Annex 4

REPORT OF THE SHARK WORKING GROUP WORKSHOP

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

28 November – 3 December 2011
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 in La Jolla California, USA from 28 November through 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.

Dr. Francisco Werner, Director of Science for NOAA Fisheries Southwest Region welcomed participants from Canada, Chinese Taipei, Japan, Mexico, United States of America (USA), Inter-American Tropical Tuna Commission (IATTC) and Secretariat of the Pacific Community (SPC) (Attachment 1). In his address, Dr. Werner thanked member nations and observers for their commitment to supporting this new working group. He said that blue and shortfin mako sharks are not targeted by U.S. commercial fisheries in the Pacific, but they are particularly important to fisheries researchers and managers in California as there is a nursery area for these species right off the southern California coast. Both species are managed under federal fishery management plans in the Pacific to ensure that their incidental and recreational take is sustainable. He acknowledged the great challenge this group faces because landings data and life history information for these sharks are limited and wished the group a successful and productive meeting in working toward conducting a blue shark assessment in 2012.

2.0 DISTRIBUTION OF MEETING DOCUMENTS

Twelve working papers and one informational document were distributed and numbered (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/11/SHARKWG-2/03, ISC/11/SHARKWG-2/05, ISC/11/SHARKWG-2/06, ISC/11/SHARKWG-2/12 and ISC/11/SHARKWG-2/INFO 1 declined posting on the ISC website.

3.0 REVIEW AND APPROVAL OF AGENDA

The draft meeting agenda was reviewed and discussed. Participants requested that a discussion of the potential input parameters for a blue shark stock assessment precede Agenda item 10 on life history studies, as well as a discussion of the potential stock boundaries to consider. Small subgroups were assigned to present on the potential input parameters for a blue shark stock assessment including stock boundaries based on the 2009 Multifan-CL assessment, (S. Teo, M. Kanaiwa, W.-P. Tsai, and T. Sippel) and a small subgroup was assigned to examine prior studies addressing life history aspects of blue and shortfin mako sharks (Y. Semba, K.-M. Liu, D. Wells). It was agreed that both subgroups would report back to the SHARKWG before Agenda item 10. With this addition, the agenda was approved (Attachment 3).

4.0 APPOINTMENT OF RAPPORTEURS

Rapporteuring duties were assigned to Yuko Hiraoka, Minoru Kanaiwa, Jackie King, Suzanne Kohin, Cleridy Lennert-Cody, Kwang-Ming Liu, Joel Rice, Rosa Runcie, Yasuko Semba, Natalie Spear, Tim Sippel, Mioko Taguchi, Steve Teo, Wen-Pei Tsai, Bill Walsh, David Wells and Kotaro Yokawa.

5.0 SUMMARY OF THE APRIL 2011 WORKSHOP AND SHARKWG WORKPLAN

Suzanne Kohin, Chair of the SHARKWG, provided a summary of the first workshop of the ISC SHARKWG, convened in Keelung, Chinese Taipei, 19-21 April 2011. The meeting was chaired by Gerard DiNardo, the ISC Chair. The goals of the workshop were to review and discuss provisional fisheries data and research, develop a work plan to conduct shark stock assessments, and elect a SHARKWG chairperson. Twelve participants from Chinese Taipei, Japan and USA attended the meeting, and 9 working group papers were discussed. Ten background papers describing relevant work on sharks were also provided. A workplan was developed addressing four topics: 1) fishery statistics, 2) biological statistics, 3) ecological research, and 4) stock assessment. Suzanne Kohin of USA was elected SHARKWG Chair.

6.0 REVIEW OF EXISTING BLUE AND SHORTFIN MAKO SHARK FISHERY CATCH AND BYCATCH DATA AND CATCH ESTIMATION PROCEDURES

6.1 Canada

6.1.1 Blue shark (Prionace glauca) bycatch statistics in Canadian fisheries, presented by Jackie King (ISC/11/SHARKWG-2/01).

There are no targeted blue shark (*Prionace glauca*) fisheries conducted 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 sharks 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 (*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 from other commercial fisheries rely solely on fisher logbook data. Recreational fisheries are monitored by creel survey programs.

Blue shark are encountered year round in the groundfish trawl fishery, with the majority of encounters occurring in August and September. The catch is concentrated along the west and north coasts of Vancouver Island. From 1996-2010 there have been a total of 2.67 tonnes of blue sharks caught by the trawl fleet resulting in a mean of 0.18 tonnes annually. In the groundfish longline fishery, blue shark are encountered May through October, with the majority of encounters occurring in August and September. Blue shark are encountered along the shelf break, with the majority of longline bycatch occurring off the West Coast of the Haida Gwaii (northern British Columbia). Bycatch varies greatly by year, with a maximum of approximately 19 tonnes in 2006 and a minimum of less than 1 tonne in several years. Approximately 5.5 tonnes of blue shark are encountered by groundfish longline gear annually. Estimates of blue shark bycatch in the salmon commercial fisheries are low, with a mean of 0.24 tonnes annually. Estimates of blue shark bycatch in the tuna troll fishery are exceptionally low, and likely unreliable. Catch per unit effort of blue shark bycatch for US observer tuna troll sets could be used to verify or estimate Canadian tuna troll catch based on effort data available. Estimates of blue shark encountered by recreational fishers are low and likely incomplete. There is no identified means of improving these recreational data.

Discussion

All discards are recorded so high spatial resolution is possible and effort data is also available. One curious observation was very high numbers of blue sharks in 2004 from the halibut longline survey. Expanded estimates of abundance based on survey catch rates, estimated a five-fold increase of blue sharks in Canadian waters in 2004 compared to all other survey years (2003-2010).

6.2. Chinese Taipei

6.2.1 Preliminary estimate of Taiwanese shark catch in the North Pacific, oral presentation by Kwang-Ming Liu.

A general summary of fishery data consisting of offshore longline (domestic, small scale), far seas longline (foreign based small longline fishery), and large longline were described. Species-specific shark catch (number and round weight) except blue shark data are available from 1990-2010 for the offshore longline fishery. Blue shark data are available from 2001 and onward (only processed weight). The primary fishing areas are 120-140 E, 20-35 N for the offshore longline fishery and blue shark dominated the shark catch, totaling 45% of the landings. The catch data of foreign based longline/far seas fishery is only available from 2008-2011. Interestingly, some of the foreign based fleet reports are submitted to other foreign countries where fishing occurs, but most not to Taiwan. Occasionally, Taiwan needs to ask SPC for those data. The observer program for the large scale longline began in 2002 and both discard and release are currently estimated. The observer data covers more than 5% of longline vessels.

Discussion

The spatial coverage of observer data used for the estimation of shark catch in the large scale longline fishery was discussed as well as the detailed process of calculation (including yearly change of ratio of shark) and the spatial distribution of observer data. The application of species-specific CPUE estimated from observer data was indicated as another method to estimate the catch of shark.

6.3. Japan

6.3.1 *Brief summary of fishery data of major shark species caught by Japanese offshore and distant-water longline in the north Pacific in 1994 – 2010, presented by Kotaro Yokawa (ISC/11/SHARKWG-2/11).*

The reported catch of blue shark, mako sharks, and salmon sharks caught by Japanese offshore and distant-water longliners in the period of 1994 and 2010 was summarized using log-book data. Reported catches of blue and salmon sharks increased up to the beginning or middle of the 2000s and decreased thereafter, while catch of mako sharks fluctuated between 400 and 700 tons. Size sampling of blue sharks was initiated in the end of 2008, and the number of size data in 2009 and 2010 are 15,000 and 13,400 respectively. The coverage of size data to the reported catch number by log-books of offshore and distant-water longliners are about 2.5 % for both two years.

Japanese data on sharks are characterized in three categories. 1) The recorded catch is only "retained" number of shark, not including discard. 2) The old records of sharks is aggregated as "sharks". 3) The majority of sharks are caught as bycatch, but one offshore fishery targets blue shark seasonally. It was noted that the data indicated in this document is different from official statistics which only includes catch (retained in the vessel for landing) and does not include the live release and dead discards. It was indicated that the estimation of dead discard or addition of live release to the logbook data is important in the Japanese data and necessary for the future stock assessment of blue shark.

The log-book reporting system of Japanese longliners changed in 1994, and one of the major revisions was to enforce the reporting of species specific data of major shark species. This includes the catch numbers and average weight of blue sharks, mako sharks and salmon sharks. Non-reported parts of log-book data were extrapolated using data of other longliners operating in the same area and season whose log-books were available. Size sampling of blue sharks was initiated in 2009, and collected data is also error checked and compiled by the National Research Institute of Far Seas Fisheries. The catch of blue shark caught by Japanese offshore and distant-water longliners increased since 1994 and peaked in 2001 with 16,400 tons and showed a continuous decreasing trend up to 2010. This was attributed to the decrease in the amount of effort of Japanese offshore surface longliners based in Kesennuma fishing port. One of the major reasons in the decrease of blue shark catch after 2001 was the decrease in the number of offshore surface longliners, down about two thirds in 2010 relative to 2001.

<u>Discussion</u>

The WG discussed how the catch data should be reported to the Plenary given that there is a difference in the official national shark catch data that is reported as landed sharks only and what the WG scientists may estimate for the stock assessment using filters and data extrapolation procedures. It was proposed that the WG will create Table 1 of reported catch of shortfin mako and blue sharks, by country and by fishery and this table will be reported for the ISC Plenary meeting. The WG also agreed to create more detailed tables that reflect estimated retained and discards for the stock assessment purposes. The SHARKWG Chair needs to take up this issue with the ISC Chair and database manager to get agreement on the contents of WG prepared tables.

6.3.2. Review of species aggregated sharks data caught by Japanese offshore and distant-water longliners in the north Pacific in 1975 – 1993, presented by Kotaro Yokawa (ISC/11/SHARKWG-2/10).

