FINAL

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ANNEX 09

22nd Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Kona, Hawai'i, U.S.A.
July 12-18, 2022

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP

July 2022

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ANNEX 09

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

March 28, April 1-6, 2022 (JST)
Webinar

1. OPENING AND INTRODUCTION

1.1. Welcoming Remarks

Hirotaka Ijima, the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC) Billfish Working Group (WG) chair opened the Western and Central North Pacific Ocean (WCNPO) striped marlin stock assessment meeting. Participated scientists are Chinese Taipei (TWN), Japan (JPN), United States of America (USA), the Pacific Community Oceanic Fisheries Program (SPC), and the Inter-American Tropical Tuna Commission (IATTC) in the meeting. The lists of participating scientists in Attachment 1.

1.2. Introduction

The WG will conduct a stock assessment for WCNPO striped marlin and agree on stock status, future projections, and sensitivity analysis results. Based on these results, the BILLWG will formulate recommendations pertaining to conservation measures for the stock. The WG will also discuss the appropriate time frame for calculating the dynamic SSB0.

1.3. Standard Meeting Protocols

The WG chair introduced protocols for the webinar meeting. The WG used Cisco Webex for this meeting, and working papers on the agenda were presented and discussed.

2. ADOPTION OF AGENDA AND ASSIGNMENT OF RAPPORTEURS

The WG adopted the meeting agenda before the stock assessment meeting (Attachment 2). The WG chair also assigned the rapporteurs for agenda items.

Agenda item	Day	Rapporteur
a. SS3 model using WCNPO growth curve	28th March	Y-J Chang, Jen Hsu
	1st April	Y-J Chang, Jen Hsu
b. SS3 model using SWPO growth curve	2nd April	H Ijima
c. SS3 model using EPO growth curve	3rd April	H Ijima
d. Uncertainty grid	4th April	J Brodziak
e. Sensitivity analysis	5th April	J Brodziak
f. Future projection	6th April	Documentation
g. Limit reference point (time frame)		

3. NUMBERING WORKING PAPERS AND DISTRIBUTION POTENTIAL

In total, two working papers were submitted (Attachment 3). The WG agreed to post these working papers on the ISC website and make them publicly available.

4. US LENGTH COMPOSITION DATA

Observed length Composition Data for Striped Marlin, Kajikia Audax, in the Hawaii Longline Fishery, 1994-2020. Jon Brodziak and Michelle Sculley (ISC/22/BILLWG-01/01)

This working paper describes the striped marlin length composition data from the USA Hawaii longline fishery that were submitted to the December 2021 ISC Billfish Working Group data preparation meeting. Striped marlin (*Kajikia audax*) size frequency data are summarized for the Hawaii-based longline fishery during 1994-2020 based on the current Pacific Islands Regional Observer Program (PIROP) data set. Annual and quarterly trends in mean lengths of striped marlin are evaluated, as well as a frequency table of the number of striped marlin measured per 5-cm length bin by year during 1994-2020. Empirical results show mean lengths for striped marlin fluctuate without trend on an annual and quarterly basis

Discussion

The WG confirmed that US longline length composition data was updated between 2018 to 2020. The **WG agreed to use these data for the current stock assessment.**

5. WCNPO STRIPED MARLIN STOCK ASSESSMENT MODELING

5.1. SS3 model using WCNPO growth curve

Preliminary Base-case Model in Stock Synthesis 3.30 for Consideration in the 2022 Western and Central North Pacific Striped Marlin (Kajikia audax) Stock Assessment using WCNPO Biological Parameters. Michelle Sculley (ISC/22/BILLWG-01/02)

A preliminary base-case model in Stock Synthesis 3.30 for Western and Central North Pacific (WCNPO) striped marlin (*Kajikia audax*) is described for consideration as the 2022 base-case model. The base-case model covers the Western and Central Pacific Fisheries Commission (WCPFC) management area north of the Equator from 1975 to 2020. It includes data from three International Scientific Committee for the Conservation of Tuna and Tuna-like Species (ISC) countries and other countries in aggregate from the WCPFC. This paper describes the data available for inclusion in the base-case model and the model using the biological parameters for the WCNPO stock. The model converges and appears to fit the data well. Initial diagnostics do not indicate major problems. Preliminary results suggest the WCNPO striped marlin stock is being fished above F_{MSY} and spawning stock biomass is below SSB_{MSY}.

Discussion

The WG selected the Stock Synthesis version 3.30.18.00 model configuration from WP-01 as the initial candidate for the base case assessment model. This model was the seventh version (mls2022_v007.ctl) of an SS3.30 model constructed since the data preparation meeting on 1st March 2022 by a modeling sub-group consisting of Michelle Sculley, Hirotaka Ijima, and Yi-Jay Chang and was named WCPNPO_SA0. The WG noted that all of the data had passed the runs test. However, the recruitment deviations likelihood component substantially impacts the R0 estimate. There are also some conflicts of R0 estimates among various CPUE indices. For the size data, the R0 was mainly driven by the US_LL. The WG member pointed out that the obvious decline of SSB between 1991 and 1994 was related to the uncertainty of length data and suggested that this phenomenon should be explained to the manager. The WG noted that the fishing mortality rate was near the historically high level in 1998-1999. Noting that this is a recruitment-driven fishery, one can expect poor recruitment started in 1995 can propagate the low recruitment condition in the following years, and therefore the recruitment remained at a lower level for the later time periods. The WG member noted that the fishing mortality rates after 1990 were estimated at a lower level compared to the 2019 assessment. The presenter replied that the difference in fishing mortality might be related to the estimation of initial equilibrium fishing mortality and revision of drift net catch in this assessment. The WG noted that using the different combinations of indices data did not change the result of ASPM analysis and recognized that the size data is more informative than the index data in the model estimation. The WG requested several candidate models runs to improve the issue raised by the above discussions:

1. WCNPO_SA1: Drop CPUE indices (S1-S4) to improve the consistency of the R0 estimate.
2. WCNPO_SA2: Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks for a simpler model configuration.
3. WCNPO_SA3: Change the size selectivity of F13 and F14 to mirror F1 and F5 because the fishing location of early high-sea drift net is more similar to the longline in this period.
4. WCNPO_SA4: Drop the US CPUE data (S03) from 1995 to 1996 to reflect the potential change in fishery catchability due to the management of the shallow set longline fishery.

