Estimating Weights of Giant Largemouth Bass

By: Terry Battisti

For the past 25 years there has been a race to catch the next world record largemouth bass. Although there have been a few close calls amongst record hunters, the 22 pound 4 ounce record caught by George Perry in 1932 has yet to be officially broken. Recently, there have been a few record size fish caught that have not been officially documented, and therefore, are not recognized as the true record.

Without a doubt, there will be no fish "more scrutinized" than the next world record largemouth bass. Proof of this lies in recent and past attempts at record fish submissions. Although a fish has a very low chance of being accepted as the new world record without proper documentation, there will always be someone that enters a fish that has a very questionable pedigree. The last submission attempt regarding an all class world record is a prime example.

In the past few months, I have been obsessed with the thought of being able to estimate the weight of these gigantic green eating machines. Past models, or formulas as many people call them, are poor at estimating the weight of a bass of such proportions. The reason for this is due to the fact that these models were fit to a population of bass that are far lower in weight than record class fish. Therefore, it is critical to develop a more accurate model to validate future submissions of trophy sized fish based on measurements typically submitted by anglers i.e., *length and girth*.

Trophy Bass Proportions

One example that shows trophy size bass are different than their smaller sisters and brothers has to do with their *Length to Weight Ratio* (L/W). Most small bass have an L/W well above 2.5, whereas fish over 16 lbs have an L/W ratio below 1.6. Data from even larger fish, say in the 18 lb class, that have been authentically measured, possess lower scores yet, in the range of 1.0 to 1.4. Another parameter, the *Length to Girth Ratio* (L/G), follows the same suit. Smaller bass, especially those under 10 lbs, typically have an L/G ratio in the 1.55 to 1.75 range, whereas fish over 16 lbs are in the 1.0 to 1.2 range.

Model Development

What does this mean, one might ask? In order to understand, one must look into the math used in developing weight estimation models. Typically, models are developed on a large sample of fish in a broad size range in order to come up with an overall model. If the density of the fish and shape dimensions, i.e. L/W and L/G, remain somewhat constant across the sample population, this method can be accurate. With largemouth bass though, this is not true.

Largemouth bass vary not only in density, but also in their shape parameters. This is evidenced by the fat watermelon shaped fish caught in California versus the long, more slender fish caught in Florida. In order to accurately estimate the weight of a bass from these two different locations, two different models would have to be developed. The reason for this lies in the inherent fit parameters used in these models.

Model development starts out theoretically by developing a pseudo-volumetric equation. This equation is almost always based on a right circular cylinder, the volume which is described by the formula:

$$Volume = \frac{\pi}{4} D^2 L \tag{1}$$

where, D equals diameter and L equals length. In order to transform this equation into something useful for fish, one takes the diameter term and puts it in terms of circumference, or Girth as for a bass. This transformation leads to the expression:

$$Volume = \frac{G^2 L}{4\pi} \tag{2}$$

Now, in order to make this volume expression relate to weight or, more correctly mass, one must multiply volume by density, ρ, as shown in equation 3. Once this is done, an expression for weight has theoretically been developed.

$$Weight = \rho \frac{G^2 L}{4\pi} \tag{3}$$

In order to make this expression work for a fish, which does not possess the dimensions of a right circular cylinder, a shape factor, k, must be introduced. By combining the shape factor, along with the density, and π, one arrives at the development of an overall fit parameter, P. Equations 4 and 5 illustrate both.

$$Weight = k\rho \frac{G^2 L}{4\pi} \tag{4}$$

$$Weight = \frac{G^2 L}{P} \qquad where \quad P = \frac{4\pi}{k\rho} \tag{5}$$

Length, girth, and weight data from a number of fish are then tabulated and the new formula for weight estimation is used, by initially guessing at a fit parameter, in order to estimate the weight of the fish. Once all the calculations have been completed, a least squares curve fit is conducted which automatically adjusts the fit parameter in order to make the modeled weights converge on the actual measured weights. The most widely used fit parameter for fish is 800 while, just recently, the IGFA has adopted the value of 927 for largemouth bass.

