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# Observed length composition data for striped marlin, *Kajikia audax*, in the Hawaii longline fishery, 1994-2020

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### Abstract

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.

#### Introduction

Striped marlin (*Kajikia audax*) are a highly migratory billfish species that are caught primarily as non-target species in the North Pacific Ocean. The western and central North Pacific stock was last assessed in 2019 by the International Scientific Committee for Tuna and Tuna-like species in the North Pacific Ocean (ISC). This assessment was an age-structured assessment in Stock Synthesis and found that the stock was likely overfished ( $F > F_{MSY}$ ) and that overfishing was occurring (SSB < SSB<sub>MSY</sub>). The ISC agreed to do a benchmark stock assessment in 2022. This working paper describes the available length frequency data from the Hawaii-based longline fishery observer database for striped marlin caught west of 150°W during 1994-2020 for potential inclusion in the 2022 assessment. Striped marlin are caught as non-target species both the shallow- set and deep-set sectors of the Hawaii longline fishery. Descriptions of the available length composition data and its temporal patterns are provided.

#### Methods

The Pacific Islands Fishery Observer Program provides detailed set-by-set data on the Hawaiibased longline fishery including the eye-fork length of fish caught in cm and a variety of operational fishing gear variables. Data are collected following the procedures in the PIROP observer manual (PIRO, 2017). Striped marlin length data were extracted from the PIROP database and provided to the ISC Billfish Working Group Chair in digital format in December 2021 (pers. comm., M. Sculley, 17-Dec-2021).

Striped marlin are caught as non-target species in both the deep-set tuna-targeting and shallowset swordfish-targeting sectors of the Hawaii-based longline fleet. Observers were first placed onboard longline vessels in 1994. Observer coverage varied significantly prior to 2000, with observer coverage ranging between 3% and 10% each year for the entire fishery (NMFS, 2017). The shallow-set sector was closed during 2001-2004 due to protected species interactions and when it reopened, 100% fishery observer coverage occurred on shallow-set trips and roughly 20% observer coverage occurred on deep-set trips (Gilman *et al.*, 2007). The deep-set trips typically occur further south than the shallow-set trips, which are concentrated around the sub-tropical frontal zone in the North Pacific where swordfish are the target species (Bigelow *et al.*, 1999).

Prior to 2006 observers measured every fish caught. Since 2006, observers measured every thirdfish caught, regardless of species. Data west of 150°W were included in this analysis to correspond with the boundary of the Western and Central Pacific Fisheries Commission, which is the WG agreed-upon boundary for the 2022 stock assessment. In total, length measurements of 43,178 striped marlin were included in the length composition data set for the 2022 assessment (Table 1).

Whole wet weights (W) of striped marlin were calculated from the length composition data by converting eye-fork lengths in cm (L) to whole wet weights in kg using the weight-length relationship from Sun *et al.* (2011). This is the length-weight relationship used for the striped marlin stock assessment since the 2015 benchmark assessment:

$$W = 4.68 * 10^{-6} * L^{3.16}$$

Striped marlin mean length observations and calculated mean weights were summarized by year and quarter (Quarters 1, 2, 3, and 4 are: Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec), by year, and by quarter and plotted for comparison. We evaluated whether there were time trends in mean sizes and size variation of striped marlin by year and quarter, by year, and by quarter using Spearman rank order correlations ( $\rho_s$ ). We also evaluated whether quarterly observations of mean size as well as size variability were associated using Spearman rank order correlations.

#### **Results and Discussion**

Measurements of the mean length of striped marlin by year and quarter showed no apparent temporal trend (Figure 1). Mean lengths by year and quarter fluctuated around an average of 134.9 cm during 1994-2020 and were not associated with the year-quarter time series ( $\rho_s = 0.09$ , P=0.36). Similarly, there was no apparent time trend in the standard deviation of mean length by year and quarter ( $\rho_s = 0.06$ , P=0.54). Within a given year, the highest mean lengths were typically observed in quarter 2, while the lowest mean lengths were observed in quarters 1 or 4. The minimum quarterly mean length was 116.5 cm observed in the first quarter of 2014 and the maximum mean length was 162.2 cm observed in the second quarter of 2010. There was a substantial negative association between mean length and the standard deviation of length by year and quarter ( $\rho_s = -0.32$ , P<0.001). There was also a significant positive association between mean length (Figure 1) and mean weight (Figure 2) observations by year and quarter ( $\rho_s = 0.99$ , P<0.001).

