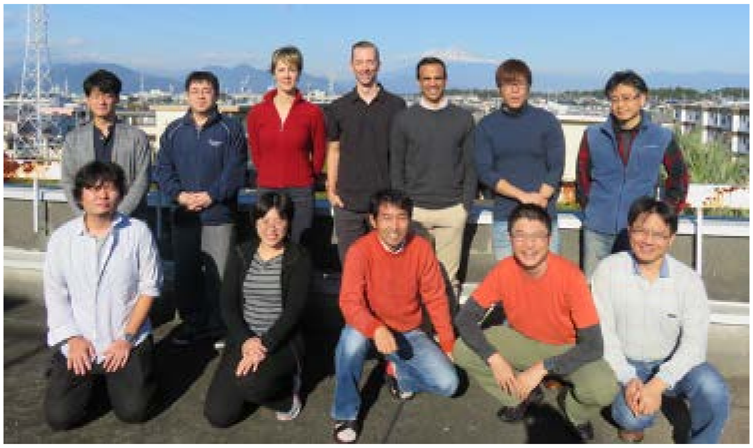
International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

28 November– 4 December 2017
Shimizu, Shizuoka, Japan



1. OPENING AND INTRODUCTION

1.1 Welcome and 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 Shimizu, Japan, from 28 November to 4 December 2017. The SHARKWG will be conducting a North Pacific shortfin mako shark assessment in spring 2017 to present at the ISC18 Plenary. The primary goals of the workshop were to: 1) examine new shortfin mako shark life history information and its relevance for productivity parameterization in the assessment; 2) finalize the input data and methodologies used to derive catch and abundance indices; 3) review size data and its collection programs; 4) establish a final assessment data submission deadline; and 5) decide on parameterizations for the stock assessment models.

Dr. Miki Ogura, division director of the project management department at NRIFSF, welcomed SHARKWG participants on behalf of the director of NRIFSF, Dr. Hideki Nakano. There were 13 meeting participants, including members from Chinese Taipei, Japan, the United States of America (USA), and the Western and Central Pacific Fisheries Commission (WCPFC), in addition to six members from Mexico that participated via google hangout (Attachment 1). In his address, Dr. Ogura reiterated the most important goal of the meeting – to verify the quality of the data for the shortfin mako shark assessment. He reported that sharks are now recognized as environmental key species, but also that some sharks are important target species for Japanese fisheries. He wished the group a productive meeting and hoped it would provide sufficient information for improved management recommendations. Despite the difficult work, he hoped that the group would enjoy their stay in Shimizu.

1.2 Distribution of Meeting Documents

Twenty-two working papers were distributed (Attachment 2). The authors of working papers 4, 10, 12, 15, 16, and 17 declined posting on the ISC website either because of data confidentiality concerns and the preliminary nature of the results, or because the paper was being prepared for publication elsewhere. The authors of working papers 4 and 10 pended posting until internal (domestic) reviews were concluded. Three working papers 16, 17, and 18 in relation to the presentation in the aging workshop were also provided.

1.3 Review and Approval of Agenda

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

1.4 Appointment of Rapporteurs

Rapporteur duties were assigned to K.-M. Liu, F. Carvalho, M. Kinney, M. Kai, W.-P. Tsai, N. Takahashi, M. Kanaiwa, S. Clarke, and Y. Semba. The approved agenda (Attachment 3) indicated the rapporteurs for each item in parentheses.

2. CATCH AND DISCARD DATA AND TOTAL CATCH ESTIMATION PROCEDURES

2.1 Canada

Shortfin mako (Isurus oxyrinchus) incidental catch statistics in Canadian fisheries. Jackie King. (ISC/17/SHARKWG-1/01)

There are no directed shortfin mako shark (*Isurus oxyrinchus*) fisheries within Canadian waters; as such, all catch statistics were for incidental encounters. Fishery encounters with shortfin mako sharks were rare within Canadian waters. All commercial groundfish fisheries (trawl, hook-and-line, and trap) in Canada are covered by a dockside monitoring program that validates landings. There were no landings of incidentally encountered shortfin mako shark. Currently, the bottom trawl and longline fisheries have 100% observer coverage, with either an at-sea observer program or electronic monitoring to record discards of incidental catches at sea. Discards of incidental catches at sea by other commercial fisheries were based solely on fisher logbook data. There were historic records of discarded shortfin mako sharks in the short-term experimental squid fishery that operated outside and within Canadian waters during the 1980s.

<u>Discussion</u>

The WG highlighted the importance of compiling all catches of North Pacific shortfin mako shark, even from fisheries with very low catches, such as those from Canada. The WG also noted that only the identified shortfin Mako catch from Canada should be included, and the "unidentified" shark catches should be considered independently of the selected stock assessment model. The WG asked if there were any size data available for the shortfin mako shark catch from Canada, and the author clarified that there were none. The WG noted that further efforts should be made by Canada to try to identify the proportion of shortfin mako shark catches in the "unidentified" shark catches.

2.2 Japan

Estimation of catches for shortfin mako, Isurus oxyrinchus, caught by Japanese coastal fisheries. Mikihiko Kai and Toshikazu Yano. (ISC/17/SHARKWG-1/02)

This working paper provided Japanese catches of shortfin mako (*Isurus oxyrinchus*) caught by Japanese coastal fisheries from 1994 to 2016. Since the species-specific shark data was not included in Japanese official coastal landing data, the catches of coastal fisheries were estimated using the available species-specific data (i.e., the ratio of shortfin mako to other sharks). Estimated catches of shortfin mako by coastal fisheries showed that the total annual catches by longline fisheries and large-mesh driftnets accounted for more than 90% of annual total catch, except for in 2005. Yearly changes in the estimated total catches fluctuated between 156 and 574 tons. Recently, it had gradually increased from 222 tons in 2011 to 506 tons in 2016.

<u>Discussion</u>
The WG discussed the catch ratios of shortfin mako to total shark catch that were appropriate to years when such ratios were not available (mostly before 2002) to estimate catches of set-net, and large-mesh driftnet fisheries in "Kesennuma" and other coastal fisheries. Total catches for Japanese coastal fisheries were estimated using the minimum, average, and maximum ratios of shortfin mako catch from the Research project on Japanese bluefin tuna (RJB) data. **The WG agreed to consider the average ratio across all years as the base case scenario and the minimum and maximum ratios in the sensitivity analysis**.

Estimation of catches for shortfin mako, Isurus oxyrinchus, caught by Japanese offshore and distant-water fisheries. Mikihiko Kai and Yasuko Semba. (ISC/17/SHARKWG-1/03)

This working paper provided the estimated catches of shortfin mako caught by Japanese offshore (from 1994 to 2016) and distant-water longline fisheries (from 1992 to 2016) in the North Pacific. Since the landings of sharks were frequently underestimated, due to their lower commercial value than other species, such as tunas and billfishes, total catches including retained and discarded/released catches were estimated using a product of the yearly changes in standardized CPUEs and the fishing effort. Two time-series of catch number for shortfin mako caught by shallow-set (from 1994 to 2016) and deep-set (from 1992 to 2016) fisheries were calculated. The catch numbers were converted into the catch weight using the average weight of shortfin mako for each area and season. The results showed that the total catches of shortfin mako in the North Pacific had gradually increased since 1992 until 2007 and reached 1007 tons, and then had gradually decreased until 2016 with the continuous reduction of fishing effort.

<u>Discussion</u>
The total catch for Japanese offshore and distant-water longline fisheries was estimated from the standardized CPUE for shallow-set and deep-set fisheries. The data used to standardize the CPUE were a subset of the entire fisheries, and were represented mostly by data from the "Kesennuma" shallow-set longline fleet targeting blue shark and swordfish. As such, this index

of estimated total catch from the entire shallow-set fishery might be an overestimate. For comparative purposes, the WG estimated the catches for “Nourin-tokei” using the shortfin mako shark ratio for filtered data in the CPUE standardization of the shallow-set fishery. It also estimated Japanese offshore and distant-water fisheries using landing information. Results showed that the trends were similar, but some differences were observed in the magnitude of the catches. The WG requested further analysis to identify potential causes for a large increase in the “Nourin-tokei” catch time series in 2005.

2.3 USA

Length composition and catch of shortfin mako sharks in US commercial and recreational fisheries in the North Pacific. Michael Kinney, Felipe Carvalho, and Steven Teo. (ISC/17/SHARKWG-1/04)

Although not a target species for US highly migratory fisheries in the Pacific, shortfin mako sharks are commonly retained by US fisheries as they are sufficiently valuable to warrant landing in most cases. Commercial catches of mako sharks by US west coast fisheries peaked in 1987 at more than 400 mt, but have subsequently declined since the 1990s. Annual catches since 2010 have been under 30 mt, with less than 20 mt caught in 2016. Recreational catches of mako sharks from commercial passenger fishing vessels and private recreational boats were highest in the 1980s (1981 = 12,996 individuals; 1987 = 21,591 individuals) but have generally declined since, with less than 250 sharks caught in 2016. Catches in the Hawaii deep-set longline fishery have generally increased since 1995, with the 2016 catch at over 5000 individuals. Catches in the Hawaii shallow-set longline fishery have been mostly stable from 2005 to 2016 at under 1000 individuals.

Discussion

The WG clarified that the longline catch was separated from the shallow and deep-set fisheries, and that the longline catch from 1994 to 2016 included both Hawaiian and Californian fleets. The total annual catch data for shortfin mako sharks in the shallow-set fishery for combined Hawaiian and Californian longline fleets was prepared by cross-checking logbook data with 100% observer coverage data after 2004. After 2001, the observer coverage was around 20% for the deep-set fishery and 100% for the shallow-set fishery. However, these percentages were much smaller (around 5%) in the 1990s. The WG suggested that US west coast commercial fisheries and recreational fisheries should be treated as the same fleet for assessment purposes as they caught similar-sized fish and operated in similar areas.

Histograms of size composition data indicated differences in the size distribution of shortfin mako shark between the Hawaii shallow-set and deep-set fisheries, but smaller size differences between males and females. Since the shallow-set and deep-set Hawaiian fisheries operate in different areas, with the former mostly in the northern Hawaiian Islands and the latter in the southern islands, the WG discussed potential causes for the size differences of shortfin mako shark between the two fisheries. For example, such differences might be caused by environmental variation, such as sea surface temperature. However, further research is necessary to clarify such causes. Another possibility is the depth of the fishing gear. The WG discussed the difference in swimming depth (vertical habitat) between juvenile and adult sharks, based on the results of a tagging study, which indicated that small shortfin mako sharks tend to swim at shallower depths, while larger individuals migrate to much deeper waters.

