FINAL

ISC/18/ANNEX/07

ANNEX 7

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

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP

17-23 January 2018
Honolulu, Hawaii, USA

July 2018

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Annex 7

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP
International Scientific Committee for Tuna and Tuna-like Species
In the North Pacific Ocean

17-23 January 2018
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1.0 INTRODUCTION

An intercessional workshop of the Billfish Working Group (BILLWG) of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) was convened in Honolulu, Hawaii, USA during 17-23 January 2018. The goal of this workshop was to prepare fishery data for the stock assessment of North Pacific swordfish in 2018 including catch by quarter data, standardized catch-per-unit effort (CPUE), size composition data by quarter, tagging data, and life history parameters.

Jon Brodziak, Chair of the BILLWG, welcomed participants from Chinese Taipei, Japan, the United States of America (USA) and the Inter-American Tropical Tuna Commission (Attachment 1). The Chair noted that there were no meeting participants from China, Korea, Canada, or Mexico.

2.0 ADOPTION OF AGENDA AND ASSIGNMENT OF RAPPORTEURS

Rapporteuring duties for the working group (WG) were assigned to Jon Brodziak, Yi-Jay Chang, Shane Griffiths, Russell Ito, Hirotaka Ijima, Minoru Kanaiwa, Michelle Sculley and Annie Yau. The meeting agenda was adopted on January 17, 2018 (Attachment 2).

3.0 COMPUTING FACILITIES

Computing facilities included a Google drive named "ISC BILLWG" for the distribution of working papers (WPs) and other meeting documents and the transfer of other information as well as a Wi-Fi wireless network access point for connection to the Internet.

4.0 DISTRIBUTION OF WORKING PAPERS AND STATUS OF ASSIGNMENTS

Working papers were distributed and numbered (Attachment 3) and it was agreed that all finalized working papers would be posted on the ISC website and made available to the public, except for working paper 9 (Attachment 3) by Ijima and Kanaiwa which was considered to be novel research that could be publishable as a journal article.

The work assignments to be addressed at the January 2018 workshop were as follows:

- Submit all outstanding catch, CPUE, and size composition data for the North Pacific swordfish stock assessment to the BILLWG Chair.

- Provide draft working papers, noting that all working papers submitted at this meeting will need to be finalized by February 13, 2018.

- Prepare information, as needed, to make any corrections to the North Pacific swordfish catch, CPUE, and size composition data table for the April 2018 BILLWG stock assessment meeting.

The ISC BILLWG Chair reported that the assignments for submitting all catch, CPUE, and size composition data for the North Pacific swordfish assessment were completed, to the extent practicable, through working paper presentations and personal communications. The Chair noted that some ISC member countries did not submit any new swordfish fishery data. The WG noted that all data and working papers were expected to be submitted to the Chair in electronic format by February 13, 2018.

5.0 REVIEW OF RECENT SWORDFISH FISHERIES

Two working papers on the topic of a review of recent billfish fisheries were presented to the WG by Ito and Sculley. The WG reviewed the working papers and discussed the information with each presenter.

5.1 U.S. swordfish fisheries in the North Pacific Ocean
Presented by Russell Ito (ISC/18/BILLWG-1/1)

U.S. swordfish fisheries in the North Pacific Ocean can be categorized by the gear types employed (harpoon, drift gill net, and longline). Harpoon fishing for swordfish in California is the oldest of the three, dating back to the early 1900's. This fishery primarily supplied the local market for swordfish until the late 1970s. Harpoon catch peaked at 1,699 mt in 1978, subsided to a more typical level the following year, then gradually decreased to a record low level in 2016. The California drift gill net fishery began in 1980 and became the largest U.S. swordfish fishery in the North Pacific Ocean the following year. Catch by this fishery peaked at 2,990 mt in 1985 then decreased in the following years. Swordfish-directed longlining in Hawaii began in 1988 and grew rapidly to become the largest U.S. fishery in the North Pacific Ocean for swordfish by 1990 with catch peaking at 5,936 mt in 1993. Many of the Hawaii-based vessels migrated to California during 2001-2004 then moved back to Hawaii in 2004 and 2005 due to regulatory changes. Some of these vessels continue to migrate between Hawaii and west coast states according to seasonality and fishing conditions.

Discussion

During the discussion, the WG noted that there were swordfish harpoon fishery catch data going back to the 1900s and that it would be positive to gather this information on historical catches. The WG requested that the nominal CPUE series for the California harpoon and gillnet fisheries be provided to the WG.

The WG noted that the Hawaii longline data are separated into “deep” and “shallow” sectors based on hooks per float.

It was noted that there was no direct information on hooks per float in the Hawaii longline logbook data prior to 1995.

The WG requested a map of California harpoon and gillnet fishery catches be provided to show the spatial pattern of catch in relation to the WCNPO/EPO swordfish stock boundary. The map was provided and showed that the virtually all of the swordfish catch occurred in the WCNPO stock region. As a result, the WG concluded that the California harpoon and gillnet fisheries data were to be included in the WCNPO swordfish stock assessment.

The WG discussed the California harpoon fishery for swordfish. It was pointed out that swordfish catches peaked at intervals of roughly 7-8 years in the California harpoon fishery during 1975-2017. These peaks were not as pronounced in the CPUE time series, but were certainly evident in nominal catch time series. The presenter noted that harpoon landings data might be available back to the early 1900s and agreed to enquire with John Childers at the Southwest Fisheries Science Center to gather this information.

The WG noted that the number of vessels in California harpoon declined from ~300 from the early 1990s to 19 in 2016, while the number of drift vessels declined from 225 to 20 over the same period. It was noted that the variability in longline swordfish CPUE was interesting, coincides with both drift gillnet and harpoon. It appears that there are 3-5 year cycles of variability in catch rate success. The reasons for the cyclic variability were not clear but the cycles may be due El Nino affecting local primary productivity, the strength of the North Pacific Gyre and the formation of current ‘fronts’ where productivity is concentrated. It was suggested that the WG could look at the Southern Oscillation Index to investigate whether El Nino/environmental drivers related to swordfish catches in the USA west coast fisheries.

The WG asked why the number of longline vessels targeting swordfish in 1995 was about one-half of the peak number of vessels in 1991. It was explained that the longline effort towards swordfish expanded while the catch per unit effort (CPUE) was around 15 fish per thousand hooks from 1991 but decreased to 10 fish in 1994. The lower CPUE made it financially unfeasible for vessels to travel further and experience declining swordfish catch rates. Longline vessels targeting swordfish declined again in 2002 from Court ordered restrictions due to sea turtle interactions. The shallow-set longline fishery was reopened in 2004 under new regulations to reduce interactions with sea turtles. The WG noted that 2005 was the first complete year for shallow-set longline fishing under the new regulations.

The WG made a request to have a figure produced for WP-01 that that shows the average swordfish CPUE by area during 2005-2015 as a comparison of long-term catch rates to the current 2016 CPUE by area. The presenter noted that the shallow-set longline fishery was shut down in March 2006 because the sea turtle interaction limit was reached. Since the shallow-set fishery was closed during the peak of the swordfish season, nominal annual CPUE was much higher than subsequent years when sea turtle interactions were below the limit and the fishery remained open throughout all or most of the year. Since 2009, the CPUE has been reasonably low with a gradual increase. Swordfish were lean in 2016 due to warmer SSTs than usual from the strong El Nino. Overall, targeting of swordfish has declined in recent years.

5.2 Size composition for swordfish *Xiphias gladius* in the Hawaii-based pelagic longline fishery for 1995-2016
Presented by Michelle Sculley (ISC/18/BILLWG-1/2)

Swordfish (*Xiphias gladius*) size frequency data are summarized for the Hawaii-based longline fishery from the Pacific Islands Regional Observer Program dataset. Data were separated into deep set and shallow set sectors to account for the targeted-species and operational differences between the two sectors. Annual and quarterly mean lengths are presented, as well as a frequency table by year, quarter, and number of swordfish measured per 5 cm length bin. Results show significant inter-annual and annual variability in mean length for the swordfish caught in the deep set sector which targets tuna. Fish caught in quarters three and four were generally smaller and largest fish were caught in quarter two. Fish caught in the deep set sector are generally smaller than those caught in the shallow set sector. Mean length for the shallow set fishery, which targets swordfish, was much less variable. Like the deep set sector, smaller fish were caught in quarter three and larger fish were caught in quarter two in the shallow set sector.

<u>Discussion</u>

The WG was presented with fish size summaries from the PIRO Observer Program length composition data. The summaries included a time series of swordfish measured, spatial distribution, box plots and histograms by shallow set and deep set sectors of the longline fishery. The WG noted that the hooks per float differed between the shallow and deep set sectors. It was also evident that there were differences in mean sizes of swordfish by quarter as well as spatial variation in mean size with larger fish in the northern parts of the WCNPO. The presenter noted that swordfish spawning occurred in quarter 2 and that new age-0 recruits were observed in the quarter 3 length composition data.

The WG agreed to accept the Hawaii length composition data and treat the deep set sector and shallow set sector as two separate fleets.

6.0 FISHERY STATISTICS FOR NORTH PACIFIC SWORDFISH

Six working papers on the topic of fishery statistics for North Pacific swordfish were presented to the WG by Ijima, Chang, Sculley, Kanaiwa and Tagami. The WG reviewed the working papers and discussed the information with each presenter.

