FINAL

ISC/23/ANNEX/05

ANNEX 05

23rd Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Kanazawa, Japan
July 12-17, 2023

REPORT OF THE SHARK WORKING GROUP WORKSHOP

July 2023

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ANNEX 05

REPORT OF THE SHARK WORKING GROUP WORKSHOP

International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC)

December 8-12, 2022
Hybrid meeting
Shimizu, Shizuoka, Japan

1. INTRODUCTION

The Shark Working Group (SHARKWG or WG) of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) held a 4-day meeting (with a Sunday break) at the Fisheries Resources Institute (FRI) in Shimizu, Shizuoka from December 8-12, 2022.

Mikihiko Kai, SHARKWG Chair, opened the meeting. Participants included members from Canada, Chinese Taipei (Taiwan), IATTC, Japan, Mexico, and United States of America (USA or US). Participants are listed in **Attachment 1**. SHARKWG Chair, Mikihiko Kai welcomed SHARKWG participants and wished everyone a successful meeting and pleasant visit to Shimizu.

2. DISTRIBUTION OF MEETING DOCUMENTS

Six working papers and 8 information papers were distributed and numbered (**Attachment 2**). Two oral presentations were also made during the meeting and numbered. All working papers except for a document number 5 and 6 were approved for posting on the ISC website where they will be available to the public.

3. REVIEW AND APPROVAL OF AGENDA

The draft meeting agenda was reviewed and adopted with a minor change (**Attachment 3**).

4. APPOINTMENT OF RAPPORTEURS

The following participants served as rapporteurs for each item of the approved agenda.

Item	Rapporteurs
1-5.	M. Kai
6	M. Kinney, Y. Semba
7a.	J. King, J. Tovar-Ávila
7b.	K.M., Liu, J. Tovar-Ávila
8.	N. Ducharme-Barth, M. Kanaiwa
9.	M. Kinney, Y. Semba
10a.	J. King, K.M., Liu
10b.	N. Ducharme-Barth, M. Hutchinson.,
11-13.	M. Kai

5. SUMMARY OF CURRENT MEETING OBJECTIVES

The Chair of the SHARKWG reviewed the current meeting objectives and the desired outcomes. The primary goal of the workshop was to discuss the appropriateness of a composite CPUE (Dynamic Factor Analysis: DFA; Peterson et al., 2021a,b) and model ensemble approach (Ducharme-Barth and Vincent, 2022) used in the stock assessment of blue shark (BSH), *Prionace glauca*, in 2022 (ISC, 2022). A secondary objective was to review the fishery data and biological parameters used in the previous benchmark stock assessment of shortfin mako (SMA), *Isurus oxyrinchus*, in 2018 (ISC, 2018) and to review the indicator-based analysis for the SMA in 2021 (ISC, 2021), and discuss work plans for the upcoming benchmark stock assessment for the SMA.

6. SUMMARY OF STOCK ASSESSMENT RESULTS FOR NORTH PACIFIC BLUE SHARK

6.1. Discussion of composite CPUE and the model ensemble approach

This working paper shortly reviewed both the composite CPUE and model ensemble approach used in the stock assessment of BSHs in the North Pacific Ocean in 2022. It also served to raise discussion points about the continued use of these methods. These discussions will expedite our understanding of the new approach and justify their usage in future stock assessment.

<u>Discussion</u>

The WG discussed the modelling approach for the North Pacific SMA. The WG noted the CAPAM meeting on model weighting and indicated that for models with lots of uncertainty there is a greater need to use model ensembles. The WG also noted that the upcoming presentation by Carolina on conceptual models will help to provide a roadmap for creating a model ensemble.

The WG asked about the issues of combining both the data prep. meeting with a discussion of composite CPUE development. The WG discussed that the data prep. meeting would need to be extended in order to include more than just a discussion of catch and CPUE data.

The WG discussed what specific outcomes from the data prep. meeting would be most useful. The WG indicated that the data prep. meeting may need to include decisions on:

1. Update annual catch, CPUE and size data (the typical update to these key data as well as decisions on what the best available information is)
2. Decisions about what CPUEs could be included in a composite CPUE and perhaps scrutinize this composite CPUE in the meeting
3. Development of a Conceptual model
4. Plan/Outline for an ensemble modeling approach (ensemble modeling outline with weighting decisions)

The WG noted that a conceptual model approach and what it entails will need to be discussed further following the presentation by Carolina. The WG noted that further discussion about the needed outcomes of the data prep. meeting should be tabled here until the Conceptual model presentation on December 10th.

6.2. Recommendation/assignments

Discussion

The WG agreed that a continued investigation into the ensemble approach is needed. Additionally, the WG indicated that it would be interested in making future projections stochastic rather than deterministic in order to avoid issues with overly optimistic projection results.

