

FINAL

ISC/24/ANNEX/12



ANNEX 12

*24th Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Victoria, Canada
June 19-24, 2024*

REPORT OF THE SHARK WORKING GROUP WORKSHOP

June 2024

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ANNEX 12

REPORT OF THE SHARK WORKING GROUP WORKSHOP**International Scientific Committee for Tuna and Tuna-like Species
in the North Pacific Ocean****Hybrid meeting of stock assessment for North Pacific shortfin mako in Honolulu, US****April 29-May 3, 2024 (US time)****1.0 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 5-day meeting at the Pacific Islands Fisheries Science Center in Honolulu, Hawaii US from April 29 to May 3, 2024. The primary goal of the workshop was to finish the benchmark stock assessment for North Pacific (NP) shortfin mako (SMA; *Isurus oxyrinchus*). In addition, the WG needed to establish a work plan to complete the assessment report for the ISC plenary held in June in 2024. Mikihiko Kai, SHARKWG Chair, opened the meeting at 1:00 pm on April 29, 2024 (eastern Pacific time). Participants included members from Canada, Chinese Taipei, Japan, Mexico, and United States of America (USA) (**Attachment 1**). SHARKWG Chair welcomed all participants.

2.0 Distribution of documents and numbering of working papers

No WG paper was distributed.

3.0 Review and approval of agenda

The draft meeting agenda was reviewed, and the agenda was adopted with minor revisions. (**Attachment 2**).

4.0 Appointment of rapporteurs

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

Item	Rapporteurs
1-4.	M. Kai
5.	J. King (Lead)
6.	M. Kinney (Lead)
7.	K. Dahl (Lead), Y. Semba
8.	S. Teo (Lead)
9.	J. King (Lead)
10.	J. King (Lead)
11-12.	M. Kai

M. Kai will lead the writing/updating of the meeting report in cooperation with the participants.

5.0 Summary of pre-assessment meeting and current meeting objectives.**5.1 Report the outcomes of pre-assessment meeting**Summary

The WG Chair reported the main outcomes of the pre-assessment meeting.

The WG reviewed biological parameters for this species and decided that the modeling should follow a hierarchical structure, with runs representing higher-level hypotheses and nested lower-level ones, based on the conceptual model (CM) for SMA. The CM highlighted that there is evidence of two pupping grounds (northwestern Pacific: WPO around the water of Japan and northeastern Pacific (EPO) around the water of California bight or Mexico). Juveniles stay in the waters off Japan and Mexico and perform seasonal migration. The subadults do a cyclic migration. The connections of adult SMA between WPO and central Pacific (CPO) and between CPO and EPO are uncertain (**Figure 1**). Large adult females can be observed in summer north of the main Hawaiian island, which may indicate a mating ground. The Japanese “Kinkai” shallow fleets, US gillnets fleet in California water and the artisanal fisheries off Mexico mainly catch juveniles and subadults, and large adult females are rare (50 % maturity size of SMA is 233 cm pre-caudal length: PCL). More mature males are caught by these fleets than mature females.

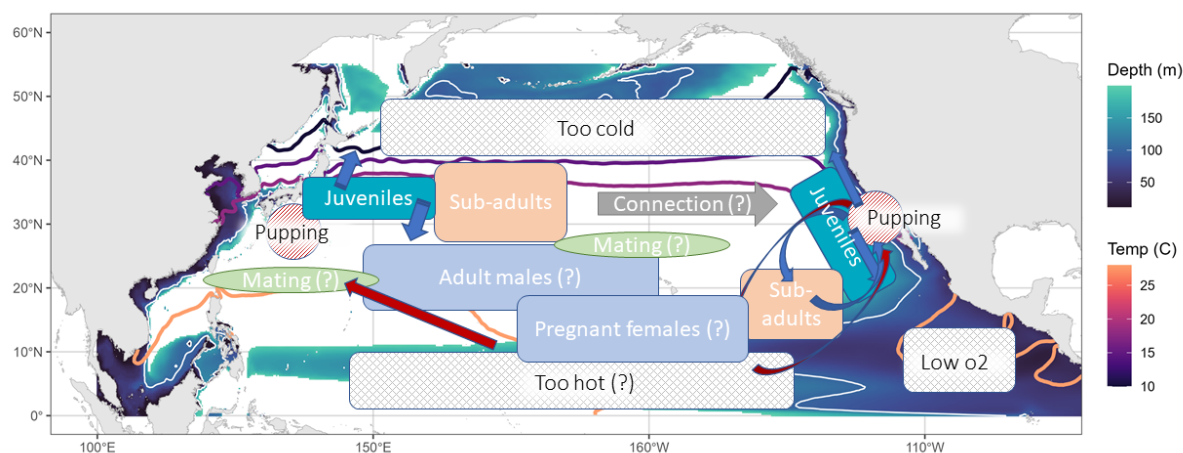


Figure 1. Conceptual model for NPO SMA. Contour lines (warm colors) are shown for the average annual 10°, 15°, 18°, and 28° C sea surface temperature isotherms. Background shading (cooler colors) shows the depth of the oxygen minimum zone (3 mL/L), a white isocline indicates a depth of 100m which could be limiting based on SMA vertical dive profiles.

The WG decided to use steepness values based on the number of pups directly with 3 fecundity scenarios (constant, linear relationship with length, and power function with length) and natural mortality (M) for juvenile (0-1 ages) and adults (sex-specific constant M; Teo et al. 2024). The WG also decided to use a lognormal prior in order to estimate M, and the M for each run was drawn only once from the M distribution. The WG decided to use the M of juvenile based on the literature (Mucientes et al., 2023). The WG estimated steepness parameters for 144 scenarios (2 scenarios of growth curve, 12 scenarios of M, 3 scenarios of fecundity, and 2 scenarios of reproductive cycle). The scenario of M includes options to have an inflated juvenile M and constant M after that (2 scenarios: Max-age vs All combined; 3 scenarios: 10, 50, 90 percentiles of uncertainty of M; 2 scenarios of Ms with and without juvenile M). Steepness simulation scenarios produced a wide range of possible values from near 0 to near 1. In addition, a large number of draws fell below the theoretical lower limit of 0.2. The WG determined to attempt the models with steepness below the theoretical limit of 0.2, with a second attempt being made fixing steepness at

0.2 if the values lower than 0.2 failed.