6.1 Brief information for Japanese fishery statistics of North Pacific swordfish (*Xiphias gladius*).
Presented by Hirotaka Ijima (ISC/13/BILLWG-1/3)

To apply the North Pacific swordfish datasets caught by Japanese vessels for Stock Synthesis 3, I summarized Japanese catch statistics and size composition data. The logbook data and the yearbook data are available statistics for the fishery catch. The logbook data has reported catch of the longline fishery that includes 5ºx 5º area information. On the other hand, the yearbook did not report the fishing ground, but almost all fisheries that reported yearbook data operated in Japanese coastal waters. The dataset format of size composition data was changed in 1999. The commercial vessels and the training vessels have observed the swordfish size composition of the longline fishery. However, their fishery ground and that size frequency are different. Size composition data of training vessel may not be consistent with Japanese longline selectivity.

<u>Discussion</u>

The presenter noted that Japanese fishery statistics for swordfish were complicated because the Japanese longline vessel category (i.e., the license definition) and the fishery statistics reporting format have changed historically. It was also noted that most of the Japanese catches of swordfish were caught with longline gear.

The WG discussed the change in Japanese logbook format in 1994 and that this change had an effect on the amount of information available for CPUE standardization. The WG concluded that it was appropriate to separate catch and effort data prior to and from 1994 to the present for the purposes of catch and effort analyses.

The presenter showed Japanese swordfish catch data for 11 proposed fleets for the Stock Synthesis assessment model based upon area stratification described in ISC/18/BILLWG-01/09, size composition availability, and fleet operations. The WG suggested that fleet 6 be combined with 10 and fleet 7 be combined with 11, since they have similar selectivities. Japan recommended using the estimated size composition from the weight data prior to 1998 as the sampling coverage of the weight data is better than the length composition data. It was clarified that catch weight prior to 1975 was estimated.

The WG noted that the catch units of the offshore distant water longline fleets (fleets 1, 2, 3, and 4) were numbers of fish while all other fleets reported catch weights. The WG noted that it will be necessary to convert the catches in numbers to catch weights for the purpose of reporting total fishery catch in the stock assessment.

The WG requested information on the amount and percentage of total swordfish catch by fleets 7, 9, and 11 in order to determine whether to combine these fleets for assessment purposes. This request was completed during the meeting and the fleets were combined.

The WG also requested a comparison of two methods for estimating the unknown and unreported catches of swordfish in 2016 for fleets 9 and 11. The two methods were the carryover method in which catch in 2016 equaled catch in 2015 and the percent of total method in which catch in 2016 by fleet was the same percentage of total catch as in 2015. The presenter completed this request during the meeting and applied both methods to the entire time series of observed and estimated catches of fleets 9 and 11 for comparison. The comparison showed that the root-mean squared error (*RMSE*) of the estimated catches using the percent of total method was lower for both fleet 9 ($RMSE_{Carryover}$=165 > $RMSE_{Percent}$=158) and fleet 11

($RMSE_{Carryover}$=144 > $RMSE_{Percent}$=101. As a result, the WG concluded that the percent total method should be applied to estimate catches for fleets 9 and 11 in 2016.

6.2 Catch and length data of swordfish (*Xiphias gladius*) for the WCNPO and EPO areas from the Taiwanese fisheries
Presented by Yi-Jay Chang (ISC/18/BILLWG-1/4)

Catch data of Pacific swordfish by the fisheries of Taiwan during 1954-2016 were obtained from the Oversea Fisheries Development Council of Taiwan. Recent five-years total catches of swordfish in the WCNPO and EPO indicated a decreasing and increasing trend overtime, respectively. Lower jaw fork length data (cm) of swordfish collected from the Taiwanese distant-water longline fishery in the western central North Pacific Ocean and eastern tropical Pacific Ocean were summarized using violin plot during 2004-2016. Length compositions are stable in both areas. However, fish with lower jaw fork length less than 100 cm were not observed after 2014.

Discussion

The WG noted that the Taiwanese swordfish fishery catch and length composition data were aggregated into the WCNPO and EPO regions north of the equator. It was clarified that only the distant water LL has length frequency data. The presenter suggested that the length composition data from 2004 to 2016 be used and that the data collected prior to 2004 not be used due to low sample sizes and data quality issues. The WG made a request to see the sample sizes for length composition data collected prior to 2004 which was completed during the meeting.

There was a question about whether the distant water and offshore longline fleets are similar enough to be combined into one fleet, especially if the offshore longline selectivity will simply mirror the distant water one. It was clarified that the vessel size differs and targeting differs. The distant water longline is more consistently targeting tuna, but the offshore longline targeting varies spatially and temporally. The presenter recommended forming 5 Taiwanese fleets for the stock assessment modeling and the WG agreed with this recommendation.

There was a question about the mean hooks per basket of the distant water longline fleet, in relation to understanding why the mean length of swordfish caught just north of Hawaii seem to be larger than the average size caught by the Japanese and USA fleets.

6.3 Standardization of the swordfish *Xiphias gladius* catch per unit effort data caught by the Hawaii-based longline fishery from 1994-2016 using generalized linear models.
Presented by Michelle Sculley (ISC/18/BILLWG-1/5)

The swordfish (*Xiphias gladius*) catch per unit effort for the Hawaii-based longline fishery was standardized from the Pacific Islands Regional Observer dataset. The fishery was divided into the tuna-targeting deep set sector and the swordfish-targeting shallow set sector. Additionally, the shallow set sector was standardized in two time periods: an early period (1995-2000) and a late period (2005-2016) because the shallow-set fishery was closed from 2001-2004, and regulations caused changes in the fleet operations thereafter. Four different models were evaluated to standardize the CPUE for each time series: the delta-lognormal model, the negative binomial model, the zero-inflated negative binomial model, and the Poisson model. The delta-lognormal model provided the best model fits and explained the most percent deviance of those evaluated. The models explained between 26-65% of the deviance in the shallow set sector and 35% of the deviance in the positive catches for the deep set sector, but only 4% of the proportion of positive catches in the deep set sector. The shallow set standardized annual CPUE values show an increase in catch rates in the early period followed by a peak in 2006 after the closure. CPUE values increased again from 2010 to the present. The CPUE values for the deep set sector were relatively flat and had high variability.

Discussion

It was pointed that using hooks per set as a predictor in the lognormal and the delta-lognormal model implied that hooks per set was being used twice in the CPUE standardization. The dependence of observed CPUE on a predictor implies that the maximum likelihood estimates of the parameters of the CPUE standardization model may be biased due to the correlation between the response and predictors. There was a suggestion that a more appropriate model formulation would be to treat the predictor hooks per set as an offset variable and to remove hooks per set as a predictive variable. As a result, there was a request that a revised CPUE standardization analysis be run in which the predictive variable of the hooks per set was removed. The requested analysis was completed during the meeting and presented to the WG for review and discussion. The WG noted that the CPUE standardization results with and without hooks per set as a predictor were very similar.

The US defines the shallow and deep set longline fishery sectors based on the number of hooks between floats. The WG asked what the basis for this definition was and it was clarified that this is a legal definition for fishery management. Regardless of the definition, US shallow longline sets are generally targeting swordfish.

The WG noted that the diagnostics for the CPUE standardization model fits were good with little patterning and no evidence of substantial misfit or bias. This was true for the original and revised model fits. The WG also noted that the estimated CPUE series from the original and revised CPUE standardization models had very similar trends. Overall, the WG accepted the revised CPUE standardization model in which hooks per float was not included as a predictor of CPUE.

The presenter noted that the deep set sector CPUE may provide an index of swordfish recruitment based on the length composition of deep set catches which included mainly juvenile fish. The WG noted that the fitted standardized CPUE series for the deep set sector was relatively flat, which may be an indication that recruitment has been relatively steady during 1995-2016.

6.4 Standardized catch-rates of swordfish (*Xiphias gladius*) for the Taiwanese distant-water tuna longline fishery in the North Pacific Ocean for 1964-2016 Presented by Yi-Jay Chang (ISC/18/BILLWG-1/6)

CPUE (catch per unit effort) of swordfish caught in the Taiwanese distant-water tuna longline fishery was standardized using delta lognormal generalized linear models for the areas of western central North Pacific Ocean (WCNPO) and eastern tropical Pacific Ocean (EPO). Year, quarter, fishing region, and the two-way interactions between quarter and fishing region were used as predictors in the standardization models for an entire period (1964-2016) and two separate periods of 1964-1999, and 2000-2016 (with and without hooks-per-basket) due to changes in targeting species and fishing ground of this fishery. Results showed that, for both areas, standardized CPUE of swordfish was generally stable during the early period 1964-1999, but increased dramatically after 2000. However, the standardized CPUE of swordfish for the WCNPO stock has stabilized since 2005, while those for the EPO stock showed an increasing trend from 2005 until present.

Discussion

The WG discussed the Taiwanese CPUE standardization analyses consisting of 4 alternative models and their diagnostics. The WG requested to see the proportion of zero observations through time in the CPUE data and this information was provided during the meeting. It was noted that the WCNPO was divided into 6 subareas for the analyses and that these subareas were based on spatial patterns of swordfish CPUE.

Based on the model fits to separate CPUE time series, the WG agreed to accept the CPUE models for separate time periods of 1964-1999 and 2000-2016 because their combined AIC was substantially lower than the CPUE model using the entire dataset for 1964-2016.

The WG noted that the spatial pattern of CPUE for 2001-2010 seemed to indicate that the Taiwanese fleets were fishing in many areas across the Pacific, but this was not observed for other decades. The presenter agreed and noted that the broad spatial pattern in 2001-2010 was likely due to changes in fishing practices and target species.