The temporal patterns for mean weight (Figure 2) were similar to those for mean length (Figure 1). In particular, the time series of mean weight and the standard deviation of weight by year and quarter had no apparent trend ( $\rho_s = 0.10$ , P=0.31 and  $\rho_s = 0.14$ , P=0.16, respectively). The mean weight time series varied about a mean of 27.5 kg during 1994-2020. The minimum quarterly mean weight was 17.6 kg observed in the first quarter of 2014 while the maximum mean weight was 46.0 kg observed in the second quarter of 2010. In contrast to the length observations, there was a substantial positive association between mean weight and the standard deviation of weight by year and quarter ( $\rho_s = 0.34$ , P<0.001). Overall, the mean length and weight observations of striped marlin by year and quarter in the Hawaii longline fishery exhibited similar empirical patterns and fluctuated without trend during 1994-2020.

The observed mean length of striped marlin aggregated by year showed no apparent long-term trend (Figure 3). Mean lengths by year and quarter fluctuated around an average of 137.7 cm during 1994-2020 and were not associated with the annual time series ( $\rho_s = 0.15$ , P=0.46). There was also no apparent time trend in the standard deviation of mean length by year ( $\rho_s = 0.10$ , P=0.61). Annual mean lengths exhibited a decline during 1994-2003, increased

through 2010 to a peak value of 153.9 cm, decreased to a minimum of 126.2 in 2011, and then remained at or above the 1994-2020 average through 2020. There was no apparent association between mean length and the standard deviation of length aggregated by year ( $\rho_s = 0.14$ , P<0.49) and there was a significant positive association between mean length (Figure 3) and mean weight (Figure 4) observations by year ( $\rho_s = 0.99$ , P<0.001).

As expected, the temporal patterns for the calculated mean weights by year (Figure 4) were similar to those for mean length (Figure 3). We found that the time series of mean weight and the standard deviation of weight aggregated by year had no apparent trend ( $\rho_s = 0.16$ , P=0.43 and  $\rho_s = 0.22$ , P=0.27, respectively). Annual mean weight observations varied without trend about an average of 29.2 kg during 1994-2020. Similar to the mean length observations, the minimum annual mean weight was 22.8 kg in quarter 1 of 2014 while the maximum mean weight was 39.8 kg in quarter 2 of 2010. In contrast to the annual mean lengths, we found a substantial positive association existed between mean weight and the standard deviation of weight by year ( $\rho_s = 0.60$ , P=0.001). Overall, the temporal patterns of the annual mean lengths and weights of striped marlin were similar and both size observations varied without trend during 1994-2020.

Quarterly time series of mean lengths for striped marlin had no apparent trend during 1994-2020 (Figure 5, panels (a) to (d)). The observed mean lengths by quarter for quarters 1 through 4 varied about average values of 128.9 cm ( $\rho_s = 0.11$ , P=0.57), 147.8 cm ( $\rho_s = 0.18$ , P=0.36), 139.0 cm ( $\rho_s = 0.01$ , P=0.97), and 129.7 cm ( $\rho_s = 0.17$ , P=0.38), respectively. Standard deviations of length by quarter for quarters 1 through 4 varied about average values of 21.7, 21.6, 18.6, and 24.5 cm, respectively.

The quarterly time series of calculated mean weights also exhibited no apparent trend during 1994-2020 (Figure 6, panels (a) to (d)). The calculated mean weights by quarter for quarters 1 through 4 varied about average values of 23.7 kg ( $\rho_s = 0.13$ , P=0.52), 35.7 kg ( $\rho_s = 0.17$ , P=0.38), 29.2 kg ( $\rho_s = 0.01$ , P=0.95), and 24.3 kg ( $\rho_s = 0.23$ , P=0.25), respectively. Standard deviations of weight by quarter for quarters 1 through 4 varied about average values of 13.1, 15.2, 12.9, and 13.8 kg, respectively.

