Improvement of the estimation of Japanese southern bluefin tuna catch based on the market statistics and research data

市場統計及び調査情報に基づく日本のミナミマグロ漁獲量推定の改善

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要約

日本の市場統計及び調査情報に基づく日本のミナミマグロ漁獲量推定の改善を試みた。独立専門家による 2022 年の市場調査レビューの結果では、方程式による漁獲量の推定について否定的であった。しかし問題点として指摘された点に対して、影響の大きいパラメータについて固定値ではなく年別に変動する値を使用すること、パラメータごとに異なる影響の度合いを考慮したうえで解釈すること、点推定値ではなく信頼範囲を持った推定値を求めること、といった改善を行った。初期的な計算結果では、推定値の信頼範囲は報告漁獲量を含んだ。漁獲量推定は、対応アプローチでの検証をさらに頑健にできると期待される。また、もしも対応アプローチにおいて大きな変化が検出された場合、漁獲量に換算して影響を判断する必要があると思われるので、市場流通情報・データから漁獲量を推定する方法は、全メンバーそれぞれに対して CCSBT としてさらに追及すべき課題と言える。

Summary

An attempt was made to improve estimates of Japan's southern bluefin tuna catch based on Japanese market statistics and research data. The independent expert in the 2022 market research review proposed a negative comment about the equation's estimation of catch. However, in response to the points pointed out as problems, we have made several improvements that using annual values rather than fixed values over the years for parameters with a large influence, that to interpret the values after taking into account the different degrees of influence of each parameter, and that calculating estimates with a confidence range instead of the point estimate. Our preliminary result showed that the range of estimate

included the reported catch. It is expected that the catch estimates make the corresponding approach which is proposed by the expert more robust. In addition, if a large change is detected in the corresponding approach, it will be necessary to convert it into the amount of catch to determine the impact. Therefore, the method of estimating the amount of catch from market distribution information for each Member is an issue that CCSBT should pursue further.

1. Introduction

Dr. Clark, who was commissioned by CCSBT as the independent market expert, reported to CCSBT in 2022 (Clark 2022) regarding the estimation of each country's catch of southern bluefin tuna (SBT) using Japanese market information. In it, she wrote that "continued use of the market formula to verify SBT catches by Japan is not recommended". The reasons given for this are: 1) market conditions have changed since 2006, and parameter values that change from year to year should be used; 2) there is no prospect of obtaining objective parameter estimates for double counting between and within markets; 3) only point estimates are obtained rather than probabilistic estimates that take uncertainty into account; 4) CDS and landing control are in place and should be used. During the planning stage in December 2021, Dr. Clark intended to represent various uncertainties with a single parameter, *w*, and use it in the formula, but abandoned this idea in the actual investigation. The reason is not clear. Instead, she advocated testing changes through corresponding approaches rather than calculate catch estimates.

We believe that there is no reason explicitly to deny the use of catch estimation formulas for the reasons Dr. Clarke lists. Regarding 1 (parameter values that change from year to year should be used), as mentioned in the Report, annual parameter values have been obtained through Japan's own research and published statistics in the two important parameters, the ratio of in-market distribution volume and the ratio of SBT in the Tokyo and Yaizu markets to the total market in Japan. Note that the reason why fixed parameter values have been used since 2006 is that although Japan proposed the use of yearly parameter values, no agreement was reached in the discussions at the ESC. Regarding 2 (no prospect of obtaining objective double counting parameter), unfortunately this is true, but as Dr. Clark indicated in her plan, double counting has a small effect on catch estimates. Regarding 3 (uncertainties, not point estimates) can be calculated, while there are difficulties in setting the uncertainty bounds. Regarding 4 (CDS and landing controls are in place and should be used), although we support implementation of verification by the corresponding approach, in addition to these, it is expected that verification with the catch estimation value by the formula will be a more robust verification.

Therefore, the purpose of this document is to update the parameters for verification of Japan's catch, obtain probabilistic estimates that take uncertainty into account, and present them as concrete results.