The WG requested asked for a plot of proportion of catches with zeros through time along with the mean catch. The request was completed during the meeting and showed that after 2000, the catch time series became more stable and had fewer zero observations. The presented noted that after 2000 there was a lot more data collected and that it was more reliable with better spatial coverage.

The WG asked why there was a sharp increase in 2000s in the EPO and noted that this pattern was also evident in the standardized Japanese swordfish CPUE. It was clarified that there were changes in Taiwanese fishing practices and target species during this time period, as shown by the patterns in hooks per float data near the western boundary of the EPO area.

The WG noted that the EPO CPUE time series included catch south of the equator to 20ºS. A map of the swordfish catches in the EPO by decade showed that much of the increase in swordfish catch occurred south of the equator. The WG suggested that removing the data south of the equator would eliminate the observed increase in CPUE; however the WG agreed that the CPUE time series as presented would be acceptable for use in the entire North Pacific assessment model.

6.5 Abundance indices of swordfish (*Xiphias gladius*) by the Japanese offshore and distant-water longline fishery in the North-Western Central Pacific Presented by Minoru Kanaiwa (ISC/18/BILLWG-1/7)

The area-separated standardized CPUE of swordfish caught by Japanese longliners in the Western and central North Pacific Ocean between 1994 and 2016 were provided. In area 1, the Northwest Pacific area, CPUE declined in the early period and increased in the late period. In area 2, the Northern central Pacific area, there was a continuous increasing trend in CPUE.

The area-separated standardized CPUEs between 1975 and 1993 in both area 1 and 2 were provided. The standardization model that was applied to CPUE data in the late period did not converge when applied to the early data. Therefore a simpler CPUE standardization model was applied to the early period CPUE data. While there were no issues for the early CPUE model diagnostics, the amount of residual deviance that was explained by the model in area 2 was low.

<u>Discussion</u>

There was a question about whether the offshore and distant-water fisheries were different enough to combine them without also accounting for them as explanatory variables or splitting out the datasets. The WG agreed to use the Japanese longline standardized CPUE as presented in this working paper for the recent time period from both Areas 1 and 2 separately, with Area 1 CPUE calculated without deep set data because of improved diagnostics.

There was a question about whether CPUE time series for Japanese longline fisheries would be available prior to 1994, and whether they should follow the fleet areas definitions as proposed in Working Paper 9. There is no weight information prior to 1994 to help discern whether the fisheries prior to 1994 exhibit similar spatial patterns. The WG requested that a 2-area CPUE standardization analysis be conducted for the Japanese longline data prior to 1994. This request was completed during the meeting and presented to the WG.

The WG reviewed and discussed the standardized CPUE for Area 1 and Area 2. It was clarified that a generalized linear model was used, although several more model forms were attempted but did not result in convergence (i.e., generalized linear mixed models or glmm, generalized additive models or gam, generalized additive mixed models or gamm). The negative binomial fit much better than the Poisson model based on BIC values. There was a request to include correlation coefficients for nominal vs standardized CPUE series in the working paper.

There was a question about why there are so few shallow sets in Area 2 from mid 1980s to early 1990s. This operation mixes day time and night time operation. Shallow set operations are fewer in later years in area 2 because of shifting from albacore to bigeye tuna. It was noted that Area 1 may indicate adult trends while Area 2 may indicate juvenile or recruitment trends.

The WG agreed to use Area 1 early Japanese longline standardized CPUE time series for the SS3.30 stock assessment model. The WG also agreed to use Area 2 early Japanese longline standardized CPUE rather than nominal CPUE because the standardized model results in proportional weighting of the data across all factors. The WG also agreed to use the standardized CPUE for the entire WCNPO without the area split for any Bayesian production model analyses that might be conducted (ISC/17/BILLWG-1/1).

6.6 Spatial distribution of swordfish catches for longline fisheries in the Western Central North Pacific Presented by Darryl Tagami (ISC/18/BILLWG-1/10)

This working paper presents recent spatial distributions for swordfish (*Xiphias gladius*) caught in the western central North Pacific from 2013-2016. The data were provided by the WCPFC in the North Pacific for longline catches. The purpose is to provide the ISC Billfish Working Group with catch and spatial distribution data for swordfish from WCPFC member countries which are not available in the ISC or ISC Billfish Working Group's data holdings. This represents the first time this catch data has been made available to the ISC for stock assessment purposes.

Discussion

The WG discussed the patterns of swordfish catch and effort by fleet in the WCPFC through time. There was an apparent increase in swordfish catches and CPUE in the western EPO region for both Japanese and Taiwanese longline fleets in the 2000s. It was noted that this increase was likely due to changes in targeting practices by the fleets and changes in swordfish distribution.

The WG also noted that the WCPFC category II catch data that were plotted in this analysis should be augmented with WCPFC category I catch data to provide the most accurate accounting of the total swordfish catch in the WCPFC region.

7.0 REVIEW OF LIFE HISTORY PARAMETERS AND ASSESSMENT MODEL STRUCTURE FOR NORTH PACIFIC SWORDFISH

Two oral presentations and two working papers on the best available information on life history parameters and assessment model structure for North Pacific swordfish were presented to the WG. Brodziak presented life history parameters for North Pacific swordfish from the 2009 and 2014 assessments based on the existing best available information. Sculley presented a comparison of the preliminary 2009 stock synthesis model and an updated 2018 assessment model for swordfish. Ijima presented an analysis of the population dynamics of swordfish using a mixture model for pattern recognition. Jon Brodziak presented an analysis that explored whether recruits-per-spawner deviations as calculated in the 2009 preliminary structured North Pacific swordfish assessment model were correlated with environmental variables. The WG reviewed and discussed the presentations by Brodziak, Sculley and Ijima.

7.1 Review of life history parameters for North Pacific swordfish Presented by Jon Brodziak (Presentation only)

Jon Brodziak presented a summary of swordfish life history parameters which were summarized and provided to the group as part of working paper ISC/17/BILLWG-01/02 by Kapur *et al*.

Discussion

The WG agreed that the presented life history parameters, which were also considered in the 2014 swordfish assessment, were likely the most recent information on swordfish life history in the North Pacific Ocean. Table 9.0 summarizes the life history parameters for the base case model. Another paper was discussed from Sharma and Arocha (2017) on a meta-analysis of life history parameters for North Atlantic swordfish which estimated steepness at 0.92. The WG noted that this was not very different from the value used for the WCNPO swordfish of 0.9. The WG agreed to continue to use the value of 0.9 for steepness. Taiwan also provided two life history research papers, Wang *et al.* (2003) which provided a different estimate of the maturity ogive for swordfish around Taiwan and Sun *et al.* (2002) which provided a different weight-length curve. The WG agreed to use the life history parameters in Kapur *et al.* (2017) for the base case model but also consider using the parameters provided by Taiwan in sensitivity runs.

Maturity ogives are:

$P_{mature}(LJFL) = \frac{1}{1+e^{-0.14(LJFL-168.2)}}$ (Wang *et al.*, 2003)
$P_{mature}(EFL) = \frac{1}{1+e^{-0.103(EFL-143.6)}}$ (Kapur *et al.*, 2017)

Length-weight relationships are:

$W = 1.35*10^{-6}*LJFL^{3.43}$ (Sun *et al.*, 2002)
$W = 1.299*10^{-5}*EFL^{3.07}$ (Kapur *et al.*, 2017)

The WG discussed the bin size for the length frequency data for the assessment. It was noted that in order to obtain separation within the model for all ages, a one centimeter bin size would be necessary. A five-centimeter bin size would allow for separation between swordfish up to age 6 or 7. Because the most of the spawning biomass is aged 3 to 6, the WG agreed a five-centimeter bin size would be adequate for the assessment model. It was suggested that the initial value for effective sample size for the assessment model be calculated using the Pennington et al. (2002) equation using the Japanese and Hawaii size data. It was also noted the Taiwanese and IATTC length composition data were in lower jaw fork length (LJFL) and would need to be converted into eye-fork length (EFL) before using it in the assessment model. An equation to calculate LJFL from EFL was presented to the group: LJFL = 8.01 +1.07*EFL (Sun *et al.*, 2002).

7.2 Preliminary comparisons of the Stock Synthesis assessment model for North Pacific swordfish
Presented by Michelle Sculley (ISC/18/BILLWG-1/8)

This working paper is provided as a reference for preparing for the 2018 benchmark North Pacific Swordfish stock assessment by the ISC Billfish Working Group. It details the parameters and model structure explored in the 2009 benchmark assessment and compares outputs of that assessment using the Stock Synthesis (SS) version SS3.24f used in 2009, with outputs using the most current version of SS, SS3.30. Results from this comparison show that there are no differences in model output from the SS3.24f version to the SS3.30 version, therefore the WG could use the SS3.30 version without continuity concerns.

Discussion

The WG discussed the presentation and noted the consistency between the results of the two SS versions applied to the same preliminary swordfish input data file. The WG noted a minor difference in the values of the total likelihood and it was clarified that this difference in total likelihood values was the result of the new parametrization SS 3.30. The WG also noted that the original input file did not include size composition data therefore the structure of model was simpler than what will be used for the benchmark assessment model. Overall, the WG concluded there were no apparent differences between the results from SS 3.24 and 3.30.