The WG indicated that the outline for the ensemble modeling approach decided at the data prep. meeting could of course be altered at the pre-assessment meeting depending on model outcomes. The WG additionally indicated that modeling outcomes at the pre-assessment meeting could result in a single base-case modeling approach. **The WG basically requested to establish a basic plan at the data prep. meeting but is aware that such a plan could change at the pre-assessment meeting as model are run and evaluated.**

The WG discussed considerations of uncertainty in the ensemble approach of North Pacific BSH and mentioned that it is necessary to consider the uncertainty in the life history parameters (e.g., natural morality) and recruitment in the future projection (from deterministic to stochastic) as future work.

7. REVIEW OF PREVIOUS STOCK ASSESSMENT OF SHORTFIN MAKO IN 2018

7.1. Review of fishery data

This working paper reviewed the fishery data used in the stock assessment for North Pacific SMA in 2018. The benchmark stock assessment was conducted using Stock Synthesis 3 with three kinds of fishery data from 1975- 2016 which includes catch data, CPUE data, and size frequency data. Catch data comprises annual catches of 18 fleets provided by four countries (Chinese Taipei, Japan, Mexico, and United States) and two Tuna-Regional Fisheries Management Organization (Western and Central Pacific Fisheries Commission, and Inter-American Tropical Tuna Commission). CPUE data comprises annual abundance indices of 9 fleets and size frequency data comprises 11 fleets provided by the above four countries. Finally, several recommendations are given for updating/revising the fishery data for the next stock assessment in 2024.

Discussion

The WG indicated that the length weight relationship is going to be very important in the stock assessment and needs to be looked at more closely as it will have a lot of influence on model outcomes since so much of the data being fed into the model is in weight, which SS (Stock Synthesis) will have to convert to numbers. The WG also pointed out that it is important to consider the length-weight relationships by sex because adult females are much bigger at the same age. This fact has the potential to under/over-estimation the impact of mortality on the stock. Such conversion was not undertaken in the previous evaluation, but fishing impact and mortality could be biased if this is not considered.

The WG noted that it is preferrable to use the data as it is originally collected. The WG questioned about the convenience of combining the data, putting them all in weight or number, or split them with early being in weight, and late being in number. The WG noted that splitting the data would be a preferable approach in such case as the use of original data is better. The WG also noted that the conversion of the data could be considered inside the model unless a sophisticated conversion method outside the model could be applied.

The WG noted that there is no direct information on number of individuals caught in most fisheries except for longline fisheries, but they could be estimated from the length frequency data and size range. The WG also noted that some of the Japanese fleets are separated into gross size bins (category) at the fishing markets and so it may be possible to convert catch into numbers for some fleets that have this additional information.

The WG asked if Chinese Taipei and Mexico could provide catches in numbers too. Chinese Taipei indicated that it would be possible to provide catch in numbers for both the large- and small- scale longline, but only for recent years regarding the small-scale longline fishery. The WG explained about the distribution and seasonality of the fisheries and indicated a potential of underreporting in logbook data due to SMA not being a target species all the time. The WG noted that 90% of catch from Chinese Taipei comes from small-scale longline fishery. The WG discussed the difference of effort between small-scale and large-scale longline fishery of Chinese Taipei and if it was reasonable for 90% of the catch to come from the small-scale longline fishery. The WG noted that some of the small-scale longline fleet seasonally targets sharks which could explain the large catches. The WG pointed out that the use of logbook data may be underreporting the catches too because the logbook data is not as reliable as observer data.

The WG also noted that it is common that SMA catch is smaller than that of BSH in each country. The WG noted that landing data since 1989 has information about both catch in number and in weight and SMA catch is not as large as BSH catch.

The WG indicated that catch of the Republic of Korea is not listed in the table of fleets used in the previous stock assessment for North Pacific SMA especially for the high seas small-mesh drift gillnet fishery. The WG noted that the paper (Ito et al., 1993) used to reconstruct the catch for BSH could also be available here to look at SMA catch for various gillnet fisheries in the western North Pacific Ocean. The WG indicated that the east coast of Chinese Taipei has a small-scale (large mesh) gillnet fishery, but it has a very minor catch of SMA as the target is billfishes.

The WG noted the possibility of using the ratio of SMA/BSH to estimate the catch in numbers, however, the WG was concerned that it may not be possible to propagate uncertainty in terms of catch estimate. The WG stressed that uncertainty in estimation of catch should be a focus in the next assessment.

The WG noted that length composition data of Mexico for the period 2006-2016 could be provided as it comes from an observer's program, but perhaps those from previous years would be limited information. The WG also noted that Mexico will inquire about the provision of catch in number.

The WG expressed concern about the strong assumptions on the estimation of SMA catch for the early period of the CPUE series based on the ratio of SMA to BSH from the late period. The WG mentioned that the uncertainty in the estimation is not as large for BSH as the catch ratio of BSH is very high compared to SMA.