The WG discussed the effect of the time block selectivity for the Japanese longline vessel (WCNPO_SA2). The WG noted that the R0 and SSB scales changed significantly, even though the fits did not change significantly for Japan's CPUE data, although fit to the JPN LL A1Q1 size data was degraded and no longer passed the runs test. The WG noted that the U.S. size and CPUE fit varied more significantly, even though the Japanese time block was changed, and discussed the reasons for this change. It is difficult to ascertain the cause in the integrated model because all data are linked. However, the WG noted that the R0 profile shows that the US size data has the largest impact and the WG decided to review the R0 profile.

The change in the early JPNDF selectivity mirror to longline resulted in a decrease in F before 1993 and a consequent increase in the SSB values due to a lower value of the initial equilibrium fishing mortality (WCNPO_SA3). The WG concluded that this was due to changing smaller selectivity. In recent years, Japanese drift net fishery have been operated within the Japanese EEZ, and the larger individuals have been caught in accounting for the seasonal migration of marlin. On the other hand, before 1993, they operated on the high seas, which overlaps with the current location of the longline fishery. Given the characteristics of the drift net fishery, it is unlikely that large fish are caught selectively, and it is possible that the selectivity rate is similar to that of the longline fishery. However, the WG noted that there is no information to support such a hypothesis.

The WG confirmed that excluding the two years of US longline CPUE data did not significantly change the results of the SS3 model (WCNPO_SA4). It was further noted that the R0 profile results were also not significantly different. **Based on these results, the working group agreed to use the entire time series of US Hawaii CPUE.**

The WG compared the WCNPO_SA0 and WCNPO_SA2 models again. Removing the time block of the Japanese longline changed the fit of the US longline size data and CPUE, not the fit of the Japanese data. The R0 profile results indicated no significant differences between these two models. The reason for this could not be clarified. However, given that it did not significantly affect the fit, **the WG agreed not to use the time block for Japanese longline length data to simplify a model,**

this reduced the number of estimated parameters by six. Recruitment continued to drive the estimation of R_0 for the WCNPO_SA2 model. In other words, these results showed that the parameter estimates for the biomass scale were unaffected by the data. **The WG agreed to check the model with the weight of the likelihood of recruitment deviations set to 0.5** (WCNPO_SA5)**.**

The WG reviewed the results of the model with a weight of 0.5 for the likelihood of recruitment deviations (WCNPO_SA5). In addition, the WG discussed the results of four different models using this model with different combinations of the CPUEs (WCNPO_SA6 - WCNPO_SA10). The WG reviewed the R0 profiles of these models, however, no significant improvement to the likelihood profile was observed. Therefore, the **WG agreed to improve the conflicts by changing the combination of input CPUEs before considering the weighting for the likelihood of the recruitment deviation**. Fishing mortality was found to be more stable when the model started in 1977 (see day 6 discussion). Furthermore, setting the early JPNDF selectivity to mirror the longline was considered to result in better consistency in the R0 profile (see day 7 discussion).

The WG discussed three models assuming different model assumptions (WCNPO_SA11-WCNPO_SA13).

The WG noted the WCNPO_SA11 model had large R, and results show initial F near 0, but catches in the mid-1970s are well above 5,000 mt, and this indicates a misfit in the model catch predictions. The WG noted that there is not much difference between CPUE fits for models the WCNPO_SA2 and the WCNPO_SA11. The WG confirmed the ASPM result of the WCNPO_SA11 that produces an unusually large stock size in late time series.

The WG noted the WCNPO_SA12 model has an initial F of about F=1.1, which is more consistent with early period catch, although this model has somewhat noisier data fitting than the prior WCNPO_SA2 model. The WG also noted that CPUE S1 and S2 failed the runs test and the ASPM results look better for the WCNPO_SA12.

The WG noted that an initial F of the WCNPO_SA13 is about F=0.96 which is consistent early period catch amounts pretty well. The WG noted that the R0 profile for WCNPO_SA13 shows that CPUE and size compositions have important influences but have decreased the impact of drift net series on profile pattern. The WG also noted that ASPM for WCNPO_SA13 shows the same pattern as the other models.

The WG members noted that the Japanese drift net fishery prior to 1977 had big uncertainty, and Japanese scientists re-estimated this fishery catch after 1977. The WG also noted available CPUE indices start in 1976.

It was suggested to combine WCNPO_SA12 and WCNPO_SA13 for the next WCNPO model configuration to emphasize better fitting aspects of both models based on the R0 profiling and changing the starting year from 1975 to 1977.

The WG noted that while the likelihood profile for WCNPO_SA11 was reasonable, the ASPM model indicated problems with the model and the initial F value was below the expected range of values based upon the early catches in the model. **Therefore, the WG agreed not to move forward exploring WCNPO_SA11 as a potential model given the meeting time constraints.**

The WG discussed three models assuming different model assumptions (WCNPO_SA14-WCNPO_SA17).

The WG noted that WCNPO_SA14 results show lots of similarities to WCNPO_SA2 fitting. The WG noted about WCNPO_SA14 that the runs test and ASPM analysis results are good, and the estimated initial F is realistic.

The WG noted that the R0 profile of WCNPO_SA15 indicated data has information on biomass scale but has some conflict with CPUE and some of the size composition data. The WG noted that WCNPO_SA15 has one CPUE fail in the runs test, which means some degradation of fit with WCNPO_SA15. The WG noted the size composition fits seem good, and the result of ASPM is similar to WCNPO_SA14.

The WCNPO_SA16 is based on WCNPO_SA15, with the S2 CPUE index (S02_JPNLL_Q3A1_Late) dropped. The WCNPO_SA16 appeared to be an improvement in fitting at the cost of removing data to be fitted, nominally the fit to the subset data appeared to be satisfactory.

The WG noted that WCNPO_SA16 has some data conflicts for size composition data. Japanese data suggested a smaller population size, USA size data suggested a large population size, and Chinese Taipei size data suggested a population size around the MLE estimate.

