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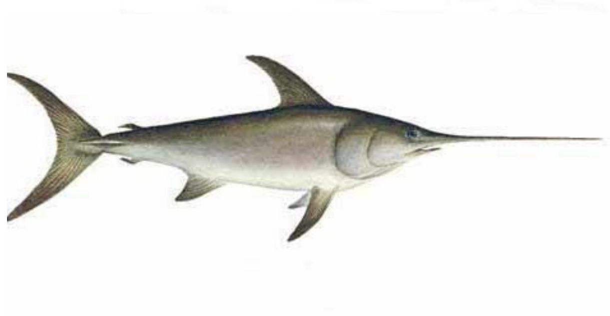
# An Investigation of Length-Based Estimates of Total Mortality for North Pacific Striped Marlin, *Tetrapturus audax*

Jon Brodziak
Pacific Islands Fisheries Science Center
NOAA National Marine Fisheries Service
Honolulu, Hawaii, USA



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# An Investigation of Length-Based Estimates of Total Mortality for North Pacific Striped Marlin, *Tetrapturus audax*

Jon Brodziak
Pacific Islands Fisheries Science Center, Honolulu, HI 96822-2326
Email: Jon.Brodziak@NOAA.GOV

Length frequency data from Japanese distant water longline fishing vessels were used to estimate mean lengths of striped marlin by year (1970-2003), quarter (1-4), and region (1-4) in the North Pacific. Japanese longline vessels in these four regions accounted for approximately 43% of the striped marlin numbers caught during 19934-2003. Observed mean lengths (lower jaw-fork length in cm) were compared to the expected growth curve from Melo Barrera et al. (2003) with K=0.23 and $L_\infty$=221 cm to estimate total mortality. The Beverton-Holt estimator of total mortality based on changes in mean length was applied to the mean value of the time series of quarterly mean lengths by region from 1970-2003. In this case, a cutoff length of 120 cm was assumed to be the critical length ($L_C$) for full susceptibility of capture by the longline fishing vessels. Striped marlin less than the cutoff length were not included in the analyses. In fact, about 9% of the striped marlin lengths (n=58527) were less than the cutoff indicating that this assumption was a gross approximation. For the Beverton-Holt estimator, total mortality (Z) is related to mean length E[L] as

$$Z = \frac{K\left(L_\infty - E[L]\right)}{\left(E[L] - L_C\right)}$$

Key assumptions for this estimator are that the fish stock conforms to von Bertalanffy growth with known parameters K and $L_\infty$, there is no variability in growth, the mortality rate is constant for all fish with length $L_C$ or greater, and the mortality rate is constant in time. The estimator also requires that the population mean length be in equilibrium with the total mortality rate Z. If this is not the case due to changes in the total mortality rate, then the nonequilibrium method of Gedamke and Hoenig (2006) can be applied to estimate mortalities before ($Z_1$) and after ($Z_2$) a change point in total mortality. We investigated the application of the Gedamke and Hoenig method to the North Pacific striped marlin longline length frequency data using beta-version software from the NOAA Fisheries Toolbox. In this application, only one possible change point in total mortality was considered. In addition, the annual mean length observations were weighted by sample size as described in Gedamke and Hoenig (2006). This weighting emphasized mean length observations based on large numbers of fish lengths and de-emphasized mean lengths based on few samples. In addition, three values of annual mean lengths were imputed as the average of the previous and subsequent values; these were area 1 in quarter 3 in 1977, area 2 in quarter 3 in 1975, and area 4 in quarter 1 in 1981. Each imputed mean length was assigned a sample size of 1 for fitting since the beta-version of the software does not allow for missing values.

Results of the Gedamke and Hoenig (2006) model are shown for cases where the maximum likelihood method converged to a solution. In this case, estimates of total mortality before ($Z_1$) and after ($Z_2$) the change point are listed with their standard errors along with the change point highlighted as a vertical line. In cases where there was no convergence, the single-period Beverton-Holt estimate of total mortality (Z) is provided.

Results for area 1 suggested that there was a seasonal decrease in total mortality during spring and summer beginning in the 1990s (Figures 1.1-1.4). In contrast, total mortality was suggested to be increasing during autumn and winter months beginning in the 1990s.

