FINAL

ISC/24/ANNEX/07

ANNEX 07

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 PRE-ASSESSMENT MEETING OF STOCK ASSESSMENT FOR NORTH PACIFIC SHORTFIN MAKO

June 2024

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REPORT OF THE SHARK WORKING GROUP PRE-ASSESSMENT MEETING OF STOCK ASSESSMENT FOR NORTH PACIFIC SHORTFIN MAKO

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

February 5-9
La Jolla, USA

1. OPENING AND INTRODUCTION

1.1. Welcome and 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 Southwest Fisheries Science Center in La Jolla, US from February 5 to 9, 2024. The primary goal of the workshop was to do the conditioning of Stock Synthesis (SS) modeling for North Pacific (NP) shortfin mako (SMA; *Isurus oxyrinchus*) assessment with new data and new platform, to check the fitting of the base scenarios proposed at the data preparatory meeting, and to test alternative assumptions. In addition, the WG need to establish work plan for the benchmark assessment held in April/May in 2024. Mikihiko Kai, SHARKWG Chair, opened the meeting at 9:00 am on February 5, 2024 (eastern Pacific time). Participants included members from The Inter-American Tropical Tuna Commission (IATTC), Japan, and United States of America (USA) (**APPENDIX 1**). SHARKWG Chair welcomed all participants.

1.2. Distribution of Documents and Numbering of Working Papers

One WG paper was distributed and numbered (**APPENDIX 2**). The WG paper was approved for posting on the ISC website (http://isc.fra.go.jp/) where they will be available to the public after ISC Plenary in June 2024.

1.3. Review and Approval of Agenda

The draft meeting agenda was reviewed, and the agenda was adopted with minor revisions (**APPENDIX 3**).

1.4. Appointment of Rapporteurs

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

Item	Rapporteurs
1-5.	M. Kai
6.	M.V. Carolina (Lead), O. Dan
7.	O. Dan (Lead), M.V. Carolina
8.	S. Teo (Lead), O. Dan
9.	N. Ducharme-Barth (Lead)
10-12.	M. Kai

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

1.5. Summary of Current Meeting Objectives.

The WG Chair mentioned the current main meeting objective as mentioned above in addition to the review of the key biological parameters such as natural mortality schedules and steepness.

2. REVIEW BIOLOGICAL PARAMETERS FOR NORTH PACIFIC SHORTFIN MAKO STOCK ASSESSMENT

Discussion

The discussion started with the philosophy to be adopted for the construction of the model ensemble. The WG decided that the modelling 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 highest-level hypotheses should be the uncertainty about stock structure. The CM was based on the Ph.D. study of Semba, and 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 WG noted that the connections of adult SMA between WPO and central Pacific (CPO) and between CPO and EPO are uncertain. Only a few tagging studies have been conducted in the NP. Large adult females can be observed only in summer north of the main Hawaiian island, show indicating that large individuals may be mating. The WG still have a few questions such as whether there is the site fidelity of adult females in the WPO and EPO, whether there are two discrete populations, or there is mixing between them. 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 PCL). More mature males are caught by these fleets than mature females.

The WG clarified that the juveniles are defined to be between 0 to 2 years old and subadults to the more than about 3 years old and less than the age at 50% maturity.

The next hierarchical level should be the assumptions about growth, which should be associated with compatible with assumptions for other life-history parameters such as natural mortality.

The WG mentioned that it is good that the Chinese Taipei weight frequency data is available.

2.1. Update the Value of Steepness and Check the Suitability of this Parameter for the Shortfin Mako from the Standpoint of the Biology.

Stock-Recruitment Relationships of Shortfin Mako, Isurus oxyrinchus, in the North Pacific. Mikihiko Kai (ISC/24/SHARKWG-2/1)

This working paper provides estimates of steepness, which represents a fraction of the unfished recruitment when spawning stock biomass is 20% of the unfished spawning stock biomass, for the stock assessment of NP SMA in 2024. The author applied an existing age-structured model considering reproductive ecology of elasmobranchs. A suite of values of steepness for NP SMA were estimated using numerical simulations with multiple combinations of life history parameters such as updated growth curve, natural mortality, reproductive cycle, and fecundity. The mean value and standard deviation of steepness with the Beverton-Holt (BH) model for 17 scenarios of biological parameters were 0.228 and 0.086. These results suggested that the stock-recruitment relationship in the NP SMA remains little density-dependent and that its productivity is much lower than that of shortfin mako in the Atlantic Ocean. The author therefore recommends reconsidering the selection of key biological parameters such as growth, natural mortality, and reproductive cycle for the stock assessment, and/or to do down-weight (or remove) such unreasonable low productivity scenarios from the assessment.

Discussion

The WG questioned about the link between body weight (spawning biomass) and reproductive output (number of recruitment) whether the body weight is reasonable to use for the estimation of steepness for shortfin mako. The WG mentioned that, since the body weight of female is just a proxy of reproductive output, it may be better to use the number of pups directly. The number of pups can vary by body length of the adult female, so 3 fecundity scenarios (constant, linear relationship with length, and power function with length) were suggested to use to derive a prior for steepness for the upcoming stock assessment. The WG noted that S3 (pre-recruitment survivorship) is calculated based on the natural mortality (M) of adults and maybe the M for juveniles should be given with higher value. The WG also noted that the assumption for S3 will be influential in the calculation of steepness. The WG clarified that "days to recruit" is 180 days, based on the information about the catch of small sized SMA. The WG finally decided that the meaning of 'recruitment' should be defined to be 0 (at births).

The WG discussed the constant M assumption and concluded that higher M for juveniles is more plausible because of their smaller body size. The WG also asked about reason for the use of gamma distribution for M instead of a lognormal distribution. It was responded that the gamma distribution was used in the published paper (Kai, 2020). The WG suggested to use a lognormal prior for M because this was what was developed by Teo (2024) to estimate the Ms in the data preparatory meeting, and the lognormal distribution has a longer tail. The WG pointed out that the M for each run should be draw only once from the natural mortality distribution, so the procedure (iii) of numerical simulation is not necessary in the calculation. The WG also pointed out to use only compatible assumptions for growth and natural mortalities (e.g., JPN growth with JPN M). The WG mentioned that the assumptions for the steepness should be consistent with the other life history parameters (growth, M, reproductive cycle, and fecundity) when modelling the different hypotheses in the ensemble.