It was noted models WCNPO_SA14-17 have similar trends but somewhat different scales and similar goodness of fit, so choosing one as being best among them may not be obvious. The WG noted that it would be useful to provide additional reasons for considering one or more of WCNPO_SA14-17 being preferred relative to others.

It was suggested that WCNPO_SA16 is the best based on the R0 profile for CPUE and overall negative log-likelihood, although it may still want to further down weight US longline size composition data to improve WCNPO_SA17 configuration.

The WG noted that down weighting the JPN driftnet data is controlling the scale of the series of biomass and F, which differ in relative trend from the previous benchmark assessment.

It was also commented that the relatively strong down weighting of the JPN drift net data was limiting the range of states of nature being considered for providing scientific advice on stock status. In particular, the down weighting proposed for the current WCNPO model sequence may imply that the drift net fishery impacts were lower than estimated in previous stock assessments.

The WG discussed how to "weight" the size compositions of the JPN, TWN, and USA fleets. It was suggested that JPN size comp would get a higher weight (of maybe 60%) with equal remaining weight (maybe about 20%) for the TWN and USA size composition data. However, some fisheries catch a large amount of fish but provide a smaller proportion of the size composition data. This makes the data weighting issue difficult with the diverse set of fleets that harvest striped marlin in the WCNPO region and that further research would be required to develop a quantitative method for weighting data within the model. It was suggested to use WCNPO_SA17 as the best model or base case.

The WG noted main uncertainties are initial conditions such as equilibrium catch amount to start the model processes. The WG also pointed out that the WCNPO scenario model fittings are primarily driven by recruitment deviation and size composition fittings. The WG confirmed that the difference between WCNOP_SA16 and WCNPO_SA17 was down weighting Japanese driftnet size data,, but there were no differences in model diagnostics. It was suggested that WCNPO_SA16 with weighting at 1 with the model where driftnet is ½ assigned value, and the WG could decide to choose between WCNOP_SA16 and WCNOP_SA18 or choose to average WCNOP_SA16 and WCNOP_SA18.

It was noted that some of the differences between WCNPO_SA16 and WCNPO_SA17 were due to differences in drift net selectivity. However, the WG notes that WCNPO_SA16 and WCNPO_SA17 have similar fits to other data and also similar R0 and also similar trends, just differences in scale. Thus, the **WG agreed that the resolution is to do the WCNPO_SA18 run and compare the goodness of fits for WCNPO_SA16 and WCNPO_SA18 as the choice in which fleet to mirroring of early drift net fishery selectivity was an important assumption.**

The WG compared the results of the model diagnostics for WCNPO_SA16 and WCNPO_SA18. The R0 profile was relatively better for WCNPO_SA18, but the WG noted that biomass levels varied widely. It was noted the major difference between WCNPO_SA16 and WCNPO_SA18 was the assumption of Japanese driftnet selectivity prior to 1993. WCNPO_SA16 assumes that post-1994 Japanese driftnet selectivity is equal to historical pre-moratorium driftnet selectivity. On the other hand, WCNPO_SA18 assumes that the post-1994 longline fishery overlaps with the pre-moratorium driftnet fishery operating area.

It was noted that neither fishery is considered to be selectively catching fish of a particular size.

The WG concluded that WCNPO_SA18 was the preferred model because of the R0 profile results and considering the background of the operations area.

The WG noted that different weightings were given to the Japanese driftnet size composition data in WCNPO_SA16 and WCNPO_SA18. Previous analyses have confirmed that the weighting of the Japanese driftnet size composition data significantly impacts abundance. However, it was noted that it is difficult to determine which weights are most appropriate. Also, the WG acknowledged that the US Hawaii longline size composition data still showed conflicts with other data.

The WG agreed on a model based on WCNPO_SA18 with the Japanese driftnet size composition data unweighted and the US Hawaii size composition data weighted down by 10% as the base case model.

5.2. SS3 model using SWPO growth curve

A Preliminary Stock Synthesis Model Conducted for the WCNPO Striped Marlin Based on the Growth Parameters of SWPO Striped Marlin. Yi-Jay Chang

A preliminary candidate base-case model in Stock Synthesis 3.30.16.00 for WCNPO striped marlin (*Kajikia audax*) using the growth parameters derived from the fish in the southwest Pacific Ocean (named SWPO_SA0) was described. It included all the data available for the WCNPO region as of the December 2021 Billfish WG data preparatory meeting. The model did not include the time-varying selectivity assumption compared to the WCNPO model. Furthermore, the model used the double-normal selectivity in the F13 and F14 JPDF early-late fleets rather than the logistic selectivity for achieving better model convergence. The preliminary candidate base-case model has converged, the model fits to the CPUE and length composition data were reasonable except for the index data of JPLL_Q3A1 late period and length data of JPDF_Q1&4 early-late. However, the model showed a pattern of inconsistency among various likelihood components (i.e., recruitment, index, and size). Especially, the log(R0) profile indicated that there is no agreement about the log(R0) estimate among the various indices. The model outputs are mainly driven by the recruitment deviation.

Discussion

It was presented the preliminary results from the modification of the Southwest Pacific Ocean life history scenario (SWPO_SA0). The presenter noted that there are patterns for the fit to the US size composition data, and could be explained by there have been some changes in the US fishery. The WG encouraged that the ASPM analysis and the R0 profile from the presented SWPO model should be checked. The WG requested as follows;

1. Change the selectivity of the Japanese driftnets (mirror F14 to F1 and F5; F25 mirror to F5).
2. Use the time-block to the US CPUE from 1995 to 1996.
3. Set the time-block to the US size composition data from 1994 – 2000 and 2001 – 2007, respectively.

The WG confirmed the value of L50 of the SWPO model. The WG agreed to use L50 = 178.4 cm in the data preparation meeting, but L50 = 152.2 cm was used in the current analysis. The WG agreed to use L50 = 152.2 cm as a more realistic assumption.

The WG reviewed the results for the SWPO_SA1 model that changed Japanese driftnet selectivity in the early period (F13, 14 to F1, 5).