Results for area 2 suggested that there was an increase in total mortality during the 1990s in each season (Figures 2.1-2.4). Total mortalities were around $Z=0.60$ prior to the change point and were at $Z=0.80$ or above following the change.

Results for areas 3 and 4 suggested that there was no detectable change in total mortality during the period investigated with the exception of a decrease in total mortality in area 4 during quarter 2 beginning in the early-1990s. Overall, the length frequency data were limited from these areas and it is not likely there was sufficient power to track trends in mortality based on changes in mean lengths in these areas. Although these analyses are simplistic, the observed changes in striped marlin mean length suggest some seasonal increases in total mortality of striped marlin occurred in regions 1 and 2 during the 1990s.

**References**

Gedamke, T., and J. Hoenig. 2006. Estimating mortality from mean length data in nonequilibrium situations, with application to the assessment of goosefish. Trans. Amer. Fish. Soc. 135: 476-487.

Melo Barrera FN, R Felix Uraga, C Quinonez Velazquez. 2003. Growth and length-weight relationship of the striped marlin, Tetrapturus audax (Pisces: Istiophoridae), in Cabo San Lucas, Baha California Sur, Mexico.

Figure 1.1. Total mortality estimates of striped marlin in fishing area 1, quarter 1.

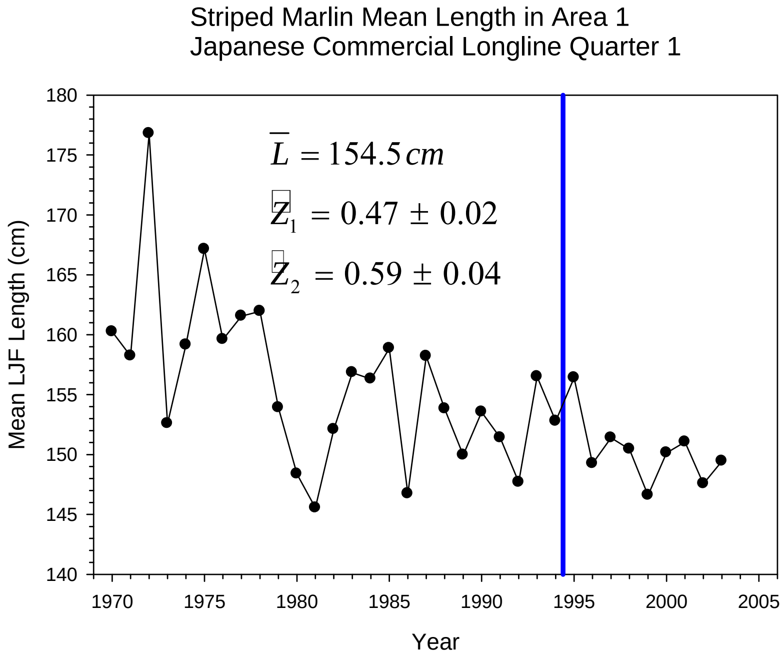


Figure 1.2. Total mortality estimates of striped marlin in fishing area 1, quarter 2.