2.4 Chinese Taipei (Taiwan)

Standardized CPUE and historical catch estimates of shortfin mako shark by the Taiwanese large-scale tuna longline fishery in the North Pacific Ocean. Wen-Pei Tsai, Yen-Jun Wang, Shan-Hui Su, and Kwang-Ming Liu. (ISC/17/SHARKWG-1/09)

The shortfin mako shark catch and effort data from the logbook records of the Taiwanese large-scale tuna longline (LTLL) fishing vessels operating in the North Pacific Ocean from 1971 to 2016 were analyzed. Due to the large percentage of zero shortfin mako shark catches, the CPUE for shortfin mako shark (i.e., the number of fish caught per 1000 hooks) was standardized using a zero-inflated negative binomial model. Both binominal and standardized CPUE for shortfin mako sharks showed stable, slightly decreasing trends. The back-estimated catch (1971–2004) was relatively low before 1995 and increased to more than 100 mt and fluctuated thereafter. Overall, the estimated weight of shortfin mako shark by-catch in the Taiwanese LTLL fishery ranged from almost 0 mt in 1971 to 156 mt in 2015, with a mean of 41 mt and 789 individuals in the North Pacific Ocean. Many factors may have affected the standardization of the CPUE trend. In addition to the temporal and spatial effects, environmental factors may affect the representation of standardized CPUEs of pelagic fish, such as swordfish and blue shark in the North Pacific. Although shortfin mako sharks are homeotherms, their behavior is also influenced by the environmental temperature. Therefore, environmental effects should be included in future standardization models.

Discussion

As the standardized CPUE after 2005 showed an increasing trend, the WG estimated the total catch before 2005 using the average nominal CPUE from 2005 to 2007. The WG also suggested that the total catch from two regions (>25° N and <25 °N) be separated based on large differences in shortfin mako shark sizes from these regions.

The WG observed that the percentage of residual deviances in the null model for the log-normal positive catch rate was small (about 10%); therefore, the standardized model could not be used to explain the variation in catch due to a bias in the pattern of residuals. The WG used a different distribution for the positive catch, as the percentage of residual deviances from explanatory factors was small. The WG also observed some bias in the diagnostics.

A delta log-normal model was used for the Chinese Taipei data and the CPUE time series was updated using the zero-inflated model. For the zero-inflated negative binomial model, the same function was applied to both zero and non-zero data. Due to the one-way relationship between "Lat" and "Lon" and CPUE in the model, the WG checked the residuals for "Lat" and "Lon". The WG commented that the zero-inflated model's CPUE was better than the previous one (log-normal model), and that the CPUE trend was similar to one originally presented. There was no clear bias in the residuals for "Lat" and "Lon" and the residuals for all predicted factors were normally distributed. **The WG agreed that the analysis was an improvement over the original**.

2.5 Mexico

Estimates of shortfin mako shark (Isurus oxyrinchus) catches by Mexican Pacific fisheries: An update (1976–2016). Oscar Sosa-Nishizaki, Luz E. Saldaña-Ruiz, David Corro-Espinosa, Javier Tovar-Ávila, José Leonardo Castillo-Géniz, Heriberto Santana-Hernández, and J. Fernando Márquez-Farías. (ISC/17/SHARKWG-1/19)

An update of the estimates for the shortfin mako shark catches landed at four states in northwestern Mexico, from 1976 to 2016, was presented. Mexican shark catch statistics by species were not available until recently, so previous shortfin mako shark catches were estimated using different sources, such as the scientific literature or estimates using more detailed local catch data. In Mexico, shortfin mako sharks are caught mainly by the artisanal and middle-size longline fisheries that target pelagic sharks or swordfish. Previous catches that were landed by the large-size longline fisheries and the drift gillnet fisheries were taken into consideration to construct the historical series. Shortfin mako sharks were not an important target species until the 1980s when the catches increased from around 60 mt to around 250 mt. With the development of the longline fishery in Mazatlan, Sinaloa, current catches have reached around 1000 mt. Estimates indicated that shortfin mako sharks were caught mainly off the western coast of the Peninsula of Baja California, and waters off the mouth of the Gulf of California.

<u>Discussion</u>
Mexico advised that catches from Baja California (BC) and Baja California Sur (BCS) should be treated as northern catches and those from Sinaloa (SIN), Nayarit (NAY), and Colima (COL) should be treated as southern catches in the stock assessment as there were considerable different sizes in each region. **The WG accepted the suggestion**. The WG asked about the source of the shortfin mako to total shark ratios after 1990 for the BC fisheries. Mexico replied that it might be available in Sosa-Nishizaki et al. (2014), but that they would check this source and reply to the Chair.

3. REVIEW OF CPUE INDICES FOR SHORTFIN MAKO STOCK ASSESSMENT

3.1 Japan

Stock abundance indices for mako shark estimated by observer data of Japanese longline data in the North Pacific Ocean. Minoru Kanaiwa, Yasuko Semba, and Mikihiko Kai. (ISC/17/SHARKWG-1/06)

Standardized CPUEs estimated using observer data from Japanese longline fisheries operating in the North Pacific between 2011 and 2016 were produced. The optimal statistical model was the generalized additive mixture model, in which “cruise ID” was a random factor and latitude and longitude were represented by 2-dimensional 3-degree spline functions. The annual trend estimated by the optimal model was flat.

<u>Discussion</u>
The WG questioned the use of this index in the assessment due to its short time series (six years from 2011–2016). The point of this analysis was to validate the Japanese abundance indices for

offshore and distant-water commercial fisheries. The CPUE time series represented the abundance off the coastal area of Japan, and is the only index for the coastal area. Therefore, despite its short six-year time series, it may still be valid. The observer data covered the whole year but was less than 10% (likely 4%). T**herefore, the WG recommended that this index not be used in the assessment model.** The WG also asked why the zero-inflated model did not perform as well as the others, when there were many zeros in the data (80% of the dataset was a zero catch). The mixed models with multiple distributions were better able to explain the time series than the zero-inflated model, despite the large number of zeros. The WG also asked which random effect explained the most variation – cruise ID or observer ID. The cruise ID included data from only a single cruise, while observer ID represented many cruises; therefore, cruise ID was better as a random effect than observer ID since it contained data for individual cruises.

Updated CPUE of shortfin mako, Isurus oxyrinchus, caught by Japanese shallow-set longliner in the North Pacific. Mikihiko Kai. (ISC/17/SHARKWG-1/07)

This working paper provides the estimated CPUE for shortfin mako caught by Japanese shallow-set longlines from 1994 to 2016 in the western and central North Pacific. Two filtering methods were used to select the most reliable vessels from data collected in the 2000s. Filtering (I) was based on the AIC estimated from CPUE standardization and compared between longline research and commercial vessels. Filtering (II) was based on the visual observations of the positive catches of shortfin mako by each vessel. A zero-inflated negative binomial model was the best standardized CPUE model with filtered data. The yearly changes in the standardized CPUE suggested that populations of shortfin mako had slightly increased since the 1990s until 2004, then further increased from 2005 to 2016. This trend was mainly caused by the continual decrease in fishing effort with a slight decrease in catch in the central and western North Pacific.

<u>Discussion</u>
The WG questioned the parameters used to estimate the intrinsic rate of natural increase (*r*). The author replied that the values were gathered from the literature (Yokoi et al., 2017) rather than the meta-analysis. The WG also questioned why a spatial-temporal generalized linear mixed model (GLMM) was not used for this analysis, and commented that it would be advantageous to use this model as it is the only peer reviewed index for shortfin mako in the Pacific. The author replied that there were time constraints. **The WG agreed that the published spatial-temporal GLMM index could be used, even without an update**. The WG also inquired if the large increase in the index was caused by a change in recruitment. The author replied that it was more likely that it was due to higher catches of small sharks or changes in migration. The training vessel index showed a larger increase over the last four years, and the WG pointed out that the area around Hawaii had an increasing population. The WG observed a pattern across a number of indices that showed an increasing trend over the last four to five years (2013–2014 showed an especially rapid increase). However, it was unable to confirm if this was related to a population increase, although it was consistent across multiple indices. The WG also pointed out that most of the operations were in area 2 and questioned why the index was not focused on this area, which appeared to be the core area of the population, or why “Lat” and “Lon” were not included in the model. Since the CPUE trends shown in Figure 6 showed an increasing trend for all areas, the author concluded that the method was robust. The author also suggested that “Lat” and “Lon” should be added to the model. The WG suggested that targeting was ineffective as it was

unlikely that fishermen were able to target blue sharks while avoiding shortfin mako sharks and more likely caught both species when they occurred together. The WG also mentioned that the original target was set using only blue shark and swordfish catches. Furthermore, the data sets must still be separated even if the effective fishing effort for blue shark and shortfin mako shark was correlated.

CPUE of shortfin mako, Isurus oxyrinchus, caught by Japanese research and training vessels in the North Pacific. Mikihiko Kai. (ISC/17/SHARKWG-1/08)

This paper presented yearly changes in standardized CPUE (catch per 1000 hooks) for shortfin mako caught by the longline fishery of Japanese training and research vessels from 1992 to 2016 in the North Pacific. Since the reporting rates of sharks from 2001 to 2013 were clearly lower than those before 2000, the data with lower reporting rates was filtered out using the prediction of the binomial GLM. Then, the nominal CPUE was standardized using the two-step model (binomial model for presence/absence and Poisson model for positive catches) to account for the high zero catch ratio and small over-dispersions in the data. The annual trends in the standardized CPUE were almost flat with large fluctuations throughout the whole period. The coefficient of variation (CV) of the standardized CPUE were <0.16. These results suggested that the abundance indices for the North Pacific shortfin mako were highly variable due to observational errors; however, the trend was stable around 0.1 from 1992 to 2016.