2. Materials and methods

The formula used was originally developed by the Japan Market Review (JMR), have been used in our analysis, and described by Dr. Clark (Clark 2022, Itoh et al. 2020). To put it simply, it use the publicly available statistical values for the amount of frozen SBT handled in the Tokyo and Yaizu markets, and extend them to the total amount handled in the entire

Japanese markets. From this, subtract the amount of frozen farmed fish, the amount of double counting between and within markets, the amount of wild frozen fish produced by foreign countries, and the amount of exports from Japan. Correction is made with the proportion of fish handled outside the market and the whole fish conversion factor (Equation 1).

$$M_t = \left\{ \frac{\left(\frac{To_t + Ya_t}{p}\right) - F_t - d_t - i_t + S_t}{r} + E_t \right\} \times c_t \qquad \text{(Eq. 1)}$$

where

M_t is the total quantity of Japan-caught SBT in Japan's markets in year t

To_t is the quantity of frozen SBT (regardless of origin) sold through Tokyo metropolitan wholesale markets in year t

Ya_t is the quantity of frozen SBT (regardless of origin) sold through the Yaizu fish market in year t

p is the proportion of frozen SBT sold in Japan's municipal wholesale markets that is sold in Tokyo and Yaizu

F_t is the quantity of frozen SBT sold in Japan's municipal wholesale markets in year t that is farmed

d_t is the proportion of frozen SBT sold in Japan's municipal wholesale markets in year t that is double counted

i_t is the proportion of frozen wild SBT sold in Japan's municipal wholesale markets in year t that is imported

S_t is the quantity of fresh, non-imported SBT in year t (if any)

r is the proportion of Japan-caught SBT sold in Japan's municipal wholesale markets

E_t is the quantity of frozen Japan-caught SBT exported in year t

and

c_t is the conversion factor to adjust market-observed quantities to their whole weight equivalents.

The obtained M_t value is then used to estimate the catch amount, taking into account the time lag between the time the fish is caught and the fish are available on the market (Equation 2).

$$c_t = \sum_{l=0}^{6} \Theta_{t,l+1} M_{t-l} \qquad \text{(Eq. 2)}$$

where

c_t is the estimated quantity of SBT caught by Japan in year t

l is the number of lags, in this case six (l=1 to 6), plus the current year (l=0)

$\Theta_{t,l}$ is a matrix of dimensions t (years) and l (lags) with each corresponding to the proportion of the market quantity observed in year t which derived from each lag l (or the current year, I=0)

M_t the total market observed quantity of SBT in each year t.

Among the 10 types of statistical values and parameters involved in determining M_t, each has a different effect on the result. Dr. Clark conducted which she called *a simple sensitivity analysis* showing the effect of reducing each statistic/parameter to 80% in the 2019 value. Although this analysis was presented only at the planning stage and was not included in the final report, it was an important analysis in understanding the methodology. This paper presents the results of an analysis using the same approach for all years.

As for parameter updates, we treated the proportion of SBT handled by the Tokyo and Yaizu markets in the entire Japanese markets (p) and the amount distributed through in-market (r). Regarding p, statistics on the amount of frozen SBT handled are published in 8 other markets (Osaka City, Yokohama City, etc.) in addition to Tokyo and Yaizu, and the percentage of Tokyo & Yaizu to the total value including these is calculated by year (Fig. 1). The in-market rate was obtained from the volume survey data. In this survey, in response to a request from the Fisheries Agency, domestic wholesalers, trading companies, and importers that handle SBT responded with the annual handling volume of SBT. The quantity purchased is reported in kg and the destination is reported in %. However, with this data, it is not possible to directly calculate the in-market rate or off-market handling amount for domestic wild frozen fish. This time, we weighted the sales to the Tokyo Central Wholesale Market as in-market, and to mass retailers, food service industry, and others as off- market, and weighted them by the volume of domestic wild frozen fish handled by each company (Fig. 2).