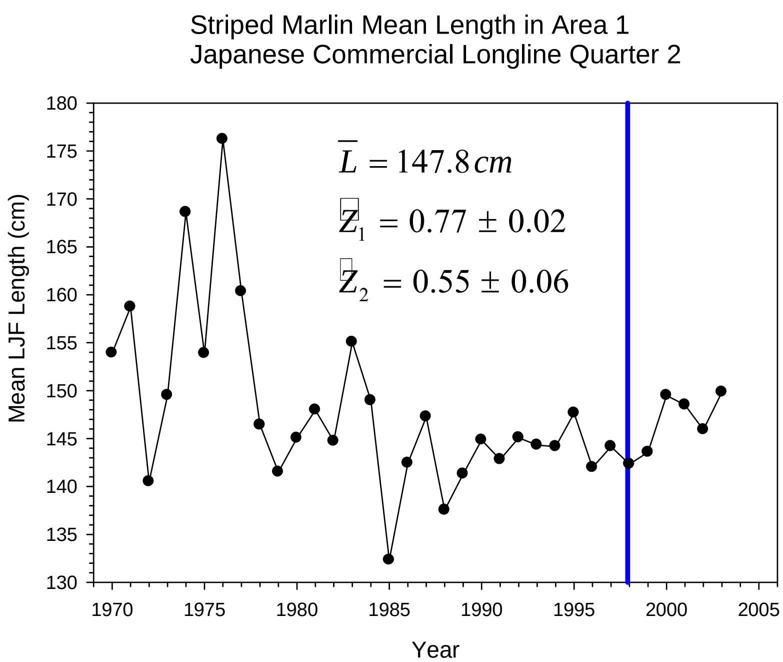

Figure 1.3. Total mortality estimates of striped marlin in fishing area 1, quarter 3.

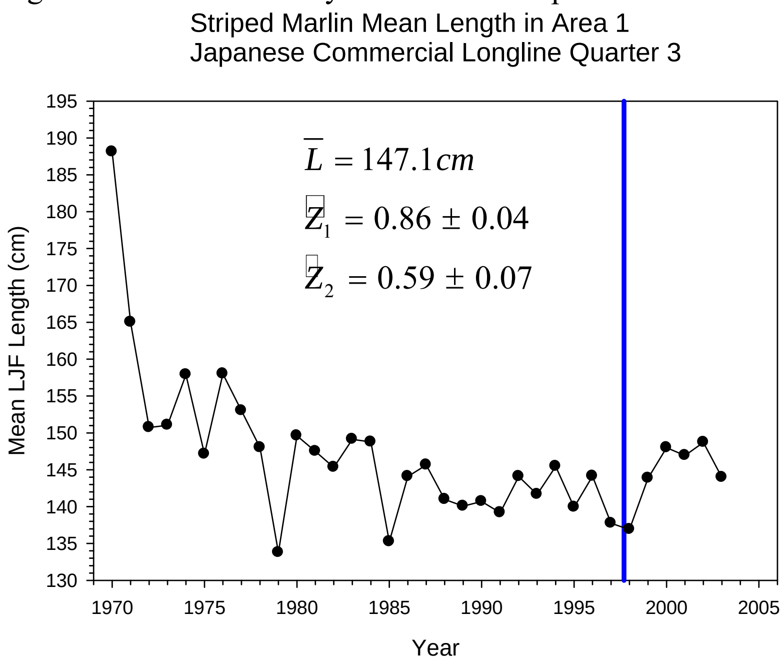


Figure 1.4. Total mortality estimates of striped marlin in fishing area 1, quarter 4.

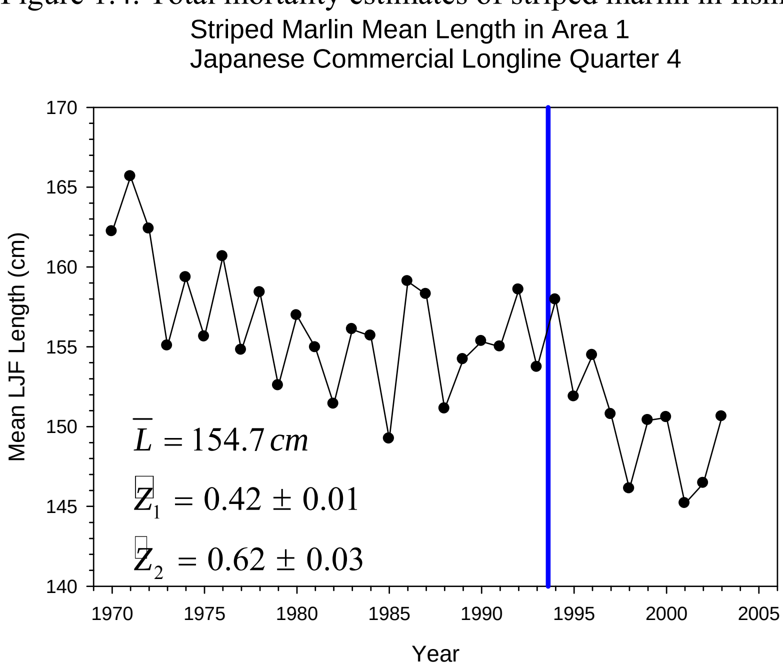

Figure 2.1. Total mortality estimates of striped marlin in fishing area 2, quarter 1.

