International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

A Comparison of the Consistency of Pacific Blue Marlin (*Makaira nigricans*) Length and Weight Composition Data From the Japanese Distant Water Longline Fleet, 1970-2011[1]

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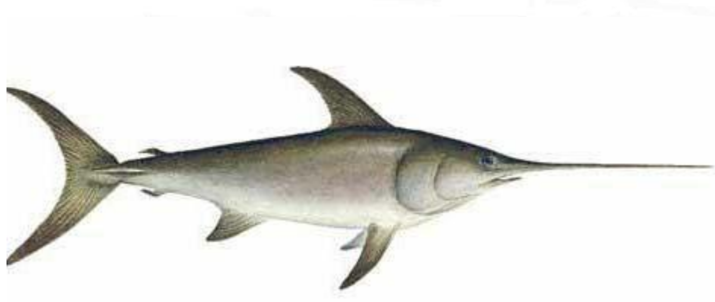

[1]Working document submitted to the ISC Billfish Working Group Workshop, 20-28 May 2013, Shimizu, Shizuoka, Japan. Document not to be cited without author's written permission.

A Comparison of the Consistency of Pacific Blue Marlin (*Makaira nigricans*)

Length and Weight Composition Data

From the Japanese Distant Water Longline Fleet, 1970-2011

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ABSTRACT

This working paper addresses the question of whether the pooled-sex blue marlin length composition data and weight composition data collected from the Japanese distant water longline fisheries provide consistent measures of the size composition of the fishery. To address this question, we apply a chi-square goodness of fit test to the length ($\underline{p}$) and length-converted weight frequency ($\underline{q}$) data by year and quarter. To test the hypothesis $H_0 : \underline{p} = \underline{q}$ that there was no difference between observed length and converted length size composition for each year-quarter combination, blue marlin eye-fork length measurements (cm) were binned into a total of $k = 6$ bins; these were: (0,140], [140,160), [160,180), [180,200), [200,220), and [220,500]. Overall, there were a total of $m = 167$ year-quarter combinations that had no zero counts in a length bin and were hence feasible for statistical comparison using the chi-square test. We tested the hypothesis H_0 for each year-quarter combination at the $\alpha = 0.05$ experiment-wise confidence level using the Bonferroni method with an adjusted $\alpha_i = \alpha / m = 0.0003$ and a

critical chi-square value of $X^2_{1-\alpha_i, k-1} = 23.27$. The hypothesis $H_0: \underline{p} = \underline{q}$ that there was no difference in size composition was rejected in 166 out of 167 or 99% of the tests. The hypothesis was not rejected only in 1975 in quarter 3. As a result, we conclude that the blue marlin length and weight composition data collected from the Japanese distant water longline fishery are not consistent.

MATERIALS AND METHODS

This working paper addresses the question of whether the pooled-sex blue marlin length composition data and weight composition data collected from the Japanese distant water longline fisheries provide consistent measures of the size composition of the fishery. A priori, we note that the observed mean length and mean weight samples appear to show different patterns by year and quarter (Figure 1).

To address this question, we apply a chi-square goodness of fit test to the length and weight frequency data by year and quarter. In particular, let $\underline{p} = \left(p_1, p_2, ..., p_k\right)$ be the vector of proportions of observed blue marlin in k length categories collected and let X_i be the number of fish in the i^{th} length bin for a total of n random samples in a given year and quarter.

Then the vector $\underline{X} = \left(X_1, X_2, ..., X_k\right)$ is a discrete random variable with a multinomial distribution and probability density function

(1.1) $$P\left(X_1 = x_1, X_2 = x_2, ..., X_k = x_k\right) = \frac{n!}{x_1! x_2! ... x_k!} p_1^{x_1} p_2^{x_2} ... p_k^{x_k}$$

Define the same set of proportions $\underline{q} = (q_1, q_2, ..., q_k)$ for the weight composition data after transforming the blue marlin weight (kg) frequencies to length frequencies (cm, eye-fork length) using the inverse of the pooled-sex length-weight relationship (Brodziak 2013) which is

$$(1.2) \qquad W = 2.768 \cdot 10^{-6} L^{3.243} \quad or \quad L = 51.736 \cdot W^{0.308356}$$

