Projecting U.S. Western and Central Pacific Longline Bigeye Tuna Annual Catch

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Introduction

The Western and Central Pacific longline fishery is subject to a catch limit for U.S. permitted vessels, which is administered by the National Marine Fisheries Service (NMFS). In 2023, the bigeye tuna (BET) limit for the Western and Central Pacific Fisheries Commission (WCPFC) Convention Area was 3,554 metric tons (t) and applies to all pelagic longline vessels with Hawaii permits fishing inside the Exclusive Economic Zone (EEZ) around the Hawaiian Islands as well as those vessels fishing without an American Samoa permit in the high seas. To forecast whether the fishery will exceed this catch limit, the Pacific Islands Fisheries Science Center (PIFSC) uses historical data to project future catches.

In recent years, fishing effort in the WCPFC Convention Area (WCPFC-CA) has significantly increased. Vessels have been required to submit longline catch and effort data with electronic reporting (ER) since September 2021. This data report provides an analysis of two proposed methodological changes in the projection of BET catch in the WCPFC-CA. Given the increase in effort, some historical catch data should be excluded from the projection. Additionally, the lookback window used by the projection can be reduced by incorporating logbook data reported via ER.

Methods

To calculate the current and forecasted catch in the WCPFC-CA, logbook catch data are provided by Hawaii longline vessels to NMFS, and PIFSC calculates estimates of average weights per fish from data provided by the State of Hawaii. These data do not include fishing activity for which logbooks have not yet been received and compiled by NMFS (for example, fishing trips still underway without electronic reporting). The catch forecast is calculated by adding estimates of future daily catch to the current cumulative catch. The forecast is uncertain because actual values of future catch in numbers of fish and average fish weight could deviate from the values assumed in the forecast. Previously, the estimates of future daily catch were based on the average daily catches, measured in metric tons, observed for those calendar months since 2008.

Catch data used in the WCPFC-CA forecast have been screened to exclude certain catches not subject to the initial WCPFC catch limit under the present regulations (i.e., catches in the N. Pacific outside the U.S. EEZ around Hawaii by vessels operating with both American Samoa and Hawaii longline permits (dual permits)). Subsequent to the fishery reaching the initial WCPFC catch limit, if such vessels become party to an agreement for attributing catch to a U.S. Territory, their catch then counts towards the attribution limit and is included in the forecast.

Recently, the amount of fishing effort has increased significantly in the WCPFC-CA, and using older data may not be appropriate for projecting catch moving forward. Plotting the annual WCPFC-CA effort shows that splitting the effort into two groups based on the 31st of December 2017 would be appropriate (Figure 1). After this date, the fishing effort increased, suggesting historical data prior to 2018 may not be appropriate to use in projecting catch. Additionally, a two-sided T-test using equal variance rejects the hypothesis that the two groupings of effort have the same mean with a p-value of less than 0.0001. With this significant change in fishing effort, using catch data prior to 2018 is not reflective of the present-day fishery, and the model should only use catch data starting in January 2018 for the BET projection.