The WG noted that the constant M at age for females from the prior distribution of M (Teo et al., 2024) that includes values of 0.05 to about 0.2, which correspond to a steepness of 0.2 to 0.62. The WG discussed the use of allocation method for M (Lorenzen et al., 2022), however, the WG concluded that the high levels of juvenile M predicted by the size seems unrealistic for sharks due to their low productivity. The WG also noted that the juvenile sharks do not have a lot of predators and occupy nursery areas where the predation risk is low. The WG further noted that a potential prior for survival of juvenile could be produce in the future from empirical studies or even from mammals, as their life history strategy is similar to sharks.

The WG finally accepted to use the modified model with the changes in the assumptions and to estimate a suite of the steepness using the following equations:

$$h = \frac{(1-r)\alpha_S\overline{SPR}_f}{4+(1-r)\alpha_S\overline{SPR}_f},$$

where α_S is the average per capita productivity at equilibrium and $\overline{SPR}_f$ is the maximum expected surviving spawner per recruit

$$\alpha_S = \frac{\sum_{a=1}^{a_{max}} N(a)\psi(L(a))p_{f,m}(a)}{\sum_{a=1}^{a_{max}} N(a)},$$

$$\overline{SPR_f} = \sum_{a=1}^{a_{max}} s(a)\psi(L(a))p_{f,m}(a),$$

where $s(a)$: $\exp(-M(a))$ is after-recruit survivorship, $\psi(L(a))$ is fecundity at length at age accounting for the reproductive cycle, $p_{f,m}(a)$ is maturity at age, and $N(a)$ are the equilibrium numbers at age. If the number of pups is assumed to be 1, the computations will be conducted in a per recruit basis. For mako sharks the pre-recruit survivorship is assumed to be 1 given a recruitment at age 0.

The WG estimated steepness parameters for 144 scenarios (2 scenarios of growth curve and natural mortality, 3 scenarios of fecundity, and 2 scenarios of reproductive cycle) after adding 2 options to have age 0 and 1 to have an inflated juvenile M, constant M after that. Steepness simulation scenario produced a very wide range of possible values ranging from near 0 to near 1, though generally falling off being around 0.8. In addition, the large number of draws falling below the theoretical lower limit of 0.2. The WG mentioned that the big factor in the wide range is the spread in the prior on natural mortality (i.e., SD = 0.329 for lognormal model). The WG also showed the narrower range of steepness for all scenarios after the small value of SD (0.05) for M was given, and the range of steepness was from 0.2 to 0.6 and the median value was around 0.31 and these values are consistent with the steepness shown in Kai (2020).

The WG added alternative scenarios, which resulted in 144 total scenarios (3 scenarios of natural mortality rates: 10, 50, 90 percentiles of uncertainty of M with a range of lognormal model with SD = 0.329, 2 scenarios of natural mortality schedules with and without juvenile M), to consider the uncertainty in the natural mortality. Priors on life history parameters were used to generate a prior distribution on steepness, based on life history theory. However, this process also resulted in a very wide range of possible steepness values, ranging from essentially 0 to 1 (**Table 1**). The WG determined to try 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. Unless those attempts failed, then the life history combination resulting in those steepness values would be ruled incompatible with the data.

The WG questioned whether it is necessary to report the MSY reference points, and it was responded that those points are needed. The WG proposed that the option (i.e., age specific Ms) would be to create factorial fixed values of adult and juvenile M, which then by default essentially fixes steepness. The WG mentioned that the option of having a different M for juvenile is sensible but should be tried in the SS3 model first. The WG noted that the ratio of juvenile to adult M could be estimated, conditional on being larger than 1. The WG raised the concern that male natural mortality obtained from empirical equations appears to be too high, which may be because the meta-analysis was teleosts, and there are inconsistencies on the relationship between maximum age, L_{inf}, and age at maturity, for those two life history strategies. The WG therefore propose to maintain juvenile mortality higher than M of adult for both sexes, and then difference for males and females The WG decided to use the M of juvenile base on the literature (Mucientes et al., 2023 see **APPENDIX 4**). Scenarios focusing on using maximum age to inform natural mortality would result in compressing the difference in natural mortality between males and females. The WG asked why not considering a scenario with same M between male and female. The WG noted that if we are focused more on just maximum age, that would push more towards a hypothesis of relatively same M between males and females. The WG also noted that one option would be to only use the maximum age as the estimator for natural mortality.

Table 1. Estimates of steepness for 144 scenarios with different combinations of key biological parameters (growth, natural mortality, fecundity, and reproductive cycle) and uncertainties in the natural mortality (age-specific Ms and low-high values of Ms).