The WG reviewed the fishery data (i.e., annual CPUEs, annual catch, and size composition data combined by year) provided at the data preparatory meetings and after that. The WG decided that the Mexican index should not be included due to a large shift in targeting over the history of the fishery. The WG supposed that if there is a large spawning population in the CPO that randomly distributes out to the edges of the Pacific, then the Japanese “Kinkai” shallow index should be representative of the population. The WG decided to fix the average CV at 0.2 for the index which the average CV is below 0.2. The WG suggested 4 general scenarios around stock structure be developed and paired with key indices: 1) Well mixed population in the entire North Pacific; 2) Western and Central Pacific is the main distributional area (i.e., representativeness of the stock); 3) Eastern and Central Pacific is the main distributional area; 4) Central Pacific is the main distributional area.

The WG suggested a tentative fleet definition with selectivities. The WG also updated the version of SS3 using the previous datasets in 2018 (except for the length-weight relationship parameter, which was corrected) and similar outcomes were obtained without issues. The WG then ran preliminary models with the new datasets up to 2024 using the new version of SS3. The WG Chair further reported that the four unofficial update web-meetings (1. 2024 FEB 23; 2. 2024 MAR 21; 3. 2024 APR 12; 4. 2024 APR 25) were conducted to check the progress of the modeling and to discuss the analysis of the assessment.

Discussion

Many difficulties arose with the assessment model that required WG decisions on alternative approaches. Those discussions occurred during the update web-meetings, which were held between official WG meetings. Given that the update web-meetings were ad hoc, many participants could not attend. In the future, these update web-meetings should be considered to be official so that the meeting materials do not need to be revisited during official meetings. If update web-meetings are to become official, they will need to be entered into the WG schedule well in advance so that members can participate. In the future, it would be good practice to provide a short summary of the update web-meeting, along with presentation files, so that decisions made can be reported as appendices to a meeting report. For this year, no rapporteurs captured discussion, but this could be accomplished for future assessments.

5.2 Meeting objectives

Summary

The WG Chair reviewed the current meeting objectives and the desired outcomes for the North Pacific shortfin mako stock. They included: 1) summarizing pre-assessment meeting; 2) reviewing issues and limitations of modeling based in SS3; 3) reviewing fishery data and biological parameters for the assessment; 4) reviewing model ensemble approach based on Bayesian state-space production model (BSPM); 5) improving the assessment model(s) through careful review of model diagnostics and re-analysis; 6) reviewing sensitivity analyses; 7) summarizing the stock status and draft conservation information; 8) finalizing the executive summary; 9) developing an outline of the stock assessment report and a plan to complete the report before the ISC Plenary; and 10) developing plans for conducting the blue shark indicator analysis in 2025.

Discussion

No discussion.

6.0 Stock Synthesis (SS3) modeling for North Pacific shortfin mako

6.1 Issue of modeling

Summary

The main modeler explained the reasons that an integrated modeling approach was not suitable for the stock assessment of NP SMA: 1) the lower catch in the early time period of the model cannot account for the upward trends in the CPUEs for the main fleets after 1993 and, 2) there is no information about the annual trends in abundance in the early time period since the early CPUE index was evaluated to be unrepresentative and removed from the model. The WG mentioned that Japan has no species-specific catch data for sharks caught in the early time period, so it is likely the estimated “Kinkai” shallow CPUE just reflected the annual trends of the blue shark population. In addition, the main modeler explained that there may be a misspecification between fishery data and biological parameters because no production function could be defined that accounted for the observed catch and CPUE data. Furthermore, the modeler mentioned that it is likely that the size composition data may provide limited information about fishing mortality and population scale due to the dome shape in selectivity.

Discussion

The WG asked for more details on what was meant by the comment about a lack of standardization of the size composition data. It was answered that depending on how size data are collected, and how representative size composition data are for a given fishery it may be necessary to account for differences in where and when size data were collected. The WG mentioned that it is possible to use a spatial temporal model or examine the size composition data themselves spatially to ensure their representativeness.

The WG questioned about the way of bias correction for the size composition data. It was answered that if port sampling was conducted on a large enough scale and vessels from across the fishing area land at the same port, then perhaps no standardization is needed. If there is spatial data associated with collected port sample data, then it is possible to run a model to check whether standardization is needed.

The WG indicated that dome shaped selectivity seems like it would continue to be a problem going forward even if some large adult females are included in the catch. It was answered that if we fix the descending limb of the dome shaped selectivity then we would be able to gain further information about fishing mortality rate (F), however, fixing selectivity in this way is difficult and somewhat arbitrary. Gaining some information from large adult females may help with this, so while we are perhaps stuck with dome shaped selectivity, there are some avenues for improvement if some larger adults are included in the data.

7. Review fishery data and biological parameters.

The WG reviewed the fishery data (i.e., annual CPUEs and annual catch)

7.1 Catch and standardized CPUE

Summary

The main modeler mentioned that the catch and CPUE data are more straightforward than the biological parameters. Annual CPUEs for the US deep-set longlines (USLL) in recent years are influenced by high numbers of SMA caught from a single vessel. Three different types of fleets:

Japanese “Kinkai” shallow longline (JPLL); Taiwanese large-scale longline (TWLL); USLL showed a generally increasing trend, particularly after 1993. A Stock Synthesis model run with very high weight placed on the length composition data was used to convert catch in weight into catch in numbers within the model using information about selectivity, the length-weight relationships, and the growth curve. The main modeler considered two catch scenarios: fixed catch scenario and estimated catch scenario. Estimated catch was developed using longline effort of all flags in the whole NP above 10 N°, translated the longline effort into the exploitation rate (F), which gets turned into catch. Some anomalous model results meant that some indices were dropped before going into the BSPM.