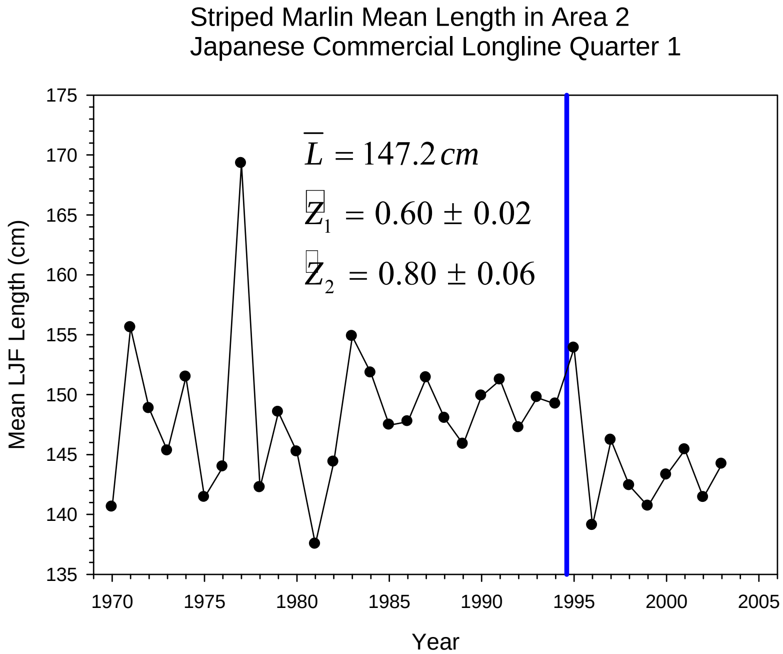


Figure 2.2. Total mortality estimates of striped marlin in fishing area 2, quarter 2.

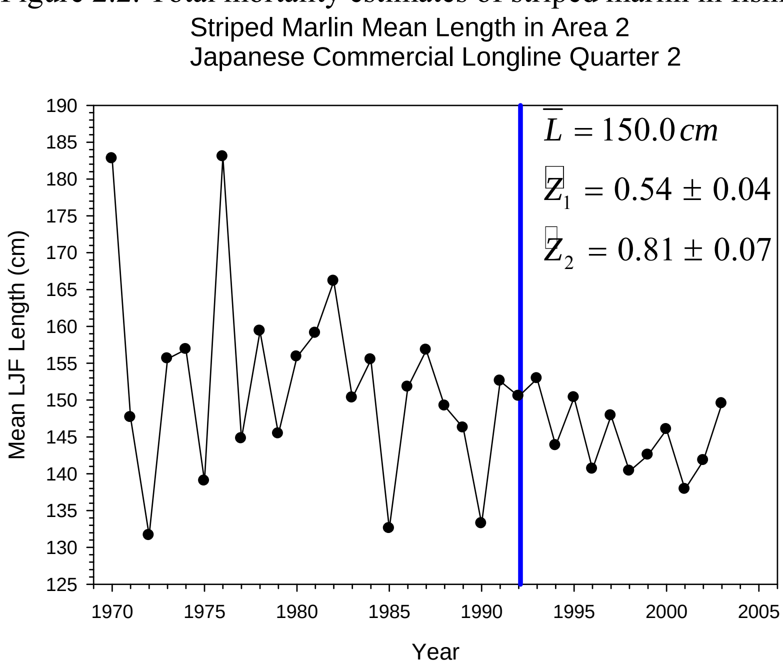

Figure 2.3. Total mortality estimates of striped marlin in fishing area 2, quarter 3.