A preliminary analysis of uncertainty was conducted under the following conditions. First, while some companies reported their customers in the volume survey with an accuracy of 1%, others reported with a rough accuracy of 10%. Therefore, we set a range of ±10% for the in-market rate. The percentage of foreign catches in the wild frozen fish at Toyosu Market is based on observations from twice-monthly management tag surveys (Fig. 3). Since the results do not cover all days of the month, the uncertainty range was set at ±10%. Regarding the amount handled in the entire Japanese markets, there may be cases where SBT is not included as an independent item in published market statistics due to the small amount handled. Because of this possibility, we also calculated if +100 tons were added to the total Japanese market handling volume (relevant only to overestimation).

3. Results

As the result of a simple sensitivity analysis, the statistical values and parameters that had the strongest influence were the in-market distribution rate r and the proportion of Tokyo Yaizu in the entire Japanese markets p (or volume in Tokyo market) (Table 1). The ratio of foreign-produced fish to wild frozen fish in the Tokyo market i is next to them. The whole fish conversion coefficient *c* also has an influence, but it is an established and definitive conversion value, and as Dr. Clark points out, there is no need to change it. It should be noted that the influence of the double count parameter value is small.

The handling ratio *p* of Tokyo and Yaizu markets to the entire Japanese markets for frozen fish has increased slightly over the years, exceeding the 78.96% assumed by JMR in many years. Updating to annual values would reduce the catch from market data. The in-market rate has fallen significantly from the 85% assumed by JMR, and has been around 60% in recent years. Updating to annual values would increase the catch inferred from the market data. The proportion of foreign catches in wild frozen fish in the Tokyo market increased to more than 40% between 2010 and 2014, but has since declined and is currently around 30%. However, the influence of this parameter is smaller than the previous two. This parameter has already been updated to an annual value. As a result of updating *p* and *r*, the estimated catch increased for 2015-2022 (Fig. 4). For 2017 and 2018, the estimated catches were close to the reported catches.

The estimated uncertainty range of catch now includes the reported catch (Fig. 5). It should be noted that the estimated catch for 2022 is currently an underestimate, as about half of the catch will come to the market in 2023.

4. Discussion

As a result of updating the *p* and *r* parameters to use annual values, the estimated catch since 2015 has become closer to the reported catch. The distribution situation of SBT products in the market would change, and it is no surprise that it has changed significantly over the 18 years from 2005 to 2022. Since annual values are available, it is naturally preferable to use them.

Dr. Clark based the inappropriateness of catch estimates on the improbability of obtaining objective parameter estimates for the double counting between and within markets. However, as she also analyzed in a simple sensitivity analysis, the influence of the double count parameter on the estimation results is small. It would cause little problem if the differences in the quantitative importance of statistical values and parameters should be appropriately recognized and includes them as uncertainties in the estimation assumptions.

Even after updating and correcting the parameters, the estimated catch (point estimate) from 2019 to 2021 is more than 1,000 tons lower than the reported catch, which is not a small difference. There might still be parameters to consider or changes in parameter values over years. This point should be pursued in the future. On the other hand, it is also recognized that indirect catch estimation from market information can only be done with coarse accuracy. Dr. Clarke's assertion that we should evaluate with a confidence range that takes into account uncertainties rather than pursuing point estimates seems appropriate. As a preliminary analysis, the uncertainty range was arbitrarily set and analyzed. In the future, there is room for improvement by further examining the uncertainties of each input statistical value and parameter, and by incorporating approaches using statistical modeling methods such as bootstrapping or Bayesian statistics with MCMC.

Dr. Clark proposed corresponding approach which compares between basic statistical values that are the basis for estimating the catch, and stated that if there were large anomalies between the catch and market distribution, they could be detected by changes that appear. We believe that the approach is important and effective. Since a large anomaly would likely result in a large change in the estimated catch, it is expected that the catch estimates will make the verification of the corresponding approaches more robust. In addition, if a large change is detected in the corresponding approach, it will be necessary to convert it into the amount of catch to determine the impact. From this point of view, therefore, the method of estimating the amount of catch from market distribution information for each Member is an issue that CCSBT should further pursue.