7.3 Pattern recognition of population dynamics for North Pacific swordfish (*Xiphias gladius*)
Presented by Hirotaka Ijima (ISC/18/BILLWG-1/9)

Size selectivity is the fundamental assumption configuring the fishery definition of integrated stock assessment models such as the stock synthesis 3. The selectivity needs to be defined by fishing area because usually selectivity depends on the fishing operational ground corresponding to fish migration or distributional patterns. To clarify spatial pattern of the Western and the Central North Pacific ocean (WCNPO) swordfish (*Xiphias gladius*) selectivity that was caught by Japanese longline fishery, we addressed the finite mixture model analysis. In this analysis, we used the Japanese longline operational data rather than the size composition data because there were substantial differences between the size compositions of commercial vessels and training vessels that operating in the same area. Using R software package of the flexmix, we constructed 1 to 6 clusters with two-dimensional linear regression models that response are mean body weight and CPUE. Regarding the covariate of the linear model, we used year, quarter or gear (hooks between floats) effects. We also set grouping factor as 5 ◦x 5 ◦ area grid. BIC selected five cluster model which responses classified two type body weight group and five CPUE trends. Comparing with spatial cluster and several results, we suggest dividing WCPO into two fishery areas.

Discussion

It was noted that CPUE and mean weight similarities in the WCNPO were analyzed using a cluster analysis (finite mixture modeling) to determine whether the WCNPO area should be split into a western region and central region for the purpose of standardizing Japanese CPUE. The WG discussed the analyses and concluded that spatial patterns in the mean size of swordfish caught by Japanese longline vessels existed between the western and eastern portions of the WCNPO. In general, larger fish are found in area 1 in the western WCNPO.

The presenter noted that the size composition of Japanese training vessels fishing around Hawaii are not consistent with swordfish catch by commercial operations and recommends that the training data be excluded from the assessment model. The WG concurred with excluding the training data based on differences in fishing area and size composition with the commercial longline fleet.

The WG noted that the two proposed regions are consistent with targeting patterns within the Japanese longline fleet and with oceanographic features which would change the relative abundance of swordfish in the WCNPO. The WG noted that this type of analysis was useful for the standardization of Japanese CPUE and the WG accepted the results of the two area split of Japanese fishery data within the WCNPO.

7.4. Environmental correlations with North Pacific swordfish population dynamics Presented by Jon Brodziak (Presentation only)

Jon Brodziak provided a presentation that explored whether recruits-per-spawner deviations as calculated in the 2009 preliminary structured North Pacific swordfish assessment model were correlated with environmental variables. It was found that swordfish recruits-per-spawner deviations were correlated with the Southern Oscillation Index.

<u>Discussion</u>

The WG discussed the possibility of attempting a similar analysis during this upcoming North Pacific swordfish stock assessment. A variety of environmental variables could be explored as correlating with the recruits-per-spawner deviations. Consideration of including such an environmental variable in any base case model would also necessitate consideration of including the same environmental variable in projections of the base case.

8.0 FINALIZE PACIFIC NORTH PACIFIC SWORDFISH FISHERY STATISTICS

8.1 Fishery Catch

The WG discussed and agreed upon the fishery catch statistics to be used for the stock assessment of North Pacific swordfish by fishing fleet (Table 8.1). The WG produced a summary of the current status of the fishery catch, CPUE, and size composition data by country and fleet (Table 8.1). The acronyms in the fleet names are defined as follows: WCNPO is Western and Central North Pacific Ocean; EPO is Eastern Pacific Ocean; OSDWLL is offshore distant water longline; OSDWCOLL is offshore distant water and coastal longline; early is the early time period; late is the late time period, Area1 and 2 are the Japanese fishery areas in the WCNPO as defined in WP-09; OSDF is offshore driftnet gear; CODF is coastal driftnet gear, JPN_WCNPO_Other is Japanese unreported longline (mainly coastal longline), bait, and net fishing gear; DWLL is distant water longline gear, TWN_WCNPO_Other is Taiwanese offshore longline, coastal longline, gillnet, harpoon and other gears; LL is longline gear; shallow is the Hawaii shallow set sector; deep is the Hawaii deep set sector; GN is gillnet gear; US_WCNPO_Other is harpoon and other gears; Mex_LL_EPO is Mexican longline gear in the EPO; WCPFC_LL is longline gear in the WCNPO; IATTC_LL is longline gear in the EPO north of the equator; IATTC_LL_Overlap is longline gear in the overlap area of the IATTC convention area and the WCNPO areas.

Annual Catch of North Pacific Swordfish by Country and Fleet

- **China:** Chinese catch data were not provided by China. Catch tables for China were updated from fishery statistics submitted to the WCPFC.
- **Taiwan:** Catch tables for Taiwan were described in WP-04.
- **Japan:** Catch tables for Japan were updated from catch statistics using new areas described in WP-03 and WP-09.
- **Korea:** Korean catch data were not provided by Korea. Catch tables for Korea were updated from fishery statistics submitted to the WCPFC and IATTC.
- **Mexico:** Mexican catch data were provided by Mexico for 2011-2016.
- **USA:** Catch tables for the USA were updated from WP-01 and other information.
- **Canada:** Canadian catches of swordfish are negligible.
- **Non-ISC Countries**: Catch tables for non-ISC countries in the WCPFC region were updated by correspondence (pers. comm., SPC) and catch tables for non-ISC countries in the EPO region were updated by correspondence (pers. comm., IATTC).

Discussion

It was noted that two ISC member countries, China and Korea, did not provide any catch time series for the 2018 BILLWG stock assessment of North Pacific swordfish.

For non-ISC countries in the WCPFC, the WG agreed to use the Category I catch data (aggregated across all areas in the WCPFC) for the stock assessment. However, some WCPFC countries only report Category II catch data (catch by area) and do not report Category I data. In these cases, the WG agreed to use the Category II data north of the equator as the best estimate of the countries swordfish catch in the North Pacific

Overall, the WG accepted the updated swordfish catch time series as the best available scientific information to conduct the 2018 stock assessment.

Table 8.1 Fishing fleet definitions for the North Pacific swordfish stock assessment with fleet code, flag (JPN is Japan, TWN is Taiwan, US is United States, MEX is Mexico, WCPFC is Western and Central Pacific Fisheries Commission, IATTC is Inter-American Tropical Tuna Commission), fleet name, time period, quarterly data availability, catch units, standardized CPUE and size composition data availability.

Fleet Code	Flag	Fleet Name	Catch Time Period	Quarterly Data ?	Catch Units	Standardized CPUE Available ?	Size Composition Data Available ?
F1	JPN	JPN_WCNPO_OSDWLL_early_Area1	1952-1993	Yes	Numbers	Yes, 1975-1993	Yes, 1970-1993, 1cm
F2	JPN	JPN_WCNPO_OSDWCOLL_late_Area1	1994-2016	Yes	Numbers	Yes, 1994-2016	Yes, 1994-2016, 1cm
F3	JPN	JPN_WCNPO_OSDWLL_early_Area2	1952-1993	Yes	Numbers	Yes, 1975-1993	No, Mirror F15
F4	JPN	JPN_WCNPO_OSDWLL_late_Area2	1994-2016	Yes	Numbers	Yes, 1994-2016	No, Mirror F15 or F11
F5	JPN	JPN_EPO_OSDWLL	1952-2016	Yes	Numbers	EPO, 1952-2016	Yes, Low coverage , 1cm
F6	JPN	JPN_WCNPO_OSDF	1960-1992	No	Weight	No	Yes, 1991-1992, 1cm
F7	JPN	JPN_WCNPO_CODF	1993-2014	No	Weight	No	Yes, Low coverage, 1cm
F8	JPN	JPN_WCNPO_Other_early	1952-1993	No	Weight	No	No, Mirror F1
F9	JPN	JPN_WCNPO_Other_late	1994-2014	No	Weight	No	No, Mirror F2
F10	TWN	TWN_WCNPO_DWLL _early	1959-1999	No	Weight	Yes, 1975-1999	No, Mirror F11 or F1
F11	TWN	TWN_WCNPO_DWLL _late	2000-2016	No	Weight	Yes, 2000-2016	Yes, 2004-2016, 1cm
F12	TWN	TWN_WCNPO_Other	1959-2016	No	Weight	No	No, Mirror F11 or F2
F13	TWN	TWN_EPO_OSDWLL_early	1967-1999	No	Weight	EPO, 1967-1999	No, Mirror F14
F14	TWN	TWN_EPO_OSDWLL_late	2000-2016	No	Weight	EPO, 2000-2016	Yes, 2004-2016, 1cm
F15	US	US_WCNPO_LL_deep	1995-2016	Yes	Weight	Yes, 1995-2016	Yes, 1995-2016, 1cm
F16	US	US_WCNPO_LL_shallow_early	1990-2000	Yes	Weight	Yes, 1995-2000	Yes, 1995-2000, 1cm
F17	US	US_WCNPO_LL_shallow_late	2005-2016	Yes	Weight	Yes, 2005-2016	Yes, 2005-2016, 1cm
F18	US	US_WCNPO_GN	1980-2016	No	Weight	Yes, 1985-2006	No, Mirror F15 or F16
F19	US	US_WCNPO_Other (Harpoon, Other)	1970-2016	No	Weight	No	No, Mirror F15 or F16
F20	MEX	MEX_LL_EPO	2011-2016	Yes	Weight	No	Yes, 2006-2016, 1 cm
F21	WCPFC	WCPFC_LL	1970-2016	Yes	Weight	No	No, Mirror F11 or F15
F22	IATTC	IATTC_LL	1975-2016	Yes	Weight	No	Yes, Low coverage, 1 cm
F23	IATTC	IATTC_LL_Overlap	1975-2016	Yes	Weight	No	No, Mirror F14 or F5

8.2 Fishery CPUE

The WG produced a summary of the standardized CPUE time series that were available for the 2018 benchmark stock assessment of WCNPO swordfish (Table 8.2) along with the source.