Discussion

The WG questioned the reason why Mexican CPUE was dropped from the model ensemble approach, and it was responded that there was serious concern about the targeting shift for the indices. The WG also questioned if the Mexican CPUE can be used for the sensitivity analysis, and it was responded not currently considered but it is possible if the WG has a consensus. **The WG finally agreed to use this index as a sensitivity analysis.** The WG asked if the fishing effort above 10 N° is reasonable for the estimation of catch, and it was responded that the equatorial data was excluded because it's less likely to catch SMA in the water south of 10 N° as shown in the map of conceptual model (**Figure 1**). The WG mentioned that it is more representative to derive effort where there is better overlap with the distribution of SMA.

The WG clarified that the two USLL CPUEs are given equal weighting of 0.5 and the weighting of CPUEs for JPLL and TWLL were given 1.0, respectively.

The WG discussed/commented how the credible intervals around the prior/posterior were calculated/estimated. The WG mentioned that there is not much information to estimate the scaling parameter. The production model can simulate the population dynamics by drawing from the priors, which are so broad that many scenarios may cause population collapse. The WG noted that wide uncertainty is due to uncertainty in the total population scale, however, it's very uninformative in terms of total population scale because there is no contrast for the increasing trends in the annual CPUE as well as the increasing trends in the annual catch in the late time period after 1993. Uncertainty in the estimation of carrying capacity (K) is also reflected by the uninformative population scale.

The WG noted that we need something or a new idea to estimate the total removals including discards and the scaling automatically for a few years or maybe next few years. It is possible to use that to anchor down what the catchability (q) potentially could be based on real data, but we must do some experiments on the current catches because we have less chance of understanding the previous historical catch, but potentially we can get a better idea of what's going on in near future. Once some portion of the time series is better estimated, we can then conduct projections backwards or forwards whatever it is to get a better idea, at least over the overall trajectory. Unfortunately, the WG currently does not have much choice. The WG also noted that the fixed catch is probably some sort of underestimation, but we do not know what that level is, and makes it more difficult to estimate the population scale.

The WG clarified how the two estimated catch scenarios are treated, and it was responded that the scenario based on the LL fishing effort would be down-weighted to 5% weight to represent an upper limit to possible catches. The WG mentioned that nine fixed catch scenarios were attempted by changing the magnitude of catch in the terminal year, either making 50% or 100%

larger or by changing the potential under-reporting rates in earlier years, but results were similar across scenarios.

7.2 *Biological parameters*

Summary

The main modeler explained the biological parameters used in the BSPM. The BSPM greatly simplifies the population dynamics, searching over 3 main parameters (i.e., Intrinsic natural growth rate (r), Initial depletion (x_0), and carrying capacity (K)) in the plausible parameter space. Main modeler adopted a “prior push forward approach” which is a numerical simulation to search reasonable priors. Negative value of r was truncated at 0 because SMA are still being caught and positive value is more reasonable for the stock of long-term population success. Initial depletion values were taken from a wide range and then various K values were simulated to see whether it is possible to get an increase trend in this population as shown in the CPUEs of main fleets.

The following process allowed us to develop informative priors. For r , the original prior was a broad distribution including a lot of values that led to extinction, so a more restricted, reasonable prior, that was able to lead to a viable population was selected. Next, further filtering was conducted to retain simulations with increasing trends in the population, conditioned on annual catch. Finally, a prior with values of r ranging from 0 to 0.2 was selected. From the same numerical approach, information about initial depletion (x_0) can be obtained. However, it is impossible to obtain a lot of information about K even if we use this numerical approach.

The main modeler mentioned that process error and observation error were estimated within the model.

Discussion

The WG asked about the number of different priors influenced on the population scale. It was answered that in total, 4 CPUE (two USLL, JPLL, and TWLL), 2 catch scenarios (fixed and estimated based on the total fishing effort above 10 N°), and 2 prior scenarios (base productivity and higher productivity) are included in the current approach, this would mean 16 different models.

The WG asked if a working/information paper of the prior push forward work could be provided to help the group better understand the approach. It was responded that the approach used here was from the stock assessment for oceanic whitetip sharks in the Western Central Pacific Ocean (section 2.24). That assessment along with the literature links ([WCPFC/SC15/SA-WP-13; Alternative Assessment Methods for Oceanic Whitetip Shark | WCPFC Meetings](#)) in the presentation file can be used to help understand the prior push forward approach.

8. Bayesian state-space production model for North Pacific shortfin mako

8.1 Review model ensemble approach

Summary and discussions

Over several days of the assessment meeting, the WG examined the results and diagnostics for a large number of preliminary BSPM models to better understand the models and develop a model ensemble to describe stock status. The number of preliminary models investigated are too large to be described in detail here and the model ensemble development was an iterative process with multiple rounds of development and discussions.

Throughout the model ensemble development process, there were several themes and

issues that the WG focused on: 1) candidate indices; 2) catch scenarios; 3) parameter priors; and 4) model diagnostics. The final model ensemble used to describe stock status and the priors for the ensemble can be found in **Table 1**.

Table 1. The combination of 32 scenarios used for the model ensemble. Four models were removed from the final models due to the convergence issue.

No	Index	Prior	Catch	Weight	No	Index	Prior	Catch	Weight
1	USLL1	ExtremeP	EstC (E of LL)	0.05	17	USLL1	ExtremP	EstC (MedF)	0.95
2	USLL2	ExtremeP	EstC (E of LL)	0.05	18	USLL2	ExtremP	EstC (MedF)	0.95
3	TWLL	ExtremP	EstC (E of LL)	0.05	19	TWLL	ExtremP	EstC (MedF)	0.95
4	JPLL	ExtremP	EstC (E of LL)	0.05	20	JPLL	ExtremP	EstC (MedF)	0.95
5	USLL1	Base-P	EstC (E of LL)	0.05	21	USLL1	Base-P	EstC (MedF)	0.95
6	USLL2	Base-P	EstC (E of LL)	0.05	22	USLL2	Base-P	EstC (MedF)	0.95
7	TWLL	Base-P	EstC (E of LL)	0.05	23	TWLL	Base-P	EstC (MedF)	0.95
8	JPLL	Base-P	EstC (E of LL)	0.05	24	JPLL	Base-P	EstC (MedF)	0.95
9	USLL1	ExtremP	EstC (LowF)	0.95	25	USLL1	ExtremP	EstC (LargeF)	0.95
10	USLL2	ExtremP	EstC (LowF)	0.95	26	USLL2	ExtremP	EstC (LargeF)	0.95
11	TWLL	ExtremP	EstC (LowF)	0.95	27	TWLL	ExtremP	EstC (LargeF)	0.95
12	JPLL	ExtremP	EstC (LowF)	0.95	28	JPLL	ExtremP	EstC (LargeF)	0.95
13	USLL1	Base-P	EstC (LowF)	0.95	29	USLL1	Base-P	EstC (LargeF)	0.95
14	USLL2	Base-P	EstC (LowF)	0.95	30	USLL2	Base-P	EstC (LargeF)	0.95
15	TWLL	Base-P	EstC (LowF)	0.95	31	TWLL	Base-P	EstC (LargeF)	0.95
16	JPLL	Base-P	EstC (LowF)	0.95	32	JPLL	Base-P	EstC (LargeF)	0.95

