EFFECTS OF HABITAT AND GROWTH FACTOR ON NATURAL MORTALITY RATE IN NORTH AMERICAN FISH SPECIES

Sierra Nawalinski, Sophia Parlati, Cole Osmun and Hunter Wacik

ABSTRACT

Our data were collected by the Virginia Marine Institute of native fish from all over the world. Our hypothesis tests were whether temperature decreases or increases growth rate among fish. There were statistical data taken on preferred water temperatures, Mortality rate, quantitative and qualitative data, family, genus, the specific location they were captured and sex of the species of fish that were captured. According to the statistical data we captured and as well as analyzed multiple sets of confirmed data and graphed according to our hypothesis. In conclusion, we rejected our hypothesis due to the fact that our data analysis such as r-squared and temperature did not correlate with the mortality rate.

Key words: Von Bertalanffy growth parameters, instantaneous natural mortality rate, temperature

INTRODUCTION

In this study, the Virginia Institute of Marine Science had previously done an online database of 230 freshwater fish species on their growth factors and life history characteristics. We tested the relationship between the von Bertalanffy growth factor, average habitat temperature, and the maximum age of the fish stock as the focal point of this study as it pertains to a fish's mortality. We used linear regression analyses to determine the effect of each variable on fish mortality rate.

METHODS AND MATERIALS

We analyzed data from the Virginia Institute of Marine Science (VIMS). VIMS compiled an online database of 230 U.S. fish species that recorded information on growth factors and life history traits. The database identified each species by order, family, genus, species, and common name, and recorded the location, mean annual temperature, and sex of the stock studied when available. The database then included the instantaneous natural mortality rate, von Bertalanffy growth factor, von Bertalanffy asymptotic length, and maximum age of the stock at that location for each species. The data was compiled from a variety of studies and papers published on North American fish species, and each resource was cited along with the species they contributed. The database is routinely updated and maintained by the VIMS. Since we had so much data to work with, we decided to look at the relationships between the three major variables, von Bertalanffy growth factor, average habitat

temperature, and maximum age of the fish stock and their effects on the species' instantaneous natural mortality. We hypothesized that growth factor would have the greatest effect on mortality and the relationship would be positive while temperature and maximum age would have smaller effects on mortality with positive and negative relationships respectively.

Since growth factor is an expression of the bodily growth of a fish species with respect to age, the higher the factor, the faster the fish grows. We thus expected that higher growth factors would result in higher mortality rates since they would likely grow, mature, and reproduce earlier in life. We expected temperature to have a positive effect as well since colder waters are more productive and can lead to longer lived fish with lower mortality rates. In regards to maximum age, the longer the species tends to live, the lower we expect their natural mortality rate to be. To test our hypothesis, we ran linear regressions. We used instantaneous natural mortality as the independent variable and checked the effect that temperature, von Bertalanffy growth factor, and maximum age each had as the dependent factors. We used the calculated p and R^2 values to determine significance and relative amount of variance explained by each regression. We plotted the residuals scatter graphs, showing the results fitted around the least squares (best fit) lines.

RESULTS

Temperature (°C) had a significant ($p=0.002$), but minor ($R^2= 0.041$) effect on mortality ($year^{-1}$). The 95% confidence intervals did not include the horizontal, meaning we rejected the null hypothesis. However, this correlation only explains about 4.1 % of the variation. von Bertalanffy growth factor also had a significant ($p<0.001$) effect on mortality, and accounted for significantly more of the variation ($R^2=0.46$). The relationship between maximum age of stock (years) and mortality was clearly nonlinear, though it was significant ($p<0.001$, $R^2=0.161$). To fit this better to a linear regression, we took the log of maximum age and replotted it against mortality and re-ran the regression. This resulted in a much more correlated relationship ($p<0.001$, $R^2=0.569$). Though all three, temperature, growth factor, and maximum age, had significant effects on the instantaneous natural mortality of each fish species, growth factor and maximum age had the highest correlation. Of these, the maximum age of the fish stock had the greatest effect, explaining about 57% of the variance

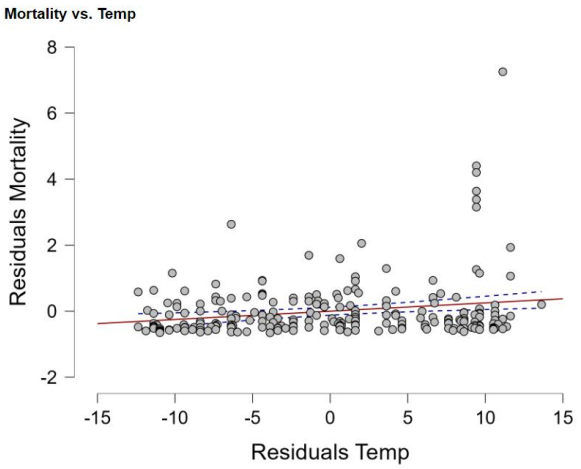

Figure 1. Linear regression of instantaneous natural mortality against average habitat temperature.