The WG noted that there is some uncertainty in the estimation of catch data for SMA in the early period as well as CPUE of Japanese shallow-set longline fishery, so the WG discussed whether it would be better to begin the model in 1994. However, previous attempts to shorten the model time period were not successful but advice from the previous assessment team of ALBWG could perhaps help the SHARKWG to determine if it is a worthwhile approach to take.

The WG noted that the size-specific length frequency data by fleet indicates that most catch is of immature females. The WG also noted that if the model has a maximum age of 31 years, but the harvest is mainly immature females the model may not be capturing all individuals in the population and providing overly optimistic outlooks.

The WG discussed potential impacts of fishing on large individuals that might be unknown, for example post-release mortality. The WG noted that SMA post release survival rates are high, and the survival depends on at vessel condition, handling and release method and the amount of trailing gear left on the animal. The WG expressed concern about post release mortality of sharks that bite through the line and are never brought to the vessel, these animals will likely be in good or fighting condition and will bite-off near the hook and so be released with minimal trailing gear, and thus we can assume that mortality for these individuals is low.

The WG noted that since the selectivity curves used in the model for all fleets are dome shaped and the SMA hook mortality is likely low, a way of dealing with potential impact on larger individuals might be to use a discard fleet in the model and create a logistic selectivity curve. The WG also noted that an approach could be to check the sensitivity of the model to a dome-shaped selectivity curve if a logistic curve is used as the base-case scenario.

7.2. Review of biological parameters

The biological parameter of North Pacific SMA used in the previous stock assessment in 2018 was summarized focusing on its growth and reproduction (i.e., maturity size and fecundity). The background behind the agreed upon parameters from previous discussions and issue included in each topic were also briefly introduced. For the biological parameters on these topics for the North Pacific population, new information which can be used as alternative parameter has not been published or shared since 2018.

Discussion

The WG questioned about the data source of SMA monthly distribution by sex and stage in the presentation and clarified that these data were from Japanese data only. The WG encouraged each country to provide such data, if available, to better understand the movement and distribution of SMA by stage.

The WG clarified that the uncertainty (confidence intervals) of growth parameters derived from the meta-analysis was estimated using a Bayesian approach.

The WG noted that the longevity estimated based on an individual of 366 cm TL (total length) using bomb-radiocarbon in the Atlantic may be underestimated as it was smaller than the maximum observed size of 387 cm TL by Taiwanese fishery. The WG noted that longevity may have a large impact on the assessment results, so the most realistic value should be selected based on the survival ratio at the longevity.

The WG pointed out that the change of longevity setting may affect the subsequent estimations of natural mortality and steepness due to the strong relationships among them. The WG noted that the study of incorporating uncertainty in biological parameters in model ensembles of integrated stock assessments (a multi variate distribution approach; Ducharme-Barth and Vincent, 2022) for southwest Pacific swordfish is a good example of how to deal with this issue.

The WG confirmed that there is no updated information about size at maturity data and agreed to use the current relationships in the upcoming SMA assessment. The WG raised a concern that age at maturity might be uncertain rather than the length at maturity due to the uncertainty in growth.

The WG confirmed that a linear relationship between fecundity and pregnant female size can be incorporated in SS modelling. The WG noted that Mexico and Chinese Taipei can provide additional fecundity data in the data prep. meeting if available. **The WG discussed the uncertainty of the reproductive cycle and agreed to use a 2-year reproductive cycle (6 pups per year) as the base case and other setting (e.g., 3 year or 2.5 year) as alternate cases.**

The WG suggested to estimate the natural mortality schedule based on life history parameters and to consider the uncertainty of these parameters by referring to the latest literature such as Maunder et al. (2023).

8. REVIEW OF INDICATOR-BASED ANALYSIS IN 2021

This working paper shortly reviewed an indicator-based analysis of North Pacific SMA conducted in 2021. Although annual catch, annual abundance indices and length frequency data were provided in the indicator-based analysis in 2021, only the abundance index was focused on in this review because the abundance index is a useful source from which to examine the trends in the abundance which have the most influence on stock status. One future issue is raised to enhance the usefulness of indicator-based analyses.

<u>Discussion</u>

The WG discussed the indicator-based analysis for SMA and BSH that was requested by the ISC plenary. The WG also discussed how the ISC plenary was satisfied with the indicators but had requested additional work to determine thresholds for the indicators that could be used to identify if the stock assessment timeline needed to be shortened. The WG further discussed what this additional work might involve, and that simulations would likely be needed to identify thresholds. The WG discussed various options for addressing this including developing a simulation, using a simplified surplus production model with updated catch and CPUE, or simply running an update assessment. The WG however was concerned that all of those options would represent significant modelling efforts which would distract from conducting improvements to the stock assessment itself.