Results

Using the method described above, length, girth and weight data from 67 fish[1] weighing 14.25 pounds or heavier were used to develop a new model based solely on the theoretical cylinder shown in Equation 5. The weight estimates from this model, deemed the 958 model for the value of the fit parameter, were then plotted versus the actual weights of the fish in study. Figure 1 shows the results of this exercise. An example of this model is shown below in Equation 6 with the 19.875 lb bass caught by Mike Long in 2004 which had Length and Girth measurements of 29.5 inches and 26.75 inches respectively.

$$Weight = \frac{(29.5\,inches)(26.75\,inches)^2}{958} = 22.03\,lbs \qquad (6)$$

Another method used in developing a weight estimation model was to keep the sum of the length and girth exponents equal to three but vary their values through a number of least squares curve fits. This would still give units of volume, which is dimensionally sound, but allows the modeler to not be constrained completely by the individual exponential values. An example can is shown in Equation 7.

$$Weight = \frac{L^a G^b}{P} \qquad (7)$$

where: $a + b = 3$

Starting out with the L exponent equal to zero and the G exponent equal to three, the exponential values were changed in increments of 0.1 until an L exponent value of three and G exponent value of zero was obtained. Then, by plotting the value of the L exponent versus the sum of the least squares analysis for each run, the optimum values for the L exponent and the G exponent were determined. An example of this model is presented below in Equation 8, again using Mike Long's 19.875 lb bass[2].

$$Weight = \frac{(29.5\,inches)^{1.5}(26.75\,inches)^{1.5}}{999} = 22.19\,lbs \qquad (8)$$

[1] Data for this study were obtained from the Texas Parks and Wildlife Department Share a Lunker Program, The City of San Diego, the California Department of Fish and Game and Mike Long (as certified by the San Diego Parks Dept.). Sixty seven trophy bass, weighing over 14.25 pounds each, were analyzed using their actual weight, length, and girth.

[2] Although, for this particular bass, the outcome is weighted high, this model produced better overall results than the IGFA and 958 Models when all fish were considered.

The final method used for model development was a purely empirical method in which the exponents of length and girth are allowed to vary along with the fit parameter during a non-linear least squares regression. This method, although not theoretically based due to the fact that the sum of the exponents is allowed to deviate from units of volume, is commonly used when more theoretical methods do not produce satisfactory results. In essence, they are ways of estimating a desired outcome when some or all of the needed theoretical parameters (in this case density) are unknown. The outcome from this analysis provided the best “overall” results of the entire study except for fish over 20lbs where it underestimated the actual weight by up to 6%. Equation 9 gives an example of how this equation is used by again, using Mike Long’s bass. All of the above models and their results can be viewed in Figure 1 and Table 1.

$$Weight = \frac{(29.5\,inches)^{0.68}(26.75inches)^{0.79}}{7.0} = 19.14\ lbs \qquad (9)$$

Another method used to determine whether the models were more accurate for bass of a certain shape was a plot of the L/G Ratio versus the Weight Percent Difference in the model result with respect to the actual weight. Negative numbers show the model under-estimated the weight of the bass while positive numbers show a result that was over-estimated. A statistically sound model should always have an even number of results above and below the Zero Line. All of the models showed good distribution above and below the line but again, the empirically fit model produced the best results. See Figure 2.

Confidence intervals were also determined for each model in order to determine exactly how accurate each model was compared to actual weights. These intervals allow the user to determine not only the validity of the model but also the amount of error that can be expected for the interval chosen. For example, if a model has a confidence interval of +/-4% at 90%, this means that 90% of the time, the model will be within 4% of the actual weight value. Three different intervals were determined, 90%, 95%, and 99%. The results of this analysis are shown in Table 2. The results show that again, the Empirical Model was by far the best in determining weight with the best certainty.

Estimating Some Well Known Bass

Using the Empirical Model in order to estimate the weight of some well known fish was done to see where these fish might possibly stand against the record. The three fish chosen were George Perry’s Record, Paul Duclos’ behemoth, and the bass caught last year by Leaha Trew. The measurements of Perry’s fish are said to have been 32.5 inches in length and 28.5 inches in girth. Measurements of Duclos’ fish were never taken but the California Department of Fish and Game studied the photograph and came up with what they feel to be a good estimate. The length being between 29 and 31 inches and the girth between 29 and 30 inches. The Trew fish was said to measure 29 inches in length and 25 inches in girth. The results are shown in Table 3.