We note that the converted length frequencies appear to show a different pattern than the observed length frequencies (Figure 2). We can now rephrase the question of whether the blue marlin length and weight composition data are consistent by testing the hypothesis $H_0 : \underline{p} = \underline{q}$ which can be evaluated using the chi-square test. The basis of the chi-square test is the random variable C where

$$(1.3) \qquad C = \sum_{i=1}^{k} \frac{(X_i - nq_i)^2}{nq_i}$$

The test statistic C converges to the cumulative distribution function of the chi-square distribution (X^2) with $k-1$ degrees of freedom. As a result, we can test the hypothesis H_0 at the α level of significance and reject H_0 in favor of $H_1 : \textit{at least one } p_i \neq q_i$ when the test statistic c is no less than the value of the chi-square distribution evaluated at the p value $1-\alpha$ with $k-1$ degrees of freedom, or

$$(1.4) \qquad c = \sum_{i=1}^{k} \frac{(x_i - nq_i)^2}{nq_i} \geq \mathrm{X}^2_{1-\alpha, k-1}$$

To test the hypothesis H_0 of no difference between observed length and converted length size composition for each year-quarter combination, blue marlin eye-fork length measurements (cm) were binned into a total of $k = 6$ bins; these were: (0,140], [140,160), [160,180), [180,200), [200,220), and [220,500]. The choice of 6 bins was made based on an average of 225 fish per bin which is roughly the total sample size of n = 226,863 lengths divided by the number of expected tests by year and quarter (168) and the number of bins (6). Overall, there were a total of $m = 167$ year-quarter combinations that had no zero counts in a length bin and were hence feasible for statistical comparison using the chi-square test.

We tested the hypothesis H_0 for each year-quarter combination at the $\alpha = 0.05$ experiment-wise confidence level using the Bonferroni method with an adjusted $\alpha_i = \alpha / m = 0.0003$ and a critical chi-square value of $\mathrm{X}^2_{1-\alpha_i, k-1} = 23.27$.

The hypothesis $H_0 : \underline{p} = \underline{q}$ was rejected in 166 out of 167 or 99% of the tests. The hypothesis was not rejected only in 1975 in quarter 3. As a result, we conclude that the blue marlin length and weight composition data collected from the Japanese distant water longline fishery are not consistent. We also note that the average proportions of fish in the observed length composition counts for the bins (0,140] and [140,160) were greater than the expected values from the weight composition data in each quarter (Figures 3.1 to 3.4). Overall, this indicated that the length composition data included higher observed proportions of smaller blue marlin less than 160 cm eye-fork length than the weight composition data.

REFERENCES

Brodziak, J. 2013. Combining information on length-weight relationships for Pacific blue marlin. International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific/Billfish WG, ISC/13/BILLWG-1/01, 9 p.

Figure 1. Mean Length and Mean Weights of Pacific Blue Marlin Sampled From the Japanese Distant Water Longline Fleet By Year and Quarter, 1970-2011