The WG suggested doing a one-off projection analysis with alternative CPUE scenarios to identify how much key CPUE indices would have to change (i.e., thresholds) in order to impact stock status. The WG eventually arrived at the idea of using the previous stock assessment to run stochastic recruitment projections for the indicator period using the known catch and CPUE. This is a similar idea to the hindcasting approach, and it was also noted that this is a similar approach to what is done in Canada so members of the ISC plenary would likely be familiar with it. The WG determined that this "hindcasting" idea would be proposed to the ISC plenary for approval with the idea of applying it instead of the next indicator analysis. The WG also noted that there are some technical details that still need to be sorted out for implementing this approach but that in theory it seems reasonable and should be feasible to implement.

9. BIOLOGICAL STUDY

9.1. Growth study of blue shark

A comparison of different models (both deterministic and stochastic) was undertaken to re-estimate the growth of BSH, *Prionace glauca,* females from Mexican waters, based on length-at-age data obtained from counting growth bands in sectioned vertebrae of 272 sharks (108–260 cm of total length). All deterministic models: the traditional von Bertalanffy growth equation (VBGE), two parameters VBGE (2P-VBGE), Gompertz, two phases Gompertz and logistic model, produced similar growth curves. However, according to the Akaike information criterion (AIC), the 2P-VBGE adjusted better to the data. The VBGE estimated the same parameters than the 2P-VBGE, while the Gompertz and Logistic models obtained similar support than the VBGE. Though the estimated asymptotic length (L_∞) was like previous estimations from Mexican waters, the growth coefficient (k) was slightly lower. Among three stochastic models based on a reparameterization of the VBGE, to take account of individual growth heterogeneity and incorporate random variation of k using three different probability distribution functions (*pdf*), the model assuming a Log-normal *pdf* adjusted better to the length-at-age data according to the Kullback-Leibler information mean. The L_∞ estimated with all the stochastic models were larger than those estimated with the deterministic models, closer to the maximum reported length of the species, whereas the expected value of k ($E[k]$) was lower.

<u>Discussion</u>

The WG noted that the higher estimates of L_∞ compared to that of the deterministic value may be due to the assumption of error structure (positive value and skewness to the right long tail especially for the selected log-normal model) of Bayesian analysis, while the deterministic model assumes a normal distribution for the error. **The WG agreed that the L_∞ difference between the two methods was likely due to this.**

The WG asked about all the growth model results being for females and wanted to know why no results were included for males. The WG noted that there were enough males to attempt estimates but when trying to fit either the stochastic or the deterministic method the models would not converge and so results for males were not included in this presentation.

9.2. Growth study of shortfin mako shark

This working paper provided an update of the age and growth of SMA (*Isurus oxyrinchus*) from the Mexican Pacific, based on the analysis of growth band counts from dorsal vertebrae of 198 individuals (110 females 74–302 cm of total length, TL, and 88 males 72–231 cm TL) caught during 2008–2018. Centrum edge analysis (CEA) and marginal increment analysis (MIA) were used to verify the periodicity of growth band formation in the vertebrae of juveniles. The von Bertalanffy growth model (VB), Gompertz, Logistic and the two parameters of VB were fitted to the length-at-age data, comparing their performance with the Akaike information criterion (AIC).

The CEA and MIA did not support the hypothesis of biannual band pair formation for juveniles, likewise for adults the periodicity could not be verified due to the low sample of large animals. Age was estimated assuming the formation of two pairs of growth bands per year during the first five years of age and one pair of bands per year afterwards. The estimated ages ranged from 0–14 for females and 0–6 for males. According to the AIC, taking into account the model with a greater biological sense, the 2-VB fitted better the length-at-age data for females (L_{inf} = 329.1, k = 0.16, L_0= 70) and VB for males (L_{inf} = 332.9, k = 0.16, L_0= 65), showing no differences in their growth curves according to the Kimura's likelihood ratio test (P>0.05). *I. oxyrinchus* presents slightly faster growth than the estimated in previous study in the region and medium longevity in comparison to other shark species, the growth parameters determined were similar with the estimated in other regions.

<u>Discussion</u>

The WG noted that there was a very limited number of adult females in the study (*n*=1 over 240cm) which leads to a large uncertainty in the estimation of growth of large females. The WG also noted that it was acknowledged that this was the case, which was a byproduct of the decision not to use samples from sharks that did not have dorsal vertebra present since vertebra taken from different parts of the spine showed different ages. The WG pointed out that this issue likely means that this growth is only representative of the juvenile stage. The WG also mentioned that this is not an uncommon problem as the capture of large sharks is in issue for SMA in other oceans of the world as well.

The WG noted that there might be a sub population in the Pacific and that the growth may be different in the Eastern Pacific Ocean as compared to other regions of the Pacific. The WG also discussed differences in age at maturity between eastern and western Pacific SMA, however it was indicated that as this stock is treated as a single stock it makes sense that age at maturity is the same between eastern and western Pacific SMA. The WG encouraged more work to be done on these topics.