<u>Discussion</u>
The WG compared the sea surface temperature (SST) probability of catch plots, and discussed the effect of SST in CPUE models. The author commented that SST did not impact the total abundance as it related more to the movement of juveniles; therefore, the SST did not directly impact the catchability in the catch equation. The WG discussed including the SST since shortfin mako can regulate their internal temperature. The WG also suggested that, based on the number of hooks per basket, a better comparison would be the shallow-set longline Hawaiian fishery. The WG suggested comparing the size composition data with the Hawaiian shallow-set or deep-set to assess consistency.

The WG pointed out that these data do not really represent independent fisheries as some originated from charter vessels. The author answered that the number of charter boats was very small compared with the number of training vessels and likely had a small impact on the overall dataset. The WG questioned why this dataset was not used in the blue shark assessment but was used for this stock assessment. The author responded that these data were not filtered during the blue shark assessment. The WG questioned whether the model could explain the variation caused by leader type. The author showed an ANOVA table, which confirmed that the leader type was statistically significant and an important factor in the analysis.

The WG suggested validating the ability of SP (probability of shark presence in the catch) to define the threshold in filtering step 2, and remove the operational data that was not recorded between 2001 and 2013. The author validated the model performance to estimate SP and provided the optimal threshold. The WG suggested that the filtering of the Japan RTV series should be corrected to avoid using a match of 1.0 between observed and estimated reporting rates as a cut-off point, and use the 2.5th percentile of the data (0.883 rounded to 0.9) as the filter (i.e., remove all values below 0.9) to allow for random errors.

The WG questioned why underreporting occurred between 2001 and 2013. The author explained that line cutting and no recording in this fishery started in 2000 and that they did not record the discard ratio of sharks caught by RTV after it increased. After 2013, the Japanese fishery agency requested that numbers of all shark catches, including discards, be recorded. The WG mentioned the similarity of the increasing trend in under or misreporting of shark catches between 2001 and 2013 to the Hawaiian deep-set index.

3.2 USA

Standardized catch rates of shortfin mako shark (Isurus oxyrinchus) caught by the Hawaii-based pelagic longline fleet (1995–2016). Felipe Carvalho. (ISC/17/SHARKWG-1/10)

Catch and effort data from the Hawaii-based pelagic longline fishery operating in the North Pacific Ocean were analyzed to estimate indices of abundance for the shortfin mako shark between 1995 and 2016. The data came from the records of the Pacific Islands Regional Observer Program (PIROP) submitted to the Pacific Islands Fisheries Science Center (PIFSC). Nominal CPUEs were calculated separately for shallow-set (target: swordfish) and deep-set (target: bigeye tuna) sectors, and standardized separately for each sector using GLMs. Models were validated using residual analysis. The best-fit models included year, quarter of the year, region, SST, bait type, and interactions between quarter of the year and region. Overall, the standardized CPUE for the deep-set sector showed a stable trend from 1995 to 2016, while the standardized CPUE for the shallow-set sector showed a slight decrease until 2012 followed by an increase in 2013.

<u>Discussion</u>
The WG suggested including the number of hooks directly in the model to account for large variation in the number of hooks per set. The author clarified that the most significant factors were bait type and quarter of the year in the lognormal model. The WG also asked whether there were data on leader type; the author replied that there were none. The WG questioned whether the residuals in the diagnostic plots were quantiles or Pearson’s, and the author confirmed that they were Pearson’s.

3.3 Mexico

Update on standardized catch rates for mako shark (Isurus oxyrinchus) in the 2006–2016 Mexican Pacific longline fishery based on a shark scientific observer program. González-Ania, L.V., Fernández-Méndez, J.I., Castillo-Géniz, J.L., Hidalgo-García, L., and Haro-Avalos, H. (ISC/17/SHARKWG-1/20)

Abundance indices for mako shark in the northwest Mexican Pacific for the period 2006–2016 were estimated using data from a pelagic longline observer program, updating a similar analysis made in 2014. Individual longline set CPUE data were analyzed to assess the effects of environmental factors, such as sea surface temperature, distance from mainland coast, and time-area factors. Standardized catch rates were estimated using two GLMs. The first model, using a quasi-binomial likelihood and complementary log-log link function, estimated the probability of a positive observation and the second, using a lognormal error distribution, estimated the mean response for non-zero observations. The importance of factors included in the models was discussed. The results showed that the abundance index trends were stable over the period of analysis, and particularly over the last four years.

Discussion

The WG questioned the constant CPUE trends over the last four years from 2013 to 2016 as the CPUE trends for blue shark showed large variation over the same time frame. The response of these species, which are physiologically different, to oceanographic changes or events could differ. The WG discussed the differences between the presented standardized CPUE index, which was based mostly on the data from the Ensenada fleet, and the index presented in 2015, which was based on data from both the Ensenada and Mazatlan fleets. The WG suggested separating these indices, and **agreed to use this standardized CPUE index in the stock assessment.**

4. SIZE DATA AND SIZE DATA COLLECTION PROTOCOLS

4.1 Japan

Size distribution of shortfin mako collected by the Japanese fleet and research program. Yasuko Semba. (ISC/17/SHARKWG-1/21)

Data from the port sampling and research program were summarized by size and sex. The port sampling data was collected exclusively in the Kesennuma fishing port, the largest shark landing port in Japan. The fisheries included in the data were an offshore longline fleet, a large-mesh driftnet fleet, and a coastal longline fleet. Research data included that from shallow-set longline (research and observer) and deep-set longline (RTV and observer) fisheries. Most of the sharks measured were juveniles, while the body sizes tended to be larger in coastal areas to offshore. In addition, the body sizes of sharks caught by shallow-set longline fisheries was smaller than that by deep-set longline.

Discussion

The WG discussed the low percentage of adult females in the Japanese size composition data. The WG also discussed the considerable amount of size data available for the stock assessment. **The WG concluded that this information should be incorporated into a stock assessment model, such as Stock Synthesis (SS).** The WG also noted the annual change in size distribution in the “Kinkai-shallow” fleet. The WG further discussed that the increase in small juveniles (<100 cm PCL) appeared after the earthquake in March 2011, which changed the operational area of the fleet and could have affected the size data. The WG noted the importance of accounting for this change in the size composition in the stock assessment model. The WG checked the sex-specific data. However, unlike the blue shark size data, there was no clear discrepancy between sex-specific size data observed in the shortfin mako shark data.

4.2 Chinese Taipei

Size composition of shortfin mako shark caught by the Taiwanese tuna longline fishery in the North Pacific Ocean. Wen-Pei Tsai, Yen-Jun Wang, Shan-Hui Su, and Kwang-Ming Liu. (ISC/17/SHARKWG-1/12)

There were two types of Taiwanese tuna longline vessels, the large-scale tuna longline vessels (LTLL, >100 Gross register tonnage; GRT) and the small-scale tuna longline vessels (STLL, <100 GRT). The sizes of shortfin mako shark caught by these two fisheries were presented. All size data not recorded in pre-caudal length (PCL) were converted to PCL using the conversion equations. The sizes of shortfin mako caught by the Taiwanese STLL from 1989–2016 in the North Pacific ranged from 61 to 338 cm PCL for females (n = 108,215), and 60 to 262 cm PCL for males (n = 101,612). The sizes of the 3016 individuals (sexes combined) derived from the LTLL ranged from 61 to 303 cm PCL and the modes were about 155 cm PCL (n = 960) and 136 cm PCL (n =2056) for areas A (>25°N) and B (<25°N), respectively. Two modes (approximately 100 and 150 cm PCL) were observed in the size distribution of shortfin mako shark from the North Pacific Ocean. This implied that the catches were comprised mostly of immature fish (females <228, male <172 cm PCL). The high proportion of immature sharks in these catches might have a large impact on the sustainability of the fishery.

<u>Discussion</u>
The WG noted a strong bimodal distribution, and suggested that the two peaks might be related to the spatial-temporal change in fishing grounds. The WG suggested separating the size data by area or season; however, the location of each catch was not available for size data from STLL. The author explained that the spatial information was only available for the size data from LTLL. The WG recommended separating the size composition data into two regions (>25°N and <25°N) based on the difference in target species of the fisheries operating in these two regions, which are albacore and bigeye tuna. **Chinese Taipei accepted this request and provided the size composition data separately for each area.**

4.3 Mexico

Size and sex of the shortfin mako caught by the Mexican longline industrial fleets recorded by on board observers in the Pacific 2006–2016. José Leonardo Castillo-Geniz, Carlos Javier Godínez-Padilla, Luis Vicente González-Ania, Horacio Haro-Avalos, and José Ignacio Fernández-Mendez. (ISC/17SHARKWG-1/11)

Spatial and explicit size and sex data (2280 females and 1720 males) from Mexican industrial longline fleets from 2006 to 2016 were used to conduct a first approximation of the geographical and seasonal size structure of shortfin mako in Mexican Pacific waters. The 50% maturity size estimated for both sexes by Semba et al. (2011) was used to determine the mature and immature conditions of the measured sharks. Ninety-nine percent of the females and 92% of the males measured were immature. A GLM was used to assess size differences by sex, zone, and year quarter and indicated no significant differences between sexes, probably because most sharks were juveniles or immature. The west coast of the Baja California Peninsula could represent a nursery and growth zone for this species in the eastern Pacific.

Discussion

The WG noted the similarity between the size composition data for the Mexican fleets from Ensenada and Mazatlan. Despite the similarity, the size composition data from the Mazatlan fleet showed slightly larger individuals than those recorded by the Ensenada fleet. **The WG acknowledged the importance of these data for the stock assessment and suggested that these two fleets should be treated separately in the stock assessment model.**

5. SUMMARY AND OUTCOMES OF AGING WORKSHOP AND NOVEMBER WEBINAR

5.1 Aging Workshop

Y. Semba briefly introduced the third aging workshop by ISC SHARKWG in Shizuoka, Japan, 19–25 October 2017 (Anonymous, 2017). The purpose of the workshop was to obtain reliable growth parameters for North Pacific shortfin mako for the upcoming stock assessment. In the workshop, ongoing work (cross-reading among national scientists) and new information on the aging of shortfin mako were reviewed, and the method for estimating age from growth band pairs and the assumptions of the meta-analysis were discussed. The effect of different enhancement methods on different band pair counts and band pair periodicity was also confirmed.