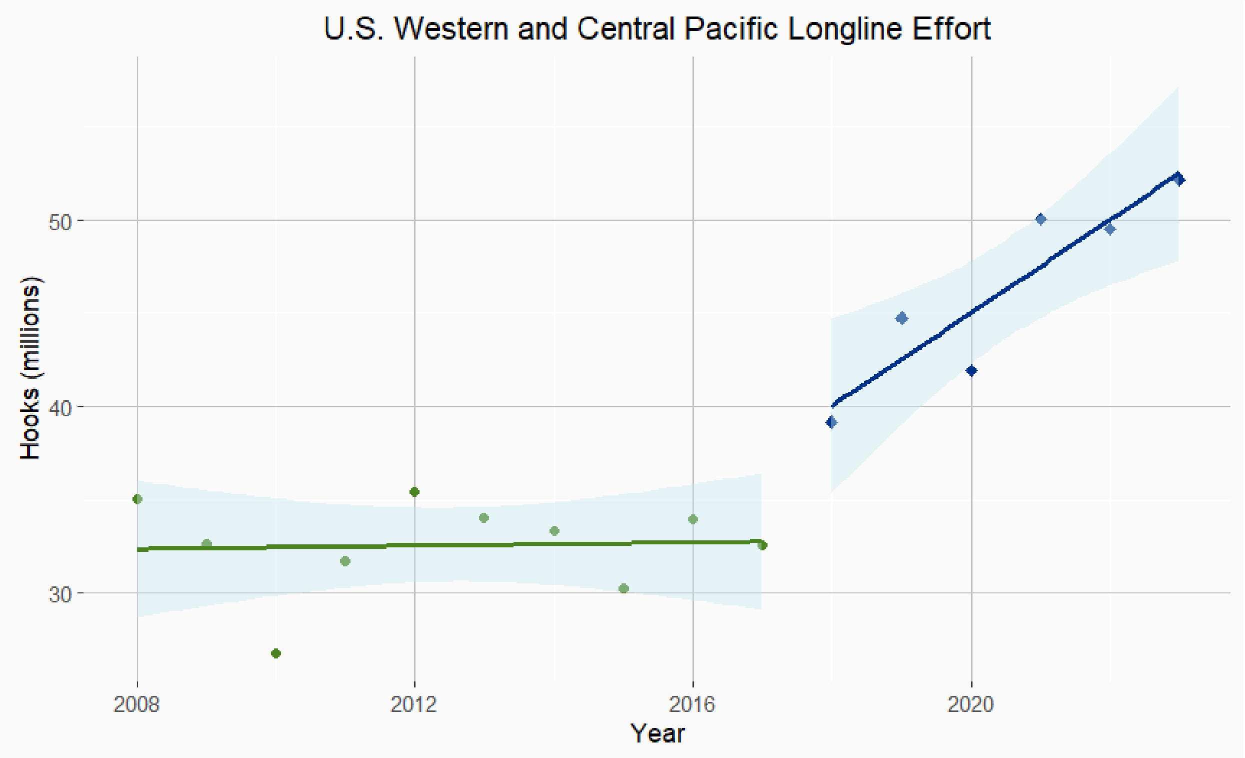

Figure 1. The WCPFC-CA longline fishing annual effort split into 2008-2017 and 2018-2023. Each grouping is fitted with LOESS curves and 95% confidence intervals. Longline effort (hooks) includes the U.S. longline effort in the WCPFC-CA and attributed effort. The longline effort does not include dual-permitted vessels.

Historically, logbook data have been compiled from paper records collected after a vessel has landed. To ensure that the projection started from a reasonably complete accounting of the catch, the data were lagged by 17 days. For example, if catch data were recorded through August 19th, the model would take the recorded data from August 2nd and begin projecting using the historical average catch from August 3rd onward on a monthly basis. In the given example, August 3–31 will use the historical average daily catch for the month of August, and similarly for September through December.

Over time, the number of vessels reporting catch electronically while at sea has increased. This allows for a more up to date accounting in the logbook database. To check whether or not ER data increased the accuracy at given lag intervals, 42 samples, where ER data and traditional data were collected at the same time, were compared to the finalized data. Figure 2 shows the average absolute error from the real time reporting to the final data based on the number of days the data were lagged.