8.1.1 Candidate Indices

During the data preparatory and pre-assessment workshops, the WG examined a number of candidate abundance indices (**Report of ISC SHARKWG meeting in FEB 2024**). The WG found that there was no index that covered the entire spatial distribution of the stock which means indices could be non-representative if the single well-mixed stock assumption isn't met. Furthermore, no index represented the reproductive component of the population due to the lack of observations for large mature females. However, the WG identified four indices that were based on good data sources, appropriately standardized, and best represented the juvenile and sub-adult portions of the population. These indices were: **1) JPLL index; 2) TWLL index; and 3) two indices from USLLs (all area vs core area)** in slightly different but substantially overlapping areas. The WG noted that the data sets for the two USLL indices overlapped substantially and therefore agreed that **the weighting of models with these indices would be half (weighting of 0.5) of the models with the other two indices (weighting of 1.0)**. For each model in the ensemble, only one index will be fit. Therefore, **there will be four abundance index scenarios in the model ensemble**. The WG agreed that the other candidate indices (e.g., Mexico longline index) would be used as sensitivity analyses in the assessment.

8.1.2 Catch scenarios

After the previous assessments (**ISC 2018**), the WG identified a large uncertainty in the estimates of total removals as a major axis of uncertainty. This stock is subject to bycatch interactions with numerous fisheries and the data collected on shark species for many fisheries may be incomplete

throughout the assessment years or collected as aggregated shark categories, especially in the early time before 1994. The WG therefore closely examined several catch scenarios as candidates of model ensemble approach.

The first catch scenario was to assume that the removals were based on the best available estimates from ISC members and RFMOs (i.e., IATTC and WCPFC), and that these were well estimated and known without error. However, preliminary models suggest that assuming catch is known without error results in poor model convergence criteria (>0 divergent transitions). **The WG therefore agreed that these models, which assumes removals are known without error, should not be included in the model ensemble.** Instead, these models would be used as sensitivity analyses.

The second catch scenario was to assume that the removals were based on the best available estimates from ISC members and RFMOs, but that these estimates had substantial uncertainty. Preliminary models with this catch scenario assumption had good convergence criteria. However, the WG noted that setting a prior for F is required for these models because F is estimated by fitting in part to the catch with observation error. Preliminary models found that the model results are sensitive to the F prior used. **The WG agreed that the model ensemble should include models with this catch scenario, which assumes that removals are known with error. The WG also agreed that this catch scenario would contain three sub-scenarios with different F priors: one F prior being consistent with the F s that were estimated in the models where catch was assumed to be known without error; and the other F priors with larger SDs (Low; 0.125, Medium; 0.25, Large; 0.5 Table 1).**

A third catch scenario was based on the total longline fishing effort (i.e., number of hooks) recorded by the tuna RFMOs (i.e., WCPFC and IATTC) and resulted in substantially different catch trends and estimates (**Figure 2**).