Using the best-fit periodicity for each dataset, the estimated growth curves were similar across different analyses. **Effectiveness of the meta-analysis was confirmed, and the preparation of the necessary dataset and assumptions were agreed.**

5.2 November Webinar

M. Kai, Acting Chair (Vice Chair) of the WG, provided a summary of the key outcomes of the 9 November 2017 webinar. Participants from Chinese-Taipei, Japan, Mexico, and US were present. Timing of the webinar was not ideal for all participants in different time zones; however, the response to the webinar was very positive. There were some frequent connection issues with google hangout for Mexico and Chinese-Taipei, and there were no participants from Canada or WCPFC due to serious connection issues. The webinar provided the WG an opportunity to share information and report on progress and work assignments between WG meetings.
The objectives of the webinar were to: 1) review preliminary results of the meta-analysis of sex-specific growth curves; and 2) review preliminary results of the analysis of other key life history parameters, such as length at maturity, relationship between maternal size and litter size, and relationship between weight and PCL.

There were some presentations by members.

N. Takahashi used Bayesian hierarchical modeling from Andrews et al. (2012) on tropical deep-water snapper and Chang et al. (2013) on Pacific blue marlin to estimate the most parsimonious von-Bertalanffy growth curves (VBG) for female and male shortfin mako in the North Pacific from seven age and growth data datasets provided by the ISC (Anonymous, 2017). The seven datasets included two for length at age estimated from length frequency data (Japan and US) and five for length at age estimated from vertebrae (Chinese-Taipei, ISC collection, Japan, Mexico, and US). There was convergence of MCMC chains for all parameters. The estimated median values of the theoretical asymptotic length (L_∞) for females and males were 293.1 cm PCL and 232.0 cm PCL, respectively. The estimated median values of the growth coefficient (k) for females and males were 0.174 year^{-1} and 0.128 year^{-1}, respectively.

The WG asked to check the diagnostics for the model in the data preparatory meeting, as it was concerned that estimates of parameter k were larger than any others for other oceans, such as the Atlantic (i.e., k = 0.087 for females; Cortés, 2017). The WG was also concerned that the parameter-k for shortfin mako was almost as large as that for blue shark in the North Pacific (i.e., k = 0.144 for females; Nakano, 1994). The WG commented that the growth rate was determined by the combinations of the growth parameters; therefore, it was difficult to compare the growth rates using only the parameter k. **The WG requested cross-validation and a sensitivity analysis without the length frequency data (JP and/or US) with equal weighting for young and old ages**.

M. Kai calculated the maximum ages for females and males using the equations: $a_{max} = \frac{5\ln(2)}{k}$ (Fabens, 1965) and $a_{max} = a_0 - \frac{\ln(0.05)}{k}$ (Taylor, 1958), and showed the maximum ages from the vertebrae from Taiwan and bomb-radiocarbon (Ardizzone et al., 2006). The maximum ages for males and females were 19.9 and 27.1 years (Fabens, 1965), and 15.5 and 21.6 years (Taylor, 1958), respectively. The growth parameters (k = 0.174, 0.128 for males and female, a_0 = -1.72, -1.79, calculated using the VBG) were estimated from the meta-analysis of growth curves (Takahashi et al., 2017). **The WG agreed to use the maximum ages of 24 and 31 years for males and females, respectively.** These maximum ages were the same as those calculated from the vertebrae from Taiwan and the bomb-radiocarbon.

The WG discussed the reproductive cycle of shortfin mako sharks, as it was an important parameter for the stock assessment. The WG needed more time to conclude whether the reproductive cycle was two years (proposed by Japan) or three years (proposed by Taiwan). The WG proposed an intermediate value for the reproductive cycle (i.e., 2.5 years); however, it was concerned about the lack of knowledge of this parameter for the lamnoid species.

The WG also discussed the length at maturity, as the Taiwanese data provided was pooled by length classes. **The Taiwanese delegate agreed to provide the original data and Japan agreed to recalculate the length at maturity using the combined data from Taiwan and Japan**.

6. BIOLOGICAL INFORMATION

6.1 Japan

Meta-analysis of growth curves for shortfin mako shark in the North Pacific. Norio Takahashi, Mikihiko Kai, Yasuko Semba, and Minoru Kanaiwa. (ISC/17/SHARKWG-1/05)

The estimated growth curves for shortfin mako sharks in the North Pacific from the Bayesian hierarchical meta-analysis of the age and growth data provided by the WG members (US, Mexico, Taiwan, and Japan) were presented. Seven datasets of length at age (five from vertebrae observations and two from length frequency analysis) were compiled. Each dataset represented an individual age and growth study conducted by a WG member, and was treated as a random effect in the meta-analysis. Estimated medians and 95% confidence intervals (CI) of posterior distribution values of the parameters $\mu\infty$ and μK (the mean of the entire population for the asymptotic length and Brody growth rate parameters, $L\infty$ and K) were 232.0 cm PCL (CI: 224.6–257.3 cm) and 0.174 year-1 (CI: 0.116–0.238), respectively, for males. For females, $\mu\infty$ was 293.1 cm PCL (CI: 255.2–335.9 cm) and μK was 0.128 year-1 (CI: 0.080–0.186). In addition, two analyses without the Taiwan data or two sets of length frequency data provided by Japan and US were also conducted to examine their impacts on parameter estimates. Compared to the previous estimates, μK was higher for both sexes in the analysis without data from Taiwan. In contrast, the μK was lower for both sexes in the analysis without length frequency data. Further additional analyses were also conducted with weighted data for larger sharks to examine the impact of missing data for larger sharks. Data for larger sharks were duplicated to fill gaps and balance the dataset across smaller and larger sharks. Results indicated that missing data for larger sharks had only a slight influence on parameter estimates (results were shown only in the presentation).

Discussion

The WG accepted the model approach based on the meta-analysis; however, it had major concerns over the inclusion of mostly small sharks, especially the length frequency data from Japan and the US. Therefore, it suggested removing the Taiwan data so that all the data represented juveniles to produce a juvenile specific growth curve, and then switch to a growth curve for older animals. The WG commented that the point of the meta-analysis was to produce a growth curve to cover all life stages, and that the growth curve did not fit well to juvenile data from Taiwan. The results of an additional test of the effect of adding older animals to the dataset showed no real shift in estimated values of k or L_{inf}.

The WG was also concerned that L_{inf} would not be achieved with a high k. In this case, the most effective approach would be to use the meta-analysis as *a priori* information and then allow SS to estimate growth within the model to account for any bias within the meta-analysis. There was a lot of uncertainty when proceeding from an indicator analysis to a fully integrated model. SS has multiple options for dealing with growth; however, the meta-analysis was a good starting point (*a priori* for growth) for the model. As certain parameters, such as catch, had inherent uncertainty we were able to account for uncertainty in growth once the model was established. A fully functioning model was used to run multiple models that altered growth, catch, etc., to examine how these different models compared.

The WG suggested that the length frequency data be removed from the meta-analysis to provide two different estimates, one with all the data, and another without the length frequency data. The WG also suggested that the ISC reference collection be removed to allow SS to estimate bias in growth within the model. This would leave two growth estimates from the model, one with all the data (minus the ISC ref collection), and one minus the length frequency data (minus the ISC ref collection). For each approach, we ran both with and without the ISC reference collection and used SS to estimate bias in growth. This lead to multiple models each with its own estimates of the impact of changing each parameter. In addition, the WG suggested that a wider range of uncertainty (CV) was needed for the growth curve.

In conclusion, **the WG agreed on two approaches to analyze shortfin mako growth**. One using the results of the meta-analysis produced by Takahashi et al. (2017) as fixed growth parameters (base case parameters), and the other using the growth parameters taken from the meta-analysis as *a priori* values for SS. To use the meta-analysis as *a priori* information, SS must be provided with age-length data with a reasonable aging error matrix. **The WG agreed, for alternative scenarios, that the ISC reference collection should be removed from the meta-analysis and used to produce the aging error matrix.** Using each scenario with results from the meta-analysis as both fixed and as *a priori* information allowed us to model each approach and examine the impacts on model outputs.

Natural mortality rates for shortfin mako, Isurus oxyrinchus, in the North Pacific. Mikihiko Kai and Hiroki Yokoi. (ISC/17/SHARKWG-1/14)

Sex-and age-specific natural mortality rates (M) for shortfin mako in the North Pacific were presented. We applied the same method used to estimate M for blue shark in the North Pacific. A constant value of target-M was estimated using an empirical equation, and then M was allocated to age using a theoretical equation developed for yellowfin tuna in the North Atlantic (Walter et al. 2016). The estimated target-M was 0.16 and 0.13 for males and females, respectively. The estimated M at age-0 was 0.39 and 0.37 for males and females, respectively. The M gradually decreased and reached 0.12 and 0.094 for the maximum ages of males and females, respectively. These results are reasonable as: (i) the M at age-0 was similar in males and females; (ii) the M at maximum age for males was higher than that for females; and (iii) the estimates of M were within the ranges those for blue shark.

<u>Discussion</u>

The WG mentioned that the analysis of natural mortality rate (M) was already in press (Kai and Fujinami, in press) and was also covered extensively in the blue shark assessment. Furthermore, occasionally this method (Walter et al. 2016) produces high values of M at small shark sizes; however, in this analysis the M for shortfin mako was lower than that for blue shark, as newborn blue sharks are much smaller. The WG inquired what the assumed age at first recruitment was, and was informed that age-0 was assumed for both sexes. The WG suggested that the maximum age be fluctuated ±3 to determine the robustness of the estimate of M (especially for age-0 M). The WG commented that maximum age may vary across fisheries, and questioned how best to determine the maximum age, and was informed that the bomb-radiocarbon study was the best estimate of maximum age. **The WG agreed to use the presented value as the base case, but**

requested tests of robustness before completing the SS model. The requested sensitivity tests were conducted and showed very little effect of changing maximum age ±3 years for either sex (Figure 1 and Table 1). It was pointed out that the M at age-0 for males was too high for some of the sensitively runs, which might cause problems since it did not match the analysis for females (despite both sexes being nearly the same size at age-0, and unlikely to have different M). However, **the WG agreed to keep the base case and use the sensitivities discussed** with the understanding that M for males in the sensitively runs was too high.