Scenario	Growth curve (approach)	para-k of growth	L1 (cm PCL)	L2 (cm PCL)	M_level	Empirical Eq of M	Use juvenile mortality	Fecundity assumption	Reproductive_cycle (year)	Female Juvenile M	Female adult M	Male Juvenile M	Male adult M	Steepness
1	JP	0.101	65	300	Low (10%)	All combined	TRUE	Constant	2	0.14	0.09	0.14	0.13	0.75
2	JP	0.101	65	300	Low (10%)	All combined	TRUE	Linear	2	0.14	0.09	0.14	0.13	0.89
3	JP	0.101	65	300	Low (10%)	All combined	TRUE	Power	2	0.14	0.09	0.14	0.13	0.76
4	JP	0.101	65	300	Low (10%)	All combined	FALSE	Constant	2	0.09	0.09	0.13	0.13	0.77
5	JP	0.101	65	300	Low (10%)	All combined	FALSE	Linear	2	0.09	0.09	0.13	0.13	0.9
6	JP	0.101	65	300	Low (10%)	All combined	FALSE	Power	2	0.09	0.09	0.13	0.13	0.78
7	JP	0.101	65	300	Low (10%)	All combined	TRUE	Constant	3	0.14	0.09	0.14	0.13	0.58
8	JP	0.101	65	300	Low (10%)	All combined	TRUE	Linear	3	0.14	0.09	0.14	0.13	0.78
9	JP	0.101	65	300	Low (10%)	All combined	TRUE	Power	3	0.14	0.09	0.14	0.13	0.59
10	JP	0.101	65	300	Low (10%)	All combined	FALSE	Constant	3	0.09	0.09	0.13	0.13	0.6
11	JP	0.101	65	300	Low (10%)	All combined	FALSE	Linear	3	0.09	0.09	0.13	0.13	0.8
12	JP	0.101	65	300	Low (10%)	All combined	FALSE	Power	3	0.09	0.09	0.13	0.13	0.61
13	JP	0.101	65	300	Med (50%)	All combined	TRUE	Constant	2	0.22	0.14	0.22	0.2	0.41
14	JP	0.101	65	300	Med (50%)	All combined	TRUE	Linear	2	0.22	0.14	0.22	0.2	0.63
15	JP	0.101	65	300	Med (50%)	All combined	TRUE	Power	2	0.22	0.14	0.22	0.2	0.4
16	JP	0.101	65	300	Med (50%)	All combined	FALSE	Constant	2	0.14	0.14	0.2	0.2	0.45
17	JP	0.101	65	300	Med (50%)	All combined	FALSE	Linear	2	0.14	0.14	0.2	0.2	0.67
18	JP	0.101	65	300	Med (50%)	All combined	FALSE	Power	2	0.14	0.14	0.2	0.2	0.44
19	JP	0.101	65	300	Med (50%)	All combined	TRUE	Constant	3	0.22	0.14	0.22	0.2	0.23
20	JP	0.101	65	300	Med (50%)	All combined	TRUE	Linear	3	0.22	0.14	0.22	0.2	0.43
21	JP	0.101	65	300	Med (50%)	All combined	TRUE	Power	3	0.22	0.14	0.22	0.2	0.23
22	JP	0.101	65	300	Med (50%)	All combined	FALSE	Constant	3	0.14	0.14	0.2	0.2	0.27
23	JP	0.101	65	300	Med (50%)	All combined	FALSE	Linear	3	0.14	0.14	0.2	0.2	0.47
24	JP	0.101	65	300	Med (50%)	All combined	FALSE	Power	3	0.14	0.14	0.2	0.2	0.26
25	JP	0.101	65	300	High (90%)	All combined	TRUE	Constant	2	0.33	0.21	0.33	0.3	0.07
26	JP	0.101	65	300	High (90%)	All combined	TRUE	Linear	2	0.33	0.21	0.33	0.3	0.15
27	JP	0.101	65	300	High (90%)	All combined	TRUE	Power	2	0.33	0.21	0.33	0.3	0.06
28	JP	0.101	65	300	High (90%)	All combined	FALSE	Constant	2	0.21	0.21	0.3	0.3	0.09
29	JP	0.101	65	300	High (90%)	All combined	FALSE	Linear	2	0.21	0.21	0.3	0.3	0.18
30	JP	0.101	65	300	High (90%)	All combined	FALSE	Power	2	0.21	0.21	0.3	0.3	0.08
31	JP	0.101	65	300	High (90%)	All combined	TRUE	Constant	3	0.33	0.21	0.33	0.3	0.03
32	JP	0.101	65	300	High (90%)	All combined	TRUE	Linear	3	0.33	0.21	0.33	0.3	0.07
33	JP	0.101	65	300	High (90%)	All combined	TRUE	Power	3	0.33	0.21	0.33	0.3	0.03
34	JP	0.101	65	300	High (90%)	All combined	FALSE	Constant	3	0.21	0.21	0.3	0.3	0.04
35	JP	0.101	65	300	High (90%)	All combined	FALSE	Linear	3	0.21	0.21	0.3	0.3	0.09
36	JP	0.101	65	300	High (90%)	All combined	FALSE	Power	3	0.21	0.21	0.3	0.3	0.04

Scenario	Growth curve (approach)	para-k of growth	L1 (cm PCL)	L2 (cm PCL)	M_level	Empirical Eq of M	Use juvenile mortality	Fecundity assumption	Reproductive_cycle (year)	Female Juvenile M	Female adult M	Male Juvenile M	Male adult M	Steepness
37	JP	0.101	65	300	Low (10%)	Amax	TRUE	Constant	2	0.14	0.11	0.14	0.13	0.62
38	JP	0.101	65	300	Low (10%)	Amax	TRUE	Linear	2	0.14	0.11	0.14	0.13	0.81
39	JP	0.101	65	300	Low (10%)	Amax	TRUE	Power	2	0.14	0.11	0.14	0.13	0.63
40	JP	0.101	65	300	Low (10%)	Amax	FALSE	Constant	2	0.11	0.11	0.13	0.13	0.64
41	JP	0.101	65	300	Low (10%)	Amax	FALSE	Linear	2	0.11	0.11	0.13	0.13	0.82
42	JP	0.101	65	300	Low (10%)	Amax	FALSE	Power	2	0.11	0.11	0.13	0.13	0.64
43	JP	0.101	65	300	Low (10%)	Amax	TRUE	Constant	3	0.14	0.11	0.14	0.13	0.43
44	JP	0.101	65	300	Low (10%)	Amax	TRUE	Linear	3	0.14	0.11	0.14	0.13	0.65
45	JP	0.101	65	300	Low (10%)	Amax	TRUE	Power	3	0.14	0.11	0.14	0.13	0.43
46	JP	0.101	65	300	Low (10%)	Amax	FALSE	Constant	3	0.11	0.11	0.13	0.13	0.44
47	JP	0.101	65	300	Low (10%)	Amax	FALSE	Linear	3	0.11	0.11	0.13	0.13	0.67
48	JP	0.101	65	300	Low (10%)	Amax	FALSE	Power	3	0.11	0.11	0.13	0.13	0.44
49	JP	0.101	65	300	Med (50%)	Amax	TRUE	Constant	2	0.22	0.17	0.22	0.19	0.23
50	JP	0.101	65	300	Med (50%)	Amax	TRUE	Linear	2	0.22	0.17	0.22	0.19	0.42
51	JP	0.101	65	300	Med (50%)	Amax	TRUE	Power	2	0.22	0.17	0.22	0.19	0.22
52	JP	0.101	65	300	Med (50%)	Amax	FALSE	Constant	2	0.17	0.17	0.19	0.19	0.25
53	JP	0.101	65	300	Med (50%)	Amax	FALSE	Linear	2	0.17	0.17	0.19	0.19	0.44
54	JP	0.101	65	300	Med (50%)	Amax	FALSE	Power	2	0.17	0.17	0.19	0.19	0.24
55	JP	0.101	65	300	Med (50%)	Amax	TRUE	Constant	3	0.22	0.17	0.22	0.19	0.12
56	JP	0.101	65	300	Med (50%)	Amax	TRUE	Linear	3	0.22	0.17	0.22	0.19	0.24
57	JP	0.101	65	300	Med (50%)	Amax	TRUE	Power	3	0.22	0.17	0.22	0.19	0.11
58	JP	0.101	65	300	Med (50%)	Amax	FALSE	Constant	3	0.17	0.17	0.19	0.19	0.13
59	JP	0.101	65	300	Med (50%)	Amax	FALSE	Linear	3	0.17	0.17	0.19	0.19	0.26
60	JP	0.101	65	300	Med (50%)	Amax	FALSE	Power	3	0.17	0.17	0.19	0.19	0.12
61	JP	0.101	65	300	High (90%)	Amax	TRUE	Constant	2	0.32	0.25	0.32	0.28	0.02
62	JP	0.101	65	300	High (90%)	Amax	TRUE	Linear	2	0.32	0.25	0.32	0.28	0.05
63	JP	0.101	65	300	High (90%)	Amax	TRUE	Power	2	0.32	0.25	0.32	0.28	0.02
64	JP	0.101	65	300	High (90%)	Amax	FALSE	Constant	2	0.25	0.25	0.28	0.28	0.03
65	JP	0.101	65	300	High (90%)	Amax	FALSE	Linear	2	0.25	0.25	0.28	0.28	0.06
66	JP	0.101	65	300	High (90%)	Amax	FALSE	Power	2	0.25	0.25	0.28	0.28	0.02
67	JP	0.101	65	300	High (90%)	Amax	TRUE	Constant	3	0.32	0.25	0.32	0.28	0.01
68	JP	0.101	65	300	High (90%)	Amax	TRUE	Linear	3	0.32	0.25	0.32	0.28	0.02
69	JP	0.101	65	300	High (90%)	Amax	TRUE	Power	3	0.32	0.25	0.32	0.28	0.01
70	JP	0.101	65	300	High (90%)	Amax	FALSE	Constant	3	0.25	0.25	0.28	0.28	0.01
71	JP	0.101	65	300	High (90%)	Amax	FALSE	Linear	3	0.25	0.25	0.28	0.28	0.03
72	JP	0.101	65	300	High (90%)	Amax	FALSE	Power	3	0.25	0.25	0.28	0.28	0.01