Conclusions

Although the models presented above provide a more accurate estimate for a trophy bass' weight than models of the past, a larger sample size of bass in the 18 to 20 pound range must be analyzed. Users of these models must understand the deviations from actual weight when applying these models to their catches. Also of interest were the results from the L/G versus Weight Percent Difference study. The reason this is interesting is shown along the L/G line at values between 1.15 and 1.20. Fish that fall within this interval are quite accurately estimated in weight with an under estimate no greater than weight 5%. This was of particular interest to me in this study due to the latest fish that was submitted for a world record. This fish, having an L/G value of 1.16 and using the empirical model, would have been estimated to weigh between 17.94 lbs and 18.83 lbs instead of the 22.5 lbs claimed.

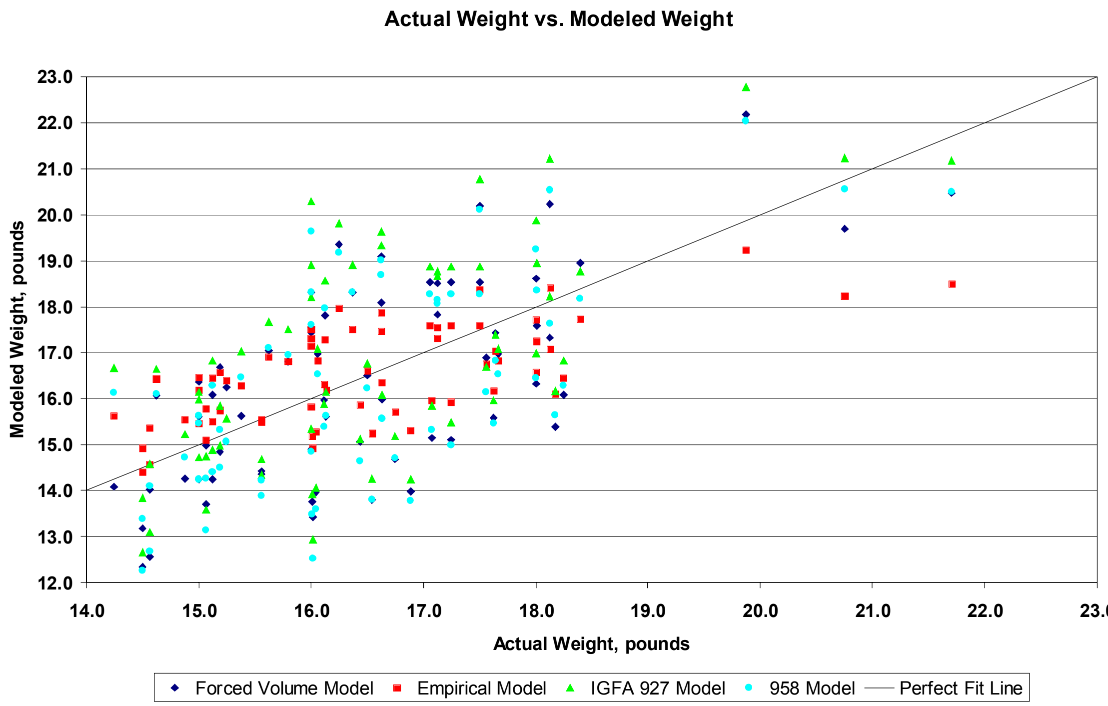

Figure 1.