9.3. Separate discussion of the length weight relationship used in the last mako assessment

The WG showed the length weight relationship of SMA from the previous assessment and noticed a large difference in the male and female length weight relationship. The WG checked the equation in the SMA report and compared it to the SS control file and noticed a mistake in the equation (10^-5 was the equation in the report, 10^-6 was in the SS control file for males). The WG agreed that this was a potentially large mistake and that the model should be rerun to see what the outcome will be with the male SMA length weight relationship fixed. The WG questioned how to handle this issue, it was indicated that testing the model will be quick, but that stock status should not be changed since the model will not be tuned to the new catch that will result from this change.

The WG reviewed the report file from the rerun SS model with the corrected length weight relationship and found that the biomass scale was cut in half but there was little to no effect on relative derived quantities (i.e., the Kobe plot and stock status of SMA).

10. OTHER MATTERS

10.1. US and Canada observer data from historical high seas drift gillnet fisheries

From the 1980s until the fishing gear was banned in 1993, substantial amounts of North Pacific BSH were caught by the high seas drift gillnet fisheries as targeted catch as well as bycatch. The high seas drift gillnet fisheries consisted of two main gear types using: 1) large-mesh driftnets primarily targeting tunas, billfishes, sharks (i.e., tuna gillnet); and 2) small-mesh driftnets targeting flying squid (i.e., squid gillnet). The three main nations using these gears were Japan, The Republic of Korea, and Chinese Taipei. The SHARKWG have been aware of the problems with the reported catches from these fisheries, and recently developed estimates of the total removals of BSH by these fisheries for the 2022 North Pacific BSH assessment. However, size composition data for these removals by the squid gillnets were not easily available. Recently, the ALBWG discovered that the high seas drift gillnet catches of North Pacific albacore during this period had substantial problems as well. Perhaps through luck or foresight, the base case model of the 2020 North Pacific albacore stock assessment has a start year of 1994, which minimizes the issues with the high seas drift gillnet catches. Nevertheless, the ALBWG has considered it is a critical to initiate a study to estimate the total removals of North Pacific albacore from both the tuna and squid gillnet fisheries from Japan, The Republic of Korea, and Chinese Taipei. In addition, size composition data from these fisheries would also be important for future stock assessments. The ALBWG have recommended collaborating with the SHARKWG on the study and publish the work in a scientific journal so that the work would be easily available to the public. To help with this proposed study, catch, effort, and size data collected by observes from the U.S. and Canada on high seas drift gillnets vessels have been obtained. The size data includes size composition data for North Pacific BSHs that could be used for future North Pacific BSH stock assessments. It is recommended that the ISC STATWG be informed of these data and stores these observer data to prevent data loss. However, it should be noted that data was collected based on multiple bilateral agreements between scientists from the fishing nations and the U.S. or Canada. Therefore, it may be necessary to discuss the idea with the ISC Plenary before proceeding.

Discussion

The WG discussed the catch and length data of historical high seas drift gillnet fisheries, data which are used by the BSH and the albacore assessments, however, recent problems with the data have been discovered. The WG noted that in the SMA assessment, the Japanese catches are only landings from the large mesh driftnet fishery, and small mesh driftnet fishery data are not included. The WG also noted that it is likely missing the fishing effort and catch of Chinese Taipei and the Republic of Korea for the high seas drift gillnet fisheries (small-mesh and large-mesh).

The WG noted that the ALBWG is proposing to work collaboratively with the SHARK WG to estimate the total removals of North Pacific albacore and key bycatch species (e.g., SMA and BSH) from both the tuna and squid gillnet fisheries from Japan, The Republic of Korea, and Chinese Taipei. The ALBWG also proposed that the results would be published in a scientific journal to provide proper documentation, and to make the data readily accessible.

The WG noted that there are US and Canada observer data for catch, effort, and size data collected on high seas drift gillnets collected by the International North Pacific Fisheries Commission. **The WG noted that these data should also be included in the assessment. The WG agreed to the collaborative study with ALBWG.**

The WG agreed that the ISC STATWG should be informed of these data and stores these observer data to prevent data loss. However, it should be noted that data was collected based on multiple bilateral agreements between scientists from the fishing nations and the U.S. or Canada. Therefore, it may be necessary to discuss the idea with the ISC Plenary before proceeding.