Scenario	Growth curve (approach)	para-k of growth	L1 (cm PCL)	L2 (cm PCL)	M_level	Empirical Eq of M	Use juvenile mortality	Fecundity assumption	Reproductive_cycle (year)	Female Juvenile M	Female adult M	Male Juvenile M	Male adult M	Steepness
73	US	0.128	65	271	Low (10%)	All combined	TRUE	Constant	2	0.14	0.09	0.14	0.13	0.73
74	US	0.128	65	271	Low (10%)	All combined	TRUE	Linear	2	0.14	0.09	0.14	0.13	0.86
75	US	0.128	65	271	Low (10%)	All combined	TRUE	Power	2	0.14	0.09	0.14	0.13	0.69
76	US	0.128	65	271	Low (10%)	All combined	FALSE	Constant	2	0.09	0.09	0.13	0.13	0.75
77	US	0.128	65	271	Low (10%)	All combined	FALSE	Linear	2	0.09	0.09	0.13	0.13	0.87
78	US	0.128	65	271	Low (10%)	All combined	FALSE	Power	2	0.09	0.09	0.13	0.13	0.72
79	US	0.128	65	271	Low (10%)	All combined	TRUE	Constant	3	0.14	0.09	0.14	0.13	0.55
80	US	0.128	65	271	Low (10%)	All combined	TRUE	Linear	3	0.14	0.09	0.14	0.13	0.73
81	US	0.128	65	271	Low (10%)	All combined	TRUE	Power	3	0.14	0.09	0.14	0.13	0.5
82	US	0.128	65	271	Low (10%)	All combined	FALSE	Constant	3	0.09	0.09	0.13	0.13	0.57
83	US	0.128	65	271	Low (10%)	All combined	FALSE	Linear	3	0.09	0.09	0.13	0.13	0.75
84	US	0.128	65	271	Low (10%)	All combined	FALSE	Power	3	0.09	0.09	0.13	0.13	0.53
85	US	0.128	65	271	Med (50%)	All combined	TRUE	Constant	2	0.22	0.13	0.22	0.21	0.38
86	US	0.128	65	271	Med (50%)	All combined	TRUE	Linear	2	0.22	0.13	0.22	0.21	0.56
87	US	0.128	65	271	Med (50%)	All combined	TRUE	Power	2	0.22	0.13	0.22	0.21	0.32
88	US	0.128	65	271	Med (50%)	All combined	FALSE	Constant	2	0.13	0.13	0.21	0.21	0.42
89	US	0.128	65	271	Med (50%)	All combined	FALSE	Linear	2	0.13	0.13	0.21	0.21	0.61
90	US	0.128	65	271	Med (50%)	All combined	FALSE	Power	2	0.13	0.13	0.21	0.21	0.36
91	US	0.128	65	271	Med (50%)	All combined	TRUE	Constant	3	0.22	0.13	0.22	0.21	0.21
92	US	0.128	65	271	Med (50%)	All combined	TRUE	Linear	3	0.22	0.13	0.22	0.21	0.36
93	US	0.128	65	271	Med (50%)	All combined	TRUE	Power	3	0.22	0.13	0.22	0.21	0.17
94	US	0.128	65	271	Med (50%)	All combined	FALSE	Constant	3	0.13	0.13	0.21	0.21	0.24
95	US	0.128	65	271	Med (50%)	All combined	FALSE	Linear	3	0.13	0.13	0.21	0.21	0.41
96	US	0.128	65	271	Med (50%)	All combined	FALSE	Power	3	0.13	0.13	0.21	0.21	0.2
97	US	0.128	65	271	High (90%)	All combined	TRUE	Constant	2	0.33	0.2	0.33	0.31	0.06
98	US	0.128	65	271	High (90%)	All combined	TRUE	Linear	2	0.33	0.2	0.33	0.31	0.11
99	US	0.128	65	271	High (90%)	All combined	TRUE	Power	2	0.33	0.2	0.33	0.31	0.04
100	US	0.128	65	271	High (90%)	All combined	FALSE	Constant	2	0.2	0.2	0.31	0.31	0.08
101	US	0.128	65	271	High (90%)	All combined	FALSE	Linear	2	0.2	0.2	0.31	0.31	0.14
102	US	0.128	65	271	High (90%)	All combined	FALSE	Power	2	0.2	0.2	0.31	0.31	0.06
103	US	0.128	65	271	High (90%)	All combined	TRUE	Constant	3	0.33	0.2	0.33	0.31	0.03
104	US	0.128	65	271	High (90%)	All combined	TRUE	Linear	3	0.33	0.2	0.33	0.31	0.05
105	US	0.128	65	271	High (90%)	All combined	TRUE	Power	3	0.33	0.2	0.33	0.31	0.02
106	US	0.128	65	271	High (90%)	All combined	FALSE	Constant	3	0.2	0.2	0.31	0.31	0.04
107	US	0.128	65	271	High (90%)	All combined	FALSE	Linear	3	0.2	0.2	0.31	0.31	0.07
108	US	0.128	65	271	High (90%)	All combined	FALSE	Power	3	0.2	0.2	0.31	0.31	0.03