Table 8.2 Available standardized indices of relative abundance (CPUE) for WCNPO swordfish. See Table 8.1 for fishery codes and acronyms.

Abundance Index	Fleet Name (Code)	Time Series	Source
S1	JPN_WCNPO_OSDWLL_early_Area1 (F1)	1975-1993	Kanaiwa et al. (WP-07)
S2	JPN_WCNPO_OSDWCOLL_late_Area1 (F2)	1994-2016	Kanaiwa et al. (WP-07)
S3	JPN_WCNPO_OSDWLL_early_Area2 (F3)	1975-1993	Kanaiwa et al. (WP-07)
S4	JPN_WCNPO_OSDWLL_late_Area2 (F4)	1994-2016	Kanaiwa et al. (WP-07)
S5	TWN_WCNPO_DWLL _early (F10)	1975-1999	Chang et al. (WP-06)
S6	TWN_WCNPO_DWLL _late (F11)	2000-2016	Chang et al. (WP-06)
S7	US_WCNPO_LL_deep (F15)	1995-2016	Sculley et al. (WP-05)
S8	US_WCNPO_LL_shallow_early (F16)	1990-2000	Sculley et al. (WP-05)
S9	US_WCNPO_LL_shallow_late (F16)	2005-2016	Sculley et al. (WP-05)
S10	US_WCNPO_GN (F18)	1985-2006	Courtney et al. (ISC/09/BILLWG-2/01)

Annual standardized CPUE of WCNPO swordfish by country and fleet

- **China:** Standardized CPUE series for China were not provided.

- **Taiwan:** Standardized CPUE series for the Taiwanese offshore and distant water longline fleet (1975-1999, 2000-2016) were provided in WP-06.

- **Japan:** Standardized CPUE series for the Japanese offshore and distant water longline fleets in areas 1 and 2 (1975-1993, 1994-2016) were provided in WP-07.

- **Korea:** Standardized CPUE series for Korea were not provided.

- **Mexico:** Standardized CPUE series for Mexico were not available because Mexican longliners do not fish in the WCNPO region. Nominal longline CPUE data for Mexican longliners operating in the EPO were provided.

- **USA:** Standardized CPUE series for the Hawaii deep set longline sector (1995-2016) and shallow set longline sector (1995-2000, 2005-2016) were provided in WP-05. Standardized CPUE series for the California drift gillnet fishery (1985-2006) were gathered from ISC/09/BILLWG-2/01.

- **Non-ISC countries:** Standardized CPUE series from non-ISC countries were not available.

Discussion

It was noted that two ISC member countries, China and Korea, did not provide any standardized CPUE time series for the 2018 BILLWG stock assessment of North Pacific swordfish. The WG noted that Mexico provided information on nominal swordfish CPUE in the Mexican longline fishery in the EPO region.

Overall, the WG accepted the updated swordfish catch time series as the best available scientific information to conduct the 2018 stock assessment.

8.3 Fishery Size Composition

The WG produced a summary of the fishery size composition data that were available for the 2018 benchmark stock assessment of WCNPO swordfish (Table 8.3) along with the source.

Table 8.3 Available size composition data for WCNPO swordfish by fishery. See Table 8.1 for fishery acronyms and codes.

Composition Index	Fleet Name (Code)	Time Series	Source
C1	JPN_WCNPO_OSDWLL_early_Area1 (F1)	1952-1993	Ijima (WP-03)
C2	JPN_WCNPO_OSDWCOLL_late_Area (F2)	1994-2016	Ijima (WP-03)
C3	JPN_WCNPO_OSDF (F6)	1991-1992	Ijima (WP-03)
C4	JPN_WCNPO_CODF (F7)	2005, 2008-2014	Ijima (WP-03)
C5	TWN_WCNPO_DWLL _late (F11)	2004-2016	Chang et al. (WP-04)
C6	US_WCNPO_LL_deep (F15)	1995-2016	Sculley et al. (WP-02)
C7	US_WCNPO_LL_shallow_early (F16)	1990-2000	Sculley et al. (WP-02)
C8	US_WCNPO_LL_shallow_late (F17)	2005-2016	Sculley et al. (WP-02)

Size composition data for WCNPO swordfish by country and fleet

- **China:** Chinese size composition data were not provided.
- **Chinese Taipei:** Size composition data for the Taiwanese offshore and distant water longline fleet (2004-2016) were provided in WP-04.
- **Japan:** Size composition data for the Japanese offshore and distant water longline fleets in area 1 (1970-1993, 1994-2016) and for the Japanese driftnet fishery (offshore: 1991-1992, coastal: 2005 and 2008-2016) were provided in WP-03.
- **Korea:** Korean size composition data were not provided.
- **Mexico:** Mexican size composition data for the longline fishery in the EPO during 2006-2016 were provided.
- **USA:** USA size composition data for Hawaii shallow and deep set longline fleets were provided in WP-02.
- **Non-ISC countries:** Size composition data (Category III) for longline fleets was received from the WCPFC prior to the meeting. It was noted that further analyses of data quality and consistency were needed to include the WCPFC size composition data in a structured assessment model.

Discussion

The size composition data provided by countries and submitted at this meeting was accepted.
Overall, the WG considered the new set of fishery statistics information to be the best available scientific information and finalized the set of input data for the base case assessment model.

The WG discussed the application of the size composition data in the stock assessment modeling. The WG noted that the majority of unfished biomass per recruit for a given cohort was expressed at age 3 through age 6. The WG also noted that there was an approximate 25 cm difference between the mean lengths at ages 3 and 6. As a result, the use of a 5 cm length bin would provide about 5 length bins to cover the primary age classes in the swordfish population modeling. This was considered to be an adequate resolution for the population dynamics modeling, noting that swordfish grow to lengths of over 200 cm. Overall, the WG agreed to use 5 cm length bins in the stock assessment model.

The WG noted that the fishery statistics were provided in several working papers. The WG agreed that all swordfish catch by country and fleet, standardized CPUE, and size composition data, would be provided in electronic format to the Chair by the end of this meeting or by 13-February-2018 via email.

9.0 FINALIZE NORTH PACIFIC SWORDFISH LIFE HISTORY PARAMETERS

The WG discussed and reached consensus on the set of life history parameters to be used for the stock assessment of the Western and Central North Pacific swordfish stock. The WG accepted the growth parameters, length-weight relationship, maturity, natural mortality, and stock-recruitment relationship as summarized in Kapur et al. (2017) and listed here (Table 9.0). As a result, the same parameters used for the 2009 preliminary structured assessment were agreed on for use in the 2018 stock assessment.

Table 9.0 Key life history, recruitment, and selectivity parameters used in the swordfish stock assessment model. The column labeled "Estimated ?" identifies if the parameters are expected to be estimated within the assessment model (Estimated), fixed at a specific value, i.e., not estimated (Fixed), or iteratively re-scaled to the match the predicted variance (Re-scaled).

Parameter (units)	Value	Estimated ?
Natural mortality (M, age-specific^{-yr})	Female: $M_0 = 0.42$, $M_1 = 0.37$, $M_2 = 0.32$, $M_3 = 0.27$, $M_{4+} = 0.22$ Male: $M_0 = 0.40$, $M_{1\text{-}2} = 0.38$, $M_{3\text{-}5} = 0.37$, $M_{6+} = 0.36$	Fixed
Length_at_min_age (EFL cm)	Female: $L(A_{min}) = 97.7$ Male: $L(A_{min}) = 99.0$	Fixed
Length_at_max_age (EFL cm)	Female: $L(A_{max}) = 226.3$ Male: $L(A_{max}) = 206.4$	Fixed
VonBert_K	Female: $k = 0.246$ Male: $k = 0.271$	Fixed
W=aL^b (kg)	Both genders: $a = 1.299 \cdot 10^{-5}$ $b = 3.0738$	Fixed
Size at 50-percent maturity (EFL cm) and maturity ogive slope parameter	Female: $L_{50} = 143.6$ $\beta = -0.103$ Male: $L_{50} = 102.0$ $\beta = -0.141$	Fixed
Stock-recruitment steepness (*h*)	$h = 0.90$	Fixed
Unfished log-scale recruitment (Ln(*R0*))		Estimated
Standard deviation of recruitment (σ_R)	$\sigma_R = 0.6$	Rescaled
Initial age structure		Estimated
Recruitment deviations		Estimated
Selectivity		Estimated
Catchability		Estimated

9.1 Growth

Growth parameters for WCNPO swordfish were taken from the study of DeMartini et al. (2007), which was considered to be the best available information by the WG. The growth model used for swordfish was the von Bertalanffy curve where mean length at age is given by:

$$L(age) = L_\infty \left(1 - \exp\left(-k\,(age - t_0)\right)\right)$$

The values of the von Bertalanffy growth curve parameters for female swordfish were:
$L_{\infty} = 230.5$, $k = 0.246$, and $t_0 = -1.24$.
For male swordfish, the values were: $L_{\infty} = 208.9$, $k = 0.271$, and $t_0 = -1.37$.

Growth dimorphism is evident for WCNPO swordfish with females attaining larger mean sizes at age than males (Figure 9.1).