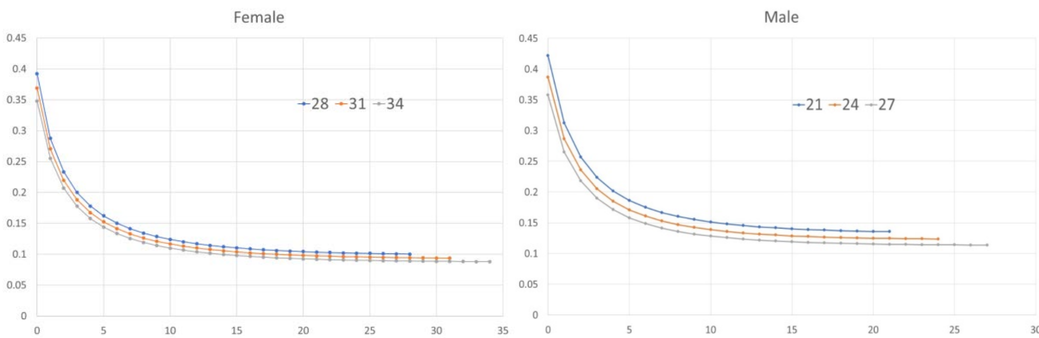


Figure 1. Sensitivity analysis of annual natural mortality rates for female and male shortfin mako. The ages 31 and 24 were used as base-cases for females and males, respectively.

Table 1. Annual natural mortality rates for female and male shortfin mako using an empirical equation from Hoenig (1983) with different maximum ages.

Female	Maximum age	28	31	34
	Natural mortality	0.1397	0.1279	0.1179
Male	Maximum age	21	24	27
	Natural mortality	0.1796	0.1599	0.1442

Revised integrated analysis of maturity size of shortfin mako (Isurus oxyrinchus) in the North Pacific. Yasuko Semba. (ISC/17/SHARKWG-1/22)

Based on the Taiwanese and Japanese data on maturity (body size and mature/immature), length at 50% maturity was estimated using logistic regression. The sample size of Taiwanese data (499 males and 747 females) was larger than that of Japanese data (123 males and 353 females). The estimated 50% maturity size was in between the Taiwanese and Japanese estimates, but closer to previous Taiwanese estimates in both sexes. This may be partly because of the larger sample size of Taiwanese data for both sexes.

Discussion

Data on size at maturity from Japan and Taiwan were combined to provide an updated sample size for male and female mako sharks. For males, 50% size at maturity increased from the original Japan estimate and was closer to the Taiwan estimate. Meanwhile, female 50% size at maturity decreased, again moving closer to the Taiwan estimate. **The WG accepted these new size at maturity estimates for both sexes and agreed that this combination of data was the best approach for obtaining an accurate overall estimate of size at maturity**.

The relationship between maternal size and litter size was also explored using the Japanese and Taiwanese datasets. Both data had very small sample sizes for litter size. Samples from both Japan and Taiwan were combined, and a new linear relationship was fitted to the data. The WG suggested that perhaps a logarithmic relationship would represent the data better. Japan agreed to further analysis and to provide an updated litter size estimate in the future. **The WG agreed to use an average litter size of 12**.

6.2 Chinese Taipei

The relation between weight and length of the shortfin mako shark in the North Pacific Ocean. Shan-Hui Su, Suzy Kohin, Julianne Taylor, Yasuko Semba, Wen-Pei Tsai and Kwang-Ming Liu. (ISC/17/SHARKWG-1/13)

Relationships between whole weight (W) and PCL in the shortfin mako shark in the North Pacific were estimated based on the data provided by Japan, US, and Taiwan. The majority of Japanese and US length data ranged from 60 cm to 200 cm PCL, with W ranging from 1.36 to 162 kg. Taiwanese data covered a wider range from 60 cm to 313 cm PCL, with W ranging from 3 to 441 kg. The maximum likelihood ratio test indicated that sex-specific W-PCL relationships were significantly different for combined data. Thus, the W-PCL was estimated as: $W = 4.62 \times 10^{-5}\ PCL^{2.77}$ for males ($n = 1147$, $P < 0.05$) and $W = 3.4 \times 10^{-5}\ PCL^{2.84}$ for females ($n = 1561$, $P < 0.05$).

Discussion

The WG acknowledged this analysis and **agreed to use the sex-specific W-PCL relationships for the stock assessment.**

6.3 Mexico

Growth estimation update of shortfin mako shark in the Mexican Pacific Ocean, through multi-model approach and different methods for age determination. José Alberto Rodríguez-Madrigal, Javier Tovar Ávila, José Leonardo Castillo-Géniz, Carlos Javier Godínez-Padilla, Felipe Galván-Magaña, J. Fernando Márquez-Farías, and David Corro-Espinosa. (ISC/17/SHARKWG-1/15)

An update of age and growth estimates for shortfin mako sharks from the Mexican Pacific Ocean, based on individuals caught during 2001–2003 and 2008–2016 was presented. Sample size had increased with respect to a previous study in the region (Ribot-Carballal et al., 2005), and new information on vertebrae growth band periodicity (biannual deposition) was used. The vertebrae of 37 individuals were processed simultaneously using different methods (stained sagittal sections, silver nitrate-stained whole vertebrae, and sectioned vertebrae processed using hard X-ray) to determine if similar growth band counts could be obtained. Centrum edge analysis (CEA, Okamura & Semba, 2009) for silver nitrate-stained whole vertebrae and marginal increment analysis (MIA, Okamura et al., 2013) for sectioned vertebrae were used to determine the periodicity of growth band formation and compare it with information from direct validation studies. The VBGF model, Gompertz, logistic, and the two parameters VBGF (2-VBGF) were fitted to the length-at-age data, and performance assessed using small sample bias-corrected Akaike information criterion (AIC_c), Akaike differences (Δ_i), and Akaike weights (w_i). The vertebrae from 256 individuals were examined [(130 females = 65–302 cm total length (TL) and 126 males = 64–267 cm TL]. The precision of growth band counts was acceptable for both whole and sectioned vertebrae although whole vertebrae produced slightly less precise counts (PA = 70/62, APE = 4.3/5.6, CV = 6.2/7.9 for intra- and inter-reader comparisons, respectively) than sectioned vertebrae (PA = 76/37, APE = 4.5/14.5, CV = 6.4/ 20.5). The precision of growth band counts for inter-method comparisons was also acceptable (mean PA = 62, APE = 6.7, CV = 9.4) and no significant differences between counts were found (ANOVA $F_{2,111} = 0.159$, $P > 0.05$), proving that all methods used produced similar age estimates. The CEA and MIA supported the hypothesis of biannual band pair formation for juveniles, concurring with previous age validation studies (Wells et al., 2013; Kinney et al., 2016); however, the periodicity could not be verified for adults due to the low sample size of large animals. Thus, age was estimated based on the formation of two pairs of growth bands per year during the first five years of growth and assuming one pair of bands per year afterwards (Kinney et al., 2016). The estimated ages ranged from 0–15 for females and 0–12 for males (whole stained central and sectioned data pooled). According to the AIC, the Gompertz model fitted slightly better the length-at-age data for females, or the VBGF model for males. However, the VBGF model was chosen as the best-fit model for both sexes due to its representation of life history values previously reported: L_∞ = 354, k = 0.11, and L_0 = 71 for females, and L_∞ = 295, k = 0.15, and L_0 = 70 for males. These life-history parameters should be used for stock assessments of the region to develop better fishery management and conservation initiatives.

Discussion

The WG clarified that the length-at-age data in this study were the same as those provided for the meta-analysis. The author responded that the same method was used, except with a few older samples included in the analysis. The maximum age was 11 in the previous study, whereas the maximum age in this study was 12. The WG pointed out that the monthly marginal increment ratio showed two peaks in March and April in a year, which was different from the Japanese analysis, and then questioned whether this was due to sharks in the eastern and western Pacific experiencing different conditions and growth rates. The author replied that it was a possibility; however, there was no evidence to explain the difference in the edge analysis. The WG also clarified use of the age data in the growth curve estimation. The author responded that the samples collected from 2006–2016 in Mexico were used and both samples from sectioned vertebrae and silver nitrate-stained vertebrae were used. The WG clarified the method (sections or silver nitrate-stained, or both) used to assign the age-at-length data. The author explained that the methods were used separately, with some individuals from each method. Counts were made for each vertebra depending on the method used for the sample. The WG questioned why the figure for the edge frequency was different in this presentation from the original figure in the paper from which the samples were drawn. The author explained that there were more samples in this presentation than in the original paper, so the resulting edge frequency was different in the two presentations. The difference in periodicity of band pair deposition between this and the previous study was questioned; the author explained that the difference (two band pairs per year vs one band pair per year) might be due to an increase in sample size.

7. DISCUSSION OF MODELING APPROACHES USED IN THE SHORTFIN MAKO SHARK STOCK ASSESSMENT

The WG reviewed the fishery data for catch and CPUE provided by the national delegation and tuna RFMO to consider the availability of the data and possible consolidation of the fleet data. **The WG agreed to use the time series from 1994 to 2016 as the time series prior to 1994 was not species specific.**

The WG also agreed that catch data provided by each country should be accepted as the best available data; however, it was necessary to discuss whether to include catch data from each country in the stock assessment model, and if so whether to combine the catches for various national fleets. National catch datasets were discussed and agreed as follows:

7.1 Catch

Canada – The WG considered that Canadian catches, although very small, should be included in the model. For catch data identified specifically as shortfin mako shark, the WG noted that species-specific identification of landings had been required in Canada since 1951 and the percentage of shark catches (across gear types and sectors) that were not identified to species level was low (15%). **Therefore, the WG agreed that unidentified lamnid sharks were likely to be salmon sharks (*Lamna ditropis*) and so only landings identified as shortfin mako sharks would be included in the Canadian catch series.**

United States – The seven separate catch series available were combined into four series for modeling. The Californian longline fleet began to mix with the Hawaiian longline fleet in the mid-1990s, so that catch data has included the Hawaiian and Californian longline fleets since 1995. Prior to 1995, there were no length composition data for the Californian fleet. Therefore, for modeling purposes, catches from the two longline fleets were combined, and the California longline fleet was assumed to have similar length compositions to the Hawaiian shallow longline fleet. The California drift gillnet and "other" fishery catches were also combined into a single fleet as the latter was small, fished in the same area, and caught similar sized fish to the former. The Hawaii longline deep-set fishery was retained as a separate catch series. The California recreational fishery was retained as a separate catch series because it was recorded in numbers rather than weight; however, since there were no length composition data it was assigned lengths from the nearby California drift gillnet fishery.