Compared with the WCNPO_SA0 model, SWPO_SA1 showed higher biomass before 1993, and lower F values were decreased, but the R0 profile was not improved. The WG decided not to move forward with this change because of the lack of supporting information for this assumption.

The WG reviewed the model results with the 1995 and 1996 US CPUE removed (SWPO_SA2). However, this model did not improve the fit nor R0 profile. The WG also discussed the US selectivity time blocks with SWPO_SA1 change. These model changes did not improve the fit, and the R0 profile showed that the estimated R0 value depended on the recruitment deviations. **Considering the R0 profile result, the WG agreed not to implement the changes in SWPO_SA1-SWPO_SA3 and agreed to check the model with a weight of 0.5 for the likelihood of recruitment deviation same as the WCNPO model.**

The WG discussed the fundamental differences between the WCNPO and the SWPO model. The WG confirmed that care should be taken when comparing F_{msy} ratios because the SWPO model assumes faster growth with higher productivity, and the shape of the YPR curve changes significantly, resulting in very different F_{msy} values from the WCNPO model. On the other hand, the SPR is comparable because the criterion of a one individual fish based value.

The WG discussed the fit of US size data, which was poor. A cubic spline selectivity pattern was attempted, but the model did not converge. It was noted that the size bisection might be seasonally dependent and is associated with striped marlin migration around the Hawaii area. It was suggested that fish from different stocks migrate to Hawaii during different seasons was also mentioned.

The results of the analysis of models with recruitment likelihood weightings of 0.1, 0.3, 0.5, and 0.7 were reported. The WG focused on the results for the R0 profile that the ratio of the recruitment deviation to the total likelihood decreased as the weight of the likelihood of recruitment deviation was reduced. However, the conflicts indicated by the CPUE and the length-frequency data did not improve, nor did the trend change. Based on these results, the WG agreed to first attempt to resolve the data conflicts. Specifically, the CPUE index of S3 and S5 were dropped, and the weight of Taiwanese size data was down-weighted to 0.3 (SWPO_SA8).

The WG noted that SWPO_SA8 improves length composition fit by being more informative (more bowl-like profile). The WG noted that CPUE fits with the initial model (SWPO_SA0) and SWPO_SA8 are similar, and the run test for CPUE series SA1 did not pass. It was noted that the ASPM diagnostics showed a similar pattern in SWPO_SA0 and SWPO_SA8 with a poor fit for a later time period, 1993-present. The WG noted that SWPO_SA8 estimated initial equilibrium F is close to 0, but SWPO_SA0 estimated a value consistent with historical catches.

The WG requested ISC catch amounts in 1974 & average prior to 1974 and this was provided. The WG noted that initial F is near zero for SWPO_SA8 and this is not accurate or useful for a model used for provision of stock status. It was noted that there were species ID issues for Japanese catch statistics for striped marlin & blue marlin prior to 1974. It was suggested that 13,000 mt average may not be realistic due to misidentification. But WG can estimate initial F with the WCNPO model, in comparison to the SWPO model. It was suggested that future assessments may attempt to estimate the catch amount in the initial time period(s). It was suggested that dropping catch in 1975 may lead to better estimability of an initial F. It was mentioned that it would be good to resolve the issue of historic species catch composition for Japanese catches of unspecified marlins, blue marlins, striped marlins and any others marlins prior to 1975. Ideally this resolution would be an outcome from an internal evaluation by Japan of the best point estimates of marlin catches by Japan by species in the North and South Pacific prior to the mid-1970s (e.g., 1975).

The WG discussed what the initial MLS catch was. It was noted that there was uncertainty in the initial catch for Japanese fleets, especially drift net fishery. The WG discussed that one could use a scenario analysis for the initial equilibrium catch. However, Japan said this approach was not preferable because this was strongly influential as an informed or uninformed assumption. This view that the initial catch could not be treated as an initial uncertainty grid was not agreed upon by all WG members, in particular the USA. There was further discussion of how to treat the initial catch (e.g., Which is better, setting 4,000 or 6,000 mt?).

The WG discussed starting the SWPO (and WCNPO) model a bit later than 1975 to accommodate the lack of good estimation of initial F in 1975. The WG noted the WG might start the model fitting a few years later, say 1977, when “better” estimates of Japanese drift net catch of Striped Marlin appear to be available.

It was noted that a spike in drift net catch data occurred in the late-1970s but has some confirmation from the best information on catch records, logbook, and port records. It was also noted that the WG might use a larger CV for catch data in catch likelihood or use a smoothing approach for input catch data to reduce the spikiness of catch pattern for JPN drift net in the late-1970s example.

The WG discussed specific details of the changes needed for the SWPO model to make the necessary changes for modified SS3 input data and control files. It was suggested that starting from 1977 would be a viable approach because there is some solid predicted and observed catch information immediately prior to that. This change to start in 1977 was agreeable to the WG, i.e., a consensus was achieved on starting new models in 1977 as a way forward.

Four models were suggested with a starting point of 1977: 1) use the same model with all available data (SWPO_SA9), 2) use all available data with down weighting for Taiwanese size compositions (F18_TWN_DWLL) (lamda=0.3) and excluding indices of USA longline (S03_US_LL) and Taiwan distant-water longline (S04_TWN_DWLL) (SWPO_SA10); 3) use all available data with down weighting for all size compositions (lamda=0.5) and excluding indices of Japanese quarter1-area1 late (S01_JPNLL_Q1A1_late), USA longline (S03_US_LL), and Taiwan distant-water longline (S04_TWN_DWLL) (SWPO_SA11); 4) use all available data with down weighting for

USA longline size compositions (lamda=0.5) and excluding indices of Japanese quarter1-area1 late (S01_JPNLL_Q1A1_late), USA longline (S03_US_LL), and Taiwan distant-water longline (S04_TWN_DWLL) (SWPO_SA12).

The WG discussed further several candidate models (SWPO_SA9-SWPO_SA12). The WG noted SWPO_SA9 has a somewhat flat CPUE likelihood. The WG noted that SWPO_SA12 has dropped several fleets based on SWPO_SA10 results and has better fitting with additional down weighting assumptions.