10.2. The use of conceptual models to structure stock assessments

A conceptual model is a simplified representation of the main processes and components of a systems and how they are related. Concept comes from the Latin noun conceptus, a thought, a purpose, an abstract and general idea. In dynamic systems, such as fisheries systems, conceptual models are useful to organize the ideas, rank the main processes and its uncertainties and structure the hypotheses of how the system works. Conceptual model is used to restrict the domain of the problem, lay out the current knowledge of the system and highlight the key uncertainties. Conceptual models guide the development of assessment models and maybe useful as communication and collaboration tool. We propose that using conceptual models can speed up and optimize the modelling process for stock assessments by "modelling what to model" and guiding the assessment workflow. The development of a conceptual model should take into consideration: 1) the objectives of the assessment, 2) the spatial and temporal scale of the problem, 3) biological aspects, 4) other aspects or patterns. The spatial scale includes the determination of the stock structure, the fisheries structure, and the overlapping of the fisheries with habitat of different ages or stages of the population. The temporal scale includes the time step, the start and end of the period to be modeled, and maximum age. The biological aspects include growth, reproduction, migration patterns, and behavioral patterns. Other aspects may include changes in productivity. The development of a conceptual model benefits from 1) reviewing the archetypes for the dynamic for similar species, 2) reviewing habitat aspects such as oceanographic patterns that may force the stock dynamics, 3) applying auxiliary and exploratory analyses such as tree analysis for length frequency data to detect patterns, 4) including experts' knowledge and stakeholder knowledge in particular aspects. Once the conceptual model is developed, the main uncertainties should become explicit. The conceptual model can be used to develop a single best-case model plus sensitivity models or a model ensemble. The hypotheses about the stock encompassed in the conceptual model can then be structured in a hierarchical way. Hypotheses for aspects that may not have information in the data could be treated as independent (orthogonal) of the other hypotheses. The processes encompassed in the conceptual model are then approximated into the assessment models. Examples from international fisheries illustrate how the use of conceptual models translated into better assessment models. The implicit conceptual model for the last SMA assessment is shown as an illustration of the approach.

Discussion

The WG noted that the most important point is the planning (i.e., a procedure for developing a conceptual model) before we start the assessment, and it is necessary to integrate multiple sources of information which gives us an opportunity to be more deliberate unlike the previous assessment where we simply do the assessment and look to make changes. The WG also noted that conceptual model leads to the construction of a concept map in order to structure the stock assessment and that this may ease of interpretability of the model. The WG recognized that an actual map can be made to expedite the understanding of what component of the population each fleet encounters which can help better model selectivity and approximate movement within the model.

The WG noted that currently the fleets are set by country and gear, however, if a conceptual model is used the fisheries definition can be reconstructed by biological interaction. The WG also noted that if fisheries operate on both adults and juvenile areas then they should be split rather than being grouped together. The WG discussed the fishery structure and noted that tree analysis can help identify how to split up fisheries if you have length frequency data. The WG was informed that North Pacific albacore used a clustering method to corroborate the splits.

The WG encourage the development of a conceptual model to help define fisheries that can help to elicit hidden data if it is identified in the conceptual model. The WG noted that even if data is not used directly in the assessment, it can be used in the conceptual model to help define the fisheries.

The WG noted that a conceptual model road map should be made for the upcoming SMA assessment. The WG pointed out that the seasonality for SMA and BSH is a key point in the conceptual model as there are seasonal migration and seasonal change of the fleet's operational area due to the targeting shift regarding the Japanese longline shallow-set fisheries. **The WG agreed that we need to look into technical details of implementation but may not need to have quarterly data for all fisheries.**

The WG confirmed that Japan and US could provide seasonal data regarding the longline fisheries, while Chinese Taipei could provide some seasonal data for longline fisheries because catch of SMA caught by Taiwanese large-scale longline fishery is too low and the annual catch is estimated using the standardized CPUE, so that provision of seasonal data may not match the estimated catch. The WG also expressed concern that the Taiwanese observer data by season may be highly variable. **The WG proposed a way of estimating the seasonal catch using the average seasonal catch ratio of observer data for the available period and combining that with the current estimation method.**

The WG noted that the conceptual model will be very different for sharks compared to albacore, due to sex segregation, dimorphic growth rates, sex-specific movement behaviors (mating grounds) and other things which will complicate the conceptual model, which makes this effort even more important to lay out.

The WG confirmed that Mexico could provide seasonal catch data in number regarding observer data for 2006-2021, while catch in numbers prior to 2006 is unavailable though a historical reconstruction of SMA catch since 70s had conducted. The WG clarified that the pupping season of SMA in the coastal and offshore areas in the Mexican Pacific waters is May to July and this pupping season is very similar to that in the western Pacific Ocean.

The WG noted that it is necessary to decide the draft of the conceptual model and to make a road map by the data prep. meeting of SMA stock assessment. The WG also noted that the best way (from the experience of swordfish and albacore workshops to proceed) is to invite people for their presentations and to summarize the results into one slide (map) that includes summaries of tagging and biological studies, length frequency analysis, cluster analysis to roughly identify the habitat of juveniles and adults.

The WG explained the movement patterns of pregnant females of SMA in the western North Pacific Ocean in relations to the reproductive periodicity. The WG noted that the pupping area should not be used as the best signal of a whole area for adult females. The WG also noted that females migrate spatially northward as gestation progresses, however, there is no information about the migration for the recovery (resting) period. The WG further noted that mating could occur in tropical area.