Chinese Taipei – Catch data were available for two fleets: small-scale longline from 1989–2016 and large-scale longline (1974–2016). Length composition data were available for both fisheries so they were retained as separate fleets in the model with individual catch series. Chinese Taipei noted that the catches for the small-scale fleet were compiled from landings data, whereas the catches for the large-scale fleet were estimated from CPUE data. **The WG agreed that the catch and size data of the large-scale fleet should be separated into two fleets (>25° N and <25° N) based on large differences in shortfin mako shark size composition data from these regions.**

Japan – Catches from various fisheries were combined into five fleets for modeling purposes. The distant-water ("enyo") and offshore ("kinkai") fisheries were combined and then split into deep- and shallow-set sectors, each with its own catch series. Coastal longline ("engan") and "other longline" catches were combined as they fished in a similar manner in the same fishing grounds, and there were no length composition data for the "other longline" fishery. The large-mesh gillnet fishery was considered as a distinct catch series, whereas the trap and "other" fisheries were considered minor fisheries with any length composition data combined into a single catch series.

Mexico – The WG considered that there were essentially two fisheries off the western coast of Mexico and each should be assigned its own catch series. The first fishery was based around Ensenada and included the Baja California and Baja California Sur fleets. The second was based around Mazatlan and included all vessels not assigned to the Ensenada fishery.

Other fleets from t-RFMO data – SPC reported catches to ISC in advance of the meeting; IATTC will provide catch data in December 2017. **The WG kept these catch series separate as they derived from different geographic areas** and were likely to derive from longline data (SPC) and purse seine data (IATTC).

In summary, the catch series used for modeling were as follows (number of series in parentheses):

Canada:	Catches reported as (specifically) shortfin mako from all fisheries (1)
US:	California and Hawaii shallow longline; Hawaii deep longline; drift gillnet and "other"; recreational fisheries (4)
Taiwan:	Small-scale longline; large-scale longline north and south (3)
Japan:	Enyo/kinkai shallow longline; enyo/kinkai deep longline; coastal and "other" longline; large-mesh gillnet; trap and "other" (5)
Mexico:	Ensenada longline; Mazatlan longline (2)
WCPFC	Various longline fisheries (1)
IATTC	Various purse seine fisheries (1)

The yearly changes in the catch time series of each nation are shown in Figure 2.

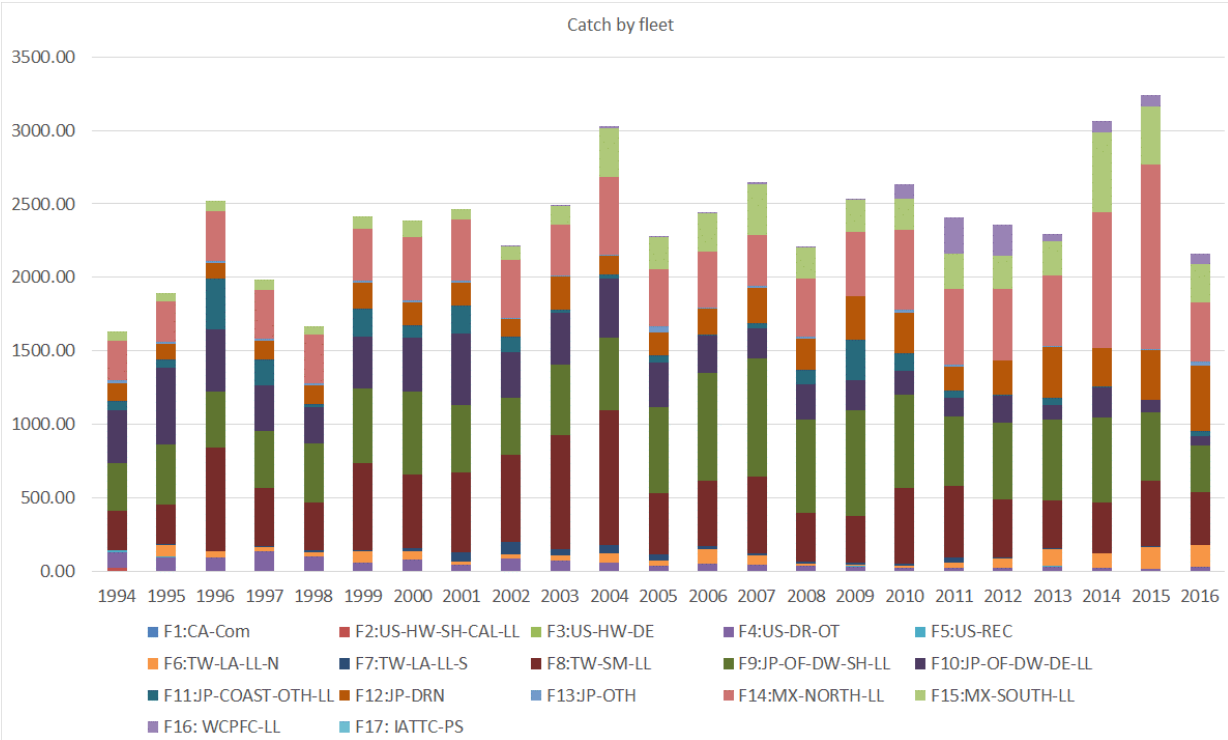


Figure 2. The yearly changes in catch time series (metric tons) of each nation. F1: Canadian all fisheries; F2: California and Hawaii shallow-set longline; F3: Hawaii deep-set longline; F4: US drift gillnet and other fishery; F5: US recreational fisheries; F6: Taiwan large-scale longline north; F7: Taiwan large-scale longline south; F8: Taiwan small-scale longline; F9: Japan enyo/kinkai shallow-set longline; F10: Japan enyo/kinkai deep-set longline; F11: Japan coastal and other longline; F12: Japan large-mesh driftnet; F13: Japan trap and other fishery; F14: Mexico Ensenada longline; F15: Mexico Mazatlan longline; F16: WCPFC; F17: IATTC;

7.2 CPUE

The WG discussed the various available CPUE series that could be used as abundance indices in the model (Figure 3). A table with various criteria to evaluate each CPUE series was compiled (Table 2). High, medium, and low priorities were assigned to the eight available CPUE series (S1-8), which comprised the US Hawaii shallow-set longline, the US Hawaii deep-set longline, the Taiwan large-scale longline, the Japan shallow-set commercial longline, the Japan deep-set research and training vessel (RTV) longline, the Japan observer longline, the Japan shallow-set commercial longline with spatiotemporal model, and the Mexico Ensenada observer longline.

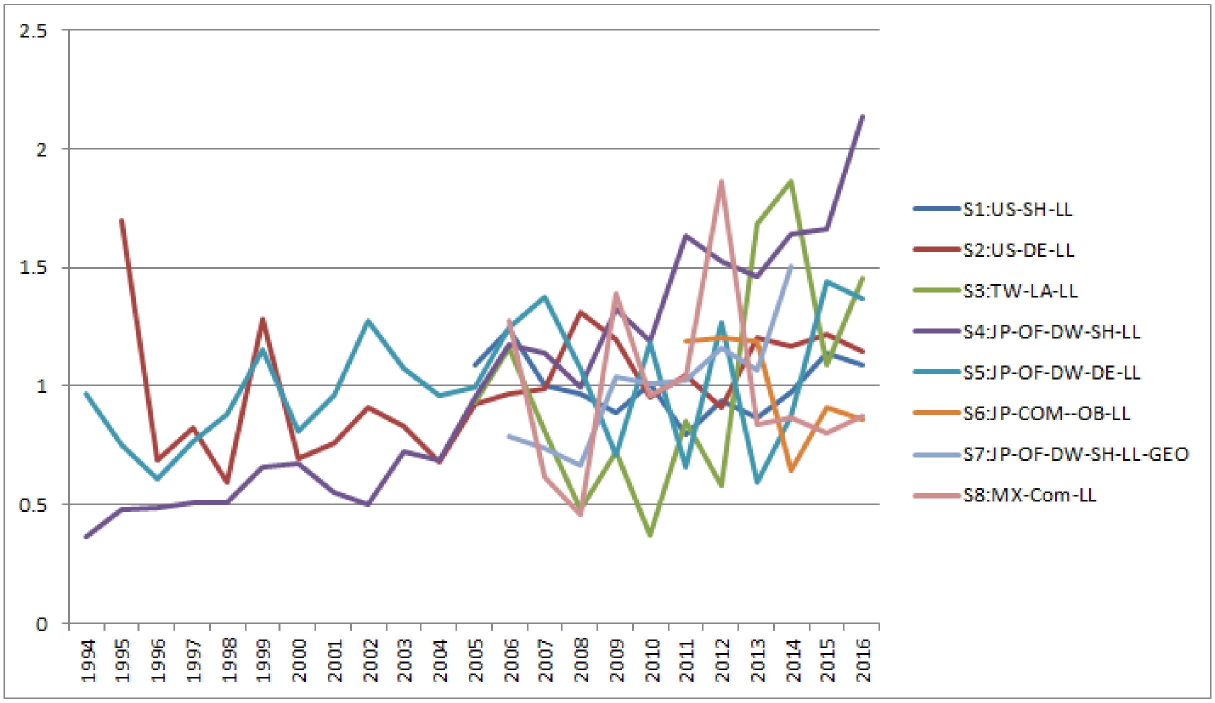


Figure 3. Available CPUE time series provided at the WG meeting. S1: Hawaii shallow-set longlone; S2: Hawaii deep-set longlone; S3: Taiwanese large-scale longline; S4: Japan shallow-set longline; S5: Japan deep-set RTV longline; S6: Japan observer longline; S7: Japan shallow-set longline with spatiotemporal model; S8: Mexico Ensenada observer longline.

The rationale for the prioritization was as follows:

1) High priority: Japan shallow-set longline.
This CPUE series was assigned the highest priority because of its long timespan, extensive coverage, and relatively high catch rates.