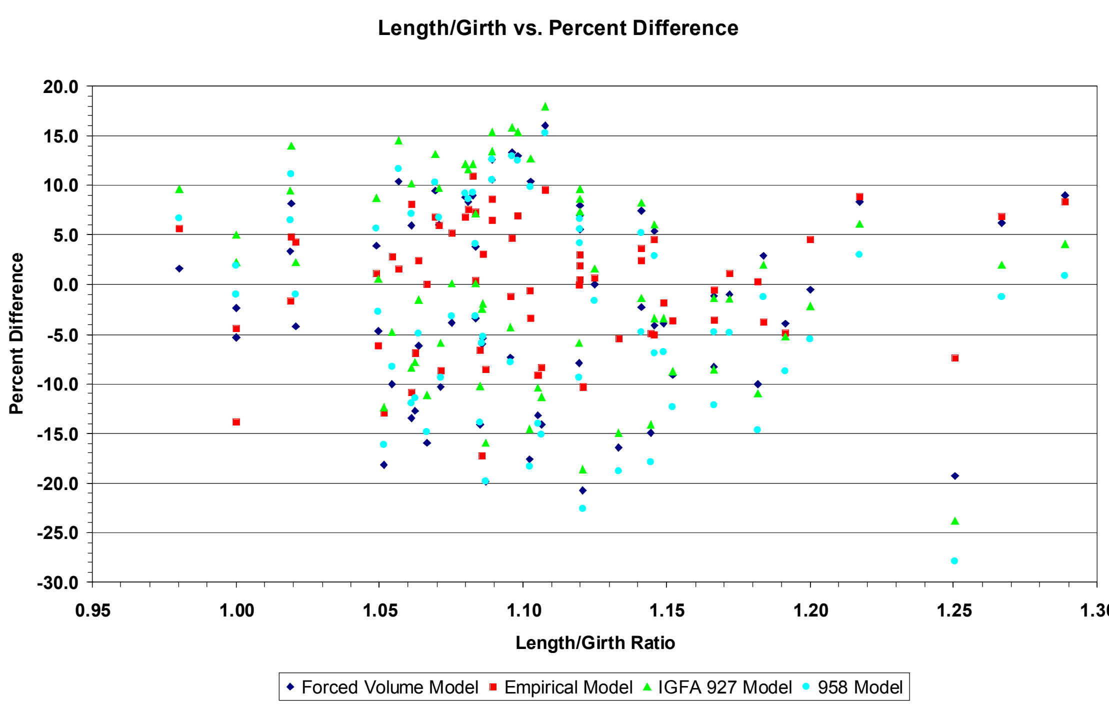

Figure 2.

Model Name	Formula	Maximum Deviation %	Sum of Least Squares
Empirical Model	$W = \frac{L^{0.68} G^{0.79}}{7.0}$	-17.29/+10.98	85.2
Forced Volume Model	$W = \frac{L^{1.5} G^{1.5}}{999}$	-20.78/+16.02	162.3
958 Model	$W = \frac{LG^2}{958}$	-27.90/+18.55	187.9
IGFA 927 Model	$W = \frac{LG^2}{927}$	-23.78/+21.77	208.2

Table 1. Three newly developed models compared to the new 927-Model developed by the IGFA.

Confidence Interval	IGFA 927 Model Percent Difference from Actual	958 Model Percent Difference from Actual	Empirical Model Percent Difference from Actual	Forced Volume Model Percent Difference from Actual
90%	**-0.9% / +3.3%**	**-4.2% / +0.1%**	**-1.4% / +1.4%**	**-3.7% / +0.3%**
95%	**-1.3% / +3.7%**	**-4.6% / +0.5%**	**-1.7% / +1.6%**	**-4.1% / +0.6%**
99%	**-2.1% / +4.5%**	**-5.5% / +1.3%**	**-2.2% / +2.2%**	**-4.9% / +1.4%**

Table 2. Confidence Intervals for models with range of mass percent deviation from actual weight.

Name	Length inches	Girth inches	Estimated Weight pounds	Estimated Weight Plus 5%, pounds
Perry	**32.5**	**28.5**	**21.49**	**22.57**
Duclos	**29**	**29**	**20.17**	**21.17**
Duclos	**29**	**30**	**20.71**	**21.75**
Duclos	**30**	**29**	**20.64**	**21.67**
Duclos	**30**	**30**	**21.20**	**22.26**
Duclos	**31**	**29**	**21.10**	**22.16**
Duclos	**31**	**30**	**21.67**	**22.76**
Trew	**29**	**25**	**17.94**	**18.83**

Table 3. Weight estimates of three well known big bass. Six different estimates were done on the Duclos fish in order to cover the entire range of length and girth measurements estimated.

Bio: Terry Battisti lives in Idaho Falls, Idaho and is a frequent contributor to In-Fisherman. Not only an avid bass fisherman, Terry also holds a Ph.D. in Chemical Engineering and likes to apply his math skills in the fishing area as well.