Sample size sensitivity analysis for calculating MRIP weight estimates

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INTRODUCTION

The Marine Recreational Information Program (MRIP), formerly the Marine Recreational Fishery Statistics Survey (MRFSS), was implemented in 1981 to provide regional based catch and effort estimates of marine finfish in United States recreational fisheries. The survey provides species specific catch estimates by stratum (species/year/wave/sub-region/state/mode/area) in numbers of fish, however corresponding weight measurements are not always available due to sampling constraints or incomplete self-reporting. Therefore, recreational landings estimates were historically provided in numbers of fish for stock assessments. When management measures, such as ACL monitoring, began requiring estimates in weight on a routine basis, a standard methodology was developed to estimate missing recreational weights (Matter and Turner, 2010). This method follows a hierarchy that requires a sample size of at least 30 fish to calculate mean weight at the stratum level, sequentially pooling samples from coarser strata until this number is achieved. The calculated mean weight is then multiplied by the estimated number of fish in a cell to calculate the missing total weight.

In 2012, as part of the MRIP re-estimation project, MRIP developed a new weight estimation methodology that was applied to weight estimates back to 2004. A mix of hot and cold deck imputation and length-weight modeling was used to fill in missing weight estimates (NOAA Fisheries). However, this still left some missing weight estimates at the stratum level. In order to provide consistent weight estimates throughout the time series, SEFSC implemented the weight estimation procedure, previously used to fill in missing weights, to produce weight estimates for all strata back to 1981 (Matter and Rios, 2013). This methodology, which uses a minimum sample size of 30 fish to calculate an average weight, was considered an improvement over the previous survey method which required weights of only two fish to calculate stratum level weight estimates. The impact of requiring 30 samples, however, has never been formally assessed.

This paper formally examines the stability of weight estimates as a function of sample size for a variety of ACL managed species. Based on this analysis, a reasonable sample size threshold can be determined at which the precision of the estimates stabilizes and further samples result in diminishing improvement. Requiring a sample size no larger than this cutoff will ensure more accurate weight estimates within strata as potentially less aggregation of samples across coarser levels will be necessary to meet the minimum sample size threshold.

METHODS

A non-parametric bootstrapping approach was used to calculate the variability in mean stratum-level weight estimates using random samples drawn from 2018 MRIP source weights (all sub-regions) of size one to thirty. Only ACL managed species with at least 30 recorded weights in a particular stratum were included in the analysis. At each stratum level, 50,000 bootstrap replicates were run for each sample size (i.e., the mean weight was calculated for 50,000 random samples of size one to thirty drawn with replacement, and the standard deviation of those 50,000 means was taken to obtain the precision of the estimate at each sample size).