In the SS model, the relationship between eye fork length (cm) and age (*L*(age)) is parameterized as:

$$L(A_{max}) = L_\infty + (L(A_{min}) - L_\infty)e^{-k(A_{max}-A_{min})}$$

where $L(A_{min})$ and $L(A_{max})$ are the predicted lengths for the youngest $A_{min} = 1$ years and oldest $A_{max} = 15$ years reference ages for the growth model, L_∞ is the theoretical maximum length, and *k* is the Brody growth coefficient. In this two gender assessment model, $L(A_{min})$ was 97.7 cm for females and 99.0 cm for males at $A_{min} = 1$. The $L(A_{max})$ values were 226.3 cm for females and 206.4 cm for males at age $A_{max} = 15$. The *k* values were $k = 0.246$ and $k = 0.271$ for females and males, respectively. The t_0 values were $t_0 = -1.24$ and $t_0 = -1.37$ for females and males, respectively. The L_∞ value for the SS parameterization of the von Bertalanffy curve was calculated as:

$$L_\infty = L(A_{min}) + \frac{L(A_{max}) - L(A_{min})}{1 - e^{-k(A_{max}-A_{min})}}$$

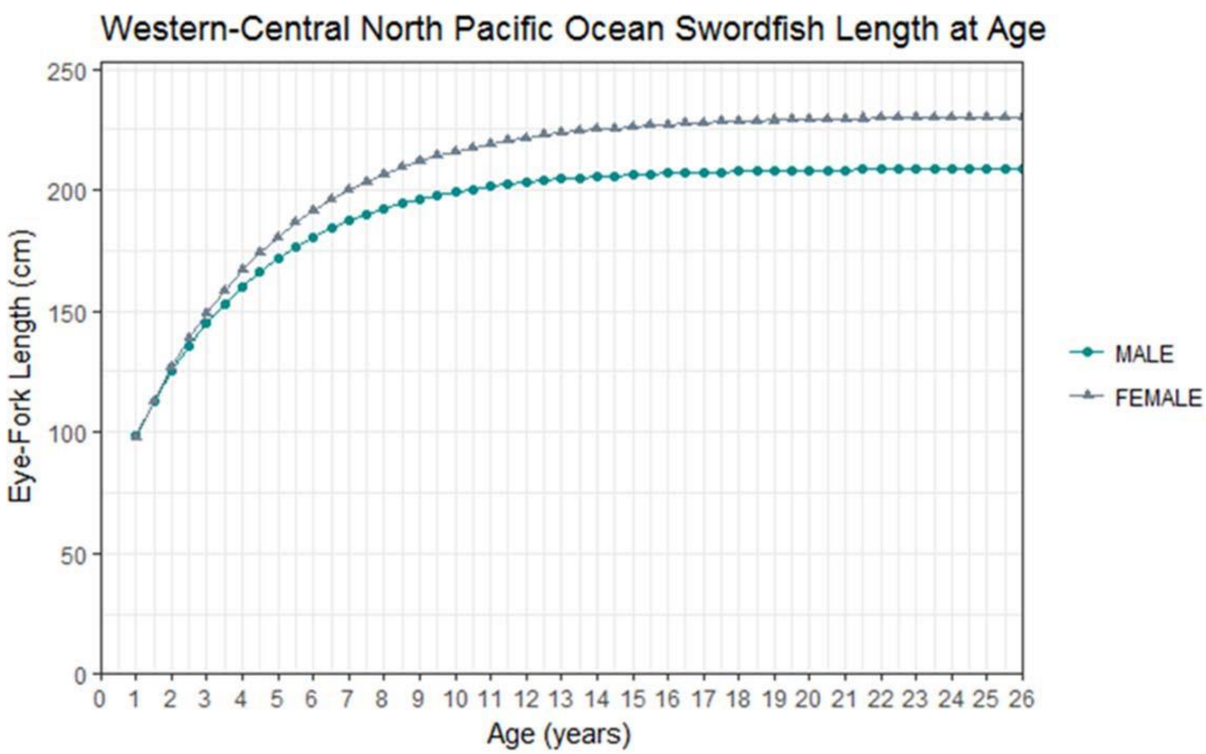

Figure 9.1 Mean length (cm, EFL) at age of WCNPO swordfish by gender to be used in the 2018 stock assessment.

9.2 Length-Weight Relationship

Length-weight parameters for WCNPO swordfish were taken from the study of Uchiyama et al. (1999), which was considered to be the best available information by the WG. The length-weight relationship used for both female and male swordfish was an allometric model where mean weight (kg) at length (cm, EFL) is given by

Female and male swordfish: $W = 1.299 \cdot 10^{-5} L^{3.0738}$

where W is the predicted fish weight at length L. These length-weight relationships were used as fixed inputs for the base case SS model (Figure 9.2).

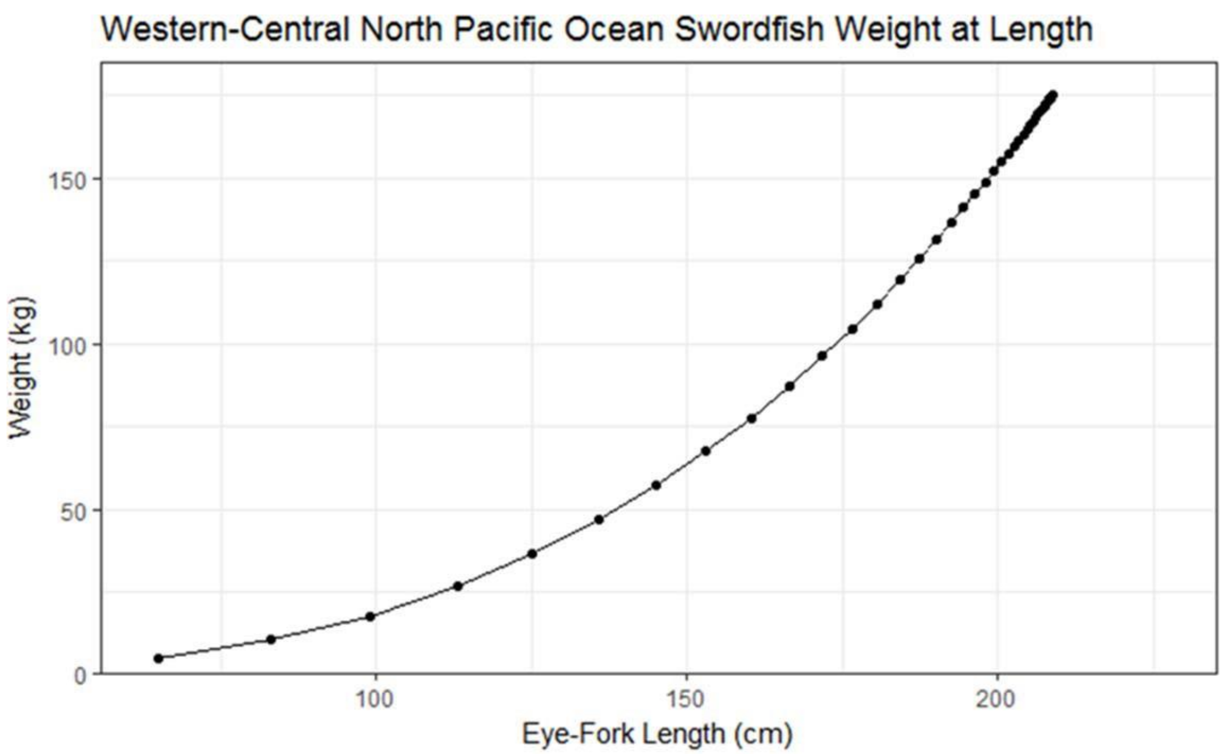

Figure 9.2 Swordfish length-weight relationship to be used in the 2018 stock assessment.

9.3 Maturity at Length

Maturity at length parameters for WCNPO swordfish were taken from the study of DeMartini et al. (2007), which was considered to be the best available information by the WG. The probability of maturity at length ($P_{mature}(L)$) was sex-specific and is modeled using a logistic curve

$$P_{mature}(L) = \frac{1}{1 + e^{\beta(L - L_{50})}}$$

where L_{50} is the length at 50% maturity (cm, EFL) and β is the slope parameter.

For WCNPO swordfish, the maturity ogive parameters for females are:

$L_{50} = 143.6$ *and* $\beta = -0.103$

The maturity ogive parameters for males are:

$L_{50} = 102.0$ *and* $\beta = -0.141$

Swordfish maturity at length curves differ by gender (Figure 9.3) with males reaching maturity at smaller sizes and younger ages than females.

For the stock assessment model, spawning timing for swordfish was set to occur in the second quarter (April-July).