Correlations between quarterly time series of mean lengths showed positive associations between two pairs of quarters out of six possible comparisons. In particular, there were notable positive associations between quarterly mean lengths in quarters 1 and 2 (Figure 5, panels (a) and (b),  $\rho_s = 0.64$ , P<0.001) and between quarterly mean lengths in quarters 2 and 3 (Figure 5, panels (b) and (c),  $\rho_s = 0.50$ , P=0.007). None of the other pairs of quarterly mean length series exhibited a notable association. The pairs of quarterly time series of calculated mean weights showed a similar pattern as the mean lengths series. There were two important positive associations between quarterly mean weights in quarters 1 and 2 (Figure 6, panels (a) and (b),  $\rho_s = 0.67$ , P<0.001) and between quarterly mean weights in quarters 2 and 3 (Figure 6, panels (b) and (c),  $\rho_s = 0.47$ , P=0.01). Overall, this indicated there was a synchronous pattern of interannual changes in mean sizes of striped marlin for quarters 1 and 2 and for quarters 2 and 3 during the 1994-2020 time series.

There were no apparent trends in mean length by year and quarter of striped marlin caught in

the Hawaii longline fishery during 1994-2020. This stable pattern of mean length was also reported by Sculley (2019) for the 1995-2017 striped marlin data set. In comparison, there was a moderate decreasing trend in annual mean lengths during 1994-2003 followed by an increasing trend during 2004-2010. Here it is important to note that the mean lengths by quarter differed over the 1994-2020 time series and that the annual mean lengths depended on the seasonal sampling intensity.

It was also apparent that a majority of the quarterly mean length observations by year (Figure 1) were lower than the reported median female size at maturity from Humphreys and Brodziak (2021). This suggested that a substantial proportion of striped marlin captured in the Hawaii longline fishery were likely immature, noting that male median size at maturity ( $L_{50}$ ) is smaller than for females (Humphreys and Brodziak, unpublished data). The relatively consistent pattern of quarterly mean lengths falling below the female  $L_{50}$  suggests that the fishing grounds of the Hawaii longline fishery coincides with a nursery area for juvenile striped marlin in the Western and Central North Pacific, similar to Sculley (2019).

There were some notable positive correlations in the interannual patterns of striped marlin mean lengths in quarters 1 and 2 and in quarters 2 and 3. This synchronous pattern coincides with the spawning season for striped marlin in the Western and Central North Pacific which occurs during May-July (Humphreys and Brodziak 2021). The largest striped marlin were consistently observed in quarters 2 and 3, which would be consistent with an expected influx of adult fish to the Hawaii longline fishing grounds during spawning season. It is also notable that the pattern of observed mean lengths in quarter 4 appeared to differ from the mean lengths in quarters 1, 2, and 3 with relatively low rank order correlations of  $\rho_s = 0.18, 0.28, and -0.30$ , respectively.

Overall, this suggested that there may be a different mixture of striped marlin cohorts or stocks available to the fishery in quarter 4 relative to the rest of the year. While the source of the observed difference between the patterns of mean lengths in quarter 4 and the rest of the quarters is unknown, we note that this pattern may affect quarterly estimates of fishery selectivity for the Hawaii longline fishery in the context of fitting quarterly length composition data in an integrated stock assessment model.

#### **Literature Cited**

Bigelow, K., Boggs, C., and He, X. 1999. Environmental effects on swordfish and blue shark catch rates in the US North Pacific longline fishery. Fisheries Oceanography 8:178-198.

Gilman, E., Kobayashi, D., Swenarton, T., Brothers, N., Dalzell, P., and Kinan-Kelly, I. 2007. Reducing sea turtle interactions in the Hawaii-based longline swordfish fishery. Biological Conservation 139:19-28.

Humphreys, R., and Brodziak, J. 2021. Revised analyses of the reproductive maturity of female striped marlin, *Kajikia audax*, in the central North Pacific off Hawaii. ISC Billfish Working Group Meeting, 13, 15-18 December 2021, ISC/21/BILLWG-02/07, 38 p.

National Marine Fisheries Service [NMFS]. 2017. Hawaii longline fishery logbook statistics non-confidential summary tables. Available online at <u>http://www.pifsc.noaa.gov/fmb/reports.php</u>, accessed 8 May 2017. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu.

Pacific Islands Region Office [PIRO]. 2017. Hawaii Longline Observer Program Observer FieldManual. Version LM.17.02. National Oceanic and Atmospheric Administration, Pacific Islands Region, Honolulu, Hawaii.