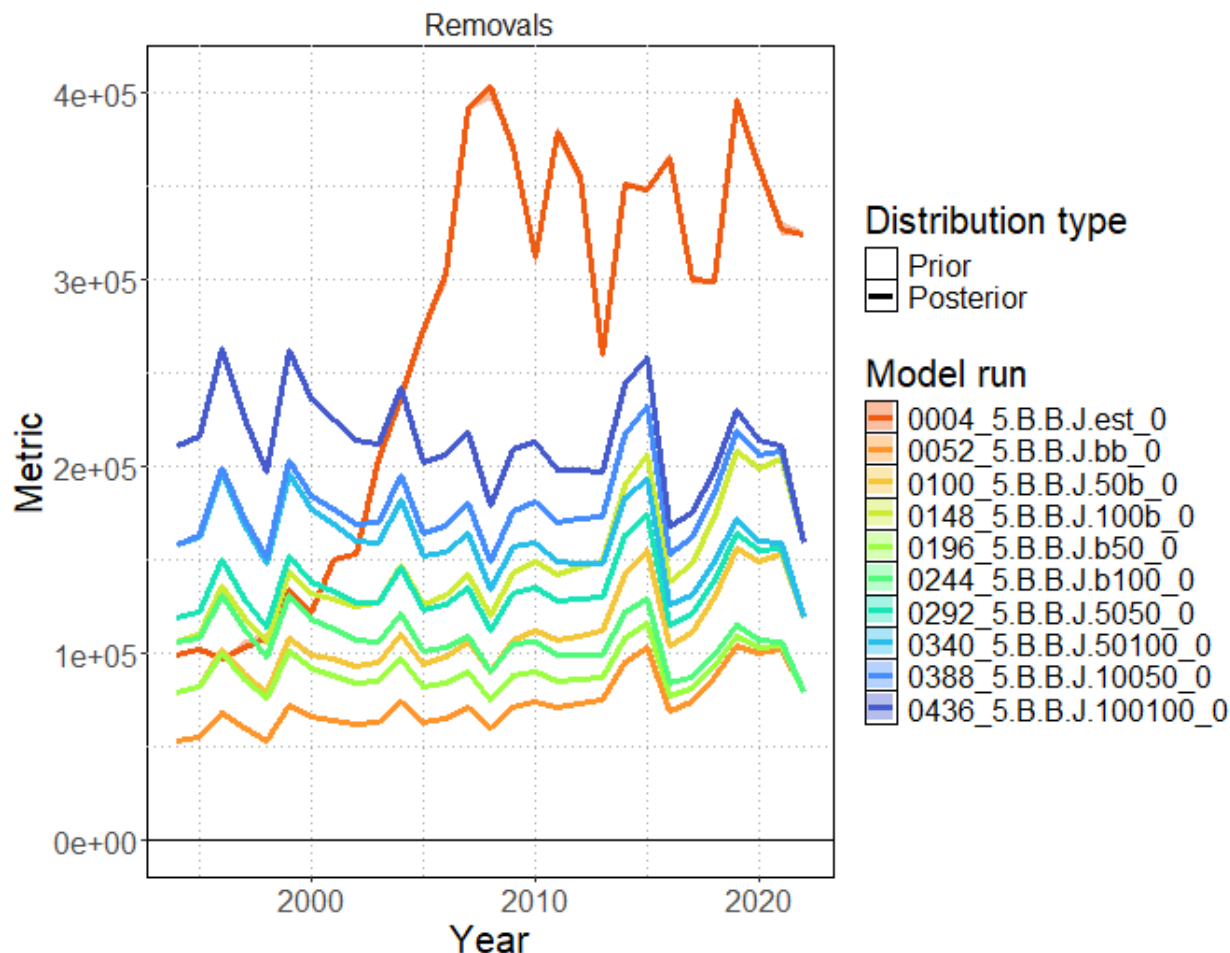


Figure 2. Annual changes in the catches (removals) for different scenarios on the uncertainties in the catches. Red line denotes the estimated catch based on the fishing effort of longline fishery in the North Pacific Ocean above 10 N°. The other lines denote the other under-reporting catch scenarios.

The WG noted that these catch estimates in the terminal year of the time series (i.e., 2022) was approximately ~2-3 times higher than the best available estimates for those years. After much discussion, **the WG agreed that this catch scenario was possible but relatively implausible compared to the other catch scenarios.** Nevertheless, given the uncertainty in the catch estimates, the WG thought it was important to include the impacts of different catch scenarios and incorporate this catch scenario into the model ensemble. However, given that this catch scenario was considered an edge case, **the WG agreed to give this third catch scenario a relatively low weight of 0.05 and give the second catch scenario a substantially higher weight of 0.95.**

8.1.3 Parameter Priors

The model ensemble was made up of BSPMs, which required priors to be set for biological parameters, observation errors, and process errors. The most important biological parameter was the log-K (or K) parameter, which determines the overall scale of the estimated population. In addition, the posteriors of the log-K and intrinsic natural growth rate (r) parameters appeared to be uncorrelated and could therefore be treated independently. Therefore, the WG noted that a single

uninformative prior for log-K would be adequate and appropriate for the model ensemble and would reduce the computational load. Subsequently, the WG also noted that models with an uninformative, uniform prior for log-K had a high proportion of models with divergent transitions, which indicates convergence issues (Monnahan 2024). On the other hand, models with a lognormal prior for log-K with large CVs (~ 1.0) had no obvious convergence issues, likely due to the smoothly changing posterior distribution. **The WG agreed that the model ensemble should use a single, uninformative, lognormal prior for log-K** (see the table of ISC 2024).

The other biological parameters were for r , initial depletion (x_0), and shape parameter (B_{msy}/K). The WG noted that preliminary models with uninformative priors had poor model convergence, likely due to exploration of poorly informed model space. Therefore, the WG developed two sets of moderately informative priors for these parameters that would result in population trends that approximated the observed trends in the abundance indices. One set of priors would tend to correspond with slightly increasing trends while the second set of priors would tend to correspond with strongly increasing trends similar to the observed indices. **After some discussion, the WG agreed that the model ensemble would include two alternative sets of priors for r , x_0 , and shape** (see the table of ISC 2024).

Priors for the observation errors of the abundance indices also needed to be set. It was proposed that the observation errors for the indices should be lognormal and consist of a fixed component (i.e., lower limit for the observation errors) specific to each index and a variable additional component. The fixed components of the observation errors were to be set equal to the estimated errors from the standardization for each index or a CV of 0.2, whichever was greater. The prior for the variable component was the same for each index and were set as half-normal with an SD of 0.2. Preliminary models indicated that each model had different observation errors and a model ensemble with different candidate indices would result in a multimodal posterior of observation errors for the ensemble. After some discussion, **the WG agreed with the proposed approach to setting the priors for the observation errors.**

Process error priors (i.e., process variability) for the model ensemble also needed to be set. After some discussion, the WG agreed to set informative priors based on Winker et al. (2018) for the process error since preliminary runs indicated estimates of process error converged to a similar value using either an informative or uninformative prior.

8.2 Review model diagnostics

Summary and Discussion

The WG examined the model convergence of the model ensemble. The presence of divergent transitions, $R_{\text{hat}} > 1.01$, or effective sample size (ESS) < 100 per chain (Monnahan 2024) were considered to be indicative of poor convergence. Some preliminary models were found to have poor convergence and were excluded from the model ensemble (e.g., see 8.1.2 *Catch scenarios*).

The WG examined the model diagnostics of the model ensemble and found that the model diagnostics were generally good. For example, fits to the candidate indices were generally good for all indices included in the model ensemble, although the fits to the JPLL were superior to the USLL and TWLL indices (**Figure 3**).