Scenario	Growth curve (approach)	para-k of growth	L1 (cm PCL)	L2 (cm PCL)	M_level	Empirical Eq of M	Use juvenile mortality	Fecundity assumption	Reproductive_cycle (year)	Female Juvenile M	Female adult M	Male Juvenile M	Male adult M	Steepness
109	US	0.128	65	271	Low (10%)	Amax	TRUE	Constant	2	0.14	0.11	0.14	0.13	0.55
110	US	0.128	65	271	Low (10%)	Amax	TRUE	Linear	2	0.14	0.11	0.14	0.13	0.73
111	US	0.128	65	271	Low (10%)	Amax	TRUE	Power	2	0.14	0.11	0.14	0.13	0.5
112	US	0.128	65	271	Low (10%)	Amax	FALSE	Constant	2	0.11	0.11	0.13	0.13	0.57
113	US	0.128	65	271	Low (10%)	Amax	FALSE	Linear	2	0.11	0.11	0.13	0.13	0.74
114	US	0.128	65	271	Low (10%)	Amax	FALSE	Power	2	0.11	0.11	0.13	0.13	0.52
115	US	0.128	65	271	Low (10%)	Amax	TRUE	Constant	3	0.14	0.11	0.14	0.13	0.36
116	US	0.128	65	271	Low (10%)	Amax	TRUE	Linear	3	0.14	0.11	0.14	0.13	0.54
117	US	0.128	65	271	Low (10%)	Amax	TRUE	Power	3	0.14	0.11	0.14	0.13	0.31
118	US	0.128	65	271	Low (10%)	Amax	FALSE	Constant	3	0.11	0.11	0.13	0.13	0.37
119	US	0.128	65	271	Low (10%)	Amax	FALSE	Linear	3	0.11	0.11	0.13	0.13	0.56
120	US	0.128	65	271	Low (10%)	Amax	FALSE	Power	3	0.11	0.11	0.13	0.13	0.32
121	US	0.128	65	271	Med (50%)	Amax	TRUE	Constant	2	0.22	0.17	0.22	0.19	0.17
122	US	0.128	65	271	Med (50%)	Amax	TRUE	Linear	2	0.22	0.17	0.22	0.19	0.3
123	US	0.128	65	271	Med (50%)	Amax	TRUE	Power	2	0.22	0.17	0.22	0.19	0.14
124	US	0.128	65	271	Med (50%)	Amax	FALSE	Constant	2	0.17	0.17	0.19	0.19	0.19
125	US	0.128	65	271	Med (50%)	Amax	FALSE	Linear	2	0.17	0.17	0.19	0.19	0.32
126	US	0.128	65	271	Med (50%)	Amax	FALSE	Power	2	0.17	0.17	0.19	0.19	0.15
127	US	0.128	65	271	Med (50%)	Amax	TRUE	Constant	3	0.22	0.17	0.22	0.19	0.09
128	US	0.128	65	271	Med (50%)	Amax	TRUE	Linear	3	0.22	0.17	0.22	0.19	0.16
129	US	0.128	65	271	Med (50%)	Amax	TRUE	Power	3	0.22	0.17	0.22	0.19	0.07
130	US	0.128	65	271	Med (50%)	Amax	FALSE	Constant	3	0.17	0.17	0.19	0.19	0.09
131	US	0.128	65	271	Med (50%)	Amax	FALSE	Linear	3	0.17	0.17	0.19	0.19	0.18
132	US	0.128	65	271	Med (50%)	Amax	FALSE	Power	3	0.17	0.17	0.19	0.19	0.07
133	US	0.128	65	271	High (90%)	Amax	TRUE	Constant	2	0.32	0.25	0.32	0.28	0.02
134	US	0.128	65	271	High (90%)	Amax	TRUE	Linear	2	0.32	0.25	0.32	0.28	0.03
135	US	0.128	65	271	High (90%)	Amax	TRUE	Power	2	0.32	0.25	0.32	0.28	0.01
136	US	0.128	65	271	High (90%)	Amax	FALSE	Constant	2	0.25	0.25	0.28	0.28	0.02
137	US	0.128	65	271	High (90%)	Amax	FALSE	Linear	2	0.25	0.25	0.28	0.28	0.03
138	US	0.128	65	271	High (90%)	Amax	FALSE	Power	2	0.25	0.25	0.28	0.28	0.01
139	US	0.128	65	271	High (90%)	Amax	TRUE	Constant	3	0.32	0.25	0.32	0.28	0.01
140	US	0.128	65	271	High (90%)	Amax	TRUE	Linear	3	0.32	0.25	0.32	0.28	0.01
141	US	0.128	65	271	High (90%)	Amax	TRUE	Power	3	0.32	0.25	0.32	0.28	0
142	US	0.128	65	271	High (90%)	Amax	FALSE	Constant	3	0.25	0.25	0.28	0.28	0.01
143	US	0.128	65	271	High (90%)	Amax	FALSE	Linear	3	0.25	0.25	0.28	0.28	0.02
144	US	0.128	65	271	High (90%)	Amax	FALSE	Power	3	0.25	0.25	0.28	0.28	0.01

2.2. Revisit the Selection of the Natural Mortality Including the Exploration of the Age-And Sex-Specific Ms

Revisit of Natural Mortality for Shortfin Mako, Isurus oxyrinchus, in the North Pacific. Mikihiko Kai. (ISC/24/SHARKWG-2/P1)

This presentation provides some materials to consider sex- and age-specific Ms because the WG agreed to explore an age structured Ms where (1) M at age-0 is different from those of the other age classes; (2) the early life stages (ages 1-2) have the same Ms between male and female and then splits by sex, at the data preparatory meeting. The new sex-specific growth curves (i.e., JP approach and US approach) were shown to discuss the different Ms by body size and survival rates of ages for male and females were also shown to discuss the plausibility of Ms from the perspective of the survival ratios until the maximum age.