The catch and effort data of Japanese offshore and distant-water longliners provide important information for assessing stock status of major shark species in the three oceans (e.g., ICCAT (2009) and Clarke (2011)) due to their quality and wide coverage. Because older Japanese log-book data of tuna-longline fisheries do not contain the information of live released and dead discarded sharks, a filtering method to extract the data of all sharks caught using the reporting rate of sharks in the log-book were developed by Nakano and Clarke (2006) and applied to the data in the Atlantic and the Indian Oceans (Matsunaga (2007) and Matsunaga (2008)). Though Japanese offshore and distant-water longliners primarily target tunas, one fleet of offshore longline based in Kesennuma fishing port seasonally targets blue shark, and this may affect the reporting rate of sharks in the longline log-book data. In the present study, the shark catch and effort data in the log-book of Japanese offshore and distant-water longliners in the period between 1975 and 1993 were reviewed to investigate adequate methods to process these data for their use in stock assessments of major shark species in the north Pacific such as blue and mako sharks. Because only species aggregated catch data is available for the period of analyzed, species specific patterns in the data were not reviewed in this study[1].

Discussion

In the present study, reporting rates of sharks are variable among fleets throughout different regions of Japan where longliners are registered. The fleets operating in Tohoku and Hokkaido report constant or gradual changes by year; however, Kyushu fleets do not, so the ratio of their target to shark catches are highly variable. A comment was made that in the North Pacific, filtering would result in picking up data of some fleets registered in particular areas of Japan, but not others. Even with the same number of hooks per basket, different fleet target different species and their shark catch could be adjusted by the area and season effects, but there are still some sets that cannot be adjusted.

Catch estimation based on both methods would allow the evaluation of estimation accuracy. **To improve the filtering of blue shark catch from the species-aggregated data, the necessity of further research on the release/discard pattern on blue shark by Tohoku or other fleets and spatial distribution pattern by size and sex was indicated. The retention pattern including the status on the live release and dead discard by Tohoku fleet was questioned and further research on this subject, especially for deep sets and operations in the eastern area was indicated.**

6.3.3 The operation pattern of Japanese tuna longline fishery with the information for prefecture of vessels register and reporting rate in the North Pacific Ocean, 1994-2010, presented by Yuko Hiraoka (ISC/11/SHARKWG-2/09).

To analyze whether existing filtering methods are acceptable in the Pacific Ocean or not, the number of operations and catch number of major fish species are compared by fleet type (*Kinkai*

[1] See Working Paper ISC/11/SHARKWG-2/10 for references.

or *Enyo*), region or prefecture in which controlling companies of fleets are based, gear configuration, reporting rate category and fishing area. More than 96% of all blue shark catch during 1994 to 2010 are caught by *Kinkai* fleet belonging to the Tohoku/Hokkaido region. High concentrations of blue shark catch are found in areas 1 and 2 and caught by both *Kinkai* and *Enyo* fleets. In contrast, the fleets operating in areas 3, 5 and 6 are mainly using deep gear and targeting tunas. Different patterns of reporting rate by belonging region or prefecture of fleets were found. Whereas a large number of operations conducted by Tohoku/Hokkaido fleets showed 100% reporting ratio regardless of fleet type and gear configuration, some prefecture's fleets perform most operations with 0% reporting ratio. Thus it is considered that these fleets do not usually report all shark catches as the Tohoku/Hokkaido fleets do. Because most deep operations in areas 5~7 show low reporting rate category, it might indicate that the abundance of blue shark is relatively low in these areas and the existing filtering method which uses ≥80% reporting rate would result in over evaluation of blue shark catch. Therefore a new filtering method should be developed. Consequently catch and effort data of Tohoku/Hokkaido fleets in areas 1, 2, 5 and 6 except for the 0% reporting rate category may be most appropriate for the stock assessment of blue shark in the North Pacific Ocean.

<u>Discussion</u>

This paper generated lots of discussion within the WG about appropriate filtering methods to extract shark data from logbooks to be used for stock assessment. Authors clarified that this paper only presents part of the proposed process to be used to estimate shark catches from Japan longline logbooks. The authors further clarified that two-steps will be required for the estimation of total catch including discards. The first step is to estimate the shark species composition (using species composition in 1994 - 2010 as a proxy for the species composition of species-aggregated shark data in 1975 - 1993), Subsequently, a second step is used to extract data from logbooks with consistent and representative shark catches, which will be used to calculate a standardized CPUE and estimate total blue and mako shark catch, including discards. For the first step, the filters used in previous studies assume that a vessel with a >80 % reporting ratio is reporting all shark catch. For example, in a study on Atlantic Ocean sharks, vessels with reporting ratio greater than 0% and <20% is assumed to be reporting mako shark catch. However, Nakano and Clarke (2006) indicated this method would underestimate the catch of shortfin mako shark. Therefore, the authors are investigating a stochastic approach for the estimation of species composition by strata, which is likely more appropriate. However, all data with >0% reporting ratio is required for this new approach. Currently, Japan scientists are still investigating the appropriate filter to use for the second filtering step and have not come to any conclusions yet. Japan scientists will report to the WG about the results of this study at the next workshop. The WG noted that using the appropriate filter to extract shark catch and effort is very important. **The WG noted that using all available data with >0% reporting rate is likely appropriate for estimating species composition (i.e., the first filter) but another reasonable technique should be developed for the second filter. The WG provided several suggestions for Japan scientists to consider in their study of this issue. For example, it was suggested that the reporting rate of individual vessels be considered and that vessels which consistently report shark catches should be identified and data from these vessels be used. The WG suggested that several filters be investigated and the appropriate filter be decided upon at the next meeting.**

6.4. Mexico

6.4.1 Swordfish and shark longline fishery of Baja California (Ensenada) Mexico, INAPESCA, presented by José Leonardo Castillo-Géniz (ISC/11/SHARKWG-2/INFO-1).

The coastal swordfish and shark drift gillnet fishery of Ensenada, BC, Mexico operates in the coastal waters of the Peninsula of Baja California. Worldwide, Mexico is one of the nations that has a considerable shark fishery with an annually production estimated around 25,000 t, sustained by a diverse group of shark species, particularly tropical carcharhinid species. In spite of Mexican extended shark fisheries, the official fishery statistics are not available by main species or species groups. In Mexico the shark catches and landings are reported by administrative monthly reports from the artisanal and industrial fisheries and by logbooks in industrial fisheries. This fishery statistics information is used to elaborate the Mexico's Official Fishery Statistics Yearbooks.

Mexico has traditionally managed its shark fisheries by the issue of commercial fishery permits. In 1993 a moratorium for new shark fishery permits in the artisanal fisheries was established, which was extended to the industrial component in 1998. In February 14, 2007 a new set of regulations and rules for all Mexican shark and ray fisheries, the Official Shark Mexican National Standard Rules (Norma Oficial Mexicana 029-PESC-2006 Pesca Responsable de Tiburones y Rayas, Especificaciones para su aprovechamiento) was approved and published in the Mexican Federal Register (Diario Oficial de la Federacion).

In the northern Pacific, along the west coast of the Peninsula of Baja California, the coastal industrial and artisanal shark fisheries target tropical and temperate pelagic species including: *Prionace glauca* (tiburon azul), *Isurus oxyrinchus* (mako) and thresher shark, *Alopias vulpinus* (coludo). The review presented included the description of the characteristics and dimensions of the fleet, fishery gear, fishery grounds and some data on production. The general catch composition of the drift gillnet fishery was: 88% sharks and 12% swordfish. Because of its low selectivity to catch swordfish and sharks, in May 2009 the use of all kind of gillnets by large and medium size shark fishery boats, along both coastlines of Mexico, was forbidden. By 2009 the operations of the swordfish and shark fleet of Ensenada, became totally surface longline sets.

In 2006 CONAPESCA (Mexico's National Fishery and Aquaculture Commission) in collaboration with the National Fisheries Institute of Mexico (INAPESCA) and the FIDEMAR Trust (Fideicomiso de Investigacion para el desarrollo del Programa de Aprovechaiento del Atun y Proteccion de Delfines y Otros en torno a Especies Acuaticas Protegidas) designed and implemented an Observer Program (OP) on board of the main shark fishery fleets operating in the northern Pacific. The objectives of the OP are to collect accurate data on shark catches, bycatch and effort. Also, FIDEMAR observers documented data on the composition of the shark catch by length, sex, weight and maturity stages. For the period 2006-2010, the OP monitored 374 shark fishery trips and 6,639 gillnet and longline sets in the northern Pacific. 16% corresponded to the Ensenada fleet. The OP coverage estimated for the Ensenada fleet was 8-10%. A 2007 preliminary analysis of the fishery operations of the Ensenada Fleet (which was comprised of 20 commercial vessels in 2010) estimated a total number of 160 fishery trips with a total catch of 1,500 t; the main species was the blue shark with 80% of the catch and 12% for swordfish. The annual mean of the official catches reported during 2000-2010 for the Ensenada Fleet were: sharks, 1,173 t and 311 t swordfish. The preliminary OP analysis data of the

Ensenada Fleet showed a catch ratio of 1 swordfish: 8 blue sharks, 95% of the sets were successful in catch blue sharks and larger blue shark catches were documented in northern region during winter months.

Other fleets targeting blue sharks and mako in the Mexican Pacific were identified: the coastal longline shark operations conducted by several artisanal fleets located along the Peninsula, the industrial longline shark fishery based in Mazatlan (State of Sinaloa) and the longline shark fishery located in Manzanillo (Colima). An estimation of the total blue shark catch produced by these Mexican fleets is not available at this time. Several sources of information that include the OP data and the results of INAPESCA shark research programs in the northern Mexican Pacific should be consulted for this purpose.

Discussion

A question was raised about whether there is catch of blue and mako sharks in the Gulf of California. No blue sharks are collected in the Gulf of California, but some makos are. The development of catch history was discussed. Based on the data from Ensenada, the application of the ratio of blue shark to other species may be one approach to estimate historical catch. The importance of consideration of seasonal migration for the catch estimation was indicated. The importance of the fishery area as a nursery/pupping area was also noted. **In addition to the data provided, it was indicated that M.S. and Ph.D. theses from students in national universities contain valuable information that should be recovered.**

6.5. USA

6.5.1 Preliminary analyses of catch and catch rate data for blue shark and shortfin mako in the Hawaii-based pelagic longline fishery in 1995–2010, presented by Bill Walsh (ISC/11/SHARKWG-2/02).