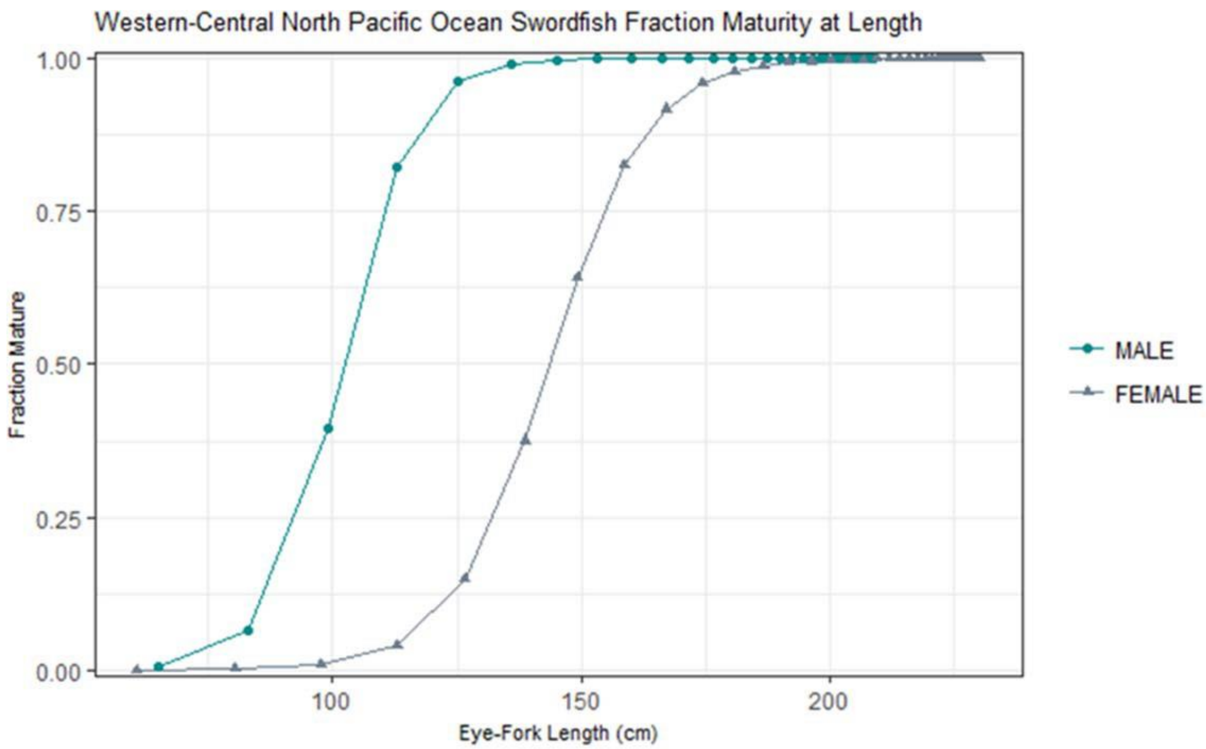

Figure 9.3 Maturity at length (cm, EFL) probabilities for female and male WCNPO swordfish to be used in the 2018 stock assessment model where the female size at 50-percent maturity was 144 cm.

9.4 Natural Mortality Rate

Natural mortality at age parameters for WCNPO swordfish were taken from the study of Brodziak (2009), which was considered to be the best available information by the WG.

Age-specific estimates of natural mortality rate for WCNPO swordfish were derived from an analysis of five M estimators based on empirical and life history methods to represent adult fish.

For WCNPO Swordfish, female natural mortality rates at age are:
$M_0 = 0.42$, $M_1 = 0.37$, $M_2 = 0.32$, $M_3 = 0.27$, $M_{4+} = 0.22$

Male natural mortality rates are: M_0 = 0.40, $M_{1\text{-}2}$ = 0.38, $M_{3\text{-}5}$ = 0.37, M_{6+} = 0.36

Natural mortality rates differ by gender for WCNPO swordfish with adult females having lower natural mortality rates than males (Figure 9.4).

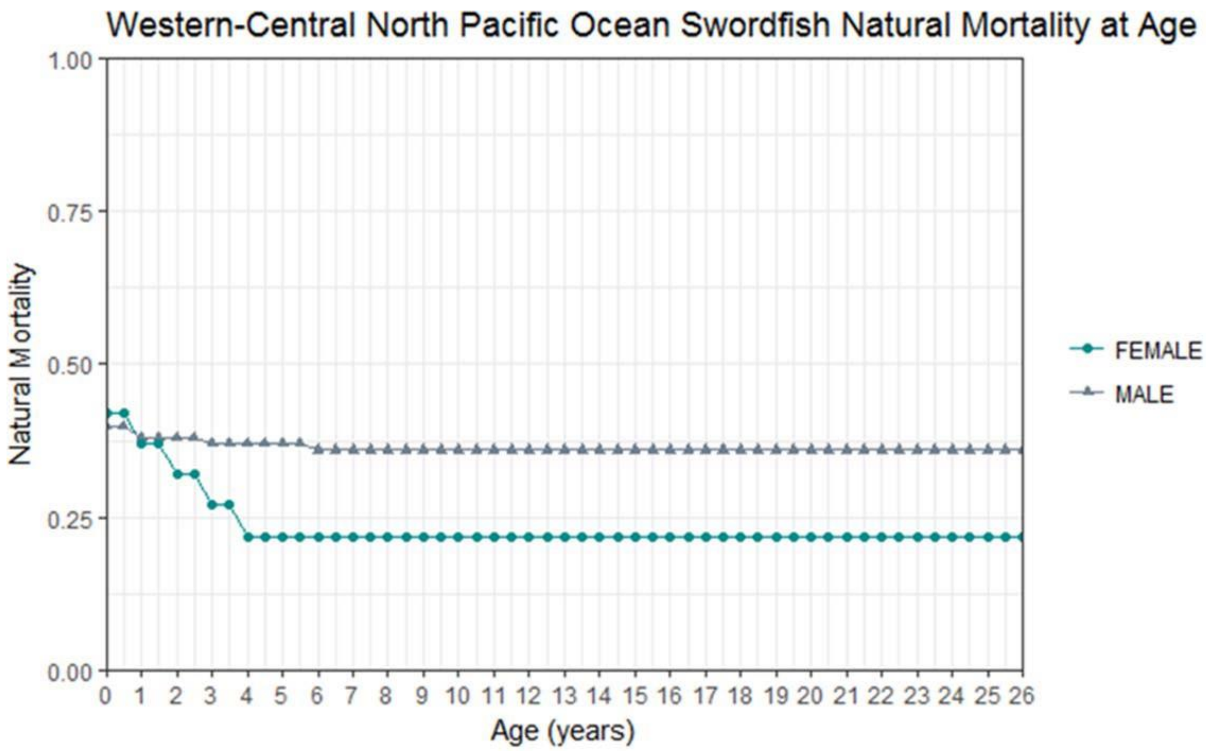

Figure 9.4 Natural mortality rates at age for female and male WCNPO swordfish to be used in the 2018 stock assessment model where the adult female natural mortality rate was $M_{4+} = 0.22$.

9.5 Stock-Recruitment Resilience

The WG agreed to use a Beverton-Holt stock-recruitment curve as the basis for predicting expected recruitment as was done for recent billfish stock assessments conducted by the ISC. The WG also discussed whether to use the value of steepness for swordfish that was estimated by Myers et al. (1999), which was $h = 0.90$. The WG noted that this value was similar to the median estimate of steepness of $h = 0.87$ for North Pacific striped marlin from Brodziak et al. (2015) and the value of $h = 0.92$ for North Atlantic swordfish (Sharma and Arocha 2017). Overall, the WG agreed to use the steepness value of $h = 0.90$ in the 2018 benchmark stock assessment.

No new information about recruitment variability (σ_R) was available, so the WG agreed to use a Beverton-Holt stock-recruitment curve with $\sigma_R = 0.6$ as the initial input with the value iteratively rescaled in the final model to match expected variability.

9.6 Life History Parameter Summary Table

Overall, the WG agreed that the table of life history parameters to be used in the 2018 stock assessment was the best available scientific information (Table 9.0).

10.0 WORK ASSIGNMENTS FOR NORTH PACIFIC SWORDFISH

10.1 Base Case Model Inputs

The WG discussed the input data for the base case stock synthesis model used to assess Western and Central North Pacific Ocean swordfish. The WG consensus was to use the fishery statistics information agreed upon in agenda item 8 and the life history information agreed upon in agenda item 9 for the base case assessment. The WG also recommends that two additional work assignments be undertaken, if time permits:

- Update the 2014 stock assessment model for WCNPO swordfish using the new data.
- Construct a swordfish stock assessment model for the entire North Pacific using the WCNPO swordfish SS model augmented with data from the EPO region north of the equator.

10.2 Base Case Model Structure for the Benchmark Assessment

The WG noted that the 2018 WCNPO swordfish stock assessment is to be a benchmark assessment. The WG discussed work needed to construct the base case model. After these discussions, the WG concluded that the base case would incorporate the following features:

- Use a 1-area model for the WCNPO
- Use 2 genders, females and males
- Use 4 seasons
- Use best available catch data
- Use best available standardized CPUE
- Use best available size composition data
- Use best available life history parameters (Table 9.0)

10.3 Sensitivity Analyses for the Base Case Model

The WG discussed about the sensitivity analysis to be carried out in the 2018 benchmark swordfish stock assessment. The WG agreed to conduct a set of sensitivity analyses similar to those used in the 2016 Pacific blue marlin assessment (Table 10.3).

10.4 Stock Projections for the Base Case Model

The WG noted that the projections conducted in the last WCNPO swordfish stock assessment were developed using a Bayesian surplus production model The WG discussed the need to develop a new approach to conduct the projections using the assessment results from SS. It was suggested that fishery managers would be better informed about the risk of alternative decisions if stochastic projections, instead of the deterministic projections, were provided. In particular, the WG agreed to conduct stochastic projections for the 2018 benchmark WCNPO swordfish stock assessment.

Table 10.3 Sensitivity analyses to characterize the effects of alternative assumptions about input data and life history parameters used in the base case model for the 2018 stock assessment of North Pacific swordfish.