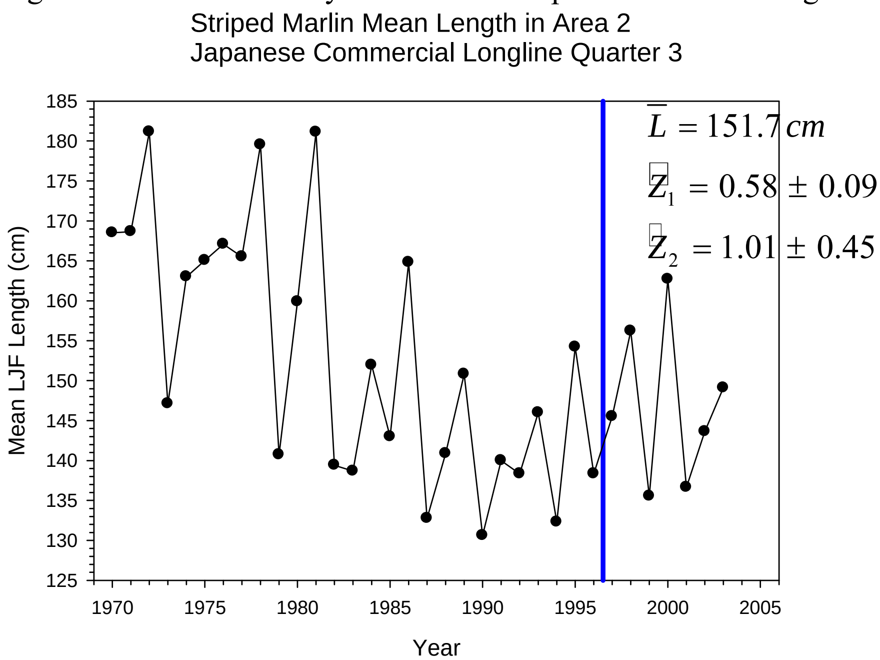


Figure 2.4. Total mortality estimates of striped marlin in fishing area 2, quarter 4.

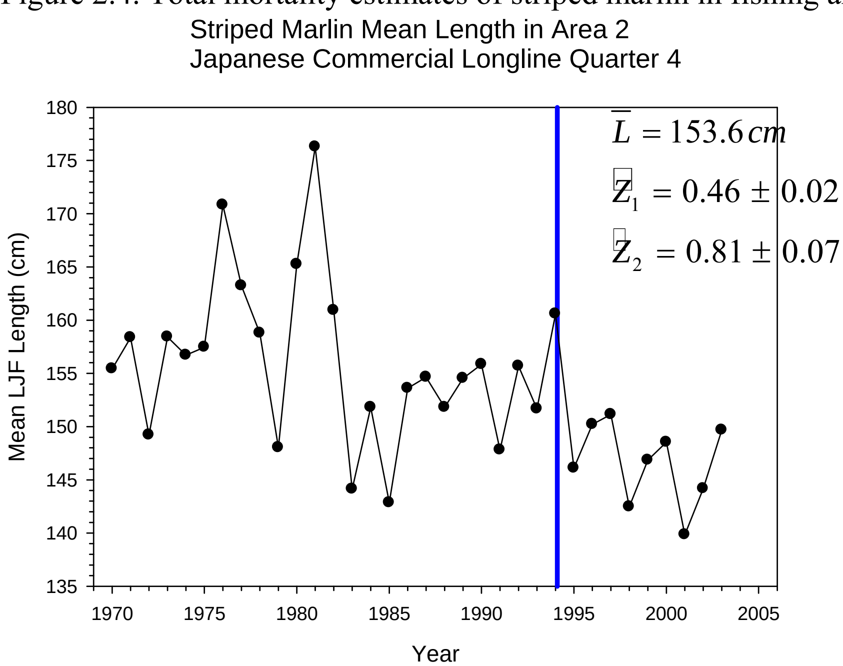

Figure 3.1. Total mortality estimates of striped marlin in fishing area 3, quarter 1.