This working paper (WP) presents catch and catch per unit effort (CPUE) data and preliminary CPUE standardizations for blue shark *Prionace glauca* and shortfin mako *Isurus oxyrinchus* from the Hawaii-based pelagic longline fishery in 1995–2010. The data come from the records of the Pacific Islands Regional Observer Program (PIROP) and commercial logbooks submitted to the Pacific Islands Fisheries Science Center (PIFSC). This WP informs the SHARKWG about the data available at the PIFSC, summarizes progress to date with these species, and outlines analytical procedures to be employed during this project. The project objective is to fit statistical models to data from pelagic longline fishery observers and then use the models to estimate fishery-wide catches and compute standardized CPUE time series for use in stock assessments. Results include a description of shark reporting patterns with an explanation of reporting bias, nominal catch statistics, summary analyses of deviance of generalized linear models (GLMs) fitted to observer data and standardized CPUE plots. Nominal CPUE for blue shark decreased between 1995 and 2010, while the percentage of zero blue shark catches increased in the deep-set sector. In contrast, shortfin mako nominal CPUE in 2004–2010 was more than double that in 1995–2001, which correspond to the periods separated by the shallow-set sector closure. A standardized CPUE plot for blue shark indicated that the standardized trend was less variable than the nominal. Regional effects associated with increased geographic expanse, and translocations of effort within both sectors of the fishery are expected to be important in the remaining analyses. Analytical concerns are outlined, and recent activities and their applicability to this project described. Detailed standardized CPUE time series results and additional size and life history information should be available for the next meeting.

Discussion

The steep decline in the standardized CPUE for blue sharks toward the end of the time period is not consistent with the flat trends for the other species. This may indicate that using an average catch ratio to estimate catch for periods without data may be problematic. **It was noted that the standardization may be improved by including interactions of sst with area/time rather than using just SST alone. It was suggested that separating the deep and shallow sectors is appropriate, or if not separating by gear, separating north and south of 30 N. The WG also suggested that these data be compared to the Japan longline data from the same area and with any other longline data that may be available for the same area from the IATTC.**

6.5.2 Preliminary estimated catches of blue and mako sharks from US West Coast fisheries, presented by Steve Teo (ISC/11/SHARKWG-2/07).

Blue and mako sharks are not primary target species for US West Coast fisheries. However, the pelagic drift gillnet and longline fisheries based on the US West Coast do catch non-negligible numbers of blue and mako sharks. Since these shark species are not the targets of these fisheries, the representativeness of commercial landings and logbook records for these species is mixed, depending on the species and fishery. In this paper, we detail the methods used to estimate catches of these species by both fisheries, primarily based on recorded logbook and observer data. For the gillnet fishery, the catch (numbers of fish retained or discarded dead) and effort (in km of net) information associated with 240 strata (20 years x 4 seasons x 3 areas) were extracted from observer data and the catch-per-unit-effort (CPUE) in each stratum was calculated. For the longline fishery, the catch (numbers of fish retained or discarded dead) and effort (in thousands of hooks) information were extracted from observer data and the average CPUE was calculated. The catches for a given year for the fisheries were then calculated from the CPUEs and effort recorded in logbooks. A comparison of estimated catches and recorded landings for mako sharks by the gillnet fishery showed that the methods described produced relatively representative estimates. It is recommended that the described methods be used to estimate catches of blue shark by the drift gillnet fishery and both species by the longline fishery. However, it is recommended that the reported landings for mako sharks from the drift gillnet fishery be used because those recorded landings are relatively representative due to the high retention rate (95.2%).

Discussion

The WG suggested that there may be other methods for estimating catch for the early period, for example, applying the observed ratio of blue or mako shark catch to swordfish catch from 1990 forward to the prior unobserved period. It was also suggested that leaving year out of the CPUE standardization may produce better estimates. Additional methods will be investigated and reported on at the next meeting. The California-based longline blue and mako shark catches since 2004, when the shallow set longline fishery was closed, were not estimated due to data confidentiality reasons. Those catches will be estimated and combined with the Hawaii-based longline shark catch to derive total estimated catch for the U.S. longline fisheries.

Discussion relevant for all members in preparing catch estimates:

The WG requested members to explain the details of any estimation process and results of fitting the analyses at the next WG meeting so the WG can evaluate the results. In addition, the WG questioned the appropriateness of using the ratios between shark and target species for the estimation of blue shark catch, as the stock level of north Pacific tuna and other target species may have changed significantly over the years. There are potentially multi-colinearity problems if different species are included as factors in standardizations.

6.6 IATTC

6.6.1. Non-member catch north of the equator, oral presentation by Cleridy Lennert-Cody

The IATTC has purse-seine effort and catch information for ISC member and non-member countries, and longline effort information for non-members, available for the north eastern Pacific Ocean (EPO). In addition, very limited information on longline shark catches of non-member countries for the north EPO is also available. For the purse-seine fishery, at-sea observer recording of non-mammal bycatch of large purse-seine vessels (>363 mt fish-carrying capacity) has increased from roughly 40% or more of sets in 1993 to complete coverage in recent years. Observers record shark bycatch information in numbers of sharks by size category (<90 cm TL; 90-150 cm TL; >150 cm TL). In addition, since 2005, information has also been collected on length (TL to nearest cm), sex, and amount of live release. Species identifications may be problematic. Information on fishing effort for all sizes of purse-seine vessels is available from observer data and logbooks. From these sources, estimates of total annual shark bycatch can be obtained for large purse-seine vessels from 1993-2010. In addition, estimates of total bycatch for small purse-seine vessels can be made, assuming that the bycatch rate information for large vessels is appropriate for small vessels. Preliminary annual estimates of total purse-seine bycatch for 1993-2010 were, on average, 97 blue sharks per year (range: 18-523), 41 shortfin mako sharks per year (range: 6-115) and 10 unspecified mako sharks per year (range: 0-55). These estimates do not include any proration of unidentified sharks. Purse-seine fishing effort information is available prior to 1993 but no corresponding bycatch information is available. For the longline fishery in the north EPO, annual estimates of effort (numbers of hooks) can be made from the mid-1970s to present. Annual EPO catches (in metric tons) of sharks have been provided to the IATTC by some countries in some years, but the available information is very limited.

Discussion

The WG agreed that the purse seine catch of blue and mako sharks seems negligible. However, the effort data for longline fisheries operating in the IATTC convention area may be useful to estimate shark catch for ISC non-participating members and non-members. A number of potential estimation methods were discussed. The WG Chair will follow up with IATTC staff to obtain any relevant longline effort data.

6.7 SPC

6.7.1. Non-member catch north of the equator, oral presentation by Joel Rice.

The main fisheries that catch blue and mako sharks in the WCPFC convention area are the tuna longline and purse seine fisheries. CPUE data exist for these fisheries calculated from SPC observer program data, though the purse seine data are considered non-informative and overall catches are assumed to be negligible. Overall effort data are based on aggregated self-reported data provided by WCPFC nations. Some sharks are caught in targeted shark fisheries, most of which use longline gear, between -20^{o}S and 20^{o}N. The majority of the observed catch comes from the longline fishery. Catch was estimated using the formula $Catch_{year=i} = CPUE_{year=i} * Effort_{year=i}$, where CPUE and effort are calculated over a 5^{o}x5^{o} grid. Multiple methods of CPUE standardization were used, but none were considered satisfactory so the yearly average was used. The preliminary estimated catches of blue and shortfin mako sharks for non-ISC flagged vessels in the Northern hemisphere were reported. It should be noted that these are initial estimates, and they may be revised if data gaps can be addressed. Catch was reported in numbers of sharks for the years 1995 to 2009. The preliminary range and average estimated catch of blue sharks for non-ISC flagged vessels in the Northern hemisphere are 1691 to 303,673 (range) and 82,377 (average). The preliminary range and average annual estimated catch of mako sharks for non-ISC flagged vessels in the Northern hemisphere are 84 to 3075 (range) and 1022 (average).

<u>Discussion</u>

The WG noted that the contours showing higher densities of blue shark in areas to the north and south of the equator seem consistent with catch data from member nations and distinct stocks north and south. However, Chinese Taipei indicated that in their distant longline fishery, blue shark catch is higher in the subtropical area than in the temperate area. **The amount of data used in some areas to generate the contours was relatively low and the WG feels it should be further investigated. It was noted that due to seasonal movement, the average CPUE might be better calculated by month for both blue and mako sharks.**

7. REVIEW OF EXISTING BLUE AND MAKO SHARK SIZE COMPOSITION DATA

7.1 USA

7.1.1 Length frequencies of the blue shark (Prionace glauca) in the eastern Pacific Ocean, presented by David Wells (ISC/11/SHARKWG-2/08).