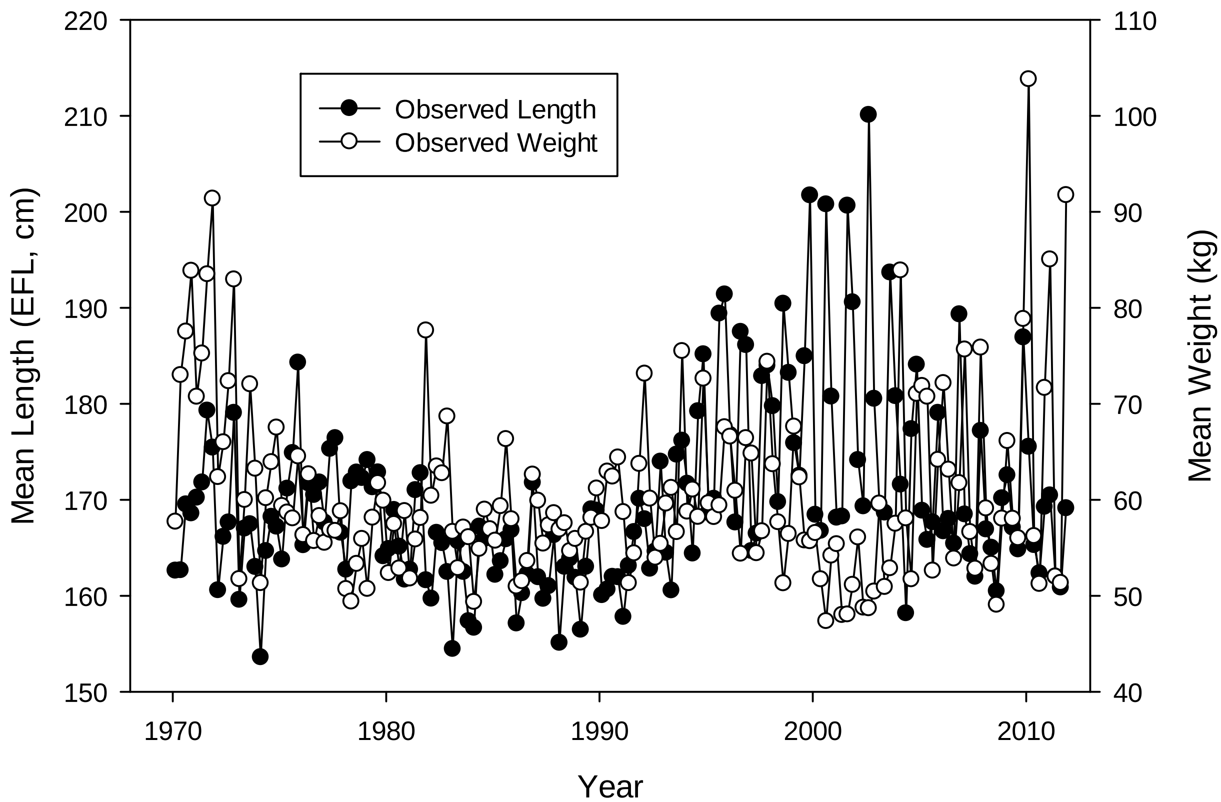

Figure 2. Observed and Converted Mean Lengths of Pacific Blue Marlin Sampled From the Japanese Distant Water Longline Fleet By Year and Quarter, 1970-2011