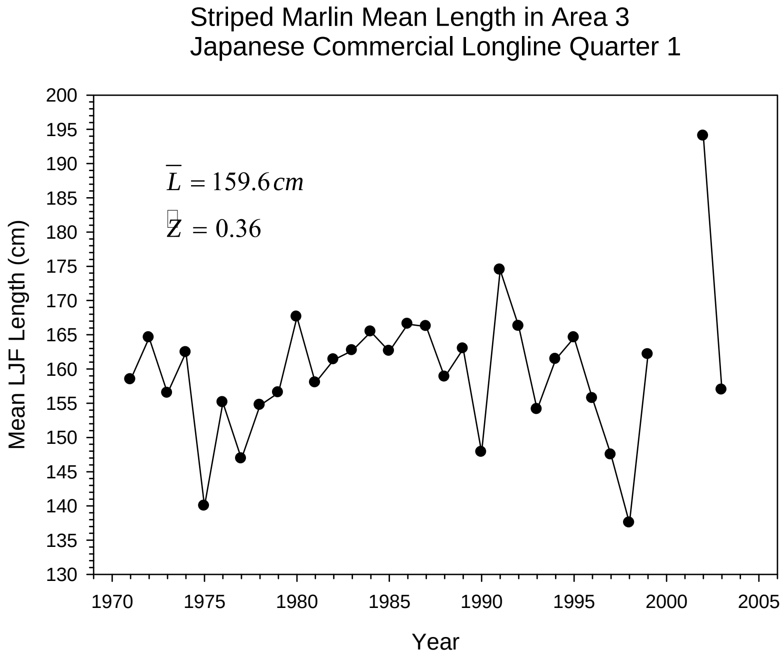


Figure 3.2. Total mortality estimates of striped marlin in fishing area 3, quarter 2.

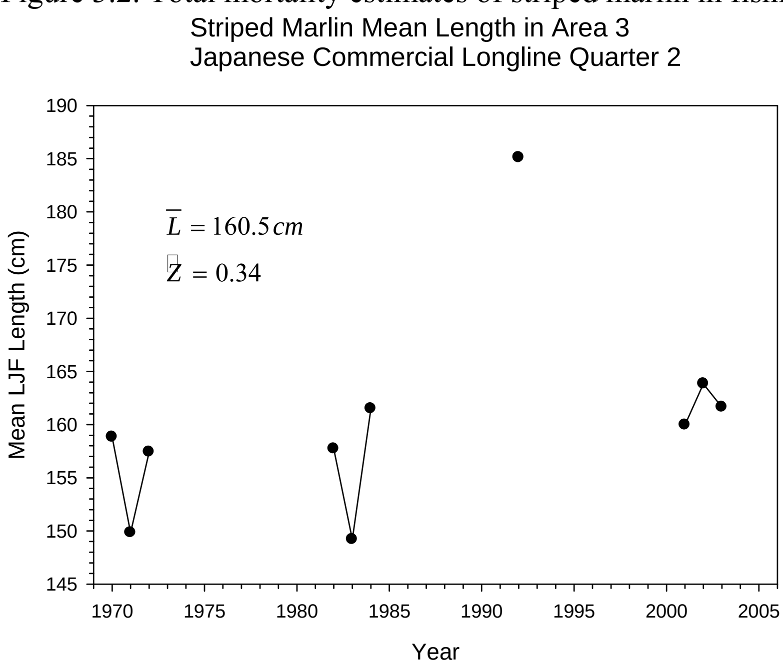

Figure 3.3. Total mortality estimates of striped marlin in fishing area 3, quarter 3.