The objective of this study was to investigate the length frequency data available for the blue shark from U.S. west coast fisheries. Specifically, we provide a summary of blue shark lengths based on two fishery datasets: 1) California drift gillnet fishery and 2) a fishery-independent NOAA Southwest Fisheries Science Center (SWFSC) juvenile shark longline survey. The primary factors investigated were blue shark lengths relative to dataset (hereafter survey type), year, and quarter. A total of 17,806 blue sharks ranging in size from 41 to 273 cm fork length (FL) and mean size of 109.8 cm FL (± 31.5 standard deviation, SD) were used to investigate trends in size distributions. Mean length of blue sharks collected from the drift gillnet fishery was 115.3 cm FL (± 29.4 SD), while smaller sizes were collected in the NOAA juvenile survey (mean size of 98.2 cm FL ± 32.7 SD). The range of blue shark lengths was similar across years relative to each survey and no significant differences in length occurred over time for either survey. Mean lengths of blue sharks were smaller from drift gillnet collections in the first two quarters (January through June) than collections in the latter two quarters (July through

December). Quarterly juvenile surveys were dominated by blue sharks collected during summer months (66 % of all sharks) since this was the primary time period collections occurred. Lengths most abundant in our data overlapped with the lengths of sharks examined in previous age and growth studies in the North Pacific. The primary size range of samples collected from the drift gillnet survey ranged between 75 and 160 cm FL corresponding to an estimated age range of one to seven years with a peak in size between 90-130 cm FL (~2-4 years of age) based on previous age and growth studies. Similarly, the majority of samples collected from the juvenile shark longline survey ranged in size from 60 to 125 cm FL, corresponding to an approximate age range of one to four years, with a peak in size of 75-110 cm FL (~1 to 3 years of age). Assuming an average size-at-maturity of 175 cm FL based on previous studies, over 96 % of the blue sharks collected in both surveys are juvenile and sub-adults and are likely sexually immature. Mako shark size data from these two surveys were also briefly presented and can be found in paper *ISC/11/SHARKWG-2/06.* (See section 10.3.1 below)

Discussion

The WG inquired if there were any sex-related size differences for blue sharks. Based on the data from this study, there were no apparent differences in the sizes of male and female blue sharks by fishery. This is likely due to the selectivity of the fisheries towards juvenile fish and hence the majority of size data came from juvenile sharks, which is before the period when sex-related differences in size becomes apparent. The WG also inquired if there are more data available for other months that were not presented. The author informed the WG that there are size data for other months but they are relatively limited due to the fishing season. The WG noted that the neonate mako sharks were caught in the eastern Pacific during different seasons from the western Pacific, which may be due to gear and regional differences. **The WG discussed if it is possible to develop a recruitment index from the juvenile shark survey data and recommended that the US further investigate the possibility of developing a recruitment index from the survey data.**

7.2 Chinese Taipei

K.-W. Liu informed the WG that blue shark size data are available for the distant water longline fishery from 2002. These lengths were measured by onboard observers. It was noted that the observers only measure the sharks that are brought aboard the vessel, which may result in a bias towards larger sizes. In the past 2-3 years, limited information on sizes of discarded fish has been collected as well. Weight frequency data are available for mako sharks caught by offshore longline fishery from 1991.

7.3 Canada

J. King informed the WG that observers make weight estimates of the sharks caught by observed vessels. In addition, the lengths of sharks caught during surveys are measured.

7.4 Japan

Japan informed the WG that limited size compositions are available for blue and mako sharks. Some of the size data were reported at the April 2011 SHARKWG meeting and detailed size data will be reported to the WG at the next WG meeting.

8. REVIEW OF REGIONAL OBSERVER PROGRAMS

The SHARKWG Chair explained that at the past SHARKWG meeting and in meetings of the former ISC BYCATWG, observer programs were identified as the most reliable data collection programs for species that are not retained in high numbers, such as sharks. Thus, it is valuable to know which of the fisheries that catch large numbers of blue and mako sharks also have observer programs. Each member nation and observer spoke about observer programs during their descriptions of fishery data under section 6.0. In addition, USA presented a table reviewing observer coverage for US west coast fisheries that have significant blue and mako catch.

The two main fisheries that catch mako and blue sharks on the US west coast are the pelagic drift gillnet fishery that operates in the EEZ and a high seas pelagic longline fishery that now targets tuna with deep sets but formerly targeted swordfish with shallow sets. The number of observed sets in the drift gillnet fishery has been 4-22% of the total number of sets since 1990, whereas observer coverage for the longline fisheries has been ~10% to 100% annually. These observer programs provide reliable data on catch, discards and species and size composition for the assessments.

Discussion

The value of observer versus logbook data was addressed. The WG acknowledged the variance in accuracy of logbook and observer data depending on the fishery. **In general, the WG agreed that observer programs are valuable for the collection of fisheries bycatch data and should be supported and/or increased going forward.** The SPC indicated that the WCPFC will be increasing required coverage for longline observer programs to 5% in the Convention area, funding provided.

9. DEVELOPMENT OF TABLES 1 (CATCH) AND 2 (EFFORT) FOR BLUE AND MAKO SHARKS

For each delegation present, spreadsheets were developed to include each fishery with blue and shortfin mako shark interactions, for which data has been collected. These individual spreadsheets were reviewed by the WG to make sure that all fisheries are accounted for. Following the meeting, the Chair will send the spreadsheets to the delegation leads. Each delegation is requested to populate their respective tables with as much detail as possible before the next SHARKWG meeting.

The WG decided not to create Table 2 - the number of vessels targeting blue and mako sharks - at this time because few fisheries actually target these species and the table will not provide useful information for the assessments. The WG Chair will consult with the ISC Chair regarding the requirement to produce Table 2.

10. LIFE HISTORY SUMMARIES FOR BLUE AND MAKO SHARKS AND DEVELOPMENT OF LIFE HISTORY MATRIX

10.1 Tagging Studies

10.1.1 A summary of blue shark (Prionace glauca) and shortfin mako shark (Isurus oxyrinchus) tagging data available from the North and Southwest Pacific Ocean, presented by Tim Sippel (ISC/11/SHARKWG-2/04).

The ISC Shark Working Group has identified tagging data as potentially useful data to examine stock structure hypotheses and provide information on movements for stock assessments. Shark tagging programs in the Pacific have been in operation since the 1960s but there is still limited information on the stock structure of highly migratory pelagic sharks, and movement data from these programs generally have not been included in stock assessments. The tagging data from U.S., Japan and New Zealand tagging programs combined do not support a hypothesis of panmixia of blue shark or shortfin mako stocks in the Pacific Ocean. Rather this evidence suggests at least northern and southern sub-populations of both species, demarked by the equator.

Discussion

The question of why recapture rates are low was raised, particularly for the Japanese deployments and why tags released by Japanese research and training vessel in the western side were not recaptured in the northeastern Pacific, while tags released in the northeastern side were recaptured in the northwestern side. It was explained that the low recapture rate of Japanese tags may be due to the fact that some major Japanese fleets in the northwest Pacific do not retain most of their catches and thus may overlook tags. This would reduce the apparent recapture rate. In the north Pacific, most of the Japanese tags attached on sharks are recaptured by Japanese research, training and commercial vessels, but in recent years, the number of vessels and efforts in the northern EPO has decreased drastically. Japanese tag attachments were conducted using research and training vessels and guidance was provided to onboard researchers and crews about treatment of fish and the method of tag attachment.

It was asked if there were differences in the time at large between the different tagging programs (i.e. areas of the Pacific), but for this paper analyses were very limited. That information is available and can be examined further. It was noted that the recovery of blue shark tags close to the equator seems to happen in the December through February months.

It was noted that a sex and/or size specific analysis of the tag data has not yet been conducted but could be valuable to identify segregation by life stages for these sharks. It was noted that a few papers address this (Nakano and Nagasawa 1996; and Mucientes et al. 2009). In addition, it may be possible to derive estimates of exploitation rates from these data. Moreover, data from electronic tags should also provide useful information. **The WG recommended that the cooperative studies of the analysis of conventional tag data should be continued, as well as implementation of new tagging programs and analysis of existing electronic tag data.**

The Chair asked the group if they wanted to see additional analysis on this. The WG believes the data are useful, and further analyses should be conducted in some form, particularly to justify whether a basin-wide or just North Pacific stock assessment is appropriate for these species.

10.2 Genetics

10.2.1 Preliminary results of blue shark (Prionace glauca) stock delineation in the eastern North Pacific based on microsatellite polymorphic loci, presented by Jackie King (ISC/11/SHARKWG-2/05).

Collaboration between Canada, U.S., Mexico, Japan and Russia began in 2011 to investigate the stock structure of blue shark (*Prionace glauca*) in the North Pacific. We report on preliminary results to date for samples from the eastern North Pacific, based on 10 microsatellite polymorphic loci. These results do not include samples from Mexico, Japan or Russia. We observed annual variation in samples obtained at the northern extent of their distribution in the eastern North Pacific (British Columbia, Canada). This annual variation was equivalent to variation observed between California and Hawaii. Chile samples are consistently the most distinctive from other geographic samples. The samples from California are distinct from Hawaiian samples; however samples from British Columbia exhibited varying commonality with other geographic samples depending on year. It is anticipated that final results will be available within one year.

<u>Discussion</u>

Though the result of this study is preliminary and analyses ongoing, there was a discussion regarding the possibility that populations of blue sharks off Hawaii and California are distinct with a mixed population in the waters off British Columbia. Similar results were obtained in a global blue shark population genetics study by Fitzpatrick et al. of Ireland to be published soon, although sample sizes were low. It will be interesting to see if the pattern remains when further results are available at the next WG meeting.

Since the first SHARKWG meeting in April 2011, ISC members have established a plan to collaboratively study blue shark population genetics in order to understand stock structure for assessment purposes. Having heard the presentation by Canada, the SHARKWG Chair asked the Japanese colleagues about their plans for studies of blue shark genetics. A summary of the plans for Canada and Japan are below.

Canada blue shark genetics workplan:

December 2011 – March 2012: Canada will sequence all available samples for British Columbia, California, Mexico, Hawaii, Japan and Chile using 10 microsatellite loci (from Fitzpatrick 2011) and 6 microsatellite loci (from Fernandez-Mendonca, unpub. data).
April 2012: Canada will analyze molecular variation, genetic diversity statistics and genetic distance matrices to estimate the relationship among the Pacific region samples .
May 2012: Canada will report results to ISC Shark WG as Working Paper.
May 2012-August 2012: Canada will prepare manuscript for journal submission. All collaborators will be co-authors and receive draft manuscript for comments and revisions.
September 2012-November 2012: Revision of manuscript as required (could include additional samples received from 2012 sampling season, i.e. Russia, Hawaii, Oregon). Input on final version from co-authors.
December 2012: Submission to journal.

Japan blue shark genetics workplan:

Japan will conduct the genetic analysis of blue sharks to estimate their stock structure and phylogeography within the Pacific Ocean using microsatellite and mitochondrial markers. So far, approximately 400 samples have been collected from various regions in the Pacific Ocean. The samples in the Taiwanese and Mexican waters will be collected within in a few months in cooperation with Taiwan and Mexico. The results using mitochondrial DNA will be reported in the next meeting in May 2012, and the results of the microsatellite analyses are scheduled to be reported in 2013. The microsatellite marker used for this analysis will also be developed.