It was noted that SWPO_SA9 and SWPO_SA12 might be adequate for providing stock status, but there may be some mismatch between rapid growth and the trends in the CPUE indices. The abundance indices need to reflect the potential rapid change in population biomass as a large (or small) cohort recruits to the fishable population. It was noted that SWPO_SA9 and SWPO_SA12 differences were based on moderate differences in R0 and initial F values, resulting in higher/lower levels of biomass and F series. The WG was concerned that fitting data with the SWPO scenario was complex, considering several models' diagnostics results. The WG also noted that size composition data fitting shows inconsistency among fleets, with some fleets indicating high R0 and others low R0 in the SWPO_SA10 model. The WG is concerned that the MSY value may also be higher than expected for the estimates of the scale of stock biomass abundance. In other words, some inconsistency was suggested between the life history parameters and the likelihood profiles and residuals for model fits.

Analyst suggests using SWPO to show the model development process as a step-wise logical approach that yielded a set of models that was not relatively credible compared to WCNPO life history scenario models. **The WG agreed not to use the SWPO set of models to provide stock status or management advice, but will include it as a sensitivity run for comparison.**

5.3. SS3 model using EPO growth curve

Developing SS3 Model Using SPO Growth Curve. Hirotaka Ijima

The author attempted to construct the SS3 model using the growth curves and 50% maturity size reported in the Eastern Pacific. First, the author used the biological parameters L1 = 74 cm, L2 = 184 cm, K = 0.23, and L50 = 181 cm. This model showed good parameter fitting and also converged. However, looking at the R0 profile, there was no CPUE and size data that minimized the log-likelihood, and recruitment deviation determined the stock scale and trend. It is necessary to increase the influence of the data on the model estimates but changing the weighting of the data seems unlikely to improve. Therefore, based on the agreement of the ISC billfish working group, the author tried to build an SS3 model with L50 = 166.5 cm. This model has also converged, but parameter estimates still depend on recruitment deviation fluctuations. According to the latest biological research, the growth of the Eastern and Southern Pacific is reported to be similar, and the assumption of growth of the striped marlin examined here is too slow. Because of these circumstances, the author suggests that these growth curves and 50% maturity sizes should not be used in this stock assessment.

<u>Discussion</u>

It was presented modifying the Eastern Pacific Ocean life history scenario (EPO_SA0 and EPO_SA1). The presenter noted that the growth curve from EPO is not biological realistic by comparing the growth models from WCNPO and SWPO. Specifically, the current study indicated that the striped marlin growth in EPO is similar to SWPO, which is faster relative to this assumption (Shimose and Yokawa 2019). Additionally, the CPUE and size data could not provide the biomass trend and scale information based on the R0 profile and ASPM analysis. The WG member noted that the recruitment deviation might be pretty crucial for determining the results in WCNPO, SWPO, and EPO models. **The WG agreed and recommended that the recruitment deviation be carefully considered in all models.**

Comparison of Yield and Spawning Biomass Per Recruit for Alternative Striped Marlin Life History Scenarios. Jon Brodziak

Three life history scenarios are being investigated for application in the 2022 benchmark stock assessment of the WCNPO striped marlin stock. These are: the Western and Central North Pacific (WCNPO), the Southwest Pacific (SWPO), and the Eastern Pacific (EPO). The life history parameters for these three scenarios are listed in Table 2 of the December 2021 data preparation workshop of the ISC Billfish Working Group. Given these parameters, predicted values of mean length and weight at age and female maturity probability at age for the three life history scenarios as well as for the life history parameters used in the 2019 striped marlin stock assessment (2019) were calculated. Age-specific selectivities for the aggregate striped marlin fishery in the WCNPO region under the three life history scenarios were based on the selectivity pattern used for the stock projections in the 2019 striped marlin stock assessment. In particular, it was assumed that the fishery selectivity for the WCNPO scenario was equal to the 2019 fishery selectivity at age. For the SWPO and EPO scenarios, the predicted mean length-at-age curves were used to approximate a time shift in age from the WCNPO selectivity pattern. In this case, the SWPO selectivity was shifted by -1 year and the EPO selectivity was shifted by +3 years. Given the assumed age-specific selectivities, the expected yield and spawning biomass per recruit curves as a function of fishing mortality rate were calculated for each scenario. The results indicated that the SWPO scenario produced yield per recruit (YPR) values that were about 2-fold higher than the WCNPO and 2019 scenarios. In turn, the EPO scenario produced YPR values that were about one-third of those under the WCNPO and 2019 scenarios. This suggested that the EPO scenario would require about 20-fold greater levels of recruitment to produce the same yield as the SWPO scenario for a fixed fishing mortality. The unfished level of spawning biomass per recruit (SBPR) for the SWPO scenario was about 50% greater than that of the WCNPO scenario, while the EPO scenario produced an unfished SBPR that was about one-fifth of that under the WCNPO scenario. Overall, the YPR and SBPR analyses indicated that there were substantial differences among the three scenarios. In particular, the EPO results suggested a stock scenario with anomalously lower yields and reproductive outputs in comparison to the WCNPO and SWPO scenarios.

Discussion

The life history parameters were presented from the WCNPO, SWPO, and EPO life history scenarios. It was noted that the yield-per-recruit (YPR) and spawning biomass per recruit (SPR) analyses indicated substantial differences among the three scenarios. In particular, the EPO results suggested a stock scenario with anomalously lower yields and reproductive outputs in comparison to the WCNPO and SWPO scenarios. The WG noted that the life history scenario of striped marlin from the EPO is not biological realistic and has different life history from the WCNPO and the SWPO. Hence, **the WG agreed to drop the EPO life history scenario model in the striped marlin stock assessment work.**

5.4. Uncertainty Grid

The WG focused on the growth curve as the most significant uncertainty in the WCNPO striped marlin stock and developed the SS3 model using three different growth curves. However, the SWPO and EPO models failed to improve conflicts between data or did not inform the R0 estimate. Based on these results, the **WG concluded that these two growth curves were inappropriate for the WCNPO stock assessment model and agreed not to create an uncertainty grid or model ensemble.**

5.5. Sensitivity Analysis

The WG has discussed what sensitivity analyses should be performed in the data preparatory meeting. The WG revised the list after determining the base case models (Table 4). **The WG agreed that all sensitivity runs would be performed on WCNPO base case model.** The working group confirmed the sensitivity analysis results which indicated that the change in biological parameters from 2019 to 2022 caused the largest deviations from the 2022 base-case model result.