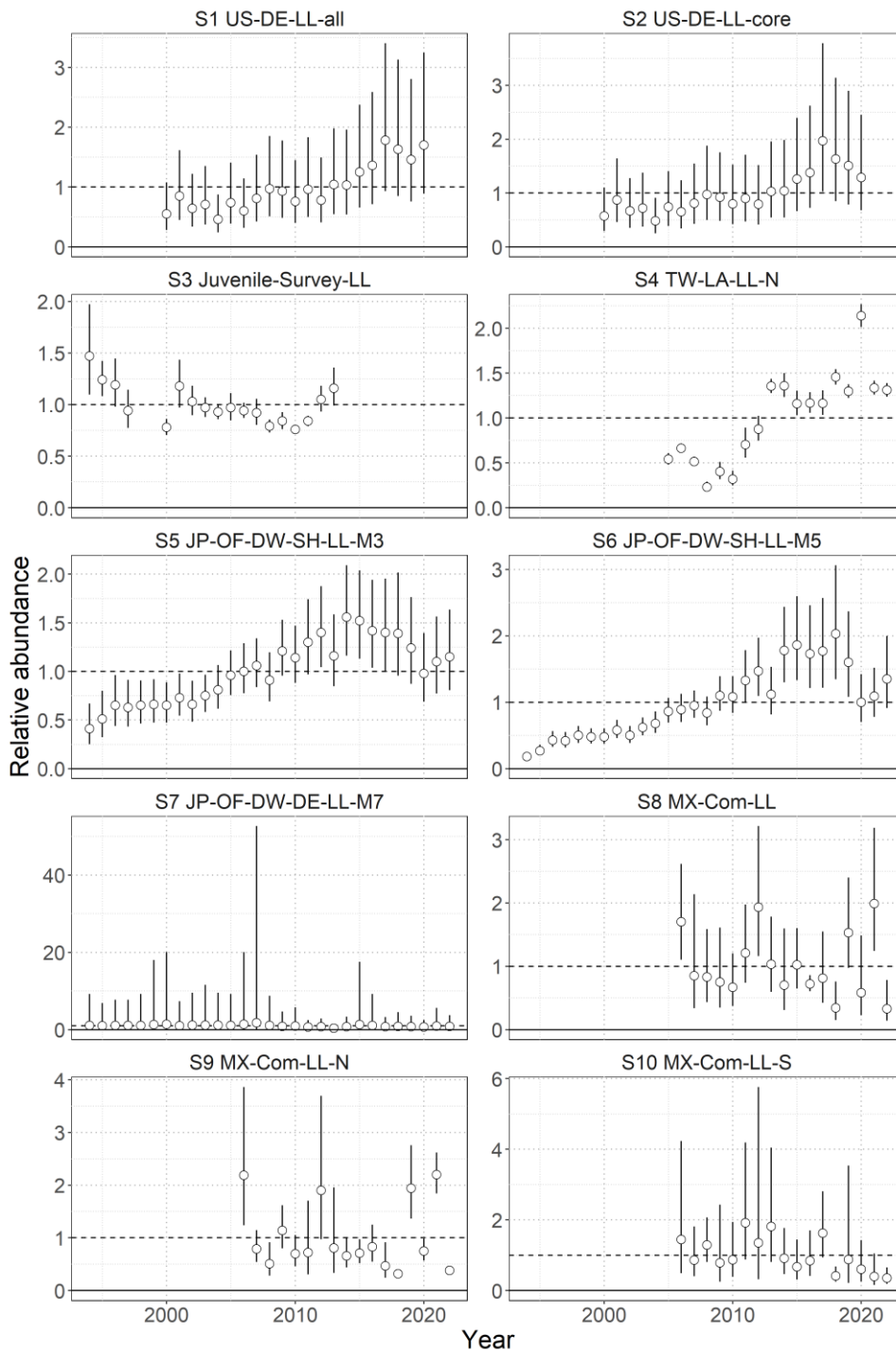


Figure 3. Standardized indices of relative abundance used in the stock assessment model ensemble and sensitivity analyses. Open circles show observed values (standardized to mean of 1; black horizontal line) and the vertical bars indicate the observation error (95% confidence interval).

The WG also performed retrospective analyses, on the model ensemble, and found the diagnostics of the model ensemble to be adequate (Table 2).

Table 2. Model configuration, ensemble weight and diagnostics for each model in the Bayesian state-space surplus production model (BSPM) ensemble.

Model	Weight (relative)	Index	Prior type	Catch	Divergences	\hat{R}	N_{eff}	Converged	RMSE	Mohn's ρ	Coverage (D/D_{MSV})	Coverage (U/U_{MSV})	MASE
1	0.026	1	Baseline	Est. (Longline)	0	1.007	639	Y	0.202	-0.011	100%	100%	1.821
2	0.026	2	Baseline	Est. (Longline)	0	1.006	876	Y	0.225	0.001	100%	100%	1.387
3	0.053	4	Baseline	Est. (Longline)	0	1.008	717	Y	0.312	-0.018	100%	100%	0.763
4	0.053	5	Baseline	Est. (Longline)	0	1.003	754	Y	0.133	-0.059	100%	100%	1.870
5	0.026	1	Extreme	Est. (Longline)	0	1.011	815	N	0.191	-0.035	100%	100%	1.376
6	0.026	2	Extreme	Est. (Longline)	0	1.004	805	Y	0.215	-0.045	100%	100%	1.164
7	0.053	4	Extreme	Est. (Longline)	0	1.004	667	Y	0.308	0.004	100%	100%	0.824
8	0.053	5	Extreme	Est. (Longline)	1	1.009	698	N	0.134	0.026	100%	100%	2.253
9	0.5	1	Baseline	Est. (F - H)	0	1.006	798	Y	0.202	0.036	100%	100%	1.721
10	0.5	2	Baseline	Est. (F - H)	0	1.007	789	Y	0.221	0.003	100%	100%	1.322
11	1	4	Baseline	Est. (F - H)	0	1.007	794	Y	0.326	-0.007	100%	100%	0.772
12	1	5	Baseline	Est. (F - H)	0	1.012	630	N	0.136	-0.100	100%	100%	1.962
13	0.5	1	Extreme	Est. (F - H)	0	1.005	807	Y	0.186	-0.023	100%	100%	1.191
14	0.5	2	Extreme	Est. (F - H)	0	1.006	839	Y	0.212	-0.014	100%	100%	1.116
15	1	4	Extreme	Est. (F - H)	0	1.008	772	Y	0.313	-0.028	100%	100%	0.828
16	1	5	Extreme	Est. (F - H)	0	1.006	763	Y	0.138	-0.060	100%	100%	2.688
17	0.5	1	Baseline	Est. (F - M)	0	1.006	769	Y	0.203	0.036	100%	100%	1.720
18	0.5	2	Baseline	Est. (F - M)	0	1.009	703	Y	0.221	0.042	100%	100%	1.333
19	1	4	Baseline	Est. (F - M)	0	1.007	767	Y	0.326	0.025	100%	100%	0.748
20	1	5	Baseline	Est. (F - M)	0	1.007	667	Y	0.137	-0.105	100%	100%	1.916
21	0.5	1	Extreme	Est. (F - M)	0	1.006	600	Y	0.185	0.005	100%	100%	1.110

Table 2 (continued). Model configuration, ensemble weight and diagnostics for each model in the Bayesian state-space surplus production model (BSPM) ensemble.