Summary table of ISC collaboration on blue shark genetics:

Blue Shark	Canada	Japan
mitochondrial DNA	–	Pacific Ocean (Ongoing)
microsatellite DNA	NorthPacific (Progrees report in this meeting)	Pacific Ocean (Ongoing)

10.2.2 Mitochondrial DNA sequence data reveals barriers to dispersal in the highly migratory shortfin mako shark (Isurus oxyrinchus), presented by John R. Hyde (ISC/11/SHARKWG-2/03).

Increasing harvest and decreasing trends in abundance of many shark species has focused the need for improved management of shark species worldwide. In an effort to better understand the connectivity of global populations of the shortfin mako shark (*Isurus oxyrinchus*) we obtained sequence data (791 bp) for the mitochondrial DNA control region from 840 individuals collected throughout the Pacific and North Atlantic Oceans. To examine temporal stability in genetic diversity and test for sampling bias we compared 11 year classes from the Southern California Bight as well as sampling events separated by 17 years off the west coast of South America. Significant heterogeneity was found globally (Φ_{ST} =0.0845, p<0.0001) and when the Pacific Ocean was analyzed separately (Φ_{ST} =0.0305, p<0.0001). The North Atlantic is highly diverged from all sampling locations in the Pacific (Φ_{ST} =0.1665 to Φ_{ST} =0.2892, p<0.0001). Significant differences existed between the North and South Pacific (Φ_{ST} =0.0422, p<0.0001) as well as between the Southeast and Southwest Pacific (Φ_{ST} =0.0142, p<0.05). Examination of temporal replicates and year class samples revealed no significant differences among collections and stable trends in diversity and female effective population size. Overall results suggest that at least three genetic stocks exist in the Pacific and that geneflow between the Pacific and the Atlantic occurs through the Indian Ocean.

Discussion

It was confirmed that the result of this study indicates a single stock of shortfin mako shark in the North Pacific but that samples from the north versus south Pacific were genetically isolated.

Since the first SHARKWG meeting in April, 2011, ISC members have established a plan to collaboratively study shortfin mako shark population genetics in order to understand stock structure for assessment purposes. Having heard the presentation by USA, the SHARKWG Chair asked the Japanese colleagues about their plans for studies of blue shark genetics. A summary of the plans for Japan are below.

Japan shortfin mako shark genetics workplan:

Japan will conduct the genetic analysis of shortfin mako on a global scale using microsatellite and mitochondrial markers to estimate their stock structure and phylogeography. The results using a mitochondrial DNA marker will be reported at a future meeting of the ISC SHARKWG. To date, approximately 500 samples have been collected from three ocean basins. Ideally, sampling locations should be spread evenly over the entire shortfin mako shark distribution, and 50 or more samples in the mating season for a single location would be desirable for the purpose of this study. Thus, additional samples from the northeastern and southeastern Pacific (e.g., California and Chile) are required. Also, more samples from both the Atlantic and Pacific will be provided by Mexico and samples from the Indian Ocean would increase the credibility of the study.

Summary table of ISC collaboration on shortfin mako shark genetics:

	USA	Japan
mitochondrial DNA	Pacific Ocean (Reported in this meeting)	Global (Progress report in the last meeting)
microsatellite DNA	Pacific Ocean (Ongoing)	Global (Ongoing)

General Discussion on Genetics:

The WG emphasized that the genetic studies regarding blue and shortfin mako sharks are important to understand population structure of sharks in the north Pacific and adjacent waters. The WG supported the proposed plans. In some cases, cooperation has already been initiated as recommended at the last ISC SHARKWG meeting in April 2011. **The WG recommends and encourages the ongoing and further collaboration on genetic studies. The WG also agreed that the genetic samples exchanged should only be used for the purpose agreed to by the WG.**

10.3 Age and Growth

10.3.1 Age validation of juvenile shortfin mako shark (Isurus oxyrinchus) tagged off southern California, USA, presented by Dave Wells (ISC/11/SHARKWG-2/06).

The purpose of this study was to validate vertebral band count aging of juvenile shortfin mako (*Isurus oxyrinchus*) and to resolve the discrepancy between observed fast growth in juvenile shortfin mako and the much slower growth predicted by age-at-length models that assume one band pair per year deposition rate in vertebrae. Oxytetracycline (OTC) labeled vertebrae of 29 juvenile shortfin mako were obtained from tag-recapture activities to determine timing of centrum growth band deposition. Tagging occurred off southern California from 1996 to 2010, with time at liberty of the 29 sharks ranging from 4 months to 4.4 years (mean=1.3 years). Growth information was also obtained from length frequency modal analyses (MULTIFAN and MIXDIST) using a 29-year dataset of commercial and research catch data, in addition to tag-recapture growth models (GROTAG) using lengths and time-at-liberty for OTC-labeled and unlabeled shortfin mako. For vertebral samples used for age validation, shark size at time of release ranged from 79 to 142 cm fork length (FL) and from 98 to 200 cm FL at recapture.

Results from band counts of vertebrae distal to OTC marks indicate two band pairs (2 translucent and 2 opaque) are formed per year for shortfin mako of the size range examined. In addition, total band pair counts at length compared well with results of a similar study in this region, suggesting vertebral readings were similar, and only assumptions about deposition rate differed. Growth rates calculated from length frequency modal analyses estimate 26.5 to 35.5 cm per year for the first age class mode (85 cm FL), and 22.4 to 28.6 cm per year for the second age class mode (130 cm FL). In addition, the tag-recapture growth model also resulted in a rapid growth rate during time at liberty for tagged fish of the two youngest age classes with estimates of 28.7 and 19.6 cm FL per year at 85 and 130 cm FL, respectively. Collectively, these methods suggest rapid growth and biannual band pair deposition in vertebrae for juvenile shortfin mako in the southern California study area.

Discussion

The WG discussed whether all individuals in this study were juveniles. OTC was injected in individuals smaller than 100 cm FL, while one of them was recaptured at a size of around 200 cm FL. The results of this study indicate that the growth rate of shortfin mako sharks in the northeast Pacific is twice that reported in other studies in other areas. The presumed faster growth would have large impacts on the results of stock assessment because it means a higher productivity and a reduced age at maturity.

Because of the possible large impacts of the results of this study, **the WG recommends that the issue of growth of shortfin mako be resolved before the stock assessment scheduled for 2013.** It was suggested that application of indirect validation methods such as MIA and CEA be conducted to compare the periodicity of growth band pair deposition. Bomb carbon methods have been used, and should be further considered, but results to date are highly variable and require very old individuals. Cooperative studies among member countries to attain this goal should be conducted at any level. **The WG also recommends that all member countries should make their best effort to collect necessary samples to verify the growth rates and band periodicity of shortfin mako sharks. It was also recommended that any tagging studies on mako sharks should include OTC tagging, although it is unlikely that the WG will have new OTC validation information for older sharks before the 2013 stock assessment.**

10.3.2. Age and growth of the blue shark, Prionace glauca, in the northwest and central south Pacific presented by Kwang-Ming Liu (ISC/11/SHARKWG-2/13).

The blue shark, *Prionace glauca*, an oceanic migratory elasmobranchii species, is one of the most common bycatch species caught by Taiwanese longliners. The specimens caught by Taiwanese small longliners were collected and used for age and growth analysis. A total of 324 females and 246 males were captured in Taiwanese waters and the northwest Pacific between Oct. 2003 and Apr. 2004. Growth band pairs of vertebrae were read and counted via X-radiographs put on a light box. Marginal increment ratio analysis indicated that the translucent and opaque bands on vertebral central were formed once a year. The Akaike's information criterion indicated that the von Bertalanffy growth function (VBGF) was the best fit for observed age at total length (TL) data. The VBGFs were significantly different between sexes using likelihood ratio test ($X^2 = 48.92$, $p > 0.05$). Growth parameters were estimated to be $L\infty = 317.4$ cm TL, $k = 0.172$ year^{-1}, and $t_0 = -1.123$ years for female, and $L\infty = 375.8$ cm TL, $k = 0.121$

year^{-1}, and t_0 = -1.554 years for male, respectively. Ages at 50% maturity were back-calculated to be 4.0 and 4.3 years for male and female, and the longevities were estimated to be 28.6 and 20.2 years for male and female, respectively.

<u>Discussion</u>

There was a discussion about how the longevity was determined because the results of this study are higher than some others. It was answered that Fabens' equation was used (the age at which 95% of $L\infty$ is reached). Longevity is really only influential in the modeling when you use longevity to estimate mortality outside the model, thus it may not have a large effect in an integrated model. There was also a discussion of the use of the age data, in the SS model, potentially to be confounded with the fact that the previous model had a max length of approximately 191 cm PCL which is much smaller than what this WG believes should be used for North Pacific blue sharks. In this study there was no effort to examine the data by size and sex, but that should be done.

10.4. Maturity

10.4.1 Reproductive biology of the blue shark, Prionace glauca, in the northwestern Pacific presented by Kwang-Ming Liu (ISC/11/SHARKWG-2/12)

This study examined the reproductive biology of blue shark *Prionace glauca* in the northwestern Pacific Ocean. All specimens of this study were captured by Taiwanese small long-liners between October 2001 and February 2003. A total of 1,079 specimens (including 576 males and 503 females) which included 40 gravid females were examined in this study. Females and males reached 50% maturity at 184.6 cm and 193.4 cm total length (TL), respectively. Observation of mating scars, fertilized eggs, and embryos indicated that the mating occurred from March to August with a 6-12 months gestation period and parturition season was between February and March. Size at birth was estimated to be 40.1 cm TL and litter size varied from 2-52 with a mean value of 25.2. The reproductive cycle was estimated to be 2 years based on the observation of 40 pregnant females without large ova in their ovaries, and 42 females with large or mature ova in their ovary and swollen uteri from 82 mature individuals.

<u>Discussion</u>

The question was raised whether the large variability in observed litter size was caused by cannibalism? It was answered that cannibalism was not the likely cause. All fertilized eggs were assumed to be litter in this study, and it was assumed they would become pups. Makos are known to cannibalize occasionally, but there is no evidence that blue sharks do. Another question was about the lack of a positive correlation between the number of pups and the mother's size. Some studies found more pups with larger animals, though this study did not, possibly due to low sample size.