$$SE_n = std((\frac{1}{n}\sum_{i=1}^{n} X_i)_j)$$

$$n = 1, \dots, 30; j = 1, \dots, reps\ (50{,}000)$$

$$X = random\ stratum\ level\ fish\ weight\ selected\ with\ replacement$$

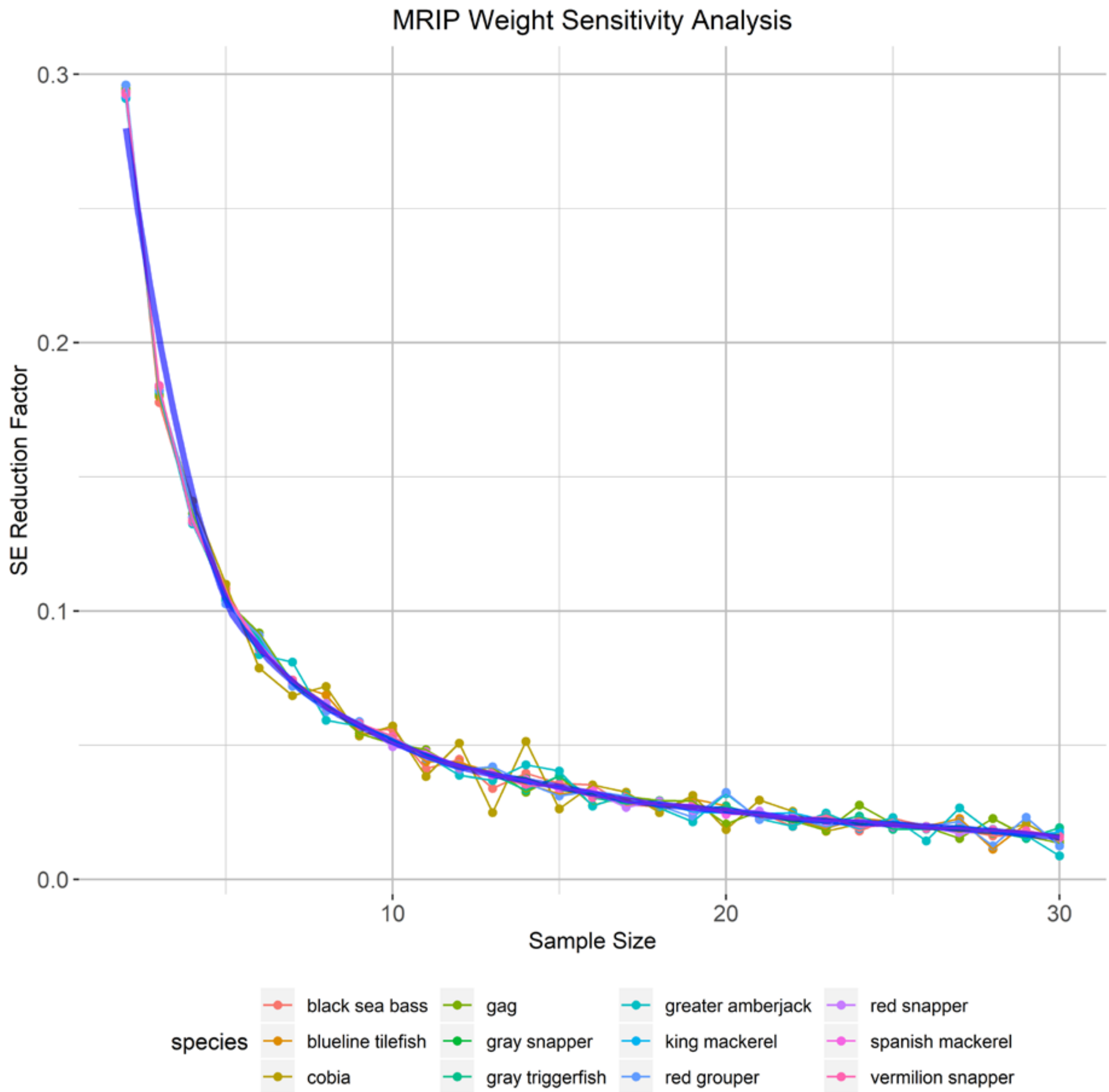
To standardize results across all species, the relative improvement in standard error with each additional sample was calculated by dividing the standard error at sample size n by the standard error at sample size n - 1. The average of these improvements was then calculated at the species level over all strata and plotted to visualize the average error reduction as a function of sample size.

$$SE\ Reduction\ Factor_{species,n} = mean(1 - \frac{SE_n}{SE_{n-1}})_{wave/subregion/state/mode/area}$$

RESULTS AND DISCUSSION

As seen in the Figure 1 below, mean weight estimates show significant gains in stability up to a sample size of about ten. Improvement begins to plateau around a sample size of fifteen, with reductions in standard error consistently below 5%. This suggests that a stratum sample size of not fewer than ten should be required to obtain reliable weight estimates, while samples greater than fifteen are likely not necessary as gains in precision are substantially diminished past this point. This follows what is expected theoretically, with reductions in standard error diminishing according to the square root of the sample size. While this analysis was only be completed for species with sufficient weight information, it is evident this pattern is consistent across multiple species.

Figure 1: Percent standard error reduction in 2018 mean weight estimates as a function of sample size.



Based on this result, it is suggested that a sample size of fifteen be used as a reasonable minimum threshold for calculating mean weight estimates before aggregating samples from coarser strata. This will result in more accurate, finer-resolution estimates, especially for species with fewer than 30 weights available in a stratum.