<u>Discussion</u>

The WG noted that the maximum age for males was inconsistent with other biological parameters (i.e., males 29 and females 31). The WG also noted that many individuals were included in the plus group for the SS output in the 2018 assessments. The WG suggested estimating the natural mortality within the model at the stock assessment in 2024. The WG, however, was concerned that the data in the model might not have information about the Ms (i.e., length composition data and their selectivity), and the estimation is influenced by the prior, although it also may be affected by the other data. The WG mentioned that there are maybe inconsistencies with the 2018 assessment model which used relationships for marine mammals (Hoenig 1983), rather than for teleosts as currently used. The WG discussed that the modelling of the sex-specific selectivity will interact with the M by sex-assumptions. The WG noted that the length selectivity may be the same for both sexes, but the age selectivity is differed by age. The WG noted that if there is no information about them in the data, the priors for the age selectivity parameters should be given. The WG discussed as to whether juvenile (age 0 and 1) individuals should have the same M as the “adult” sharks. The WG determined that by default juveniles would have a higher natural mortality than adults, though with the exact ratio of this difference allowed to vary.

3. REVIEW FISHERY DATA FOR NORTH PACIFIC SHORTFIN MAKO STOCK ASSESSMENT

The WG reviewed the fishery data (i.e., annual nominal CPUEs, annual catch, and size composition data combined by year) provided at the data preparatory meetings and after that. The WG generated summary plots of the various available indices (**Figure 1**), along with the subset of indices proposed for use in the assessment (**Figure 2**).

3.1. CPUE

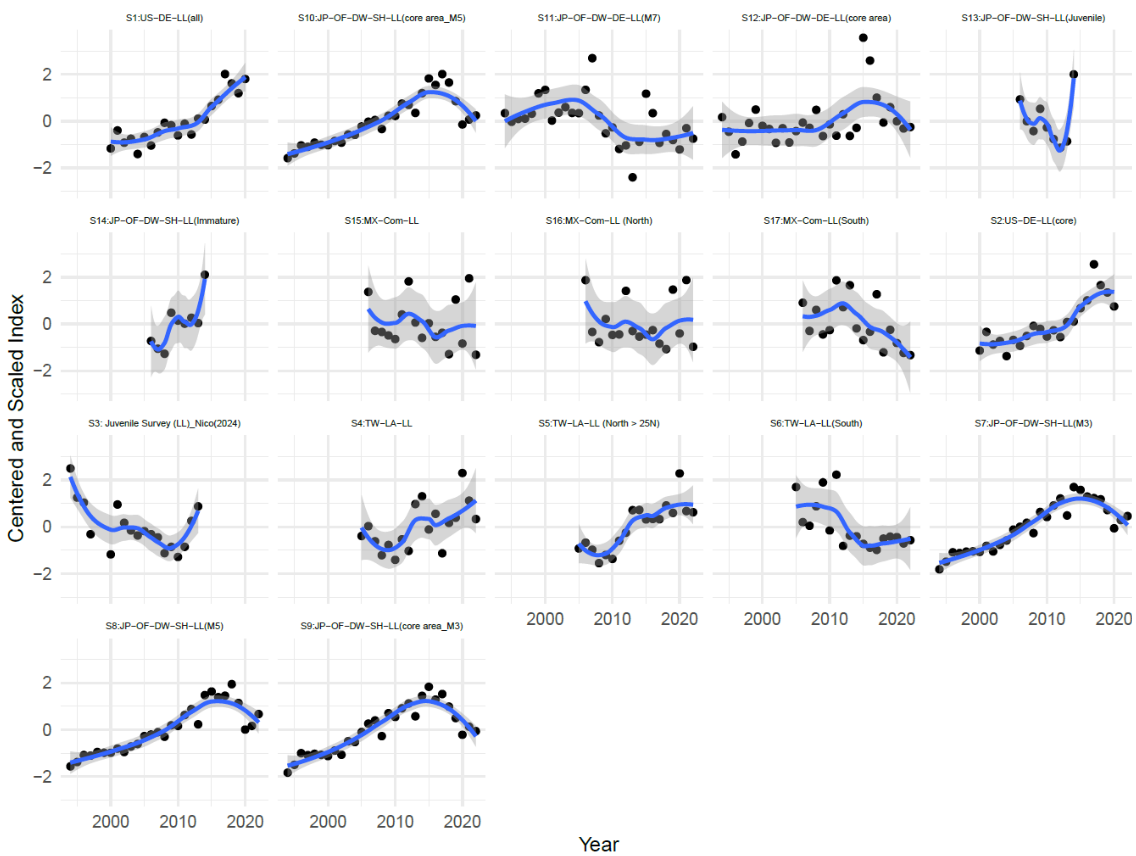

Figure 1. Annual CPUEs of all fleets. Filled black circle denotes the observed CPUE, shaded grey denotes CV of CPUE, and the blue line denotes the fitted through smoothing function.