5.6. Future Projection

Future projections were deterministically calculated using SS3 options based on the scenario that was agreed upon at the data preparation meeting. The WG discussed the rebuilding plan of the WCNPO striped marlin stock that the WCPFC Commission requested. Although the stock status is close to the biological rebuilding target and fishing mortality have been decreasing, there have been concerns about low recruitment in recent years. It was also noted that the stock assessment's future projections were deterministic and did not take into account stochastic recruitment. **The WG agreed that particular rebuilding calculations were unnecessary but that additional calculations should be made for all management scenarios with current low recruitment status and F scenarios that satisfy the rebuilding targets** (Table 5). These runs were completed after the assessment workshop using the average recruitment for the last 20 years, 2001-2020 and were provided to the WG via correspondence.

5.7. Limit Reference Point

In Search of Reference Points for WCNPO Striped Marlin. Jon Brodziak

The ISC Billfish Working Group (WG) has been asked to evaluate dynamic unfished biomass (or B0) reference points for WCNPO Striped Marlin. This presentation described some analyses of biological and environmental time series to help to address the question of what would be an appropriate time window for setting dynamic B0 reference points. The presentation provided some background on nonstationarity in the ocean environment and on the WG treatment of Striped Marlin recruitment dynamics for future stochastic projections and describes the probable state of nature that recruitment strength and pattern is influenced by both maternal, e.g., spawning biomass, and environmental, e.g., ENSO process effects. The question of the time window for determining an appropriate window for setting dynamic B0 reference points was framed in the context of prevailing conditions, or which ecological, environmental and fishery factors were expected to affect stock productivity. Time series analyses were conducted on six biological and environmental series taken from the 2021 assessment update and online data repositories during 1975-2017 for potential impacts on productivity. The three biological series were Striped Marlin recruitment, spawning biomass and recruits per spawner from the 2021 assessment update (ISC BILLWG 2021). The three environmental series were: two annual averaged indices for the El-Nino Southern Oscillation [ENSO] (the Oceanic Nino Index (ONI, https://psl.noaa.gov/enso) and the Multivariate

ENSO Index (MEI, v2, https://psl.noaa.gov/enso)) and an index for the Pacific Decadal Oscillation (PDO, NDJFM-average, https://www.ncdc.noaa.gov/teleconnections/pdo/). In addition, the three life history scenarios being investigated for the 2022 benchmark stock assessment, the WCNPO, SWPO and EPO, and the life history scenario from the 2019 stock assessment (2019 WCNPO) were used to calculate estimates of yield per recruit, spawning biomass per recruit and mean generation time for Striped Marlin as a function of life history parameters and survival rates in equilibrium. Here the fishery selectivity used to calculate fishing mortality at age was derived from the selectivity at age pattern used for the Striped Marlin stock projections conducted for the 2019 WCNPO assessment with age-based shifts for the SWPO (-1 year) and EPO (+3 year) scenarios. Results of the analyses indicated that the unfished mean generation times for the WCNPO, SWPO, and 2019 WCNPO life history scenarios were about 5 years, while the results for the EPO scenario indicated an unfished mean generation time of about 10 years.

Given these analyses, correlation analyses for the six time series along with time indicated that there were several important associations among pairs of series. These included important negative time trends for both recruitment and spawning biomass as well as positive associations between recruitment and both spawning biomass and recruits per spawner (a measure of early life history survival success). Autocorrelation function analyses of the six time series showed that recruitment and spawning biomass exhibited substantial serial correlations from lags 1 to 7 years. In contrast, recruits per spawner had no apparent important serial correlations while the ENSO and PDO series showed negative lag-2 and positive lag-1 correlations, respectively. Partial autocorrelation functions analyses showed that recruitment and spawning biomass both showed important conditioned correlations that were positive at lag-1. Similarly, the recruits per spawner series showed no important conditioned correlations while the ENSO and PDO series showed negative lag-2 and positive lag-1 conditioned correlations, respectively. Cross correlation analyses of the sets of pairs of time series showed that there were important positive cross correlations between recruitment and spawning biomass series at lags -9 to 7 years, which indicated that these series exhibited synchronous fluctuations for a time window of more than a decade. Other important cross correlations showed a positive association between recruitment and the ENSO and PDO environmental processes at a lag of -1 year. Overall, the time series analyses showed that the recruitment and spawning biomass series were nonstationary with important positive cross correlations, as might be expected. The time series analyses also indicated that there were some short-term serial correlations within and between the ENSO and PDO series and that, these environmental series were positively associated with recruitment at a lag of -1 years.

Change point analyses conducted to assess when there might be change in the mean or variance of the individual time series showed that several series had consistent change points. For recruitment, there appeared to be a change point in year. Spawning biomass showed a similar pattern with a probable change point in year. In contrast, the recruits per spawner time series showed no apparent change points during 1975-2017. The environmental time series showed little evidence for change points although there was. Overall, the change point analyses suggested that the mean and variance processes for the recruitment and spawning biomass time series of Striped Marlin changed in the mid-1990s. This suggests that the current window of prevailing environmental conditions for these indicators of productivity extends backwards in time for about 20 years or so.

Last, the presentation provided an example of the calculation of a time series of dynamic B0 reference points for Striped Marlin based on a 15-year time window, starting in 1990 with the initial time window extending from 1975 to 1989 (15 years with a one-year lag for assessment) and the last time window extending from 2002-2016. Here an example time series of dynamic B0 values were calculated as the product of the average recruitment during the time window times the unfished spawning biomass per recruit at equilibrium. It was noted that this 15-year example only provided an illustration of the dynamic B0 calculation for Striped Marlin and that the WG would need to review this and other information to make a determination of what an appropriate time window would be.

Discussion

It was recommended that a 20 year time window be used, and the WG members noted that the PDO series also shown in the meeting and this series indicates a natural shift in PDO from warm to cold phase around 1997-1998, more or less coincident with change point analysis results for striped marlin recruitment and spawning biomass series from the 2019 stock assessment and the presentation shown that indicated there was some change in mean and variance of both series in the mid to late 1990s.