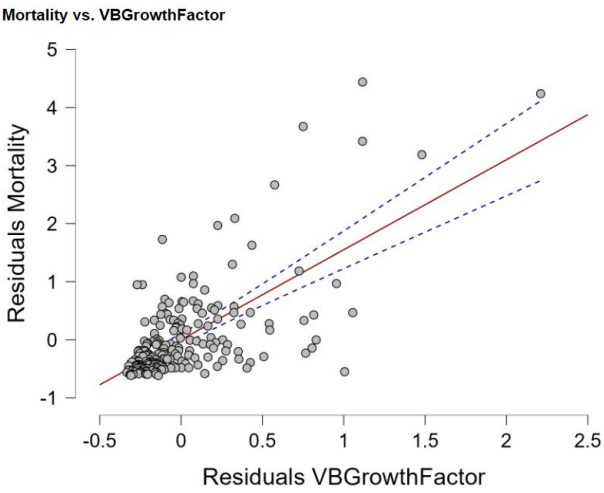

Figure 2. Linear regression of instantaneous natural mortality against von Bertalanffy growth factor.

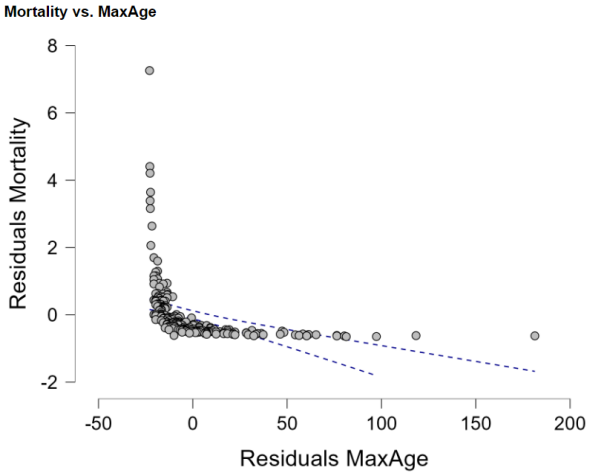

Figure 3. Linear regression of instantaneous natural mortality against maximum age of the fish stock.

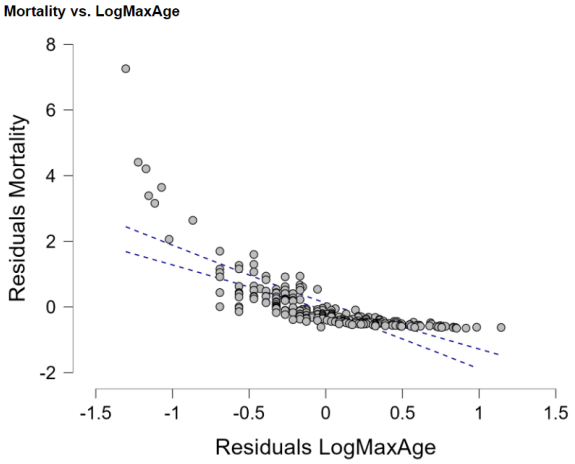

Figure 4. Linear regression of instantaneous natural mortality against logarithm of maximum age.

DISCUSSION

Instantaneous natural mortality is an expression of the likelihood of death of any individual in a population over a very short time period. This value differs across the species in the database, and we wanted to see if these variances were due to any of the other factors recorded in the data. von Bertalanffy growth factor, average habitat temperature, and maximum age of the fish stock all had significant effects on mortality rate. As we expected, temperature and growth factors had positive relationships with mortality. This indicates that warmer habitats tend to host fish species with higher mortality rates. This may be due to colder water being more nutrient rich and tending to support more long lived and slower growing species. However, this relationship was minor and only explained a small portion of the variance. von Bertalanffy growth factor is an expression of the rates of growth over a fish's lifespan. The larger the growth factor, the faster the fish grows. Thus, we hypothesized that higher growth factors, thus faster growing fish, would have higher mortality rates. This

relationship was significant and did explain more of the variance (46%) more than temperature did. We originally thought that this would be the biggest impact on mortality. However, it turned out that the maximum age of the fish stock had the greatest effect, explaining about 57% of the variation in mortality rates. When originally plotted, this relationship was clearly nonlinear, and so it was re-run as the logarithm of the maximum age. This resulted in a much more linear relationship with a higher degree of correlation. This indicates that the older the fish stock could get, the lower their natural mortality rates. Though we had expected this relationship, we were surprised to see that it had a greater correlation than the growth factor. Our results indicate that temperature, von Bertalanffy growth factor, and maximum age reported in the fish population have significant effects on the natural mortality rate, with maximum age having the highest effect. Species with higher habitat temperatures, higher growth factors, and lower maximum ages have higher instantaneous natural mortality rates. Growth factor and maximum age may be able to be used as predictors or indicators of natural mortality rates. This would allow us to use other life history traits of fish species to understand their risk of death. This does align with other publications that have found correlations between von Bertalanffy growth factor and natural mortality (Zhang and Megrey 2009). These parameters and relationships may be useful in conservation efforts and understanding population response to disasters. By understanding how growth rates and maximum age affect mortality rates, we can get a better understanding of populations, their age structure, and how and why they grow, reproduce, and die.

ACKNOWLEDGMENTS

We thank Dr. Neil Pelkey, for statistical analysis assistance

LITERATURE CITED

Essington, T.E., J.F. Kitchell and C.J. Walters. 2001. The von Bertalanffy growth function, bioenergetics, and the consumption rates of fish. Canadian Journal of Fisheries and Aquatic Sciences **58**: 2129–2138.

Kimura, D.K. 1980. Liklihood methods for the von Bertalanffy growth curve. Fishery Bulletin **77**: 762-776.

Zhang, C.-I. and B. A. Megrey. 2009. A revised Alverson and Carney model for estimating the instantaneous rate of natural mortality. Transactions of the American Fisheries Society **135**: 620–633.