Sculley, M. 2019. Striped Marlin (*Kajikia audax*) length data available from 1995-2017 in the Hawaii-based longline fishery. ISC Billfish Working Group Meeting, 14-21 January 2019, Honolulu, Hawaii. ISC/19/BILLWG-1/04, 16 p. Available at: <a href="http://isc.fra.go.jp/pdf/BILL/ISC19\_BILL\_1/ISC19\_BILL\_1/ISC19\_BILLWG\_WP1-4.pdf">http://isc.fra.go.jp/pdf/BILL/ISC19\_BILL\_1/ISC19\_BILL\_1/ISC19\_BILLWG\_WP1-4.pdf</a>

Sun, C.L., Hsu, W.S., Chang, Y.J., Yeh, S.Z., Chiang, W.C., and Su, N.J. 2011. Age and growth of striped marlin (*Kajikia audax*) in waters off Taiwan: A revision. ISC Billfish Working Group Meeting, 24 May-1 June 2011, Taipei, Taiwan. ISC/11/BILLWG-2/07, 12 p. Available at:

http://isc.ac.affrc.go.jp/pdf/BILL/ISC11\_BILL\_2/ISC11BILLWG2\_WP07.pdf

## ISC/22/BILLWG-01/01

| Year | 20 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95  | 100 | 105 | 110 | 115 | 120 | 125 | 130 | 135 | 140 | 145 | 150 |
|------|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1994 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 4   | 5   | 14  | 18  | 20  | 20  | 12  | 11  | 13  | 23  | 35  | 50  |
| 1995 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 4  | 3   | 12  | 41  | 43  | 56  | 35  | 44  | 75  | 91  | 87  | 71  | 56  |
| 1996 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   | 5   | 20  | 48  | 93  | 84  | 60  | 54  | 86  | 118 | 123 | 82  |
| 1997 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 2   | 10  | 21  | 33  | 31  | 14  | 17  | 15  | 26  | 23  | 24  | 43  |
| 1998 | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 1  | 3   | 8   | 7   | 14  | 21  | 42  | 28  | 45  | 64  | 82  | 86  | 73  |
| 1999 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 6   | 4   | 21  | 33  | 31  | 37  | 26  | 26  | 32  | 27  | 34  | 30  |
| 2000 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 2   | 6   | 20  | 50  | 88  | 92  | 44  | 22  | 37  | 38  | 59  | 47  |
| 2001 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 13 | 28  | 112 | 296 | 454 | 396 | 346 | 282 | 348 | 452 | 439 | 362 | 293 |
| 2002 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 2  | 0  | 5  | 13  | 86  | 137 | 210 | 185 | 131 | 83  | 100 | 119 | 192 | 226 | 195 |
| 2003 | 1  | 0  | 0  | 0  | 1  | 1  | 1  | 0  | 6  | 29 | 87  | 328 | 654 | 851 | 596 | 348 | 291 | 377 | 523 | 632 | 552 | 447 |
| 2004 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 2  | 2  | 5  | 20  | 103 | 262 | 366 | 332 | 225 | 128 | 159 | 178 | 272 | 330 | 384 |
| 2005 | 0  | 0  | 0  | 0  | 4  | 3  | 3  | 5  | 14 | 64 | 121 | 208 | 186 | 190 | 247 | 249 | 187 | 194 | 245 | 294 | 379 | 558 |
| 2006 | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 2  | 0  | 6  | 8   | 23  | 47  | 76  | 87  | 123 | 132 | 148 | 179 | 258 | 210 | 165 |
| 2007 | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 2  | 0  | 6  | 5   | 13  | 18  | 22  | 30  | 14  | 10  | 17  | 24  | 33  | 44  | 47  |
| 2008 | 0  | 0  | 1  | 0  | 1  | 1  | 0  | 3  | 5  | 11 | 19  | 29  | 40  | 50  | 61  | 49  | 69  | 107 | 120 | 121 | 136 | 125 |
| 2009 | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 3  | 2   | 12  | 24  | 26  | 45  | 37  | 38  | 42  | 77  | 82  | 83  | 100 |
| 2010 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1   | 1   | 6   | 7   | 5   | 7   | 12  | 8   | 13  | 27  | 42  | 70  |
| 2011 | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 7  | 21 | 33  | 67  | 138 | 221 | 233 | 166 | 110 | 101 | 72  | 93  | 79  | 67  |
| 2012 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 4  | 10  | 36  | 38  | 57  | 66  | 66  | 60  | 42  | 54  | 82  | 83  | 102 |
| 2013 | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 2  | 1  | 5  | 7   | 30  | 60  | 50  | 42  | 33  | 31  | 38  | 60  | 74  | 103 | 115 |
| 2014 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 2  | 7   | 35  | 77  | 93  | 65  | 56  | 45  | 69  | 83  | 101 | 119 | 94  |
| 2015 | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 2  | 0  | 8   | 8   | 24  | 26  | 31  | 24  | 16  | 41  | 45  | 61  | 109 | 141 |
| 2016 | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 2  | 4   | 13  | 34  | 64  | 96  | 107 | 57  | 36  | 54  | 52  | 64  | 53  |
| 2017 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 2  | 2  | 3   | 7   | 32  | 68  | 96  | 80  | 44  | 50  | 74  | 76  | 75  | 72  |
| 2018 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 5  | 5   | 28  | 48  | 84  | 101 | 117 | 82  | 85  | 57  | 91  | 104 | 110 |
| 2019 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 2  | 4   | 11  | 31  | 66  | 105 | 115 | 113 | 112 | 122 | 120 | 120 | 104 |
| 2020 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 2  | 4   | 2   | 16  | 25  | 34  | 46  | 55  | 77  | 100 | 97  | 111 | 126 |