The WG discussed how the reproduction cycle was estimated. The 2 year reproduction cycle in this study was based on the finding that only 50% of adult-size females were pregnant in the mating season. The WG felt the need for **further studies as the number of samples and their areal coverage was limited. The WG agreed that the scenario of a 2 year reproduction cycle should be conducted in the next stock assessment, at least as a sensitivity.** Because the reproductive cycle should have a large impact on the results of stock assessment as it is directly correlated to the productivity of stock, **the WG recommend member countries collect necessary samples to help confirm the reproductive cycle of blue sharks.**

The group discussed the base case assumptions for recruitment and pupping season. It was suggested that these may differ by area. The WG agreed that these **two parameters will be decided by reviewing available size data at the next meeting.**

10.5 Review of Life History Tables

The WG asked David Wells and Yasuko Semba to conduct a literature survey regarding relevant life history parameters used for stock analysis of the north Pacific blue sharks and shortfin mako sharks.

10.5.1. Blue Shark

A life history table of blue sharks was summarized in order to capture some of the major biological parameters of this species (Appendix 4). A focus was on reproduction and age and growth. Blue sharks exhibit placental viviparity, a reproductive mode where the maternal adult gives birth to live young that have developed a yolksac placenta. Some uncertainty exists on the breeding season, but the majority of studies indicate spring time as the primary birthing season. Female gestation period ranges from 9-12 months, but the breeding frequency may be annual or every two years. Blue shark length at birth ranges from 40 to 50 cm FL, but may be less in the northwest Pacific. Litter size averages 25-30 pups, but can vary from 1 to over 50 individuals. Age at sexual maturity differs by species with males reaching 50% sexual maturity from 4-6 years of age and females from 5-7 years of age. Length at 50% sexual maturity is more variable; males mature at between 170-185 cm FL and females between 175 and 190 cm FL. Longevity was a bit variable depending upon methods used. Using hard parts (vertebrae), male longevity is around 16 years, while females live 12-15 years. Males and females are estimated to live around 20 years (or more) using theoretical longevity models based on von Bertalanffy growth parameters. A range of different length conversions, growth models, and size to weight equations were presented and it was determined that each would likely vary by region and the size/age of blue sharks used for each equation/model. **The working group suggested that a more detailed description of the size range, sample size, and detailed geographical description will be needed in order to utilize this information efficiently for the next meeting.**

10.5.2 Shortfin Mako Shark

A life history table of shortfin mako was summarized in order to capture some of the major biological parameters of this species (Appendix 4). After general biological characteristics of this species were introduced, the existing information on reproduction and age and growth was introduced. Shortfin mako exhibits aplacental viviparity (ovoviviparity) with oophagy, and sexual dimorphism in many traits such as growth trajectories, maximum size, and size at sexual maturity. A few parameters were in relatively good agreement among studies, but most of existing life history parameters showed wide variation among studies.

With regard to the parturition season, many studies suggest that winter-spring time is the primary birthing season but possibly extends into summer. Some uncertainty exists regarding the mating season and existing reports suggest sometime between January and September. Female gestation period ranges from 9-25 months followed by a resting period of unknown length, and the breeding frequency may be biennial or triennial. Estimates of shortfin mako length at birth range from 70 to 74 cm TL and litter size from 4-17 with a mean of 12. The relationship between maternal length and litter size is variable depending on the study. The length at 50% sexual maturity is variable depending upon study for females at between 278-307 cm TL, and less variable for males at 180-210 cm TL. Longevity is also highly variable depending upon the definition used; estimates are as low as 9 and 18 years for males and females, respectively, and as high as 45 years using either hard parts or theoretical equations or some combination thereof. Empirical age estimates are confounded by the uncertainly regarding band pair deposition rates. To reduce uncertainty regarding aging on this species, clarification of the periodicity of the growth band pair deposition is urgent.

Discussion of life history tables:

As a first step to evaluate regional differences in growth trajectories, the working group suggested that more detailed descriptions of the size ranges, sample sizes, and geographical areas will be needed in order to utilize this information efficiently for the next meeting. **The differences in growth models, enhancement methods, and other aspects of the aging studies also need to be considered. For biological sampling of sharks, the importance of multinational cooperation was again emphasized.**

The WG expressed concern that some growth curves reported in past scientific papers for the North Pacific do not include confidence intervals, results for individual samples, nor the sizes associated with the samples used. In the future, for aging studies it is recommended that estimated growth curves be compared to reported growth curves and their confidence intervals to see the actual difference among curves. Since Yasuko Semba is conducting an aging study of shortfin mako with a large number of samples, it was suggested data from other studies be compared to see if they fall within the 95% confidence bounds of her estimated curve.

The WG recognized that it is important to know the variability in length at age 1 and $L\infty$ for the model, or alternately an aging error matrix could be used. The reliability of the estimated ages for younger and older sharks can largely affect catch-at-age estimates and thus, the results of the stock analysis. **Thus, the WG recommends that estimates of variability in length at age should be included in reports of age, growth and maturity.**

The WG also noted that the best strategy for the stock analysis may be to use an average growth curve derived from reported ones. Further, the WG noted that it is a good idea to integrate the results of reported studies to estimate an average growth curve for use in the stock analyses conducted by the WG. It was highly recommended that the ISC member countries submit their sample results for aging studies to obtain average growth curves, which will be intended for stock assessment use only within the ISC.

The WG also noted that the choice of growth model applied to the sample results is another important aspect to consider in order to obtain the most reliable age and growth relationship. This issue was discussed further in the ISC Shark Aging Workshop held 5-6 December, 2011.

Although the general migration patterns of blue and mako sharks are already addressed in some prior studies, **the WG feels that further details regarding their distributions and migrations**

are necessary. This type of information is very important for an accurate understanding of the fishery data as well as for the construction of a realistic stock analysis models. Sex-specific size and maturity information can be the basis for these studies. The WG agreed to conduct an integrated review of all available size data at the next meeting scheduled for spring 2012. Each member country shall submit all blue shark size data with fine scale of sampling locations by fishery and by season for the next meeting.

Recommendations:

- In the future, each reported growth curve should be reported with confidence intervals and compared to previously reported curves in order to assess differences among curves.

- The reliability of the estimated age of the youngest and oldest sharks can greatly affect the estimation of catch at age and thus, the results of stock analysis. Thus, the WG recommends that estimates of variability in length at age should be included in reports of age, growth and maturity.

- The WG agreed that all members will review and report on all available size data in the next meeting scheduled in the spring 2012. In addition, the WG members should bring all blue shark size data at the finest resolution as possible by fishery and by season to the next meeting so that further examinations can be made.

The WG discussed about a standard measurement of length to use for the ISC blue shark assessment and **agreed to use total length as the assessment standard because much of the size sampling by member countries is collected as total length. The WG agreed that all size data submitted to the ISC database and to the ISC shark WG must be converted to total length in cm and whole weight in kg, and the conversion factors should also be reported to WG.** Some published studies provide conversion factors among length types (AL, TL, FL, PCL) and weight types (whole, gilled and gutted, headed and gutted), some by sex, size class or other factors. **The WG recommend further study of detailed conversion factors with larger sample sizes.**

11. DISCUSSION OF LAST NORTH PACIFIC BLUE SHARK ASSESSMENT AND POTENTIAL MODELING SCENARIOS FOR THE 2012 BLUE SHARK ASSESSMENT

11.1. Previous north Pacific blue shark stock assessment, oral presentation by Steve Teo.

A subgroup reviewed the MULTIFAN-CL model from 2009 and presented a summary of the model configuration and parameter estimates used. MULTIFAN-CL was a spatially structured model with four regions in the North Pacific (between 140° E to 130° W). The 2009 assessment also employed a Bayesian surplus production model. The Working Group did not select the model to use in the upcoming assessment and will make a decision at its May 2012 meeting. However, given that much is known about the biology of blue shark and that there are considerable size data available, either an age-structured production model or an integrated model such as MULTIFAN-CL or SS3 will likely be recommended. An age-structured population model was proposed for consideration since it allows for the use of knowledge regarding the species to fix biological parameters, rather than have the model estimate them. The integrated model previously used probably estimated too many biological parameters. In addition, an age structure population model allows for fishery-specific selectivities. The period of coverage for catch and effort data for the stock assessment will be 1971-2010. Catch data are to be provided in weight (whole fish in kg) and size data to be provided in total length (cm).

The Working Group used the compiled life history table for blue sharks to recommend suitable ranges or values for model parameters, to be either fixed (age-structured population model) or estimated within bounds (integrated model). **The Working Group recommended potential improvements to the model, if an integrated model is to be employed for the upcoming assessment. The growth curve used to estimate age composition from size composition should be re-estimated using available size-at-age data.** The stock recruitment relationship was a Beverton-Holt curve, and this is a questionable relationship for sharks. In addition, the steepness parameter employed (mode of 0.9) was too steep. **Alternate stock recruitment estimates, such as the Brodziak method or estimated using SS3 as per the upcoming silky shark assessment, should be explored. The best shape for selectivity curves should be decided by the Working Group for each fishery, rather than a single cubic-spline curve.** If selectivity is sex and season-specific for each fishery, then estimating movement between areas is not necessary. This could also cope with any potential sex bias in fisheries, but requires some data on sex ratio. Specific decisions regarding age and growth parameters were delayed until after the age and growth workshop. Since the model may incorporate a seasonal component (seasons 1-4), fisheries data should be compiled by seasons. **The most appropriate season to designate for recruitment (pupping) in the model is tentatively season 2 (April-June), and a reproductive cycle of 1-2 years should be considered. Reasonable bounds for M are 0.2-0.3 based on previous demographic analyses.**

The upcoming assessment will include all waters in the north Pacific, including coastal areas in both the EPO and WPO. A decision regarding the area delineation is delayed until the May 2012, but will likely either be a single whole north Pacific area or two north Pacific areas delineated by 150° W (the management boundary between IATTC and WCPFC). Inclusion of the coastal areas may require catch estimation for unreported catch. Catch per unit effort from similar fisheries operating the in same area will be used to expand reported effort in order to estimate these unreported catches. **The Working Group selected five north Pacific strata for these catch estimations (see Figure 1). The tentative modeling input parameters and model structure are provided in Table 1.**

Figure 1. Area stratification for catch summaries and potential stock analysis for the 2012 blue shark assessment.