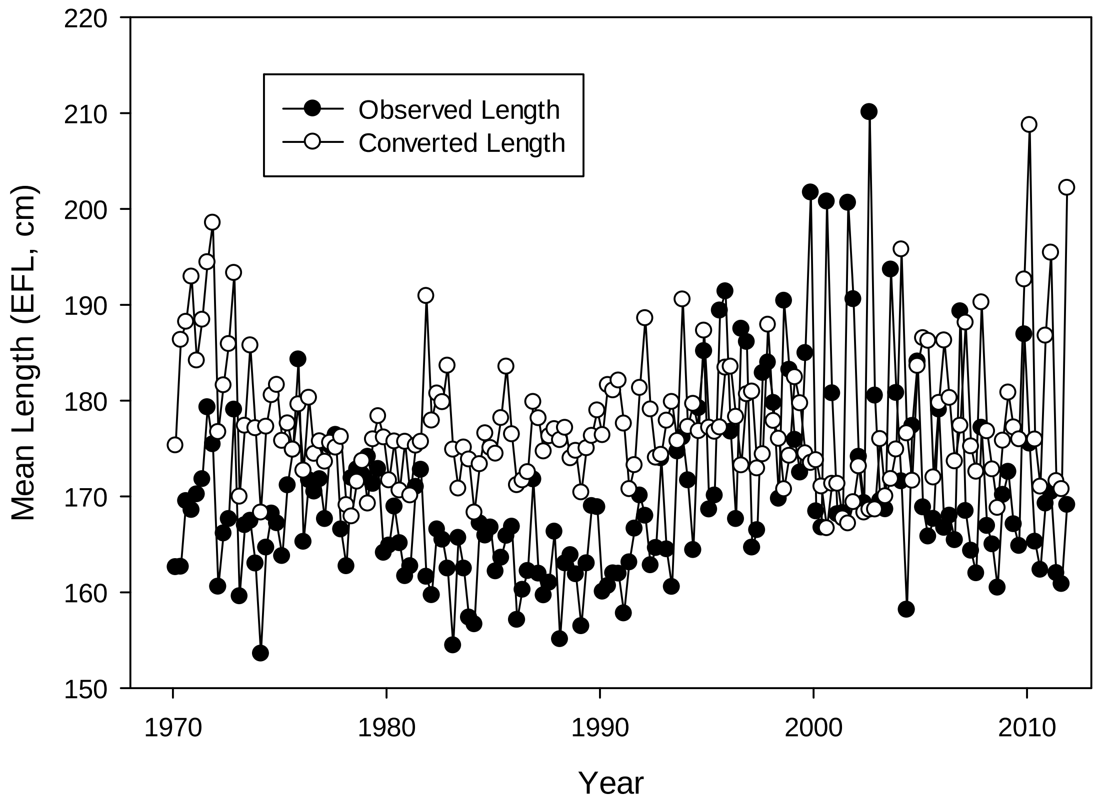

Figure 3.1. Comparison of Average Japanese Distant Water Longline Blue Marlin Length and Converted Weight Composition in Quarter 1, 1970-2011

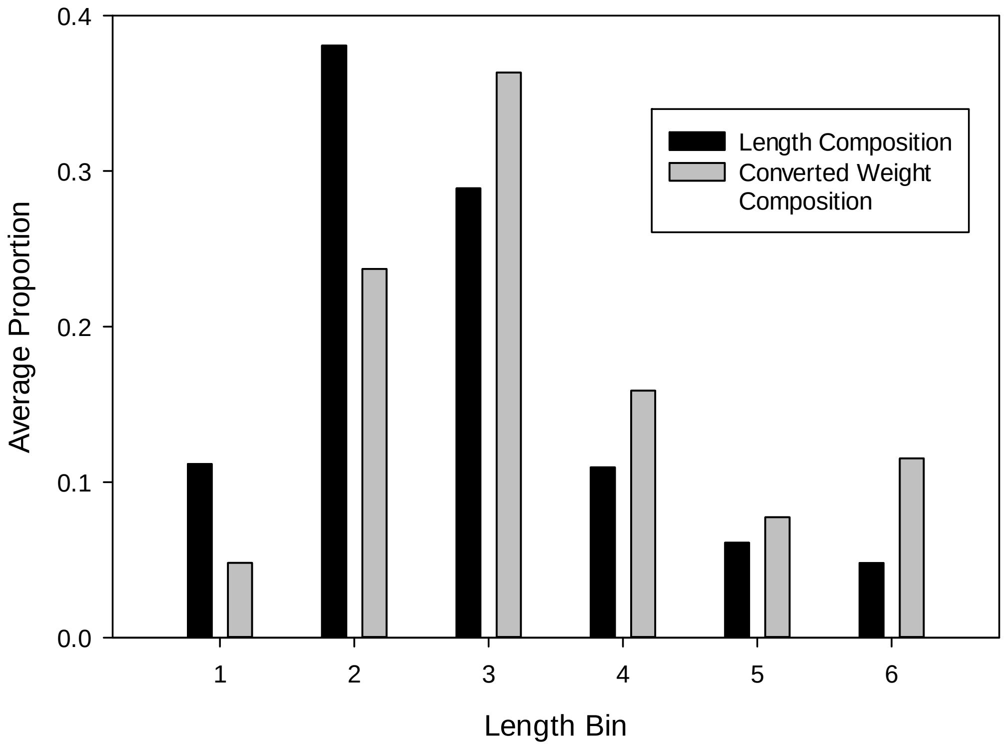

Figure 3.2. Comparison of Average Japanese Distant Water Longline Blue Marlin Length and Converted Weight Composition in Quarter 2, 1970-2011