Model	Weight (relative)	Index	Prior type	Catch	Divergences	\hat{R}	N_{eff}	Converged	RMSE	Mohn's ρ	Coverage (D/D_{MSY})	Coverage (U/U_{MSY})	MASE
22	0.5	2	Extreme	Est. (F - M)	0	1.007	813	Y	0.211	0.045	100%	100%	1.026
23	1	4	Extreme	Est. (F - M)	0	1.007	797	Y	0.312	0.007	100%	100%	0.831
24	1	5	Extreme	Est. (F - M)	0	1.007	842	Y	0.139	-0.092	100%	100%	2.774
25	0.5	1	Baseline	Est. (F - L)	0	1.009	566	Y	0.203	0.051	100%	100%	1.731
26	0.5	2	Baseline	Est. (F - L)	0	1.006	768	Y	0.222	0.051	100%	100%	1.307
27	1	4	Baseline	Est. (F - L)	0	1.006	785	Y	0.325	0.010	100%	100%	0.756
28	1	5	Baseline	Est. (F - L)	0	1.005	785	Y	0.135	-0.107	100%	100%	1.932
29	0.5	1	Extreme	Est. (F - L)	0	1.01	667	Y	0.186	0.013	100%	100%	1.115
30	0.5	2	Extreme	Est. (F - L)	0	1.012	696	N	0.212	0.023	100%	100%	1.014
31	1	4	Extreme	Est. (F - L)	0	1.006	789	Y	0.312	-0.020	100%	100%	0.837
32	1	5	Extreme	Est. (F - L)	0	1.005	770	Y	0.14	-0.103	100%	100%	2.795

The WG examined the effect of using a BSPM to estimate the population dynamics of a stock with long longevity, late female maturity (230 cm PCL; ~age-12), and growth and maturity at size significantly different by sex (Semba et al. 2017). The WG was concerned that a production model does not have enough structure to account for the sex-and-age specific structure of SMA, which may lead to biased results. Therefore, the WG used a series of age-structured production model (ASPM) simulations, with biological parameters that were consistent with the assessment, as operating models and the BSPM models from the assessment as estimation models, to estimate the potential bias of the BSPM estimates. The model structures and parameters of the ASPM operating models mimicked the preliminary SS3 models developed in the pre-assessment workshops. The primary difference is that low-fecundity stock recruitment relationships were used for stock-recruitment. 1,000 biological scenarios of ASPM simulations were performed and resulted in widely varying population and abundance index trajectories. Given that the primary indices fitted in the BSPM had increasing trajectories, the WG considered it is important to only use the simulations with increasing indices (average terminal index values $\geq 150\%$ of the average initial index values). The WG noted that the terminal year estimates of depletion (D) in the BSPM had a median bias of $\sim 7\%$ as compared to the ASPM operating models. The WG agreed that the estimated bias should be clearly reported in the assessment report but noted that the ASPM simulations have similar issues to the BSPM estimation models including large uncertainties in the biological parameters and catch data. Therefore, **the WG agreed that the reported bias and corresponding corrections should be treated with caution in the determination of stock status and any potential fisheries management.**

8.3 Review sensitivity analysis

Summary and Discussion

The WG noted that the most important sensitivities were already included in the model ensemble, and therefore sensitivity analyses are relatively less important for this assessment as compared to assessments using a base case model approach. The WG examined some of the sensitivity models and found them to have expected results. The WG also developed a list of sensitivity models (see the table of ISC 2024) to be included in the assessment report.

8.4. Final conclusions of model ensemble

The WG examined the results of the final model ensemble in detail. The model ensemble consisted of 32 scenarios, but 4 scenarios were found to have convergence issues (**Table 1**). The results from the converged models were compared with the full model ensemble, which showed that removing the models with convergence issues did not affect the overall results of the assessment. Therefore, the models with convergence issues were not used to determine stock status and all further analyses did not use these models.

The WG also found that the indices in the model ensemble were well fitted. The model ensemble also showed negligible retrospective patterns, with the majority of models having a Mohn's rho between -0.10 and 0.05 in the converged models (**Table 2**). The WG examined the posterior distributions of parameters and important management quantities and found the model ensemble results to be reasonable and useful to determine stock status and develop conservation information.

The WG examined the bias of surplus production model using simulations based on the age-structured production model that suggest that under circumstances representative of the observed SMA fishery and population characteristics (e.g. dome-shaped index selectivity, long lag to maturity, and increasing indices), the BSPM ensemble may produce biased results. Representative simulations suggested that the $D_{2019-2022}$ estimate has a positive bias of approximately 7.3 % (median).

9. Establishment of work plan for the stock assessment report

9.1 Finalize the outcomes of model ensemble approach, model diagnostics, sensitivity analysis, and future projection.

Discussion

The WG agreed that future projections should include current U, $U \pm 20\%$, and U_{MSY} . It was noted that these projection scenarios were applied to the last stock assessment to provide future projections.

9.2 Distribute the draft of stock assessment report.

Discussion

The WG agreed that the summaries provided in relevant Working Papers for catch and CPUE input data can be used in the Data section of the stock assessment report. The lead author was concerned about completing the draft document in time for distribution to the WG members and **it was agreed that as sections are completed, they will be distributed via email for comment.** The draft stock assessment will be compiled and ready for final distribution to the WG by **May 23, 2024 (US time).** **The WG agreed that the Executive Summary, which will be drafted during this current meeting, can be finalized within a week, and distributed to the IATTC, which has requested to receive it prior to their SAC meeting.**

9.3 Complete the stock assessment report

Discussion

The WG member committed to the provision of comments and acceptance of the draft stock assessment in a timely manner to allow for completion and distribution to the Plenary by June 1, 2024.