2) Medium priority: Hawaii shallow-set longline, Mexico Ensenada observer longline, Japan deep- set RTV longline, and Taiwanese large-scale longline.
The Hawaii shallow-set longline series was considered valuable because the CPUE was relatively high and the observer coverage was 100%; however, the spatial extent of this fishery was relatively small and there was some misfit of the standardized model using a lognormal distribution.

The Mexico Ensenada series was considered important as it was the only series representing the Eastern Pacific and might serve as a recruitment index since most of the catch was juveniles.

The WG debated whether the Japan deep-set RTV longline data should be given a medium priority, and ultimately agreed it was valuable as it was an observer series and covered a wide geographic area. Fluctuations in the series were considered to have arisen from a reduction in the number of vessels in the RTV fleet in recent years. While other Japanese fleets are also experiencing reductions, this trend in the RTV fleet may influence the CPUE series more because the number of vessels in this fleet was relatively low from the beginning, especially compared to the commercial fleet. It was suggested that the RTV series was most reliable after

1993, so model inputs for this series should start then. The partial overlap of the Japan RTV series with the Hawaii shallow-set series was discussed, but did not pose a problem. It was suggested that the filtering of the Japan RTV series should be corrected to avoid using a match of 1.0 between observed and estimated reporting rates as a cut-off point, and use the 2.5^{th} percentile of the data (0.883 rounded to 0.9) as the filter (i.e., remove all values below 0.9) to tolerate random errors.

The Taiwan large-scale longline series was assigned a low priority at first due to the poor fit of the statistical model; however, changing the model from the delta-lognormal model to the zero-inflated negative binomial model greatly improved the fit. Therefore, this time series was assigned a medium priority due to the extensive spatial coverage and relatively high catch rates that were statistically robust.

3) Low priority: Hawaii deep-set longline, Japan observer longline, Japan shallow-set longline with spatiotemporal model

The Hawaii deep-set longline series was considered valuable because of its relatively long length although the catch rates were low (compared to the Hawaii shallow-set longline) and the observer coverage was less than that for the Hawaii shallow-set longline fishery. The Hawaii standardized deep-set longline series also showed some misfit in the lognormal model. The WG noted that the ISC Billfish Working Group found that Hawaii observer program changes in 2002 might have caused some bias in the CPUE series in the periods before and after. At first the ISC Billfish Working Group decided not to use any data prior to 2002, but later some of the pre-2002 data was used after the data contributing to the bias was removed. As this kind of analysis had not been done for sharks, the Hawaii deep-set longline series was not recommended for use in the shortfin mako shark assessment, except potentially as a sensitivity test.

The Japan longline observer series was assigned a low priority mainly because it only began in 2011.

The Japan shallow-set longline series based on a spatioemporal model (Kai et al. 2017) was predicted using the shallow-set longline catch and effort data and the length data. The length-disaggregated GLMM accounted for the spatial-temporal changes in species by size classes and operations. This complex model was more reliable than the general statistical model. However, this time series was assigned a low priority because the catch and effort data were almost the same as those of the Japan shallow-set longline and the time series (2006–2014) was shorter.

The WG discussed whether the model should focus on the high priority series, using the medium priority series only when they did not jeopardize the fit of the high priority series. The low priority series would be used mainly as sensitivity runs. Series will be prioritized within SS using data weighting, with lower weights assigned to lower priority series.

Table 2. Characteristics of the indices considered and their priority in the 2017 stock assessment.

Nation	USA	USA	Mexico	Taiwan	Japan	Japan	Japan	Japan
Fishery	Hawaii-DSLL	Hawaii-SSLL	Ensenada-observer LL	Largescale LL	shallow LL	deep LL (RTV)	observer LL	shallow LL with spatio-temporal model
Time series length	22 years (1995-2016)	12 years (2005-2016)	11 years (2006-2016)	12 years (2005-2016)	23 years (1994-2016)	25 years (1992-2016)	6 years (2011-2016)	9 years (2006-2014)
Comments	Reasonable, but concerns for statistical assumption.Diagnostic, find some bias of the lognormal model and for the deepset, exploration of the effect of the changes of the observer program in 2002.	Diagnostic, find some bias of the lognormal model	Reasonable statistically.Coverage area is relatively small in the North Pacific. Can be considered as recruitment index.	Reasonable, however lower power of explanation in the model was observed. Coverage area is large.	Coverage area is relatively large. Reasonable but concerns for statistical assumption, some bias in ZINB (QQplot).	Area of operation overlaps with Hawaii-DSLL. Coverage area. Coverage area is relatively large. Find some bias in the positive catch standardization. Recent reduction and the relatively low fishing effort compared to commercial vessels may have effect on the large fluctuation of index.	Coverage of observation is smaller than 10% (around 4%?). Coverage area is not large.	Coverage area is relatively large. Statistically reasonable but shorter time period compared to Japan shallow LL. Issue of the use of the same dataset with the shallow LL of Japan.
Priority	Low	Meidum	Meidum	Meidum	High	Meidum	Low	Low

7.3 Initial Equilibrium Catch

The WG briefly discussed obtaining a value for the initial equilibrium catch. A starting value was assumed (see discussion of model parameters in Section 10.5), although this could be easily revised in subsequent analyses to explore sensitivity. It was probably sufficient to base this on a notional value of catch in the 1950s and 1960s. A value of 40% of the first year shark catch was used in the blue shark assessment. **The WG agreed to assume 100% of 1994 shortfin mako catch as a value for the initial equilibrium catch.**

7.4 Decisions of the Stock Assessment Model

The WG decided that SS would be the primary model, although the SS model could be downgraded to an age-structured surplus production model if necessary. The WG also requested flexibility in the model, and decided not to fix too many parameters (such as selectivity) before it was established. The WG requested to start with the high priority index from Japan and then add medium priority indices once the model was functioning. The WG considered pursuing a Virtual Population Analysis (VPA) approach as an alternative to the SS to avoid the difficulty of estimating an initial condition, or setting selectivity. It will also be useful to compare the outcomes of a VPA to that from the SS.

The WG agreed to run an SS model as the primary modeling approach. The WG also agreed to run VPA as an alternative model; however, this model was used as a sub-model to examine the effect of the initial conditions and selectivity of the SS. The WG agreed not to use the Bayesian State-Space Production Model approach (BSSPM) as the WG collected sufficient fishery (catch, CPUE, and size data) and biological information to run the SS model and the biological characteristics of the shortfin mako shark were more suited to the age/size and sex-specific model than the production model. The growth curve, size-at-maturity, length-weight relationships, and natural mortality rate were largely different between male and female shortfin mako, and differed by ages (working papers 5, 13, 14, and 22). The analysis of spatial and temporal distribution based on size also supported the sex and size segregation (Sippel et al., 2015). In addition, most of the catch originated from immature shortfin mako and might not have reflected changes in stock spawning biomass.

7.5 Discussion of the Stock Synthesis Modeling Approach, Including the Choice of Input Parameters and Priors

The WG reviewed the parameter specifications and tentatively decided on the specifications in Table 3 for the reference cases and alternative runs.

Table 3. Tentative Stock Synthesis model specifications and key input parameter choices.

GROUP	Variable	Reference values	Alternatives	Description / Comments
CPUE	CPUE Series	Japanese shallow-set LL series (JP)	Each time series (Japanese deep-set; Taiwanese large-scal LL; Hawaii-Shallow-set LL; Mexican observer LL)	CV's will be estimated from the catch and indices outside the model by the Francis (2011) method.
M	Natural Mortality	Walter et al. (2016) method II using Takahashi et al. (2017) growth with Tmax=31 and 24 for F and M and constant Target-M (Hoenig 1983)	M with Tmax=±3 for both sexes	Sex specific
LF	Sample size for length frequency data	Scalar of 0.2	Scalar of 1.0 and from Francis 2011.	5 cm precaudal length bins; numbers indicate lower limits of bin (i.e., put fish of XX cm into XX cm bin).
SR	Stock Recruitment Function	LFSR calculated using base case h which come from the method (Kai and Fujinami, 2017)	LFSR calculated for the 12 variations in life history parameters (two reproductive cycle, two types of growth parameters, three types of maximum ages)	
	Sigma R (SD on the recruitment deviations)	0.3	SigmaR =0.2 or 0.4	
Growth	Linfinity	232.0 cm PCL for male; 293.1 cm PCL for female	244.4.0 cm PCL for male; 315.5 cm PCL for female	Takahashi et al.(2017)
	parameter-k	0.174 for male; 0.128 for female	0.139 for male; 0.097 for female	
	L0	60 cm		
Catches/Fisheries		1 catch time series with 16 (17?) fisheries		
Region Structure		1 region		
Time Frame		1994-2016		
Selectivity	Length Based	Estimated by fishery from submitted size data. Mirrored for those fisheries without length comps		
Plus Group		31		
Length-weight relationship		F: Wt=4.62x10^{-5}PCL$^{2.77}$ M: Wt=3.40x10^{-5}PCL$^{2.84}$		Su et al. (2017)
Litter Size		Constant litter size		12 (Semba and Liu 2017)
Breeding Periodicity		2 yr and 3 yr		Reference from Semba et al. (2011); Joung and Hsu (2005)
Tmax	Longevity	31 for female and 24 for male		Ardizzone et al. (2006); Anon(2017)
Maturity equation	Parameter-a	10.98 for male; 0.14652 for female		Logistic equation; reference case from Semba and Liu (2017)
	Parameter-b	minus 25.06499 for male; minus 34.23496 for female		
Maturity at size	50% maturity size	166.3676 cm PCL for male; 233.6538 cm PCL for female		Logistic maturity; reference case from Semba et al. (2017)
Diagnostics		retrospective analysis (5 yr), residual analysis, neg-logliklihood profiles, age structured production model		

The WG will determine the selectivity for each fleet using the size data, with logistic curves fitted to the size data.

For aging data within the SS model, the **WG agreed that three scenarios should be checked for the aging error matrix.** One in which all band pairs were treated as 1 year, a second in which the first 10 band pairs were treated as 2 band pairs per year, and a third with 1 band pair per year. The final scenario was intended to convert the band pair counts to age depending on which nation provided the samples. The US and Mexico had the band pair switch, while data from Chinese Taipei and Japan were counted as each band pair representing only one year.

Projections are conducted on key model runs based on the average selectivity and *F*s during the three-year period from 2013–2015. Projections are conducted for 10 years and assume the status quo *F*, higher and lower *F* (± 20% of status quo), and F_{msy}.