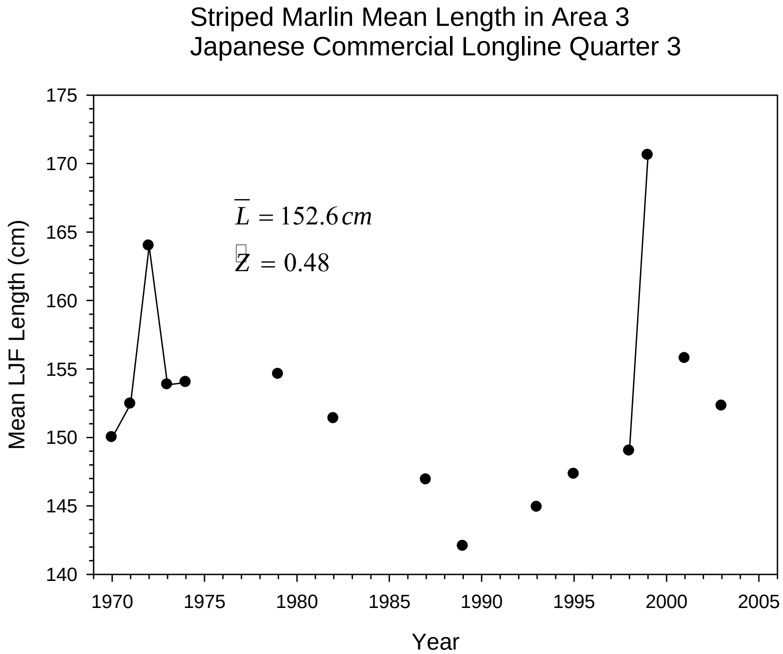


Figure 3.4. Total mortality estimates of striped marlin in fishing area 3, quarter 4.

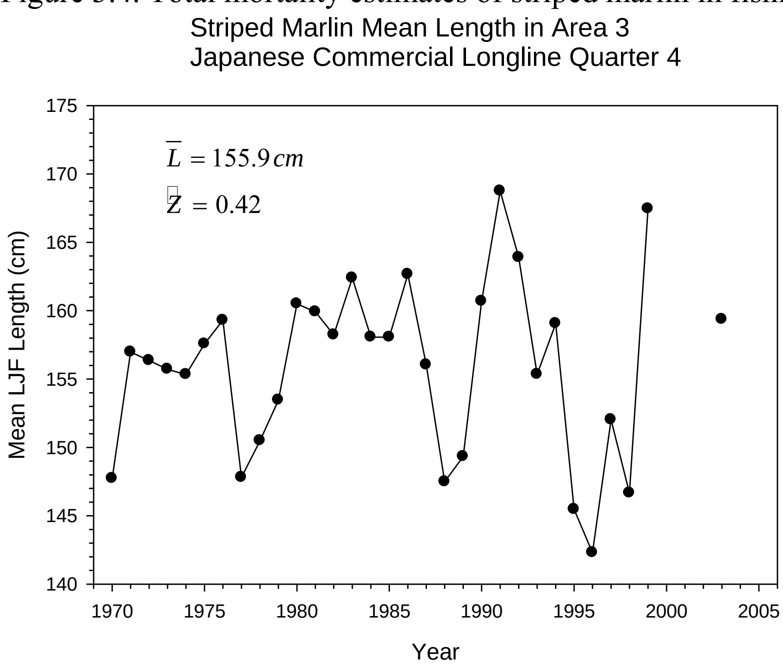

Figure 4.1. Total mortality estimates of striped marlin in fishing area 4, quarter 1.

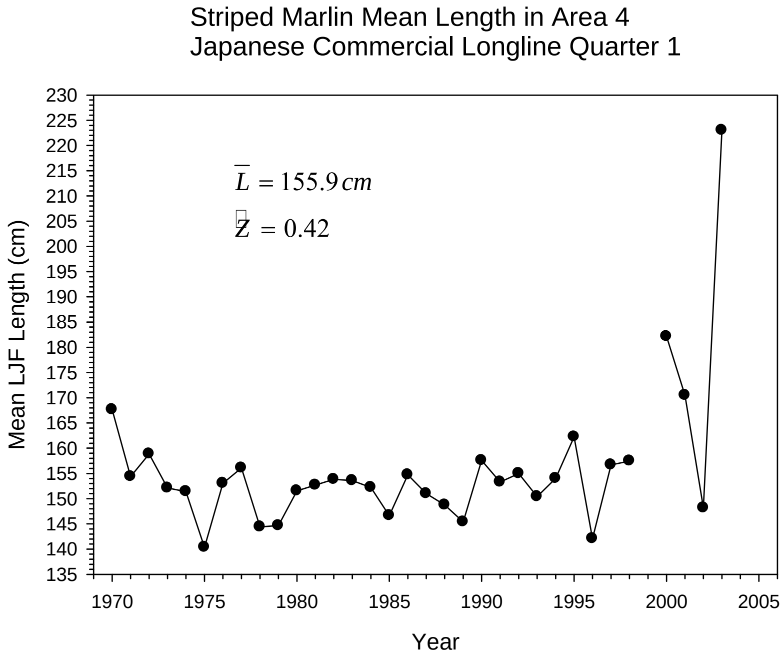


Figure 4.2. Total mortality estimates of striped marlin in fishing area 4, quarter 2.

