Monitoring Largemouth Bass Morphometrics

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Introduction

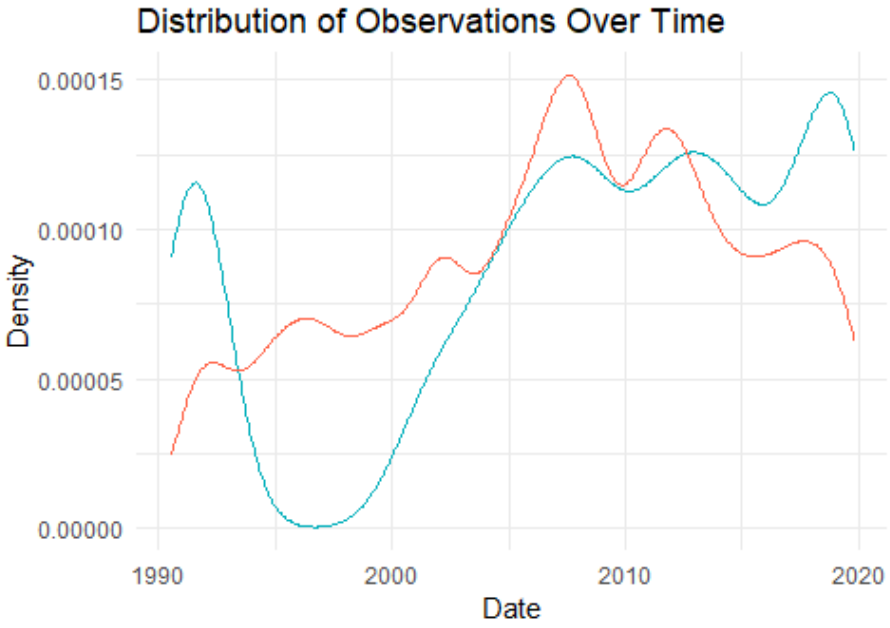
The Long Term Resource Monitoring (LTRM) program performs standardized monitoring of the different constituents within the upper Mississippi River System. One of which, the biotic constituent, consists of the fish that live in the Mississippi River's ecosystem. Fish are an important part to the Mississippi River System, because they often affect other elements within their ecosystem, such as other biota. The importance of monitoring and researching fish allows the LTRM to detect adverse trends within the ecosystem and take actions when needed. The purpose of this analysis is to detect if there are any morphometric changes in the community of largemouth bass over time. In particular, to find if the relationship between length and weight for largemouth bass is changing over time. The data collected for this analysis was taken from Lake Onalaska between 1990 and 2019 and was grouped by the decade in which they were observed.

Statistical Methods

All statistical analyses were done in `R` (Version 3.6.3; R Core Team 2020). The `tidyverse` package (Version 1.3.0; Wickham et al., 2019) was used for the cleaning, preparing, manipulation, and graphing of the data. Other packages used for statistical analyses were: `lubridate` (Version 1.7.8; Garret Grolemund and Hadley Wickham, 2011), `GGally` (Version 1.5.0; Barret Schloerke et al., 2020), `mice` (Version 2.3.0; Stef van Buuren and Karin Groothuis-Oudshoorn, 2011), `EnvStats` (Version 2.3.1; Millard SP, 2013), `dunn.test` (Version 1.3.5; Alexis Dinno, 2017), and `clinfun` (Version 1.0.15; Venkatraman E. Seshan, 2018). Kernel smoothing was applied to the distribution of observations over time and loess smoothing was applied to compare the relationship between length and weight. A Shapiro-Wilk's test was used to assess the normality of the largemouth bass weight and length. The Dunn test was used to test for a difference in fish morphometrics between the decades, and a Jonckheere-Terpstra test was used to assess if fish weight was increasing over the three decades observed. The Kendall Trend Test was paired with a bootstrapping function to create a bootstrapped slope relating length to weight for each decade. To assess if there was a significant difference in the slopes between the three observed decades, a 95% confidence interval was applied to the result of $\beta_i - \beta_j$, where β_i was the slope for the most recent of the two decades being compared. All tests were computed at the $\alpha = .05$ level.

Results

Figure 1 shows an overall increasing trend in the number of total observations from 1990 to 2007, where the LTRM had its peak number of observations (red line). The trend then starts to decrease from 2007 to 2019. Also shown in Figure 1, there is a small number of complete observations recorded from 1990 to 1994, with no instances of complete observations after 1994, until 2000 (blue line). From the year 2000, the number of complete observations starts to increase until 2007. From 2007 to 2019 the trend in complete observations is relatively static, except for in 2019, where there is a small increase in the number of complete observations. By comparing both densities in Figure 1, it can be shown that most observations from 1990 to 1994 were complete cases, while cases from 1994 to 2000 were all incomplete. It can also be shown that both the number of complete and total observations increased from about 2000 to 2007. From 2007 onward, the number of total observations decreased, but the number of complete observations increased slightly, resulting in a higher proportion of complete data for that time span.