It was also noted generation time of striped marlin is five years, and 20 years is four generation times.

The WG agreed that twenty years is the most appropriate 20% dynamic B0 (20%$SSB_{F=0}$) calculation time window considering these discussions.

The WG also discussed how to show the Kobe plot. **It was agreed that the x-axis of the Kobe plot is the rebuilding target determined by the WCPFC commission (20%$SSB_{F=0}$), and the y-axis is the F ratio that correspond to 20%$SSB_{F=0}$. It was also agreed not to use a specific color for the background of the Kobe plot because there are no reference point for this species.**

6. CIRCULATE WORKSHOP REPORT

The WG Chair made a draft of the workshop document and distributed it to the WG members. The WG members browsed and proofread the draft on an e-mail basis.

7. ADOPTION

After the circulation of the adopted workshop document by e-mail, the WG adjourned the Western and Central North Pacific Ocean striped marlin stock assessment meeting on 16:00 10th May 2021 (JTS).

8. REFERENCES

Shimose, T. and Yokawa, K., 2019. Age estimation of striped marlin (*Kajikia audax*) in the eastern North Pacific using otolith microincrements and fin spine sections. Marine and Freshwater Research, 70(12), pp.1789-1793.

Table 1. Tested SS3 models using WCNPO growth.

No	Model change
WCNPO_SA0	Presented on the first day
WCNPO_SA1	Drop all late period CPUE
WCNPO_SA2	Drop JPN LL time brock (F1: 1997-2003, F5: 1994-2003)
WCNPO_SA3	Change JPNDF mid selectivity mirror (F24: F13 to F1, F25: F14 to F5)
WCNPO_SA4	Drop US LL CPUE (1995-1996)
WCNPO_SA5	Lambda of Rec devs = 0.5 (SA2 base)
WCNPO_SA6	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, Down weight recruitment devs, lambda to 0.5
WCNPO_SA7	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, Down weight recruitment devs, lambda to 0.2
WCNPO_SA8	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, Down weight recruitment devs, lambda to 0.5 and only S1, S2, and S5
WCNPO_SA9	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, Down weight recruitment devs, lambda to 0.5 and only S3 and S6
WCNPO_SA10	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, Down weight recruitment devs, lambda to 0.5 and down weight JPNDF F13 and F14 size comp to variance adjustment 0.5
WCNPO_SA11	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, and only S1, S2, and S5
WCNPO_SA12	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, and only S3 and S6
WCNPO_SA13	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, and down weight JPNDF F13 and F14 size comp to variance adjustment 0.5
WCNPO_SA14	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, start in 1977
WCNPO_SA15	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, start in 1977, down weight F13 and F14 size comp to variance adjustment 0.5, drop S3 and S4
WCNPO_SA16	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, start in 1977, down weight JPN DF F13 and F14 to 0.5, drop S2, S3, and S4
WCNPO_SA17	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, start in 1977, down weight JPN DF F13 and F14 to 0.25, drop S2, S3, and S4
WCNPO_SA18	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, start in 1977, change F23 and F24 selectivity to mirror F1 and F5, respectively, drop S2, S3, and S4
Base case model	Drop F01 1997-2003 and F05 1994-2003 selectivity time blocks, start in 1977, change F23 and F24 selectivity to mirror F1 and F5, respectively, drop S2, S3, and S4, estimate initial F

Table 2. Tested SS3 models using SWPO growth.

No	Model change
SWPO_SA0	Presented on the first day
SWPO_SA1	Change JPNDF mid selectivity mirror (F24: F13 to F1, F25: F14 to F5) (SA0 base)
SWPO_SA2	Drop US LL CPUE (1995-1996) (SA1 base)
SWPO_SA3	Set time block (USLL: 1994-2000, 2001-2007), Change JPNDF mid selectivity mirror (F24: F13 to F1, F25: F14 to F5) Drop US LL CPUE (1995-1996)
SWPO_SA4	Lambda of Rec devs = 0.1 (SA0 base)
SWPO_SA5	Lambda of Rec devs = 0.3 (SA0 base)
SWPO_SA6	Lambda of Rec devs = 0.5 (SA0 base)
SWPO_SA7	Lambda of Rec devs = 0.7 (SA0 base)
SWPO_SA8	S3 and S4+Down-weight TW length composition (*0.3) (SA0 base)
SWPO_SA9	Model starting year from 1977 (SA0 base)
SWPO_SA10	SA9+Drop S3 and S4+Down-weight TW length composition (*0.3) (SA9 base)
SWPO_SA11	SA9+Drop S3,S4, and S1+Down-weight all length compositions (*0.5) (SA9 base)
SWPO_SA12	Drop S3,S4, and S1+Down-weight USA length composition (*0.5) (SA9 base)

Table 3. Tested SS3 models using EPO growth.

No	Use base case	Model change	R0 profile	ASPM
EPO_SA0	-	Presented on the first day	No information	No information
EPO_SA1	No	Change L_{50} value (181cm to 166.5cm)	No information	No information

Table 4. The list of sensitivity runs.

RUN	NAME	DESCRIPTION
Alternative Life History Parameters: Natural Mortality		
1	base_case_highM	Alternative natural mortality rates are 10% higher than in the base case
2	base_case_lowM	Alternative natural mortality rates are 10% lower than in the base case
Alternative Life History Parameters: Recruitment Variability (σ_R)		
3	base_case_large_σ_R	A larger σ_R (0.9).
Alternative Life History Parameters: Stock-Recruitment Steepness		
4	base_case_h095	Alternative higher steepness with h=0.95
5	base_case_h079	Alternative lower steepness with h=0.79
6	base_case_h070	Alternative lower steepness with h=0.70
Alternative Life History Parameters: Maturity Ogive		
7	base_case_L50_177	Alternative maturity ogives with L50 177 cm (Used in the 2015 assessment)
8	base_case_L50_181	Alternative maturity ogives with converted L50 from Chang et al. (2019)
Alternative Model Configuration		
9	Base_case_S1994	Start the assessment model in 1994 instead of 1975
10	Base_case_S1975	Start the assessment model in 1975 instead of 1977
Alternative catch assumption		
11	Drop_VNCN_catch	Drop the Vanuatu and Chinese catch
12	SWPO_SA9	SW Pacific Growth model
13	Growth_2019	Use biological parameters from 2019 base-case model
14	base-case_DFselec	Alternative mirroring for F24 (F13) and F25 (F14)

Table 5. The list of future projection scenarios.