References

Clarke, S. (2022) Verification of All Members' Catch through Monitoring of Southern Bluefin Tuna Product Distribution -Report-. 97pp. CCSBT-CC/2210/19.

Itoh, T., Y. Tsuda and Y. Morita (2020) Monitoring of Southern Bluefin Tuna trading in the Japanese domestic markets: 2020 update. CCSBT-ESC/2008/22.

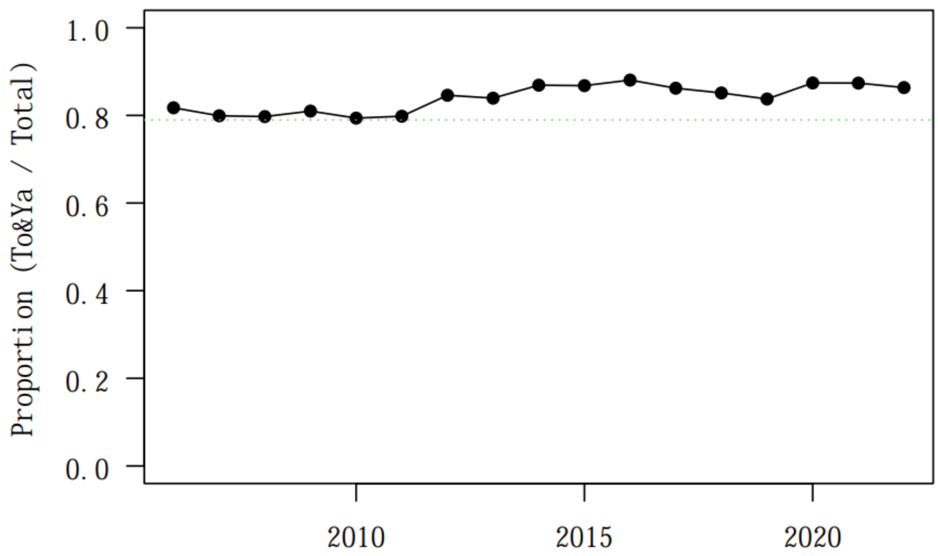

Figure 1. Proportion of frozen SBT treated in Tokyo & Yaizu markets to the entire Japanese markets.

Green line is 78.96% assumed by JMR.

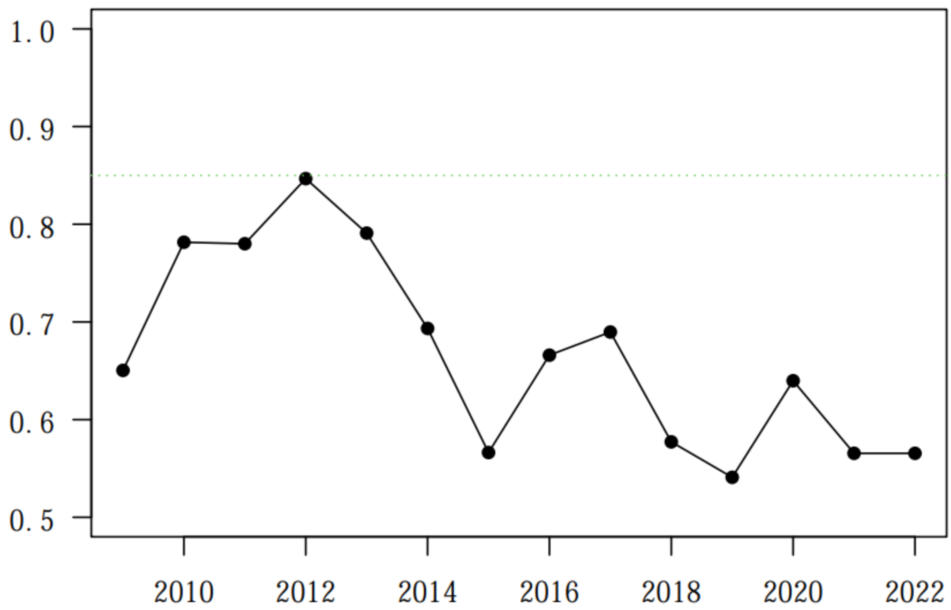

Figure 2. Proportion of in-market distribution volume of frozen fish in the Tokyo market calculated from the handling volume survey data

Green line is 85% assumed by JMR.