*The blue line represents the distribution of samples for only complete cases, and the red line represents the distribution of samples for all cases.
Figure1

In **Figure 2**, there does not appear to be visual evidence of a difference in the relationship between length and weight when comparing the three decades. But if we look at where the observations are graphed, most of the observed fish lengths and weights in the first decade are all under 400 mm and 1,250 g. In the second decade, there are more observed morphometrics greater than 400 mm and 1,250 g than in the first decade. Meanwhile, the observed morphometrics from 2010 to 2019 appear similar to those observed from 2000 to 2009 but are still greater than those observed from 1990 to 1999.

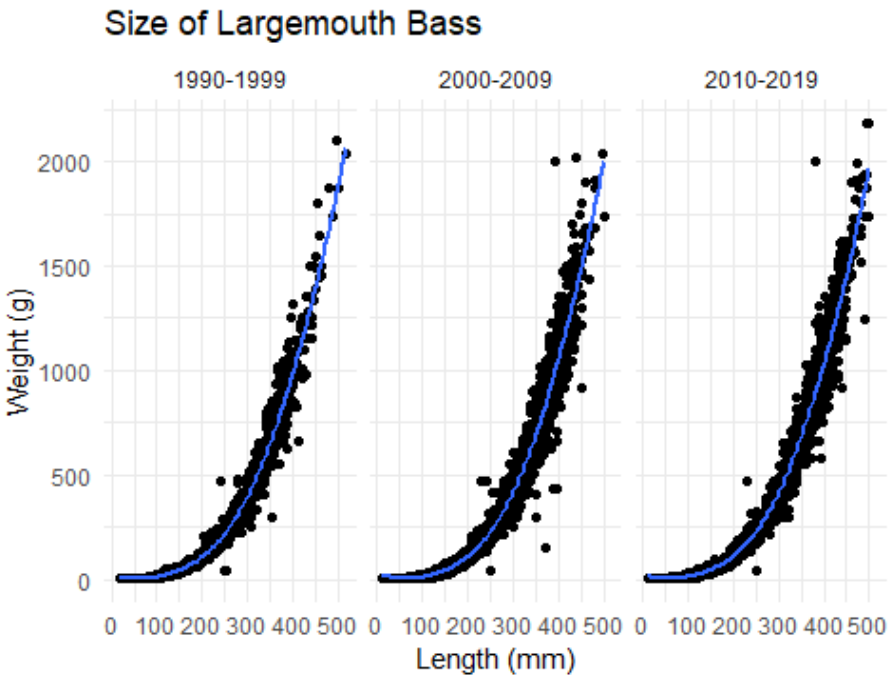


Figure 2.

Using Dunn's test to compare the fish weights throughout the decades, there was significant evidence of a difference in fish morphometrics between the decades of 1990-1999 and 2000-2009 ($p<0.001$), between the decades 1990-1999 and 2010-2019 ($p<0.001$), and between the decades 2000-2009 and 2010-2019 ($p=0.008$). By using the Jonckheere-Terpstra test, the observations were grouped by their decade, and it was found that there is significant evidence of an increasing trend in weight, through the decades ($JT=4.12e+07$, $p<0.001$).

The relationship between weight and length for the decade of 2000-2009 is significantly different than the weight and length relationship for the decade of 1990-1999 (0.236, 0.416), where it is greater from 2000-2009 (**Figure 3**).

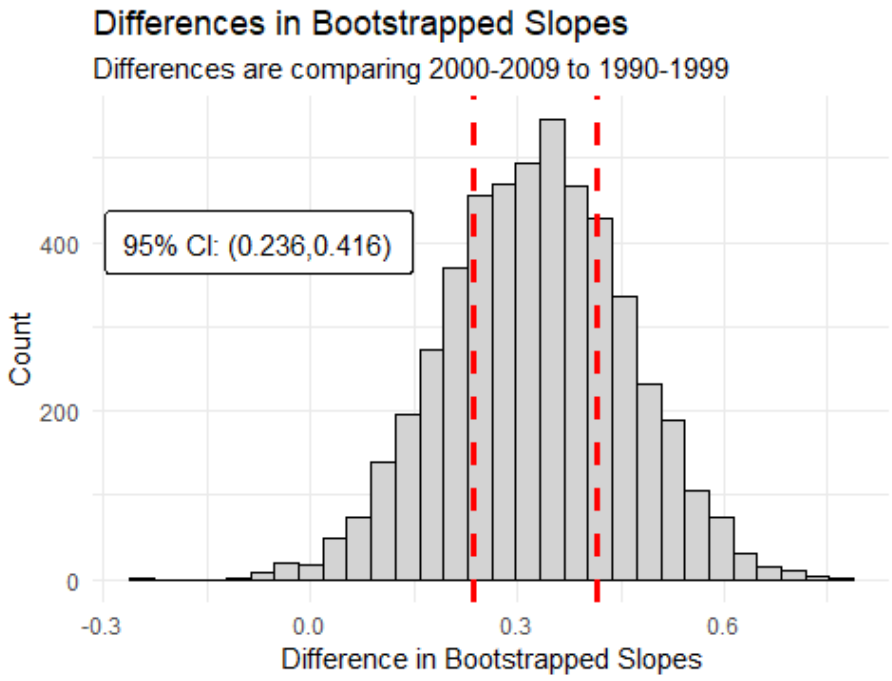


Figure 3.