Projection	Scenario		Years	Recruitment Scenario
1	F-Based	$F_{status\ quo}$ (Average F 2018-2020)	20	S/R Curve
2	F-Based	F_{MSY}	20	S/R Curve
3	F-Based	Highest F (Average F 1998-2000)	20	S/R Curve
4	F-Based	Low F ($F_{30\%}$)	20	S/R Curve
5	F-Based	$F_{20\%SSBF=0}$	20	S/R Curve
6	F-based	FstatusQuo	20	Last 20yrs recruitment
7	F-Based	$F_{20\%SSBF=0}$	20	Last 20yrs recruitment
8	F-Based	F_{MSY}	20	Last 20yrs recruitment
9	F-Based	Highest F (Average F 1998-2000)	20	Last 20yrs recruitment
10	F-Based	Low F ($F_{30\%}$)	20	Last 20yrs recruitment

APPENDIX 1. LIST OF PARTICIPANTS.

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APPENDIX 2. MEETING AGENDA

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

BILLFISH WORKING GROUP (BILLWG)

INTERSESSIONAL WORKSHOP ANNOUNCEMENT and AGENDA

Meeting Style: Webinar meeting using Webex
The WG chair will inform the link at the day before the meeting.

Meeting Dates: March 28th, 2022 9:00-13:00 (JST)
April 1-4th, 2022 9:00-13:00 (JST)
April 5-6th, 2022 11:00-15:00 (JST)

Meeting Goals: The ISC BILLWG will conduct the stock assessment for Striped marlin in the Western and Central North Pacific Ocean (WCNPO) and agree on stock status, future projections, and sensitivity analysis results. Based on these results, the BILLWG will formulate conservation information. The ISC BILLWG also discuss the appropriate time frame for calculating the dynamic SSB0.

Meeting Attendance: Please respond to Hirotaka Ijima (Email: ijima@affrc.go.jp) if you plan on attending this meeting

Working Papers: Submit working papers to Hirotaka Ijima by March 25th.

BILLWG Contact: Hirotaka Ijima (Ph.D, ISC BILLWG Chair)
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AGENDA

March 28th (Monday), 9:00 - 13:00 (JST)

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. Numbering working papers and distribution potential
4. US size composition data
5. WCNPO striped marlin stock assessment modeling
   a. SS3 model using WCNPO growth curve
   b. SS3 model using SPO growth curve
   c. SS3 model using SPO growth curve
   d. Uncertainty grid
   e. Sensitivity analysis
   f. Future projection
   g. Limit reference point

April 1st (Friday), 9:00 - 13:00 (JST)

5. WCNPO striped marlin stock assessment modeling
   a. SS3 model using WCNPO growth curve
   b. SS3 model using SPO growth curve
   c. SS3 model using SPO growth curve
   d. Uncertainty grid
   e. Sensitivity analysis
   f. Future projection
   g. Limit reference point

April 2nd (Saturday), 9:00 - 13:00 (JST)

5. WCNPO striped marlin stock assessment modeling
   a. SS3 model using WCNPO growth curve
   b. SS3 model using SPO growth curve
   c. SS3 model using SPO growth curve
   d. Uncertainty grid
   e. Sensitivity analysis
   f. Future projection
   g. Limit reference point

April 3rd (Sunday), 9:00 - 13:00 (JST)

5. WCNPO striped marlin stock assessment modeling
   a. SS3 model using WCNPO growth curve
   b. SS3 model using SPO growth curve
   c. SS3 model using SPO growth curve
   d. Uncertainty grid
   e. Sensitivity analysis
   f. Future projection
   g. Limit reference point

April 4th (Monday), 9:00 - 13:00 (JST)

5. WCNPO striped marlin stock assessment modeling
   a. SS3 model using WCNPO growth curve
   b. SS3 model using SPO growth curve
   c. SS3 model using SPO growth curve
   d. Uncertainty grid
   e. Sensitivity analysis
   f. Future projection
   g. Limit reference point

April 5th (Tuesday), 11:00 - 15:00 (JST)

5. WCNPO striped marlin stock assessment modeling
   a. SS3 model using WCNPO growth curve
   b. SS3 model using SPO growth curve
   c. SS3 model using SPO growth curve
   d. Uncertainty grid
   e. Sensitivity analysis
   f. Future projection
   g. Limit reference point

April 6th (Wednesday), 11:00 - 15:00 (JST)

6. Circulate workshop report
7. Adoption

APPENDIX 3. THE LIST OF WORKING PAPERS

ISC/22/BILLWG-01/01	Observed length composition data for striped marlin, *Kajikia audax*, in the Hawaii longline fishery, 1994-2020 Jon Brodziak and Michelle Sculley Jon.Brodziak@noaa.gov
ISC/22/BILLWG-01/02	Preliminary Base-case Model in Stock Synthesis 3.30 for Consideration in the 2022 Western and Central North Pacific Striped Marlin (*Kajikia audax*) Stock Assessment using WCNPO Biological Parameters Michelle Sculley michelle.sculley@noaa.gov
Presentation 1	A Preliminary Stock Synthesis Model Conducted for the WCNPO Striped Marlin based on the growth parameters of SWPO striped marlin. Yi-Jay Chang yjchang@ntu.edu.tw
Presentation 2	Developing SS3 model using SPO growth curve. Hirotaka Ijima ijima@affrc.go.jp
Presentation 3	Comparison of Yield and Spawning Biomass Per Recruit for Alternative Striped Marlin Life History Scenarios Jon Brodziak Jon.Brodziak@noaa.gov
Presentation 4	In Search of Reference Points for WCNPO Striped Marlin Jon Brodziak Jon.Brodziak@noaa.gov