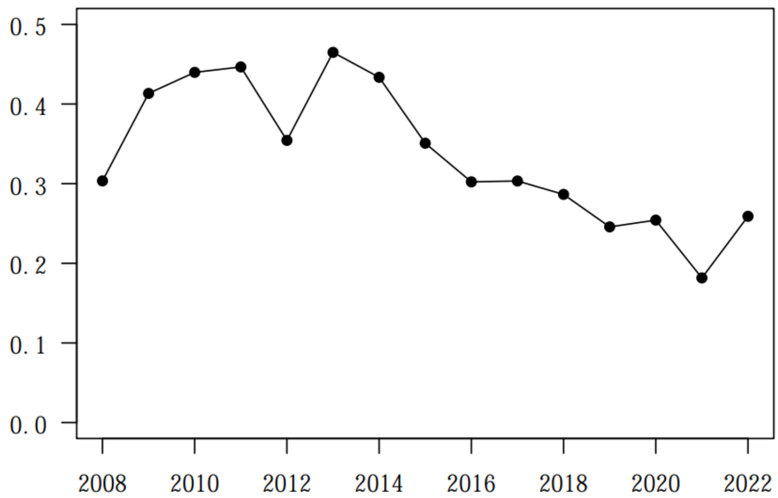

Figure 3. Proportion of foreign catch in wild frozen fish by year in the Tokyo market based on the management tag survey data

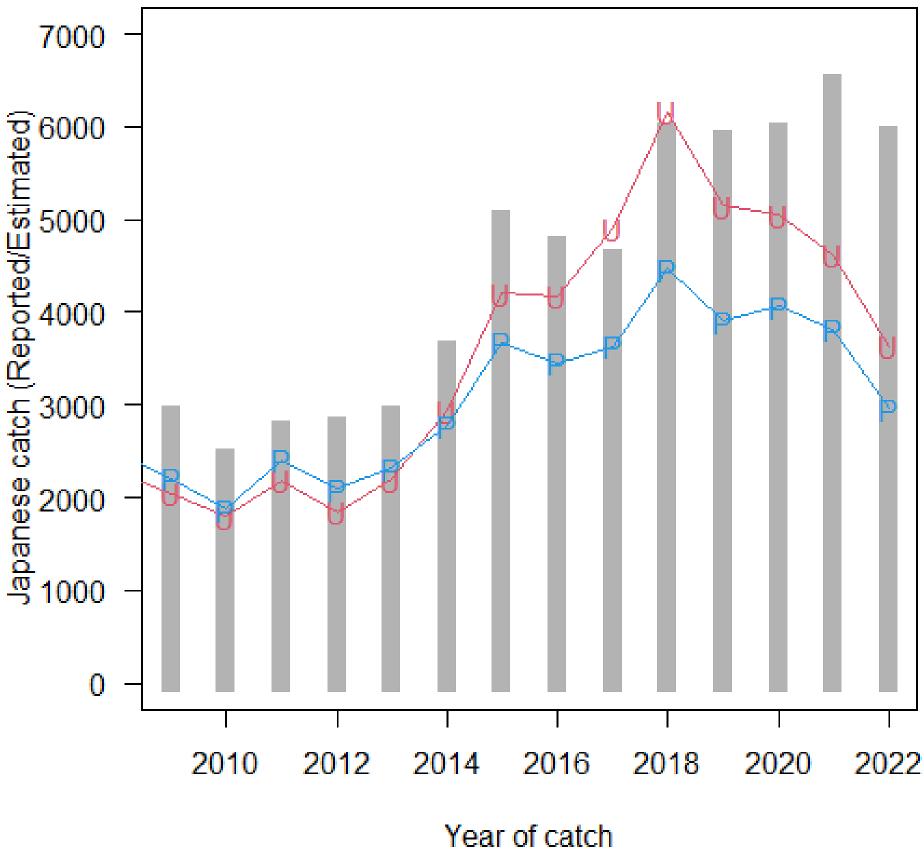

Figure 4. Estimates of Japan's southern bluefin tuna catch updated with in-market rate (r) and share of Toyosu and Yaizu (p) in the total Japanese market based on market statistics and survey data.