The WG noted that it is better to provide fine scale data as much as possible for the assessment modeler because it is easier to combine data than to separate it later. The WG also noted that all the biological data should be assembled before data prep. meeting, and it would be good to develop the straw man conceptual model prior to the data prep. meeting because it will inform a lot of the discussion on how to handle uncertainties and answer question of base case versus ensemble.

The WG suggested to start the discussion now and to build the concepts out, providing time for input and comments from experts. The WG also suggested that the biologists work intercessionally to collate the inputs and map out the conceptual model and present the initial draft at the half-day ISC Shark meeting during ISC Plenary meeting and provide a working paper for the data prep. meeting.

11. Future SHARKWG meetings

A tentative schedule for upcoming SHARK WG meetings was adopted:

July 10/11 2023 Kanazawa, Japan	Half day ISC SHARKWG meeting: Discussion of the conceptual model for SMA.
July 12-17 2023 Kanazawa, Japan	ISC23-Plenary meeting in Japan
Early November 2023 Yokohama, Japan	ISC SHARKWG meeting: data preparatory meeting for stock assessment of SMA
February-March 2024 La-Jolla	ISC SHARKWG meeting: pre-assessment meeting for SMA
April-May 2024 La-Jolla or Hawaii	ISC SHARKWG meeting: stock assessment meeting for SMA

12. CLEARING OF REPORT

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

13. ADJOURNMENT

The Chair thanked all participants for attending and for their hard work. He indicated that he will be in touch regularly over the coming months to finalize the working group report and looks forward to seeing many of the participants in July at the Plenary meetings in Kanazawa, Japan.

The meeting was adjourned at 11:52 JST on December 12, 2022.

14. LITERATURE CITED

Cassidy D. Peterson, Michael J. Wilberg, Enric Cortés, Robert J. Latour. 2021. Dynamic factor analysis to reconcile conflicting survey indices of abundance. ICES J. Mar. Sci. 78, 5. 1711 – 1729.

Cassidy, D. Peterson, Dean L. Courtney, Enric, Cortés, Robert, J. Latour. 2021. Dynamic factor analysis to reconcile conflicting survey indices of abundance. ICES J. Mar. Sci. 78, 9. 3101 – 3120.

Freddy O. Lopez, Javier E. Contreras-Reyes, Rodrigo Wiff. 2017. Incorporating uncertainty into a length-based estimator of natural mortality in fish populations. Fish. Bull.115, 355 – 364.

ISC. 2018. Stock assessment of Shortfin Mako Shark in the North Pacific Ocean through 2016. Annex 14 of ISC Plenary Report 2018, July 11-16, Yeosu, Korea.

ISC. 2021. Report of indicator analysis for shortfin mako shark in the North Pacific Ocean. Annex 5 of ISC Plenary Report 2021, July 12-15 and 19, Webinar.

ISC. 2022. Stock assessment and future projections of blue shark in the North Pacific Ocean through 2020. Annex 12 of ISC Plenary Report 2022, July 12-18, Kona, USA.

Ito, J., Shaw, W., Burger, R.L. 1993. Symposium on biology, distribution and stock assessment of species caught in the High Seas driftnet fisheries in the North Pacific Ocean held by the standing committee on biology and research at Tokyo, Japan in 1991. Vancouver, Canada.

Maunder, M.N., Hamel, O.S., Lee, H.H., Piner, K.R., Cope, J.M., Punt, A.E., Ianelli, J.N., Castillo-Jordán, C., Kapur, M.S., and Methot, R.D. 2023. A review of estimation methods for natural mortality and their performance in the context of fishery stock assessment. Fish. Res. 257: 106489.

Nicholas, D. Ducharme-Barth, Matthew T. Vincent. 2022. Focusing on the front end: A framework for incorporating uncertainty in biological parameters in model ensembles of integrated stock assessments. Fish. Res. 255, 106452.

Takahashi et al. 2017. Meta-analysis of Growth Curve for Shortfin Mako Shark in the North Pacific. ISC/17/SHARKWG-3/05.

APPENDIX 1: LIST OF PARTICIPANTS

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APPENDIX 2. MEETING DOCUMENTS, PRESENTATIONS AND INFORMATION PAPERS

WORKING PAPERS

ISC/22/SHARKWG-3/1	Discussions on the issues of composite CPUE and the model ensemble approach for blue shark in the North Pacific Ocean. **Mikihiko Kai** (kai_mikihiko61@fra.go.jp)
ISC/22/SHARKWG-3/2	Review of fishery data used in the benchmark stock assessment for North Pacific shortfin mako. **Mikihiko Kai,** (kai_mikihiko61@fra.go.jp)
ISC/22/SHARKWG-3/3	Review of biological parameter of shortfin mako (*Isurus oxyrinchus*) in the North Pacific used for the stock assessment in 2018. **Yasuko Semba** (semba_yasuko25@fra.go.jp)
ISC/22/SHARKWG-3/4	Review of indicator-based analysis of North Pacific shortfin mako conducted in 2021. **Mikihiko Kai,** (kai_mikihiko61@fra.go.jp)
ISC/22/SHARKWG-3/5	Re-estimation of shortfin mako shark (*Isurus oxyrinchus*) growth in the Mexican Pacific through a multi-model approach and verification of juvenile's growth band periodicity. **Rodríguez-Madrigal JA, Tovar-Ávila J, Castillo-Géniz JL, Godínez-Padilla CJ, Márquez-Farías JF and Corro-Espinosa D.** (javier.tovar@inapesca.gob.mx)
ISC/22/SHARKWG-3/6	Re-estimation of age and growth of blue shark (*Prionace glauca*) females in the Mexican Pacific through a multi-model approach. **López-López LE, Tovar-Ávila J, Blanco-Parra MP, Castillo-Géniz JL, Godínez-Padilla CJ and Amézcua F.** (javier.tovar@inapesca.gob.mx)