Sensitivity Analyses for Input Data

1. **Alternative CPUE trends**. Fit the model to alternative set(s) of standardized CPUE.
2. **Exclude length composition data**. Fit the model to alternative length composition data to account for fleets with more uncertainty in their data.

Sensitivity Analyses for Life History Parameters

3. **Alternative natural mortality rates (*M*)**. Fit the model using higher and lower adult natural mortality value for females and males, where juvenile M is scaled as in the base case.
4. **Alternative stock-recruitment steepness (*h*)**. Fit the model using alternative steepness values.
5. **Alternative growth curves**. Maximum size. Fit the model with the length at the maximum reference age set to alternative values of $L(A_{max})$ using a Brody growth coefficient *k* that is consistent with the size-at-age Amin in the base case. Alternative growth parameters. Use growth curve from Sun and Wang (2002).
6. **Alternative maturity ogives**. Fit the model using alternative values of L_{50} as the length at 50% probability of maturity values. Alternative maturity parameters. Use the maturity ogive from Wang et al. (2003).

10.5 Working Subgroup for Assessment Modeling

The WG proposed the designation of Michelle Sculley as the lead assessment modeling person for the North Pacific swordfish stock assessment. Hirotaka Ijima and Yi-Jay Chang were also designated to provide direct support for the modeling efforts and further support for the stock assessment modeling and projections will also be provided by Jon Brodziak and other WG members, depending on their availability.

11.0 OTHER BUSINESS

The WG discussed other business, including future assessments, future meetings, and other issues.

11.1 Future Assessments

The WG Chair suggested that a North Pacific striped marlin stock assessment update would be due in 2019. It was also suggested that the WG consider conducting a management strategy evaluation for a billfish species.

11.2 Future Meetings

The next meeting of the ISC Billfish Working Group will be held in Shimizu, Japan. The purpose of this meeting is to conduct the modeling needed to complete the assessment modeling for the WCNPO swordfish stock. This meeting is planned for April 17-24, 2018 and will be held at the National Research Institute for Far Seas Fisheries Laboratory in Shimizu, Japan. The Chair noted that there would be an election for a new WG Chair at the April meeting.

The Chair noted that the WG would hold several conference calls prior to the next intercessional meeting in Shimizu to discuss work assignments and progress on the swordfish stock assessment modeling efforts.

12.0 ADJOURNMENT

The workshop was adjourned at 4:30 PM on 23 January 2018. The BILLWG Chair expressed his appreciation to the rapporteurs and to all participants for their contributions to completing a successful meeting.

13.0 REFERENCES

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Attachment 1. List of Participants

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Attachment 2. Meeting Agenda

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

BILLFISH WORKING GROUP (BILLWG)

INTERCESSIONAL WORKSHOP ANNOUNCEMENT

Meeting Site: NOAA Fisheries Honolulu Service Center at Pier 38
1139 N. Nimitz Hwy, Suite 220, Honolulu, HI 96817

Meeting Dates: January 17-23, 2018

Goals: The BILLWG is holding an intercessional meeting to complete data preparation for the North Pacific stock assessment. This includes preparation of CPUE standardization analyses, catch by quarter data, size frequency data, and tagging data. The primary goal is to finalize all of the swordfish stock assessment data in preparation for the modeling meeting to be held in Shimizu, Japan in April 2018.

Working Paper Deadline: Submit working papers to Jon Brodziak (email: Jon.Brodziak@noaa.gov). **Authors are responsible for bringing their own copies (10) on the first day of the meeting.**

Local Contact: Jon Brodziak, ISC BILLWG Chair
PIFSC, 1845 Wasp Boulevard, Honolulu, HI 96818
Email: Jon.Brodziak@NOAA.GOV Tel: 808-725-5617

AGENDA

January 17 (Wednesday), 8:30-9:00 – Registration

January 17 (Wednesday), 9:00-16:30

1. Opening of Billfish Working Group (BILLWG) Workshop
   a. Welcoming Remarks
   b. Introductions
   c. Standard Meeting Protocols

2. Adoption of Agenda and Assignment of Rapporteurs

3. Computing Facilities
   a. Access
   b. Security Issues

4. Numbering Working Papers and Distribution Potential

5. Review of Recent Swordfish Fisheries
    a. Review of Recent Developments and Issues
    a. Review of Availability of Fishery Data by Country
    b. Review of Information on BILLWG Web Page: http://isc.fra.go.jp/working_groups/billfish.html

6. Fisheries Statistics for North Pacific Swordfish
    a. Fishery Data and Definitions
        (1) ISC Countries
        (2) Non-ISC Sources
    b. North Pacific Swordfish Catch by Fishery
        (1) ISC Countries
        (2) Non-ISC Sources
    c. Standardized CPUE by Fishery
        (1) ISC Countries
        (2) Non-ISC Sources
    d. Other Biological Information

January 18 (Thursday), 8:30-16:30

6. Fisheries Statistics for North Pacific Swordfish, Continued
    a. Fishery Data and Definitions
        (1) ISC Countries
        (2) Non-ISC Sources
    b. North Pacific Swordfish Catch by Fishery
        (1) ISC Countries
        (2) Non-ISC Sources
    c. Standardized CPUE by Fishery
        (1) ISC Countries
        (2) Non-ISC Sources
    d. Other Biological Information

January 19 (Friday), 8:30-16:30

6. Fisheries Statistics for North Pacific Swordfish, Continued
    a. Fishery Data and Definitions
        (1) ISC Countries
        (2) Non-ISC Sources
    b. North Pacific Swordfish Catch by Fishery
        (1) ISC Countries
        (2) Non-ISC Sources
    c. Standardized CPUE by Fishery
        (1) ISC Countries
        (2) Non-ISC Sources
    d. Other Biological Information
7. Review Life History Parameters and Assessment Model Structure for North Pacific Swordfish
    a. Growth
    b. Length-Weight Relationship

c. Maturity and Fecundity
d. Natural Mortality Rate
e. Stock-Recruitment Resilience

January 20 (Saturday), 8:30-16:30

8. Finalize Summaries of North Pacific Swordfish Fishery Statistics
    a. Catch Table
    b. Standardized CPUE Table
    c. Size Composition Table
    d. Input Data for Stock Synthesis

9. Finalize Life History Parameters for North Pacific Swordfish
    a. Growth
    b. Length-Weight Relationship
    c. Maturity and Fecundity
    d. Natural Mortality Rate
    e. Stock-Recruitment Resilience
    f. Life History Parameter Summary Table
    g. Input Data for Stock Synthesis

January 21 (Sunday), No Meeting

January 22 (Monday), 8:30-16:30

8. and 9. Complete All Work

10. Work Assignments for North Pacific Swordfish
    a. Stock Synthesis Model Inputs
    b. Ecosystem Indices
    c. Working Subgroup for Assessment Modeling

11. Other Business
    a. Future Assessments
    b. Future Meetings
    c. Other Issues

12. Rapporteurs and Participants Complete Report Sections

January 23 (Tuesday), 8:30-16:30

13. Clearing of Meeting Report
14. Adjournment

Attachment 3. Working Papers

ISC/16/BILLWG-1/01	U.S. swordfish fisheries in the North Pacific Ocean. Russell Y. Ito, John Childers and Yuhong Gu russell.ito@noaa.gov
ISC/18/BILLWG-1/02	Size composition for swordfish *Xiphias gladius* in the Hawaii-based pelagic longline fishery for 1995-2016. Michelle Sculley, Maia Kapur and Annie Yau michelle.sculley@noaa.gov
ISC/18/BILLWG-1/03	Brief information for Japanese fishery statistics of North Pacific swordfish (*Xiphias gladius*). Hirotaka Ijima ijima@affrc.go.jp
ISC/18/BILLWG-1/04	Catch and length data of swordfish (*Xiphias gladius*) for the WCNPO and EPO areas from the Taiwanese fisheries. Yi-Jay Chang, Chi-Lu Sun, Jhen Hsu and Su-Zan Yeh yjchang@ntu.edu.tw
ISC/18/BILLWG-1/05	Standardization of the swordfish *Xiphias gladius* catch per unit effort data caught by the Hawaii-based longline fishery from 1994-2016 using generalized linear models. Michelle Sculley, Annie Yau and Maia Kapur michelle.sculley@noaa.gov
ISC/18/BILLWG-1/06	Standardized catch-rates of swordfish (*Xiphias gladius*) for the Taiwanese distant-water tuna longline fishery in the North Pacific Ocean for 1964-2016. Yi-Jay Chang, Chi-Lu Sun, Jhen Hsu and Su-Zan Yeh yjchang@ntu.edu.tw
ISC/18/BILLWG-1/07	Abundance indices of swordfish (*Xiphias gladius*) by the Japanese offshore and distant-water longline fishery in the North-Western Central Pacific. Minoru Kanaiwa minoru.kanaiwa@gmail.com
ISC/18/BILLWG-1/08	Preliminary comparisons of the Stock Synthesis assessment model for North Pacific swordfish. Michelle Sculley and Annie Yau michelle.sculley@noaa.gov

ISC/18/BILLWG-1/09	Pattern recognition of population dynamics for North Pacific swordfish (*Xiphias gladius*). Hirotaka Ijima and Minoru Kanaiwa ijima@affrc.go.jp
ISC/18/BILLWG-1/10	Spatial distribution of swordfish catches for longline fisheries in the Western Central North Pacific Darryl Tagami and Haiying Wang darryl.tagami@noaa.gov