**Table 1**. Number of striped marlin measured in the Hawaii-based longline fishery from 1994-2020 in 5 cm bins. Bin values indicate the maximum size of fish in the bin, inclusive.

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| Year | 155 | 160 | 165 | 170 | 175 | 180 | 185 | 190 | 195 | 200 | 205 | 210 | 215 | 220 | 225 | 245 | 255 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1994 | 39  | 38  | 37  | 28  | 15  | 6   | 10  | 3   | 2   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 1995 | 60  | 45  | 52  | 34  | 17  | 12  | 8   | 2   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 0   |
| 1996 | 55  | 34  | 23  | 18  | 16  | 6   | 3   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 1997 | 32  | 35  | 37  | 23  | 10  | 5   | 5   | 1   | 0   | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 0   |
| 1998 | 55  | 20  | 12  | 6   | 4   | 5   | 2   | 2   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 0   |
| 1999 | 35  | 28  | 33  | 22  | 21  | 6   | 3   | 2   | 1   | 1   | 1   | 0   | 0   | 0   | 0   | 0   | 0   |
| 2000 | 53  | 36  | 23  | 13  | 6   | 5   | 0   | 3   | 2   | 0   | 0   | 1   | 0   | 0   | 0   | 0   | 0   |
| 2001 | 215 | 140 | 100 | 65  | 31  | 20  | 7   | 1   | 5   | 2   | 1   | 0   | 1   | 0   | 0   | 0   | 0   |
| 2002 | 149 | 117 | 90  | 64  | 33  | 15  | 9   | 3   | 0   | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 1   |
| 2003 | 291 | 249 | 200 | 138 | 67  | 17  | 10  | 0   | 1   | 2   | 2   | 2   | 1   | 1   | 0   | 0   | 0   |
| 2004 | 310 | 192 | 103 | 69  | 45  | 25  | 10  | 2   | 0   | 2   | 0   | 1   | 0   | 0   | 0   | 0   | 0   |
| 2005 | 521 | 508 | 378 | 249 | 100 | 56  | 38  | 4   | 10  | 5   | 3   | 2   | 1   | 0   | 0   | 0   | 0   |
| 2006 | 133 | 104 | 103 | 61  | 43  | 19  | 15  | 0   | 2   | 1   | 2   | 2   | 0   | 0   | 0   | 0   | 0   |
| 2007 | 52  | 63  | 38  | 27  | 32  | 10  | 3   | 1   | 2   | 1   | 1   | 0   | 0   | 0   | 0   | 1   | 0   |
| 2008 | 122 | 119 | 137 | 100 | 60  | 31  | 14  | 9   | 9   | 3   | 0   | 1   | 0   | 3   | 0   | 0   | 0   |
| 2009 | 113 | 116 | 113 | 111 | 74  | 24  | 24  | 4   | 2   | 0   | 0   | 0   | 0   | 1   | 0   | 0   | 0   |
| 2010 | 66  | 66  | 72  | 55  | 39  | 23  | 14  | 2   | 1   | 1   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 2011 | 56  | 54  | 67  | 46  | 43  | 16  | 6   | 4   | 6   | 1   | 0   | 2   | 0   | 0   | 0   | 0   | 0   |
| 2012 | 66  | 65  | 57  | 37  | 13  | 12  | 8   | 3   | 1   | 1   | 0   | 1   | 0   | 1   | 0   | 0   | 0   |
| 2013 | 77  | 88  | 72  | 65  | 28  | 19  | 7   | 6   | 0   | 1   | 0   | 1   | 0   | 0   | 0   | 1   | 0   |
| 2014 | 64  | 51  | 49  | 31  | 18  | 16  | 7   | 2   | 1   | 1   | 0   | 2   | 0   | 0   | 0   | 0   | 0   |
| 2015 | 170 | 123 | 86  | 55  | 33  | 14  | 13  | 6   | 0   | 1   | 0   | 1   | 0   | 2   | 1   | 0   | 0   |
| 2016 | 71  | 90  | 94  | 64  | 44  | 26  | 16  | 3   | 3   | 0   | 1   | 0   | 0   | 0   | 0   | 0   | 0   |
| 2017 | 78  | 71  | 51  | 32  | 22  | 18  | 16  | 5   | 2   | 1   | 1   | 0   | 0   | 0   | 0   | 0   | 0   |
| 2018 | 95  | 76  | 52  | 27  | 19  | 13  | 11  | 4   | 2   | 1   | 0   | 0   | 0   | 0   | 0   | 1   | 0   |
| 2019 | 85  | 85  | 63  | 49  | 30  | 9   | 10  | 3   | 0   | 0   | 1   | 2   | 1   | 0   | 1   | 0   | 0   |
| 2020 | 70  | 48  | 40  | 23  | 16  | 3   | 6   | 3   | 2   | 1   | 0   | 0   | 0   | 1   | 0   | 3   | 0   |
|      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