10. Other matters

10.1 Election of ISC SHARKWG Chair and Vice Chair

Discussion

The WG agreed to hold elections at the June 17, 2024, half day WG meeting in Victoria, BC. Suggested nominations include Mike Kinney (US, Chair) and Yasuko Semba (Japan, Vice Chair). **The WG agreed that the role of Data Manager (currently Yasuko Semba) can be re-assigned to another member if required,** but that it is likely that the responsibilities of Vice Chair will not be too onerous, so it is possible to fulfill both roles.

10.2 Necessity of the indicator analysis for blue shark and shortfin mako

Discussion

The WG agreed that it is necessary to complete indicator analysis based on updated catch and CPUE. In 2025, the indicator analysis for blue shark will be completed.

11. Future SHARKWG meetings

11.1 *A half day meeting before the ISC Plenary (June 17, Canada time)*

Discussion

The WG Chair mentioned that the hybrid meeting will be convened and the WG will conduct the election of Chair and Vice chair. Also, the WG will check the presentation of stock assessment for NP SMA.

11.2 *ISC Plenary (June 19-24, Canada time)*

11.3 *SHARKWG meeting (autumn/winter)*

Discussion

The WG Chair suggested to host the meeting in Japan, and if possible, the meeting will be held in “Kesennuma” city in the northeastern Japan, but if it is impossible, Japan will host the meeting in Yokohama city.

12. Clearing of report

A draft of the report was reviewed by the participants and the content accepted. The Chair will make minor editorial changes and circulate a draft for comments before finalizing the report.

13. Adjournment

The WG Chair thanked everyone for a successful assessment meeting! The meeting was adjourned at 15:54 on Friday May 3, 2024 (US time).

Literature Cited

- ISC. 2018. Stock Assessment of Shortfin Mako Shark in the North Pacific Ocean Through 2016. 18th Meeting of the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean. Yeosu, Republic of Korea, July 11–16, 2018.
- Mucientes, G., Fernández-Chacón, A., Queiroz, N., Sims, D. W., & Villegas-Ríos, D. 2023. Juvenile survival and movements of two threatened oceanic sharks in the North Atlantic Ocean inferred from tag-recovery data. *Ecology and Evolution*, 13, e10198. <https://doi.org/10.1002/ece3.10198>
- Teo, S.L.H., Ducharme-Barth, N.D., Kinney, M. 2024. Developing natural mortality priors for North Pacific shortfin mako sharks. ISC/24/SHARKWG-1/2.
- ISC. 2024. Stock Assessment of Shortfin Mako Shark in the North Pacific Ocean Through 2022. 24th Meeting of the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean. Victoria, British Columbia, Canada, June 17-24, 2024.

**Attachment 1:
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Attachment 2

Meeting Documents, Presentations, and Information Papers

PRESENTATIONS

ISC/24/SHARKWG-3/P1	Summary of pre-assessment and current meeting objectives. Mikihiko kai. (kai_mikihiko61@fra.go.jp)
ISC/24/SHARKWG-3/P2	Stock assessment model update: 01, February 21/22, 2024- Online. Nicholas Ducharme-barth (nicholas.ducharme-barth@noaa.gov)
ISC/24/SHARKWG-3/P3	Stock assessment model update: 02, March 21/22, 2024- Online. Nicholas Ducharme-barth (nicholas.ducharme-barth@noaa.gov)
ISC/24/SHARKWG-3/P4	Stock assessment model update: 03, April 11/12, 2024- Online. Nicholas Ducharme-barth (nicholas.ducharme-barth@noaa.gov)
ISC/24/SHARKWG-3/P5	Stock assessment model update: 04, April 24/25, 2024- Online. Nicholas Ducharme-barth (nicholas.ducharme-barth@noaa.gov)

Attachment 3

SHARK WORKING GROUP (SHARKWG)

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

STOCK ASSESSMENT MEETING (HYBRID) FOR NORTH PACIFIC BLUE SHARK

**April 29-May 3, 2022 (Canada, Mexico: Ensenada; Mexico City, US: Hawaii;
LA Jolla)**

Meeting Hours: 13:00 - 15:45 (Hawaii time; in-person begins ~8:30)

Meeting Hours: 16:00 - 18:45 (Canada, Ensenada, and LA Jolla time)

Meeting Hours: 18:00 - 20:45 (Mexico City time)

**April 30-May 4, 2024 (Japan, China, Chinese Taipei, New Caledonia, and
Republic of Korea)**

Meeting Hours: 10:00 – 12:45 (New Caledonia time)

Meeting Hours: 08:00 – 10:45 (Japan and Republic of Korea time)

Meeting Hours: 07:00 – 9:45 (China and Chinese Taipei time)

DRAFT

1. Opening of SHARKWG Workshop
 - a. Opening remarks (SHARK WG Chair)
 - b. Introductions
 - c. Meeting arrangements
2. Distribution of documents and numbering of Working Papers
3. Review and approval of agenda
4. Appointment of rapporteurs
5. Summary of pre-assessment meeting and current meeting objectives
6. Stock Synthesis (SS3) modeling for North Pacific shortfin mako
 - a. Issues of modelling
7. Review of fishery data and biological parameters.
8. Bayesian state-space production model for North Pacific shortfin mako
 - a. Review of model ensemble approach
 - b. Review of model diagnostics
 - c. Review of sensitivity analysis
9. Establishment of work plan for the stock assessment report
 - a. Finalize the outcomes of model ensemble approach, model diagnostics, sensitivity analysis, and future projection.
 - b. Distribute the draft of stock assessment report.
 - c. Complete the stock assessment report.
 - d. Submit the report to the ISC Chair by June 1st (Canada time).
10. Other matters
 - a. Election of ISC SHARKWG Chair and Vice Chair

- b. Necessity of the indicator analysis for blue shark and shortfin mako
- 11. Future SHARKWG meetings
 - a. A half day meeting before the ISC Plenary (June 17, Canada time)
 - b. ISC Plenary (June 19-24, Canada time)
 - c. SHARKWG meeting (autumn/winter)
- 12. Clearing of report
- 13. Adjournment