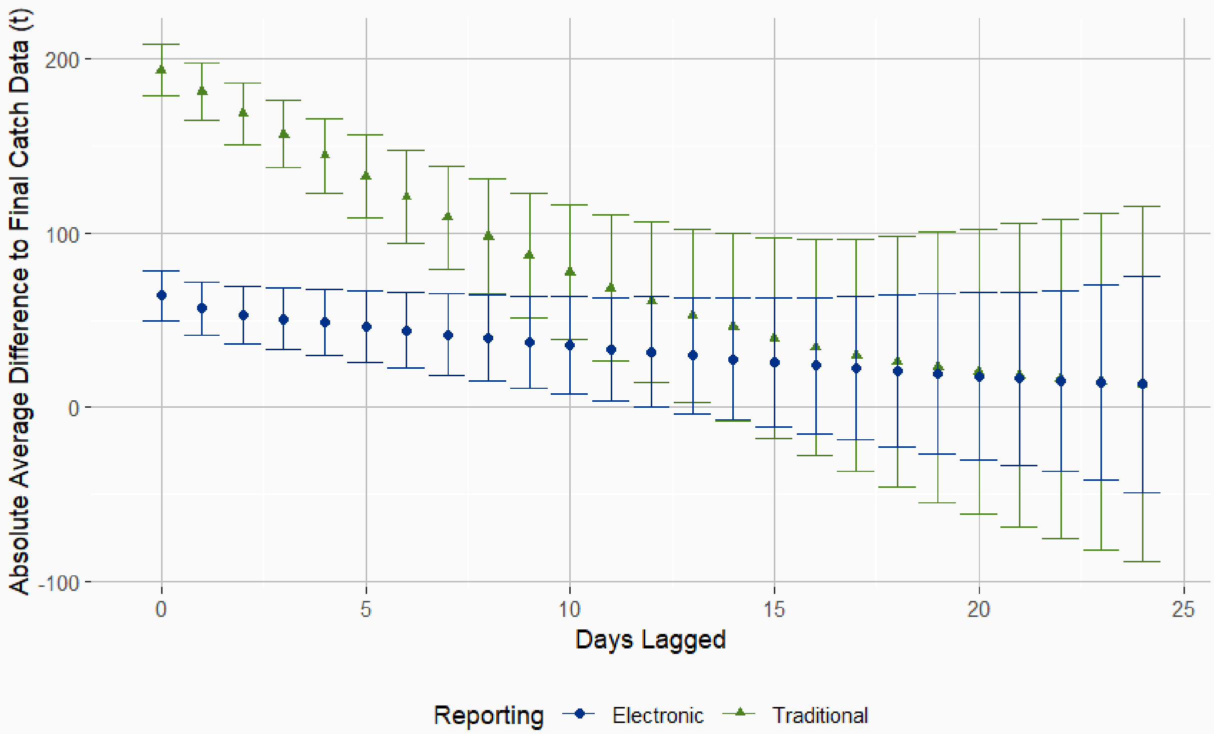

Figure 2. The average absolute error of the reported catch in metric tons (t) when compared to the final catch numbers for 42 periods of time ranging from June 2022 to May 2024 are plotted against the days lagged. The error bars reflect one standard deviation from the lag day's mean difference.

There are some known data errors in the ER data. First, there may be instances when both the ER data and the paper logs get entered into the database for the same trip. These are corrected once discovered but may bias the ER data to result in higher catch estimates. There are cases where the ER data get revised downward as these corrections take place. Additionally, the database occasionally has test data which could also bias both sets of data upwards, although the relative size is usually small. These data are eventually removed but may affect some of the catch totals.

Figure 2 shows that the ER data, on average, were closer to the final catch data than the collected paper data, as one would expect since the ER data incorporate more trips that are ongoing. However, since the ER data are sometimes biased upwards by the trips that are initially double counted, the difference in the final catch number may be reduced, as the latest catch data are typically undercounted. Some vessels are delayed in reporting their catch. The remaining differences between the ER data and the final catch data are likely driven by the ~5–12% of permitted trips that are still reported solely via paper logs and the lag time between the end of a haul and the processing of the data by the PIFSC data stream. The differences in the final weights of fish that are used vs. the default average applied before the trip weights are available also causes discrepancies. Calculating these potential sources of error and bias to the differences between the final catch and the ER data is challenging, would require significant database expertise, and is outside the scope of this report.

The initial 17-day window was chosen to capture the majority of trips up to that point in the year. However, several trips are longer than average, and the 17-day lag will not cover 100% of catch to that point. Similarly, a 5-day lag with electronic reporting covers the majority of trips. There are some trips that use paper reporting, which is not always included in the 5-day catch total. These same trips are also not guaranteed to be counted in the 17-day traditional lag if they are long trips or encounter other delays. Additionally, there are occasional transmission and processing delays that can affect the total catch calculated on a 5-day lag. Despite these factors contributing errors to the projection's starting point, a 5-day lag appears to represent an appropriate balance between older data, which miss known catch, and newer data which may be incomplete.

Comparing tests between the 17-day traditional and 5-day ER lags does not provide a statistically significant result due to the nature of the data. There are 42 sets of data in which the traditionally reported and ER data are simultaneously produced. The data are paired, and true outliers make both data sets non-normal and non-symmetric. These characteristics violate most assumptions for statistical testing, so a heuristic approach, such as capturing the majority of the trips reporting data electronically, is more practical and aligns with the initial intentions of the original selection of a 17-day lag window.