**Figure 1**. Time series of mean lengths (EFL, cm) of striped marlin by year and quarter in the Hawaii longline fishery (green circles) during 1994-2020 relative to the 1994-2020 average (black line) and estimated length at median maturity (female L50, green line) reported by Humphreys and Brodziak (2021).



**Figure 2**. Time series of calculated mean weights (kg) of striped marlin by year and quarter in the Hawaii longline fishery (green circles) during 1994-2020 relative to the 1994-2020 average (black line).





**Figure 3**. Time series of mean lengths (EFL, cm) of striped marlin by year in the Hawaii longline fishery (green circles) during 1994-2020 relative to the 1994-2020 average (black line).



**Figure 4**. Time series of calculated mean weights (kg) of striped marlin by year in the Hawaii longline fishery (green circles) during 1994-2020 relative to the 1994-2020 average (black line).

**Figure 5a**. Annual time series of mean lengths (EFL, cm) of striped marlin during quarter 1 (blue circles with  $\pm 1$  standard deviation error bars) in the Hawaii longline fishery relative to the 1994-2020 average (black line).



**Figure 5b**. Annual time series of mean lengths (EFL, cm) of striped marlin during quarter 2 (green circles with  $\pm 1$  standard deviation error bars) in the Hawaii longline fishery relative to the 1994-2020 average (black line).



**Figure 5c**. Annual time series of mean lengths (EFL, cm) of striped marlin during quarter 3 (red circles with  $\pm 1$  standard deviation error bars) in the Hawaii longline fishery relative to the 1994-2020 average (black line).



**Figure 5d**. Annual time series of mean lengths (EFL, cm) of striped marlin during quarter 4 (yellow circles with  $\pm 1$  standard deviation error bars) in the Hawaii longline fishery relative to the 1994-2020 average (black line).



**Figure 6a**. Annual time series of mean weights (kg) of striped marlin during quarter 1 (blue circles with  $\pm 1$  standard deviation error bars) in the Hawaii longline fishery relative to the 1994-2020 average (black line).



**Figure 6b**. Annual time series of mean weights (kg) of striped marlin during quarter 2 (green circles with  $\pm 1$  standard deviation error bars) in the Hawaii longline fishery relative to the 1994-2020 average (black line).



**Figure 6c**. Annual time series of mean weights (kg) of striped marlin during quarter 3 (red circles with  $\pm 1$  standard deviation error bars) in the Hawaii longline fishery relative to the 1994-2020 average (black line).



**Figure 6d**. Annual time series of mean weights (kg) of striped marlin during quarter 4 (yellow circles with  $\pm 1$  standard deviation error bars) in the Hawaii longline fishery relative to the 1994-2020 average (black line).