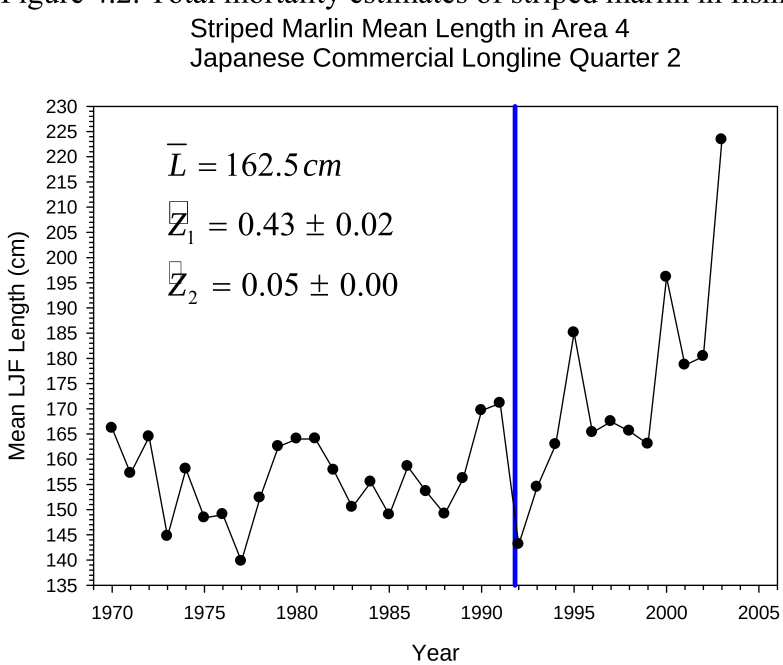

Figure 4.3. Total mortality estimates of striped marlin in fishing area 4, quarter 3.

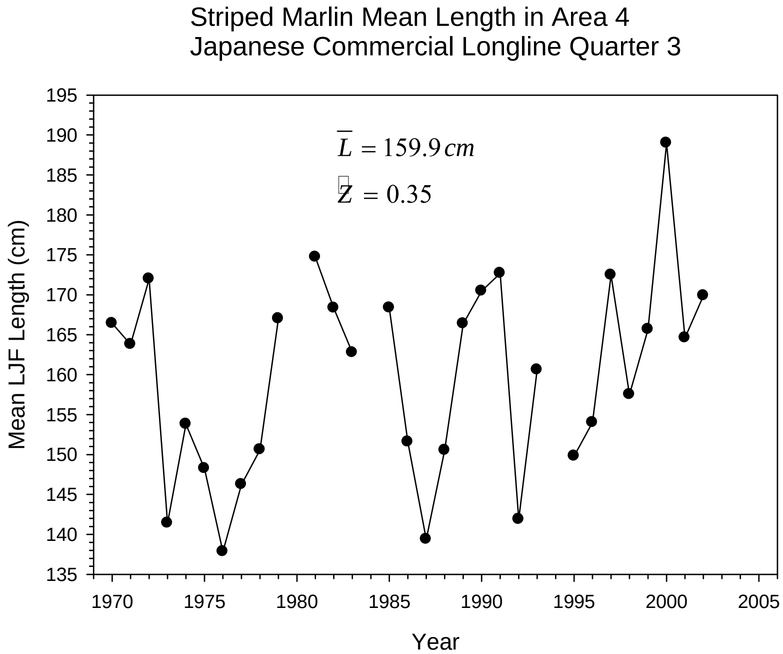


Figure 4.4. Total mortality estimates of striped marlin in fishing area 4, quarter 4.