REFERENCES

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APPENDIX

Figure 2: Application of minimum sample size thresholds to South Atlantic Golden Tilefish.

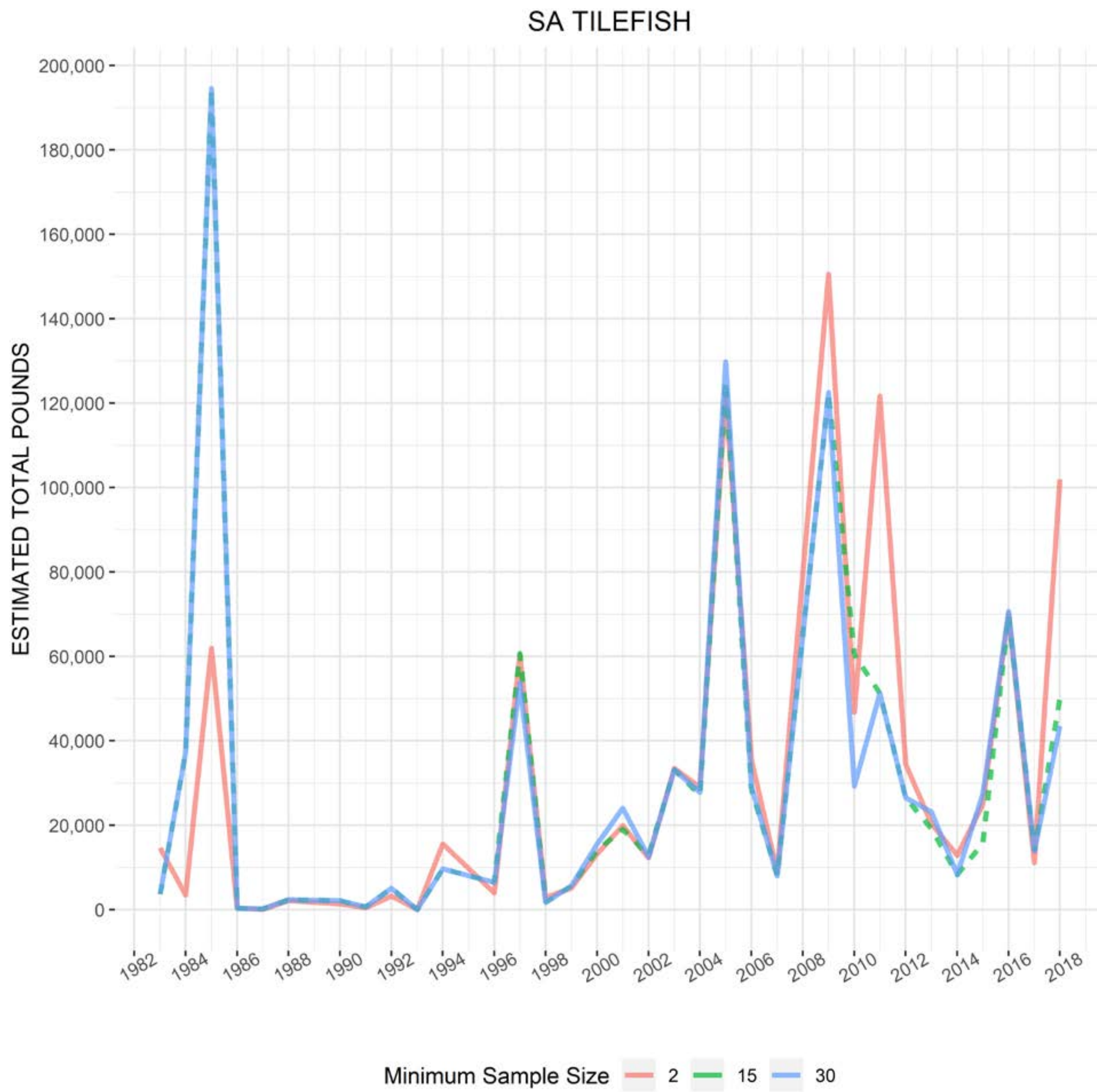

Figure 3: Application of minimum sample size thresholds to Gulf of Mexico Vermilion Snapper.