PRESENTATIONS

ISC/22/SHARKWG-3/P1	US and Canada observer data from the historical high seas drift gillnet fisheries. **Steven L. H. Teo** (steve.teo@noaa.gov)
ISC/22/SHARKWG-3/P2	The use of conceptual models to structure stock assessments: a tool for collaboration and for "modelling what to model". **Carolina Minte-Vera, Mark N. Maunder, Haikun Xu, Steven L.H. Teo and Alexandre Aires-da-Silva** (cminte@iattc.org)

INFORMATION PAPERS

ISC/22/SHARKWG-3/ INFO-1	Dynamic factor analysis to reconcile conflicting survey indices of abundance. 2021. ICES J. Mar. Sci. 78, 5. 1711 – 1729. **Cassidy D. Peterson, Michael J. Wilberg, Enric Cortés, Robert J. Latour**
ISC/22/SHARKWG-3/ INFO-2	Reconciling conflicting survey indices of abundance prior to stock assessment. 2021. ICES J. Mar. Sci. 78, 9. 3101 – 3120. **Cassidy, D. Peterson, Dean L. Courtney, Enric, Cortés, Robert, J. Latour**
ISC/22/SHARKWG-3/ INFO-3	Stock assessment of shortfin mako in the North Pacific Ocean through 2016. 2018. **ISC/18/ANNEX/15**.
ISC/22/SHARKWG-3/ INFO-4	Report of indicator analysis for shortfin mako shark in the North Pacific Ocean. 2021. **ISC/21/ANNEX/5**.
ISC/22/SHARKWG-3/ INFO-5	Stock assessment and future projections of blue shark in the North Pacific Ocean through. 2020. **ISC/22/ANNEX/12**.
ISC/22/SHARKWG-3/ INFO-6	Meta-analysis of Growth Curve for Shortfin Mako Shark in the North Pacific. ISC/17/SHARKWG-3/05. **Takahashi, N. et al.**
ISC/22/SHARKWG-3/ INFO-7	Incorporating uncertainty into a length-based estimator of natural mortality in fish populations. 2017. Fish. Bull.115, 355 – 364. **Freddy O. Lopez, Javier E. Contreras-Reyes, Rodrigo Wiff.**
ISC/22/SHARKWG-3/ INFO-8	Focusing on the front end: A framework for incorporating uncertainty in biological parameters in model ensembles of integrated stock assessments. Fish. Res. 255, 106452. **Nicholas D. Ducharme-Barth, Matthew T. Vincent**

APPENDIX 3. AGENDA

SHARK WORKING GROUP (SHARKWG)
INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC
HYBRID MEETING AGENDA
December 8-12, 2022
Fisheries Resources Institute
Japan Fisheries Research and Education Agency
Shimizu Shizuoka

DRAFT

Meeting Hours: 9:00-12:00 Japan time (8-10,12 December)
8:00-11:00 Chinese Taipei time (8-10,12 December)
14:00-17:00 Hawaii time (7-9,11 December)
16:00-19:00 LaJolla, Mexico (Ensenada), and Canada time (7-9,11 December)
We will work Saturday and take day off on Sunday.
Last day, we will start 1 hours late.

1. Opening of SHARKWG Workshop
   a. Welcoming remarks
   b. Introductions
   c. Meeting arrangements
2. Confirmation of document paper and presentation with numbering
3. Review and approval of agenda
4. Appointment of rapporteurs
5. Meeting objectives
6. Summary of stock assessment results for North Pacific blue shark
   a. Discussion of composite CPUE and the model ensemble approach
   b. Recommendation/assignments
7. Review of previous stock assessment of shortfin mako in 2018
   a. Review of fishery data
   b. Review of biological parameters
8. Review of indicator-based analysis in 2021
9. Biological study
   a. Growth study of blue shark
   b. Growth study of shortfin mako shark
   c. Other matters
10. Other matters
   a. US and Canada observer data from historical high seas drift gillnet fisheries
   b. The use of conceptual models to structure stock assessments
11. Future SHARKWG meetings
12. Clearing of report
13. Adjournment