U is the updated estimate. P is the previous estimates with parameters fixed. Bars are reported catches.

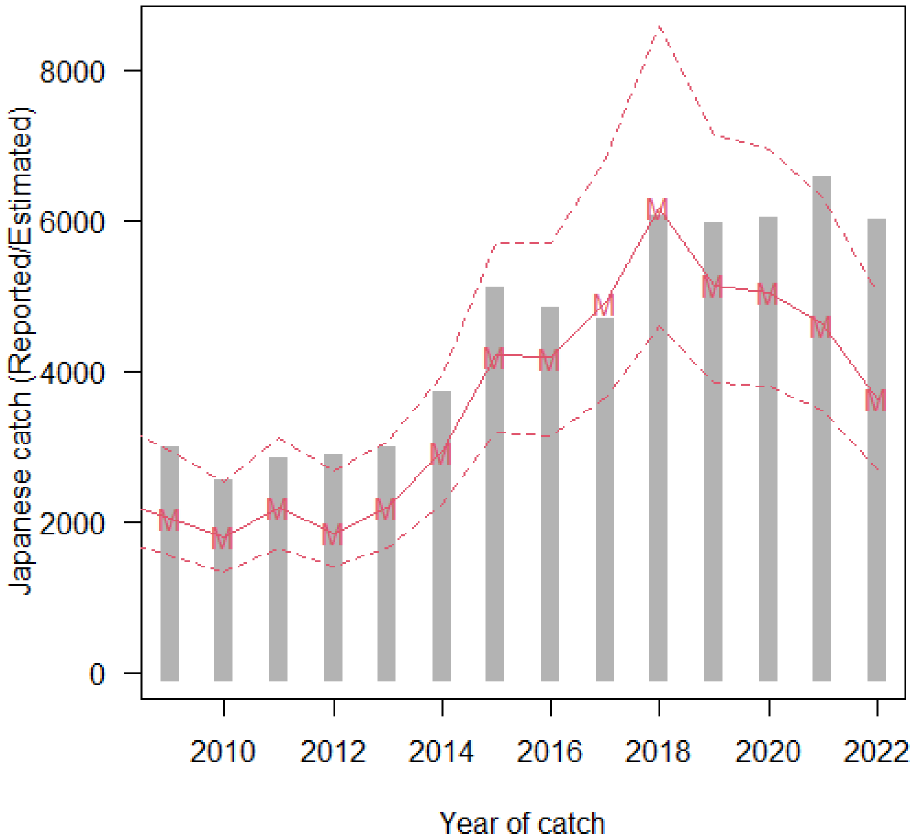

Figure 5. Estimated Japanese southern bluefin tuna catch within the specified uncertainty range.

M is the base case. The dotted lines are the assumed uncertainty range. Note that recent years, especially 2022, have been underestimated as some of the catch has not yet come to the market.

Table 1. Results of "simple sensitivity analysis" examining changes when each parameter is reduced to 80%.

v.2021 is calculated for the 2021 catch year. Mean and SD are 10-year mean and standard deviation from 2013-2022.

	Base	To	Ya	p	F	d	i	r	c	E
factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
before		3,218	755	0.790	0.145	0.118	0.182	0.850	1.15	96
after		2,574	604	0.632	0.116	0.095	0.145	0.680	0.92	77
v.2021	3,813	-16.2%	-3.5%	24.6%	3.9%	3.2%	5.8%	24.6%	-19.7%	-0.3%
Mean	3,506	-16.2%	-3.0%	23.9%	6.9%	3.5%	8.4%	23.9%	-19.1%	-0.9%
SD	646	0.4%	0.3%	0.7%	2.9%	0.3%	2.9%	0.7%	0.6%	0.6%