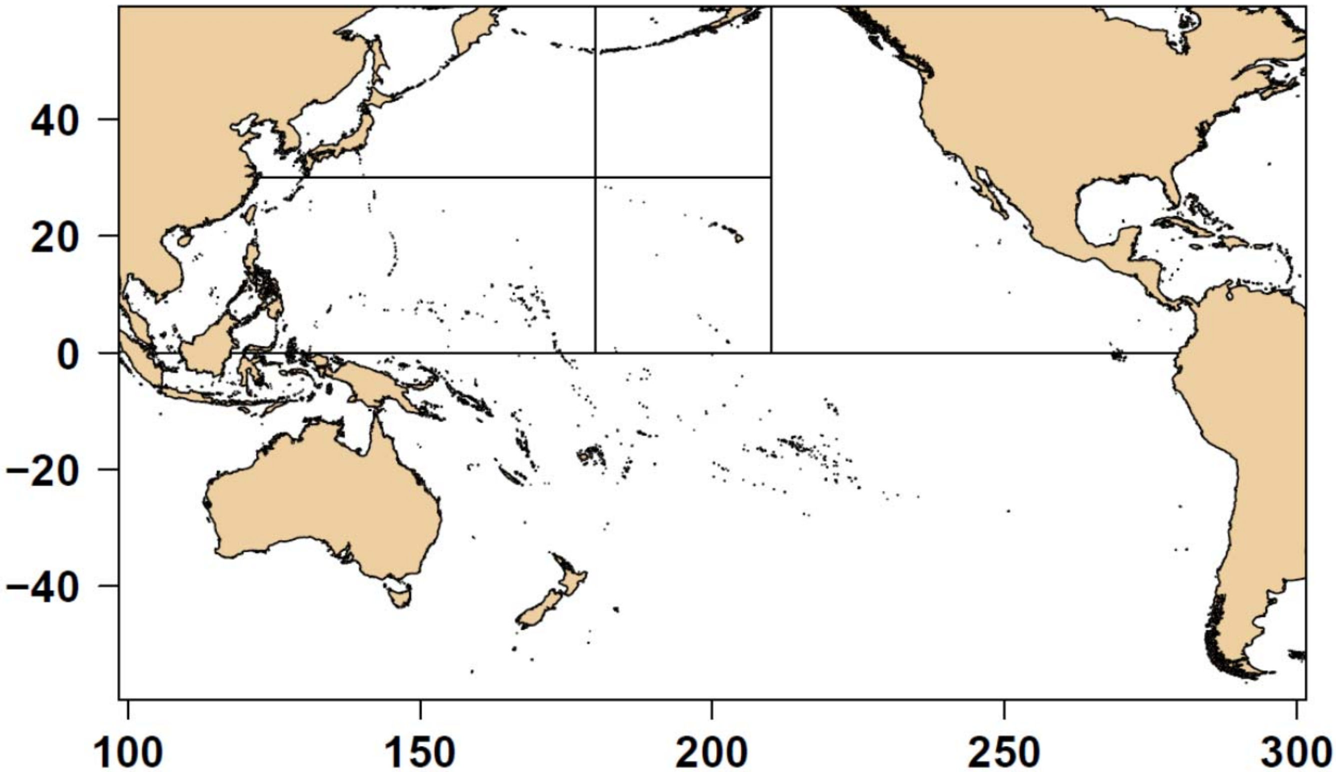

Table 1. Notes on potential model parameters and structure for the assessment of blue shark in 2012.

Parameter or Model Structure	Notes
Model type	Need to examine data at next meeting before making decision: options include integrated statistical catch-at-age (e.g., SS3 type), age-specific production, or surplus production model
Spatial structure	Need to examine data at next meeting before making decision: options include 1) whole of north Pacific, or 2) divide north Pacific into 2 areas at the 150° W line
Time span	Tentatively 1971-2010
Seasonality	Catch and size data quarterly, CPUE annual
Sex structure	Examine size by sex at next meeting
Age structure	Tentatively annual up to 20+
Growth	To be discussed in the age & growth workshop
Reproductive cycle	Current evidence suggests once every 1 or 2

	years but it will be discussed at next meeting before making decision
Length measurement	Standard total length in cm
Weight measurement	Whole weight in kg
Length-weight relationship	To be discussed at next meeting: potentially one relationship for whole north Pacific or region-specific relationships
Stock recruitment relationship	To be discussed at next meeting; potential options include estimating within model or use Brodziak method
Recruitment season	Tentatively Season 2 (Apr-Jun)
Natural mortality	To be discussed at next meeting; options include age-specific mortality or use demographic methods; likely to be approximately 0.2-0.3
Spatial structure for estimating unreported catch	To be finalized at next meeting: tentatively use Fig. 1 to delineate spatial strata

12. UPDATE WORKPLAN AND DEVELOP ASSIGNMENTS FOR 2012 ASSESSMENT

General Research Priorities/Recommendations

- Continue work on blue and shortfin mako shark 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.
- 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.
- Due to the paucity of fishery data on sharks, 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 little information.
- Continue research on age and growth and reproductive biology of blue and shortfin mako sharks through collaborations.
- All member countries should 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 stock assessments.

Work Plan for Blue Shark Assessment

For Working Group Members:

- Compile retained catch and total discard estimates for blue sharks identified fisheries (in distributed Tables 1) in mt whole weight or numbers of fish for entire N. Pacific and 2 regions of the N. Pacific divided at the IATTC/WCPFC boundary (150° W). Provide detailed documentation on estimation procedures as well as the sequential procedures and results. Provide information on how the data were originally collected and conversion equations used (e.g. if recorded in numbers and converted to weight). Catch estimation procedures for unreported catch are to be applied by reasonable time and area strata appropriate for each fishery.
- Catch estimates for non-participating members and non-members will be derived between May and July and reported at the July workshop and tentatively will be calculated by quarter and using the smaller area strata as identified (see Figure 1).
- Each nation should compile and report on their quarterly size data in standard total length for each of the identified fisheries by area, by sex when possible. Provide information on how the data were originally collected (e.g. if recorded in precaudal length, and the conversion equation).
- Document any changes in fisheries, regulations, operations or other factors for the data sets provided so that changes in catchability or selectivity can be considered.
- Continue planned work on blue shark genetics and report results at next meeting (Japan/Canada).

- For the life-history-matrix, include a more detailed description of the size range, sample size, and detailed geographical description in order to utilize this information (Wells/Semba).
- Compile information on post-release survival to decide on how to handle the catch of live-released sharks (USA).
- Explore stock recruitment relationships and natural mortality schedules for blue sharks.

Assignments for Chair:

- Obtain effort data for other nations fishing in North Pacific (e.g. China, Korea, Central American nations, etc.) so that catch can be estimated by WG, including data held by SPC and IATTC.
- Confirm with ISC database manager and STATWG Chair about the contents of the official ISC database and SHARKWG plenary report tables. Values may differ from estimated catch data needed for the stock assessment work.
- Confirm the type of data necessary to include in the assessment report with ISC Chair and SHARKWG delegation leads.
- Request all category II data for major tuna and billfish species for non-participating members.

13. UPDATE ON PELAGIC SHARK ASSESSMENT ACTIVITIES OF OTHER ORGANIZATIONS

13.1. IATTC

A. Aires-da-Silva summarized upcoming IATTC shark assessment work. Various types of data are available from the purse-seine and longline fisheries operating in the Eastern Pacific Ocean. Bycatch data from large purse-seine vessels are available from 1993 to the present. Sex- and size-specific data for bycatch of large purse-seine vessels are available from 2005 to the present. For other fisheries some effort, catch and biological data are also available. The IATTC held a technical meeting on sharks December 7-9, 2011 in La Jolla, California during which a preliminary stock assessment of silky sharks in the EPO was discussed. The assessment is expected to be finalized in advance of the IATTC Science Committee meeting in May 2013. Oceanic whitetip will be the next species assessed, likely in 2013. IATTC has ongoing shark bycatch mitigation research.

13.2. SPC

J. Rice described the Secretariat of the Pacific's Oceanic Fisheries Program shark research plan, available at http://www.wcpfc.int/node/2950. In summary, the SPC in currently undertaking silky shark and oceanic whitetip shark stock assessments for the western central Pacific Ocean. These are slated for presentation in August 2012 at the Science Committee meeting. Blue shark and mako shark stock assessments are slated for completion in August 2013. At this time it is assumed that the area covered will be the WCPFC Convention Area, southern hemisphere for both blue and mako sharks. A thresher shark stock assessment and the final report are due in

2014. The quality and quantity of data are key factors determining the effectiveness of any stock status analysis. Due to the historical lack of shark reporting on the logsheets of most fleets, analyses of the WCPFC and SPC-OFP data holdings conducted to date under the Shark Research Plan have been based only on observer data. Observer data have been limited to <1% coverage of the longline fishery in recent years, most of which is concentrated in Exclusive Economic Zones (EEZs). Because there are important gaps and biases in observer datasets (e.g. skewed coverage by area and fleet), it is important to remain cognizant of the need to secure other sources of data to supplement analyses based on observer data.

Discussion

In response to an inquiry regarding what SPC might need from the ISC to complete this plan, the answer was additional data from commercial fleets, high seas, and any (as yet) unreported catch and effort that ISC member nations have. The Chair committed to communicate with SPC regarding shark assessment work of interest to both groups.