The relationship between weight and length is significantly different for the decade of 2010-2019 when compared to the decade of 1990-1999 (0.16, 0.35), where the relationship from 2010-2019 is greater (**Figure 4**).

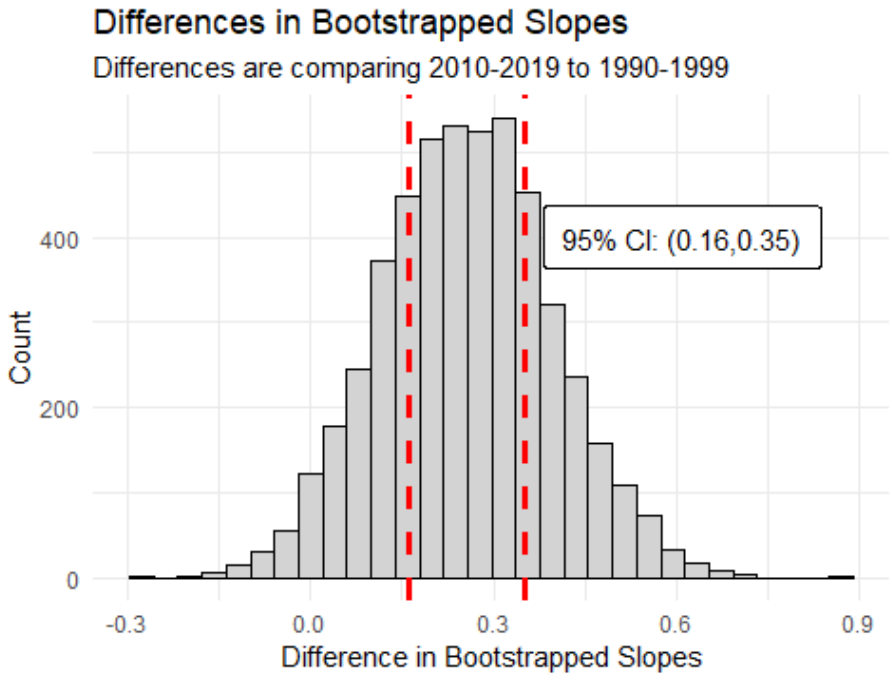


Figure 4.

In comparing the weight and length relationships for the decades of 2010-2019 and 2000-2009 (**Figure 5**), there was no significant evidence of a difference between relationships, for the two decades (-0.163, 0.018).

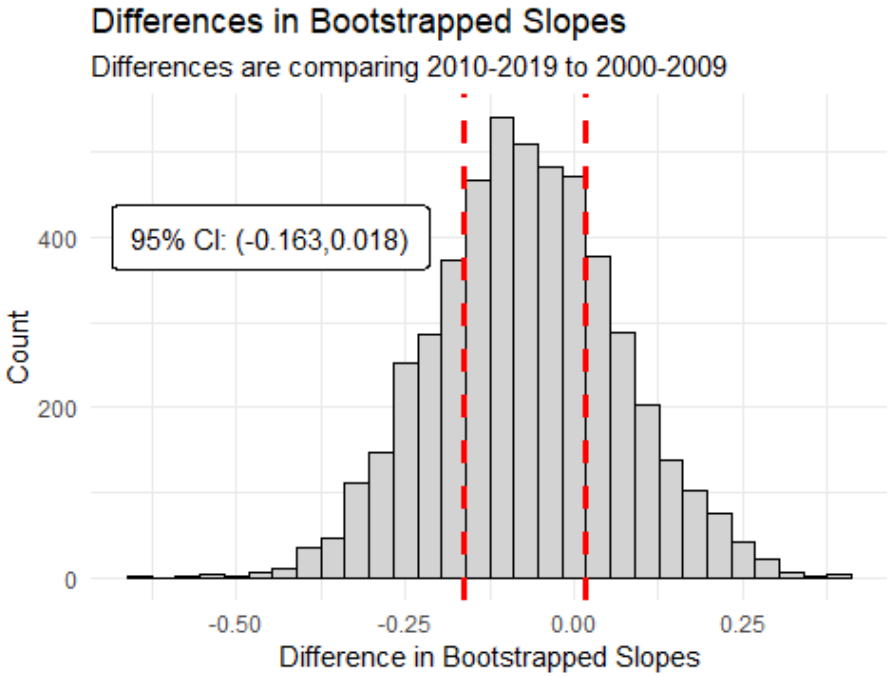


Figure 5.

In conclusion, there are morphometric changes in the largemouth bass community. The relationships between weight and length have increased significantly since 1990 but have been on a small but steady incline since 2000. Based on the previous tests and analysis, the largemouth bass community is gradually growing, with respect to their morphometrics.