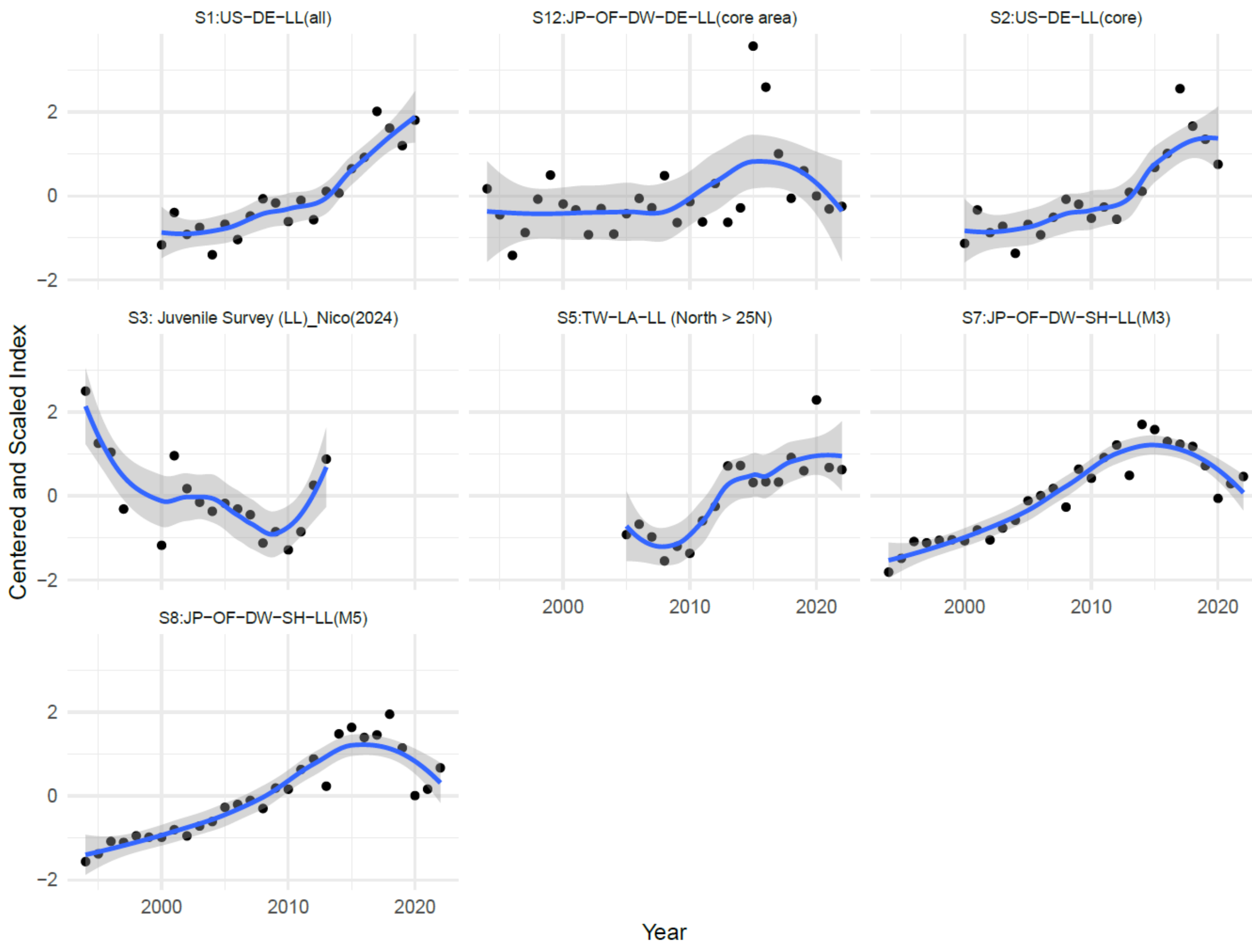

Figure 2. Annual CPUEs of some key fleets. Filled black circle denotes the observed CPUE, shaded grey denotes CV of CPUE, and the blue line denotes the fitted through smoothing function.

Discussion

The WG noted that not having an index in the EPO isn't necessarily a bad thing, depending on hypotheses considered in the model ensemble. If for example there is a large spawning population in the CPO that randomly distributes out to the edges, then the Japanese Kinkai shallow index should be representative of the population. The WG also noted that the Mexican index should not be included due to a large shift in targeting over the history of the fishery.

The WG discussed the weighting methods of the CPUEs and decided to fix the average CV at 0.2 for the index which the average CV is below 0.2. The WG questioned about the high CVs for the index of US fleet and noted that this is likely a model artifact since re-estimating the model with a different configuration resulted in an average CV of 0.33. Given that, the WG rescaled the CV for the US index to 0.33.

The WG suggested at least 4 general scenarios around stock structure developed and paired with key indices:

- Well mixed population in the entire North Pacific
    - US juvenile survey + US Hawaii deep LL + JP Kinkai shallow LL
    - US juvenile survey + JP RTV deep LL + JP Kinkai shallow LL

  - US juvenile survey + TW Large LL north + JP Kinkai shallow LL
- Western and Central Pacific is the main distributional area (i.e., representativeness of the stock)
  - US Hawaii deep LL + JP Kinkai shallow LL
  - JP RTV deep LL + JP Kinkai shallow LL
  - TW Large LL north + JP Kinkai shallow LL
- Eastern and Central Pacific is the main distributional area
  - US juvenile survey + US Hawaii deep LL
  - US juvenile survey + JP RTV deep LL
  - US juvenile survey + TW Large LL north
- Central Pacific is the main distributional area
  - US Hawaii deep LL
  - JP RTV deep LL
  - TW Large LL north

3.2. Catch

Discussion

The catches of many fleets were reconstructed. The WG requested the annual catch of EPO, excluding the main ISC countries (i.e., Japan, US, and Chinese Taipei), be provided. The WG noted that since catches are aggregated by year, it is impossible to start the fishing year when the pupping season occurs. Clarifications about the Mexican longline and artisanal catch data are needed and plausible reconstruction scenarios need to be proposed (see item 9).

3.3. Size Composition Data

Discussion

The WG noted that it is needed to do down-weight the length composition data form the total sample sizes currently being used. Most of the size composition data is not raised to the catch, because the catch is reconstructed for wide areas and cannot be matched with the size composition data. The WG clarified the size bins of length composition data in the SS3 model, and it was responded that 5cm or 7cm size bins and 2-3 kg weight bins were used at the 2018 assessment. The WG noted that the size selectivity is estimated using the size data of own fleet and the size selectivity is mirrored if there is no size composition data or if the data is poor. The WG suggested a tentative fleet definition (Table 2).

Table 2. Summary of tentative fleet definitions with selectivity.

No	Fleet name	Unit	Duration	Country	Selectivity
F1	CA commercial	mt	1986-2014	Canada	F5
F2	US california LL	mt	1981-1994	US	F6
F3	US hawaii shallow-set LL	number	1985-2022	US	F3
F4	US hawaii deep-set LL	number	1971-2022	US	F4
F5	US other commercial and DGN	mt	1981-2022	US	F5
F6	US charter and private recreational	number	2005-2022	US	F32
F7	TW small-scale tuna LL	number	1989-2022	Taiwan	F7
F8	TW large-scale tuna LL north	number	1971-2022	Taiwan	F13
F9	TW large-scale tuna LL south	number	1971-2022	Taiwan	F4
F10	TW Large mesh DGN early	mt	1987-1992	Taiwan	F20
F11	TW high seas squid DGN early	mt	1981-1992	Taiwan	F13
F12	JP Kinkai-shallow LL early	mt	1975-1993	Japan	F13
F13	JP Kinkai-shallow LL late	number	1994-2022	Japan	F13
F14	JP Kinkai-shallow LL discard	number	1994-2022	Japan	F14
F15	JP deep-set LL early	mt	1975-1991	Japan	F16
F16	JP deep-set LL late	number	1992-2022	Japan	F16
F17	JP coastal water and othe LL	mt	1994-2022	Japan	F13
F18	JP coastal water and othe LL discard	mt	1994-2022	Japan	F14
F19	JP trapnet and other fishery	mt	1994-2022	Japan	F13
F20	JP large mesh DGN late	mt	1994-2022	Japan	F13
F21	JP large mesh DGN early	mt	1975-1992	Japan	F13
F22	JP high seas squid DGN early	number	1981-1992	Japan	F13
F23	MX landings north	mt	1976-2022	Mexico	F23
F24	MX landings south	mt	1976-2022	Mexico	F24
F25	MX DGN and artisanal catch	mt	2017-2022	Mexico	F5
F26	IATTC PS	mt	1971-2022	IATTC	F3
F27	IATTC Korea LL	number	2010-2022	Korea	F4
F28	KR high seas squid DGN early	mt	1981-1992	Korea	F13
F29	WCPFC CN LL	number	2002-2022	China	F4
F30	WCPFC LL excluding JP, TW, US, CH,	number	2002-2022	WCPFC	F4
F31	IATTC LL excluding JP, TW, US, MX	number	1971-2022	IATTC	F4
F32	US survey	number	1994-2013	US	F32