14. DEVELOPMENT OF A BIOLOGICAL SAMPLING PLAN FOR SHARKS FOR INCLUSION IN ISC BIOLOGICAL SAMPLING PLAN

The WG discussed the ISC proposal for a multi-species biological sampling program (http://isc.ac.affrc.go.jp/pdf/ISC9pdf/Annex_12_ISC9_PROPOSAL_July09.pdf). At the April 2011 SHARKWG meeting, the WG was tasked with developing a shark specific biological sampling plan to incorporate into the broader ISC Biological Sampling Plan. At this time, the WG did not feel prepared to decide which fisheries could contribute which samples, and what are the highest research priorities since the WG is still reviewing life history information and has not yet taken a close look at catch by size and sex by fishery. The WG will work toward developing a shark specific biological sampling plan at future meetings.

15. REVIEW DRAFT SHARKWG WEBPAGE

The Chair presented an outline of the shark working group webpage. This outline included a brief description of the formation of the shark working group and its mission, a general description of the working group responsibilities and species of interest, and a more detailed description of blue and shortfin mako sharks. The descriptions of blue and mako sharks included both fishery and biological information in addition to the stock status. The group decided it would be useful to provide the life history tables for both species and to cite any relevant biological parameters noted on the webpage. A general consensus of several key important parameters was also noted. The webpage summary concluded with the working and background papers from working group participants. In general the WG felt the draft once completed should represent the SHARKWG information appropriately.

16. FUTURE MEETINGS

The next intercessional SHARKWG workshop was tentatively scheduled for the last week in May or first week in June, 2012 in Shizuoka, Japan. Full participation from all member nations and observers is encouraged.

17. OTHER MATTERS

Multi-national collaborations were identified as important to support future stock assessment work of the ISC SHARKWG. The Chair encouraged and committed to help facilitate collaborations. ISC delegations indicated the need to identify the researchers involved in these collaborations, and to state in writing the specific objectives of each project as it gets underway to ensure that shared data are guided by these objectives and that primary authors and contributors are agreed to.

18. CLEARING OF REPORT

The Report was reviewed and provisionally approved by all participants pending the opportunity to review a few incomplete sections. The Chair circulated the revised version to all WG members for comment prior to finalization.

19. ADJOURNMENT

The meeting was adjourned at 2:38 pm, December 3, 2011.

Attachment 1. List of Participants

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Attachment 2. Meeting Documents

WORKING PAPERS

ISC/11/SHARKWG-1/01	Blue shark (*Prionace glauca*) bycatch statistics in Canadian fisheries. Jacquelynne King (jackie.king@dfo-mpo.gc.ca)
ISC/11/SHARKWG-1/02	Ongoing and planned analyses of catch and catch rate data for blue shark and shortfin mako in the Hawaii-based pelagic longline fishery in 1995–2010. William Walsh (william.walsh@noaa.gov)
ISC/11/SHARKWG-1/03	Mitochondrial DNA sequence data reveals barriers to dispersal in the highly migratory shortfin mako shark (*Isurus oxyrinchus*). Amber Michaud, John R. Hyde, Suzanne Kohin, Russell Vetter (john.hyde@noaa.gov)
ISC/11/SHARKWG-1/04	A summary of blue shark (*Prionace glauca*) and shortfin mako shark (*Isurus oxyrinchus*) tagging data available from the North and Southwest Pacific Ocean. Tim Sippel, James Wraith, Suzy Kohin, Valerie Taylor, John Holdsworth, Mioko Taguchi, Hiroaki Matsunaga, and Kotaro Yokawa (tim.sippel@noaa.gov)
ISC/11/SHARKWG-1/05	Preliminary results of blue shark (*Prionace glauca*) stock delineation in the eastern North Pacific based on microsatellite polymorphic loci. Jacquelynne King, Mike Wetklo and Ruth Withler (jackie.king@dfo-mpo.gc.ca)
ISC/11/SHARKWG-1/06	Age validation of juvenile shortfin mako shark (*Isurus oxyrinchus*) tagged off southern California, USA. R.J. David Wells, Susan E. Smith, Suzanne Kohin, Ellen Freund, Natalie Spear, and Darlene A. Ramon (david.wells@noaa.gov)
ISC/11/SHARKWG-1/07	Preliminary estimated catches of blue and mako sharks from US west coast fisheries. Steven L. H. Teo, Vardis Tsontos, and Suzanne Kohin (steve.teo@noaa.gov)
ISC/11/SHARKWG-1/08	Length frequencies of the blue shark (*Prionace glauca*) in the eastern Pacific Ocean. R.J. David Wells and Suzy Kohin (david.wells@noaa.gov)
ISC/11/SHARKWG-1/09	The operation pattern of Japanese tuna longline fishery with the information for belonging region of vessels and reporting rate in the North Pacific Ocean, 1994-2010. Yuko

	Hiraoka, Mioko Taguchi, Minoru Kanaiwa and Kotaro Yokawa (yhira415@affrc.go.jp)
ISC/11/SHARKWG-1/10	Review of species aggregated sharks data caught by Japanese offshore and distant-water longliners in the north Pacific in 1975 – 1993. Kotaro Yokawa and Tsubasa Ando (yokawa@fra.affrc.go.jp)
ISC/11/SHARKWG-1/11	Brief summary of fishery data of major shark species caught by Japanese offshore and distant-water longline in the north Pacific in 1994 – 2010. Kotaro Yokawa and Tsubasa Ando (yokawa@fra.affrc.go.jp)
ISC/11/SHARKWG-1/12	Reproductive biology of the blue shark, *Prionace glauca*, in the northwestern Pacific. Shoou-Jeng Joung, Hua-Hsun Hsu, Kwang-Ming Liu, and Tzu-Yi Wu (kmliu@mail.ntou.edu.tw)

INFORMATION PAPER

ISC/11/SHARKWG-2/INFO-1	Swordfish and shark longline fishery of Baja California (Ensenada) Mexico, INAPESCA. José Leonardo Castillo-Géniz, Luis Vicente Gonzalez-Ania, Alejandro Liedo-Galindo and Francisco J. Martínez-García (ptiburon@yahoo.com)

Attachment 3. Meeting Agenda

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

INTERCESSIONAL WORKSHOP AGENDA

28 November to 3 December, 2011
SWFSC Torrey Pines Court Conference Room
La Jolla, CA, USA

1. Opening of Shark Working Group (SHARKWG) Workshop: 28 November, 10:00
    - Welcoming Remarks – Dr. Cisco Werner, Science Director for NOAA Fisheries Southwest Region
    - 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 April 2011 Workshop and SHARKWG Workplan
6. Review of existing blue and shortfin mako shark fishery catch and bycatch data and catch estimation procedures
    - Canada
    - Chinese Taipei
    - Japan
    - Mexico
    - USA
    - IATTC for non-member catch north of the equator
    - SPC for non-member catch north of the equator
7. Review of existing blue and mako shark size composition data
8. Review of regional observer programs
9. Development of Tables 1 (catch) and 2 (effort) for blue and shortfin mako sharks
10. Review of life history/biological information on blue and shortfin mako sharks and development of a "life history matrix" containing information from past studies

Subgroup to report on input parameters and stock boundaries to consider for the 2012 blue shark assessment.

Subgroup to report on prior work addressing life history aspects of blue and shortfin mako sharks.

- Tagging studies
- Genetics (with update on proposed collaborations)
- Age and growth (general discussion with focus on details and collaborations during the Shark Aging Meeting)
- Maturity
- Spatial distribution by size and sex

11. Discussion of the last north Pacific blue shark assessment and review of potential modeling platforms and scenarios for the 2012 blue shark assessment

12. Update Workplan and develop assignments for the 2012 blue shark assessment

13. Update on pelagic shark assessment activities of other organizations

    - IATTC
    - SPC

14. Development of a biological sampling plan for sharks for inclusion in ISC Biological Sampling Plan

15. Review draft SHARKWG webpage

16. Future meetings

17. Other matters

18. Clearing of Report

19. Adjournment

Attachment 4. Tables of Key Life History Parameters for Blue and Shortfin Mako Sharks in the North Pacific

Note: These tables will be evolving work products of the ISC SHARKWG and will be updated as new information becomes available. The information below represents what was identified by WG participants as of December 3, 2011 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.

Blue Shark Life History Characteristics	A: Known with high confidence	B: Known with moderate confidence	C: Highly uncertain
Reproduction	Placental viviparity - A mother gives birth to live young that develop in a yolk sac which differentiates into a placenta after yolk is depleted.		
Gestation	9-12 months		
Breeding frequency		1-2 years	
Sex ratio at birth	1 to 1		
Litter size	range 1-54; average 25-30		
Length at birth	40-50 cm FL		
Length at 50% maturity		Males: 170-185 cm FL Females: 175-190 cm FL	
Age at 50% maturity	Males: 4-6 years, Females: 5-7 years		
Maximum length	380 cm TL		
Longevity	Males: 16 years, Females: 12-15 years		
Length conversions	TL=(PCL+2.505)/0.762 TL=(FL+1.122)/0.829 TL=(AL+2.474)/0.286		
Length-weight relationship *	All: $Wt(kg)=2.57 \times 10^{-5}\ TL^{3.05}$ M: $Wt(kg)=3.838 \times 10^{-6}\ TL^{3.174}$ F: $Wt(kg)=2.328 \times 10^{-6}\ PCL^{3.294}$ M: $Wt(kg)=3.293 \times 10^{-6}\ PCL^{3.225}$ F: $Wt(kg)=5.388 \times 10^{-6}\ PCL^{3.102}$ All: $Wt(kg)=5.009 \times 10^{-6}\ FL^{3.054}$ All: $Wt(kg)=1 \times 10^{-6}\ FL^{3.23}$		
Growth models *			M: $TL_t= 295.3[1-e^{-0.175(t+1.113)}]$ F: $TL_t= 241.9[1-e^{-0.251(t+0.795)}]$ M: $PCL_t= 308.2[1-e^{-0.094(t+0.993)}]$ F: $PCL_t= 256.1[1-e^{-0.116(t+0.1.306)}]$ M: $PCL_t= 289.7[1-e^{-0.129(t+0.756)}]$ F: $PCL_t= 243.3[1-e^{-0.144(t+0.849)}]$ M: $TL_t= 375.8[1-e^{-0.121(t+1.554)}]$ F: $TL_t= 317.4[1-e^{-0.172(t+1.123)}]$

* 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

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		
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		361 cm FL	
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