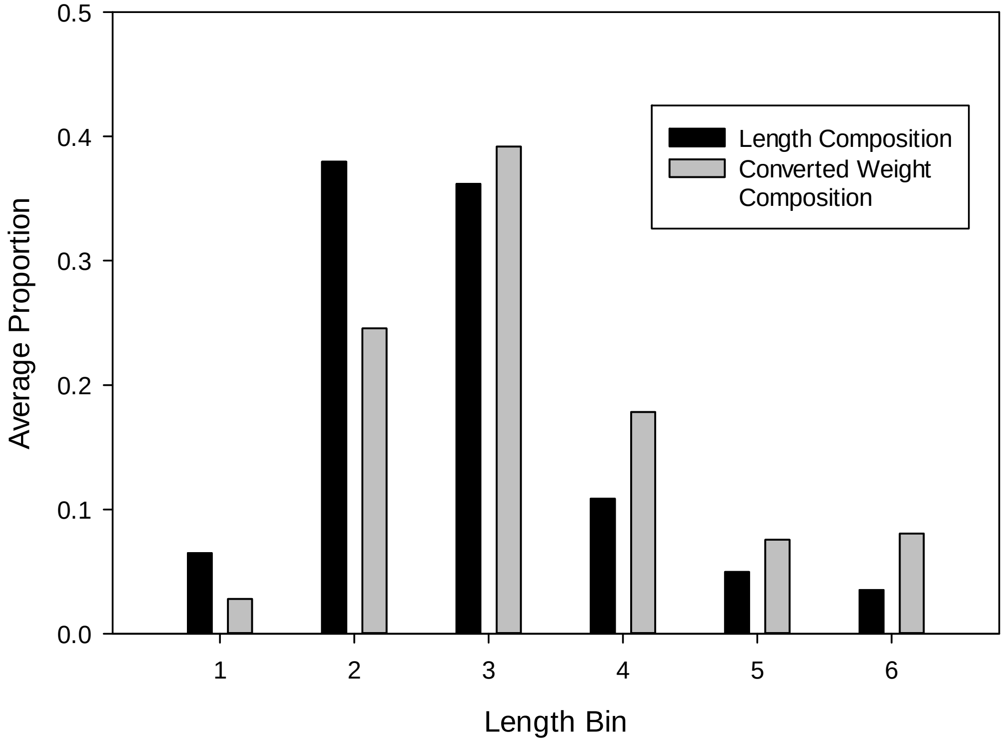

Figure 3.3. Comparison of Average Japanese Distant Water Longline Blue Marlin Length and Converted Weight Composition in Quarter 3, 1970-2011

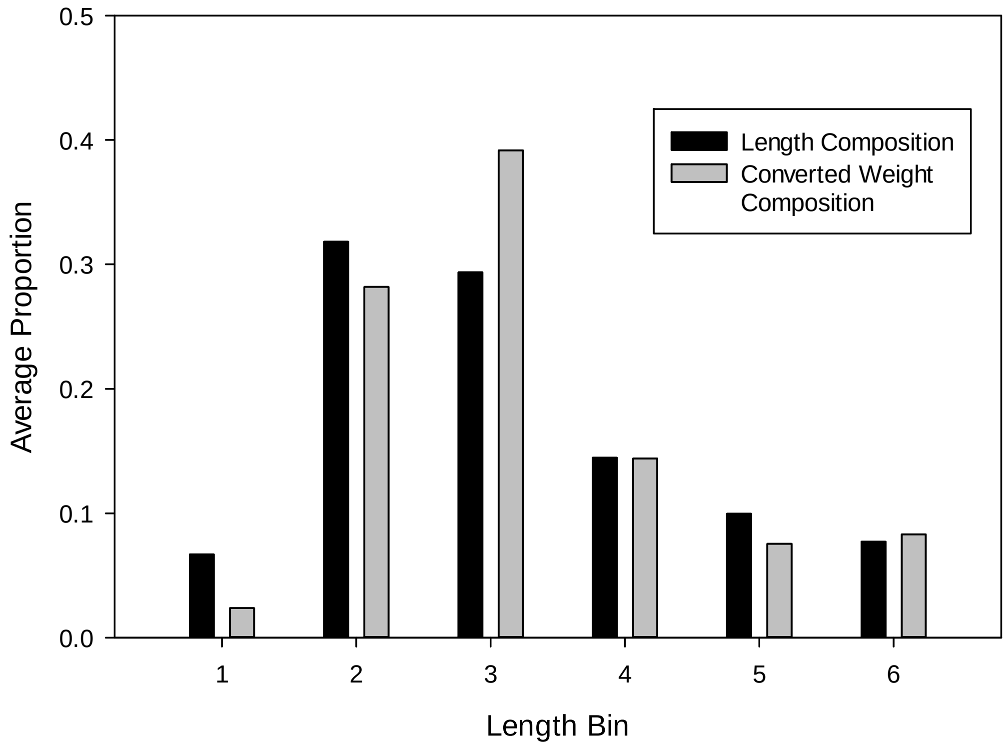

Figure 3.4. Comparison of Average Japanese Distant Water Longline Blue Marlin Length and Converted Weight Composition in Quarter 4, 1970-2011