4. STOCK SYNTHESIS (SS3) MODELING FOR NORTH PACIFIC SHORTFIN MAKO

Discussion

The WG reviewed the predicted steepness based on the 10%, 90% and median values of M (juvenile, male, and female) as well as combinations of fecundity, maturity parameters (Table 1). Some combinations of low and high M, fecundity, maturity parameters result in very low (<0.2) and high steepness values. Although some of the steepness values appeared to be implausible based on our current understanding of mako shark biology, the WG decided to run preliminary models with the entire ensemble of steepness values, and see if the population dynamics makes sense, and re-evaluate at the online meetings that will be held a few times before the assessment meeting.

4.1. Update the Version of SS3 and Datasets

The WG updated the version of SS3 using the previous datasets in 2018 except for the parameter of length-weight relationships which was corrected, and the similar outcomes were obtained without issues. The WG ran preliminary models with the new datasets in 2024 to the new version of SS3.

4.2. Conduct the Conditioning of SS and Select the Reasonable Combinations of Datasets.

The WG decided on hypotheses that translate into the combination of particular indices of abundance (see item 7.3). The final set of runs should be decided after a reasonable "ancestral" model is developed.

4.3. Test Alternative Assumptions.

Several assumptions were discussed and will be taken into account when developing the final "ancestral" model.

5. ESTABLISH WORK PLAN FOR STOCK ASSESSMENT

The WG decided to meet about every 2-3 weeks online to discuss progress with the assessment models. The first meeting with be held not later than the end of February. The first tentative date is February 22th 4PM (San Diego time).

The WG noted that catch data will be updated with data from IATTC.

The WG also noted that Mexican catches should be checked and a description of how the catches for the artisanal fisheries were obtained should be provided. A clarification about the provided catches should be given as it constitutes substantial proportion of the catches in the later years. In particular, these questions should be addressed: are catches for all sharks or only mako shark, is there double counting between the longline and the artisanal catches, what would be plausible scenarios for catch reconstruction when data is not available.

Preliminary runs will be:

- ✓ fitting to the CPUE data and downweighing the composition.
- ✓ increase the total catch before 1994.
- ✓ start the model after 1993 and estimate the initial_F and early recruitment deviations (not fitting to the equilibrium catch).

Schedule of reporting for the stock assessment including the arrangement of tasks.

- ✓ Executive summary to be drafted at the next hybrid meeting at Honolulu.
- ✓ Tentative deadline for the full report: 19th of May 2024.

6. OTHER MATTERS

The WG asked if the annual catch of Mexico in the North (Landings of Baja California state and Sur) and South (Landings of Sinaloa, Nayarit, Colima) include the catch of artisanal and driftnet fisheries from 2017 to 2022 that was presented at the data preparatory meeting in January. The WG clarified that the artisanal and driftnet catch has already been included in both catch of landings. Therefore, the WG decided to remove the artisanal and driftnet catch of Mexico from the data set of SS.

7. FUTURE SHARKWG MEETINGS

7.1. Stock Assessment Meeting for SMA (Honolulu /April 29-May 3 in 2024)

The WG discussed the time schedule of the meeting and confirmed the available time of the meeting room (until 3:45 pm), so the WG decided that the ISC SHARKWG Chair will arrange the meeting schedule including whether we will do the hybrid meeting.

7.2. ISC Plenary (Canada, JUNE in 2024)

The ISC SHARKWG Chair announced that the election of ISC SHARK WG Chair and Vice Chair will be held at the upcoming ISC Plenary meeting, June in 2024.

8. 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.

9. ADJOURNMENT

The WG Chair thanked everyone for a productive meeting! The meeting was adjourned at 16:30on Friday February 9, 2024 (US time).

LITERATURE CITED

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82: 898–903.

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APPENDIX 1: LIST OF PARTICIPANTS

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APPENDIX 2: MEETING DOCUMENTS AND INFORMATION PAPERS

WORKING PAPERS

ISC/24/SHARKWG-2/1	Stock-recruitment relationships of shortfin mako, *Isurus oxyrinchus*, in the North Pacific. **Mikihiko kai.** (kai_mikihiko61@fra.go.jp)

PRESENTATIONS

ISC/24/SHARKWG-2/P1	Revisit of natural mortality for shortfin mako, *Isurus oxyrinchus*, in the North Pacific. **Mikihiko kai.** (kai_mikihiko61@fra.go.jp)

APPENDIX 3: AGENDA

SHARK WORKING GROUP (SHARKWG)

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

Pre stock assessment meeting for North Pacific shortfin mako in La-Jolla, USA

February 5-9, 2024
Meeting Hours: 09:00 – 16:00 (La-Jolla)
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 current meeting objectives
6. Review biological parameters for North Pacific shortfin mako stock assessment.
7. Review fishery data for North Pacific shortfin mako stock assessment.
8. Stock Synthesis (SS) modeling for North Pacific shortfin mako
9. **Establish work plan for stock assessment**
10. **Other matters**
11. **Future SHARKWG meetings**
    a. Stock assessment meeting for shortfin mako (Honolulu, APR29-May3 in 2024)
    b. ISC Plenary (Canada, JUNE 17-24 in 2024)
12. **Clearing of report**
13. **Adjournment**

APPENDIX 4: SURVIVAL RATIO OF JUVENILE SHORTFIN MAKO

Mucientes et al. (2023) provide estimates of dispersal, survival, and proportion of fishing mortality in the North Atlantic for the shortfin mako shark (*Isurus oxyrinchus*). Their results are based on multi-event models applied to tag-recovery of 132 shortfin makos tagged over a decade. A total of 30 makos (22.73%) were recovered by the longline fishery between 2009 and 2017. Tag-reporting rate (percentage of returned information when a tagged shark was caught) was estimated to be high (0.794 ± 0.232 SE). Mean annual survival, as predicted was 0.618 ± 0.189 SE for shortfin mako. Models predicted that fishing caused more than a half of total mortality in the study area for the species was 0.576 ± 0.209, and more than a third of tagged individuals dispersed from the study area permanently (0.359 ± 0.073).