In December 2023, the WCPFC adopted Conservation and Management Measure 2023-01, established an annual BET catch limit for the United States of 6,554 t for 2024–2026 while also removing the authority to attribute longline bigeye tuna catch to the U.S. Participating Territories through specified fishing agreements. While this amounts to a 3,000 t increase in limit from previous years, it also removes the up to 3,000 t of U.S. territorial BET that was allocated to U.S fishing vessels through specified fishing agreements in recent years. Therefore, the limit is consistent with past overall catch for this fishery and is unlikely to result in changes to fisheries performance or behavior. The forecast will project the catch (t) in the WCPFC-CA up to 31 December of each year.

Conclusions and Recommendations

The BET catch projections can be improved by calculating the monthly catch averages using data collected since 2018. The efforts for 2017 and earlier are not representative of the current fishery. Also, using ER reporting allows for a reduction in lag time. As discussed above, the characteristics of the paired data did not allow for statistical testing between the 17-day traditional reporting and the 5-day ER lags. Using a 5-day lag should allow for a more recent starting point for the annual catch projections and incorporate more catch data without significantly changing the accuracy when compared to the prior method of a 17-day lag using traditional reporting.

Appendix

Historical Monthly Bigeye Tuna Catch (t)

Table 1. The U.S. monthly catch for bigeye tuna reported in metric tons (t) in the WCPFC-CA. The gray highlights reflect periods when the fishery had a closure, and thus they are excluded from the monthly average calculations detailed in the projection methodology above. The monthly catch is the U.S. vessel catch plus any catch attribution in territorial agreements and does not include catch from dual-permitted vessels.

	2008	2009	2010	2011	2012	2013	2014	2015
Jan	667.6	383.0	402.4	516.3	451.8	543.6	469.6	714.3
Feb	488.6	312.2	357.6	409.9	407.5	426.3	417.6	489.1
Mar	340.8	199.7	275.6	611.2	209.2	434.9	284.9	554.4
Apr	356.2	272.8	383.2	398.7	305.2	232.2	235.3	462.7
May	618.8	237.0	314.7	384.1	398.6	347.5	375.4	495.2
Jun	173.0	224.2	359.7	218.3	367.9	270.3	308.2	420.3
Jul	137.9	283.2	330.1	210.7	487.1	150.8	254.3	223.1
Aug	205.9	297.8	297.7	133.7	181.4	169.6	409.1	
Sep	270.5	300.0	194.8	121.0	152.5	130.2	378.8	
Oct	537.7	299.8	352.6	367.0	371.4	365.2	338.6	454.1
Nov	455.8	484.1		299.8	550.3	521.5	574.1	686.6
Dec	439.5	438.5		630.4	623.2	560.6	748.4	753.9
Total	4,692.2	3,732.2	3,268.5	4,300.9	4,506.0	4,152.7	4,794.1	5,253.5

	2016	2017	2018	2019	2020	2021	2022	2023
Jan	713.7	585.4	518.1	494.1	517.2	698.9	443.2	409.5
Feb	669.7	459.4	361.4	461.1	541.5	575.3	371.5	416.1
Mar	557.1	333.8	558.0	512.2	536.0	554.7	518.6	432.1
Apr	519.8	272.8	287.1	538.4	659.0	443.7	599.0	474.2
May	456.2	374.0	411.7	638.2	610.4	452.8	568.2	592.8
Jun	526.4	374.3	282.8	441.9	193.1	372.4	394.3	309.8
Jul		284.2	188.5	284.4	252.9	246.9	173.5	146.8
Aug		199.3	166.6	222.7	201.9	210.2	212.6	264.5
Sep			305.0	334.4	209.5	322.4	247.5	404.2
Oct	369.6		394.8	534.1	505.0	352.8	482.9	458.0
Nov	550.3	659.6	706.1	433.8	671.0	524.3	466.8	349.1
Dec	788.5	730.8	645.5		576.1	493.4	390.0	500.9
Total	5,151.3	4,273.5	4,825.6	4,895.4	5,473.5	5,247.8	4,868.1	4,757.8