7.6 Discussion of Input Parameters and Priors for the Virtual Population Analysis

The WG decided to use the same input parameters, configurations, and priors for the VPA model as those used in the SS model. The scenario of the future projection is also the same as that used in the SS model. Diagnostics of the model are limited as the characteristics of the estimation process and the configurations are different from the SS model. **The WG agreed that the main modeler for the VPA should decide which diagnostics are necessary**.

8. ESTABLISHMENT OF WORK PLAN FOR THE ASSESSMENT AND FINAL DATA SUBMISSION DEADLINE

<u>The WG Members</u>

- All outstanding final assessment data for the base case and alternative runs are to be sent to the SHARKWG Chair by 11 December 2017.
- All members should conduct updated analyses or prepare supporting documentation based on requests made during the meeting. Members must ensure that the WG reports describing any data used in the assessment adequately describe estimation methods with appropriate detail and diagnostics.
- US modelers to take the lead on SS modeling, with correspondence via F. Carvalho, and Japanese modelers to take the lead on the VPA modeling, with correspondence via M. Kanaiwa.
- Conduct base case and sensitivity runs in advance of assessment workshop.
- Calculate projections in advance of the assessment workshop.
- Small modeling subgroup meeting tentatively scheduled for February 2018 (La Jolla, US)

<u>The WG Chair</u>

- Finalize the WG data preparatory meeting report and submit the report to the ISC secretariat by 3 January 2018 (within 1 month).
- Contact IATTC to obtain updated information on non-ISC fleets reporting shortfin mako catch in the North Pacific and finalize IATTC data by the data submission deadline 31 December 2017.
- Compile and distribute final assessment base case data by 31 December 2017.

9. OTHER MATTERS

M. Kai of Japan was elected Chair of the WG and Y. Semba of Japan was appointed as data manager for the WG. The Chair reminded all members that an election for a new SHARKWG Vice Chair will be held at the next stock assessment meeting in April 2018. The new Chair announced that the ISC review of the stock assessment for shortfin mako will be conducted by an independent scientist, and he/she will join the assessment meeting in April 2018. Chinese Taipei and Mexico requested their data on aging not be used in the publication of the meta-analysis of growth curves as it was to be submitted in a separate paper on aging in the future.

10. FUTURE SHARKWG MEETINGS

The small modeling WG meeting will be held in the third or fourth week in February 2018 (dates TBD) in La Jolla, CA, US, to improve the configuration and parameterizations of the age-structured model (SS). The WG meeting will be held in the third or fourth week in April 2018 (dates TBD) in La Jolla, CA, US, to complete the shortfin mako stock assessment. The Chair requested a half-day meeting in July 2018 (dates TBD) prior to the ISC Plenary.

11. CLEARING OF REPORT

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

12. ADJOURNMENT

The Acting Chair thanked all participants for attending and contributing to a very productive meeting. He also thanked the Japanese delegation for the incredible hospitality, for their support with logistics in advance of the meeting and throughout the week, and for the wonderful reception. The meeting was adjourned at 17:01, 4 December 2017.

13. LITERATURE CITED

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Attachment 1 - List of Participants

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Attachment 2 – Working Papers

ISC/17/SHARKWG-1/01	Shortfin mako (*Isurus oxyrinchus*) incidental catch statistics in Canadian fisheries. J.R. King (jackie.king@dfo-mpo.gc.ca)
ISC/17/SHARKWG-1/02	Estimation of catches for shortfin mako, *Isurus oxyrinchus*, caught by Japanese coastal fisheries. M. Kai and T. Yano (kaim@affrc.go.jp)
ISC/17/SHARKWG-1/03	Estimation of catches of shortfin mako, *Isurus oxyrinchus*, caught by Japanese offshore and distant-water fisheries. M. Kai and Y. Semba (kaim@affrc.go.jp)
ISC/17/SHARKWG-1/04	Length composition and catch of shortfin mako sharks in US commercial and recreational fisheries in the North Pacific. M. Kinney, F. Carvalho, and L.H. Teo (michael.kinney@noaa.gov)
ISC/17/SHARKWG-1/05	Meta-analysis of growth curves for shortfin mako shark in the North Pacific. N. Takahashi, M. Kai, Y. Semba, and M. Kanaiwa (norio@affrc.go.jp)
ISC/17/SHARKWG-1/06	Stock abundance indices for mako shark estimated by observer data of Japanese longline fisheries in the North Pacific Ocean. M. Kanaiwa, Y. Semba, and M. Kai (kanaiwa@ bio.mie-u.ac.jp)
ISC/17/SHARKWG-1/07	Updated CPUE of shortfin mako, *Isurus oxyrinchus*, caught by Japanese shallow-set longliner in the North Pacific. M. Kai (kaim@affrc.go.jp)
ISC/17/SHARKWG-1/08	CPUE of shortfin mako, *Isurus oxyrinchus*, caught by Japanese research and training vessels in the North Pacific. M. Kai (kaim@affrc.go.jp)
ISC/17/SHARKWG-1/09	Standardized CPUE and historical catch estimates of shortfin mako shark by Taiwanese large-scale tuna longline fishery in the North Pacific Ocean. W.P. Tsai, Y. J. Wang, S. H. Su, and K.M. Liu (kmliu@mail.ntou.edu.tw)
ISC/17/SHARKWG-1/10	Standardized catch rates of shortfin mako shark (*Isurus oxyrinchus*) caught by the Hawaii-based pelagic longline fleet (1995–2016). F. Carvalho (felipe.carvalho@noaa.gov)
ISC/17/SHARKWG-1/11	Size and sex of shortfin mako recorded by onboard observers in the Mexican longline industrial fleets in the Pacific 2006–2016. J.L. Castillo-Geniz, C.J. Godínez-Padilla, L.V. González-Ania, H. Haro-Avalo, and J.I. Fernández-Mendez (gonzalez_inp@yahoo.com.mx)

ISC/17/SHARKWG-1/12	Size composition of shortfin mako shark caught by the Taiwanese tuna longline fishery in the North Pacific Ocean. W.P. Tsai, Y.J. Wang, S.H. Su, and K.M. Liu (kmliu@mail.ntou.edu.tw)
ISC/17/SHARKWG-1/13	Relation between weight and length of shortfin mako sharks in the North Pacific Ocean. S.H. Su, S. Kohin, J. Taylor, Y. Semba, W.P. Tsai, and K.M. Liu (Susanzernike@gmail.com)
ISC/17/SHARKWG-1/14	Natural mortality rates for shortfin mako, *Isurus oxyrinchus*, in the North Pacific. M. Kai and H. Yokoi (kaim@affrc.go.jp)
ISC/17/SHARKWG-1/15	Growth estimation update of shortfin mako shark in the Mexican Pacific ocean, through multi-model approach and different methods for age determination. J.A. Rodríguez-Madrigal, J.T. Ávila, J. L. Castillo-Géniz, C.J. Godínez-Padilla, F. Galván-Magaña, J.F. Márquez-Farías, and D. Corro-Espinosa (albertorm.mx@gmail.com)
ISC/17/SHARKWG-1/16	Standardization of mako shark ageing through different vertebrae enhancement methods and comparison of growth estimates from Eastern and Western North Pacific Ocean. J.A. Rodríguez-Madrigal, J.T. Ávila, and Y. Semba (albertorm.mx@gmail.com)
ISC/17/SHARKWG-1/17	Application of EPMA to juvenile shortfin mako (*Isurus oxyrinchus*) collected in the western and central North Pacific Ocean. Y. Semba (senbamak@affrc.go.jp)
ISC/17/SHARKWG-1/18	Update of growth of juvenile shortfin mako (*Isurus oxyrinchus*) in the western and central North Pacific Ocean. Y. Semba (senbamak@affrc.go.jp)
ISC/17/SHARKWG-1/19	Estimates of shortfin mako shark (*Isurus oxyrinchus*) catches by Mexican Pacific fisheries: An update (1976–2016). O. Sosa-Nishizaki, L.E. Saldaña-Ruiz, D. Corro-Espinosa, D. Corro-Espinosa, J. Tovar-Ávila, J. L. Castillo-Géniz, H. Santana-Hernández, and J.F. Márquez-Farías (ososa@cicese.mx)
ISC/17/SHARKWG-1/20	Update on standardized catch rates for mako shark (*Isurus oxyrinchus*) in the 2006–2016 Mexican Pacific longline fishery based on a shark scientific observer program. L.V. González-Ania, J.I. Fernández-Méndez, J.L. Castillo-Géniz, L. Hidalgo-García, and H. Haro-Ávalos. (luis.gania@inapesca.gob.mx)
ISC/17/SHARKWG-1/21	Size distribution of shortfin mako collected by Japanese fleet and research program. Y. Semba. (senbamak@affrc.go.jp)
ISC/17/SHARKWG-1/22	Revised integrated analysis of maturity size of shortfin mako (*Isurus oxyrinchus*) in the North Pacific. Y. Semba and K. M. Liu (senbamak@affrc.go.jp)

Attachment 3 – Workshop Agenda

SHARK WORKING GROUP (SHARKWG)
INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC
INTERCESSIONAL WORKSHOP AGENDA

28 November – 04 December 2017
National Research Institute of Far Seas Fisheries
Shimizu, Shizuoka, Japan

Meeting begins at 9:00 am Monday.

1. Opening of SHARKWG Workshop
    a. Welcoming remarks – Dr. Miki Ogura, Vice director at NRIFSF
    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. Catch and discard data and total catch estimation procedures (Carvalho, Takahashi)
6. Review CPUE indices for shortfin mako stock assessment (Kinney, Kanaiwa)
7. Size data and size data collection protocols (Carvalho, Semba)
8. Summary and outcomes of aging workshop and November webinar (Semba, Tsai)
9. Biological information (Kinney, Liu)
10. Discuss modeling approaches for use in the shortfin mako assessment (Clarke, Carvalho, Kinney)
11. Establish work plan for the assessment and final data submission deadline (Kai, Liu)
12. Other matters (Kai, Tsai)
    a. Election of chair and appointment of data manager
13. Future SHARKWG meetings (Kai, Semba)
    a. Small WG meeting (modeling)
    b. Shortfin mako stock assessment meeting
14. Clearing of report
15. Adjournment