Can a Fatmeter^{TM} be Used to Determine the Sex of Lake Sturgeon (*Acipenser fulvescens*)?

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Abstract:

It is very important that the sex and maturity of each Lake Sturgeon harvested is correctly identified, as one fish can make the difference between allowing Lake Sturgeon spear fisherman another day to fill their tag or ending the spearfishing season. The purpose of this study was to determine if the sex of Lake Sturgeon can be reliably determined in a non-invasive manner using fat content readings from a Distell Fatmeter[TM]. Three lateral and three ventral readings were taken with the Fatmeter from 71 Lake Sturgeon harvested during the 2013 and 2014 spearing seasons on Lake Winnebago including the Upper Lakes. Linear discriminant analyses and logistic regression were used to determine if the sex of the fish could be accurately determined from the Fatmeter readings. We found that Fatmeter readings cannot be used to reliably determine the sex of Lake Sturgeon in the Lake Winnebago System during the Lake Sturgeon spearfishing season**.**

Introduction:

The Lake Winnebago Lake Sturgeon (*Acipenser fulvescens*) fishery is highly regulated with strict harvest caps set for juvenile and adult females as well as male Lake Sturgeon. The stage of maturity of the harvested male and female Lake Sturgeon play a role in determining how long the season will be open. When the harvest caps are reached, the Lake Sturgeon spearing season closes. Thus, it is very important that the sex and maturity stage of each Lake Sturgeon is correctly identified, as one fish can make the difference between immediately closing the season or allowing it to continue for one more day.

Determining of the sex of Lake Sturgeon is time consuming because the gonads must be excised and visually examined to identify the sex of the fish. An alternative method for sex determination may exploit the difference in fat percentage between male and female fish due to egg production prior to spawning. Specifically, the Distell Fatmeter™ (hereafter, called Fatmeter), which has been used in the commercial fishing industry to determine the fat content in fish fillets, may be used to measure the fat content of whole, undissected Lake Sturgeon. The purpose of this study was to determine if the sex of Lake Sturgeon could be reliably determined in a non-invasive manner using fat content readings from the Fatmeter. Determining the sex of Lake Sturgeon by using a Fatmeter would be much faster and cleaner than determining sex by excision.

Methods:

Lake Sturgeon were sampled from Lake Sturgeon harvested during the Lake Winnebago Lake Sturgeon spear fishing season in February, 2014. Every Lake Sturgeon brought to the registration station was weighed to the nearest tenth of a pound, measured to the nearest tenth of an inch, scanned for a PIT tag, and checked for a monel tag. Each Lake Sturgeon that did not have large puncture wounds from the spear, was not frozen, or did not have an excessive buildup of ice was tested with the Fatmeter. The Fatmeter readings were taken at three locations directly below the lateral line (L1, L2, L3) and at three ventral locations directly beneath the lateral measurements (V1, V2, V3; Figure 1). The sex and maturity stage (Table 1) of each Lake Sturgeon was visually determined from excised gonads.
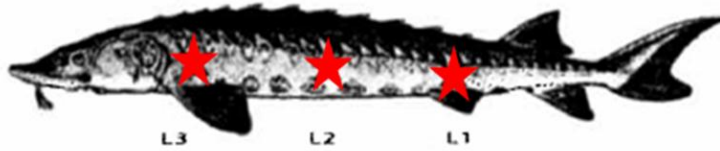
Figure 1. The ventral placement for the measurements with the Distell Fatmeter corresponds with the lateral measurement placement (L3, L2, L1).

Table 1. Reproductive maturity stages of Lake Sturgeon.

Maturity			
Male Stages		Female Stages	
M1	Not developed testes	Fv	Immature
M2	Fully developed testes	F1	Not developed ovaries
		F2	Early vitelogenesis
		F4	Fully developed
		F6	Spent

Logistic regressions were used to determine if individual Fatmeter readings (e.g., L1 or V3) could accurately predict the sex of Lake Sturgeon. Linear discriminant analyses were used to determine if a combination of Fatmeter readings, fish length, and fish weight could accurately predict the sex of Lake Sturgeon. A rejection level of 0.05 was used for all statistical tests, which were performed in the R v3.1.0 environment (R developed Core 2014).

Results:

Individual Fatmeter readings or readings averaged by location (e.g., lateral or ventral) did not provide accurate predictions of sex (Figure 2). The combination of all six Fatmeter readings, without fish length or weight, accurately predicted sex for only 54.5% of females and 50.0% of males (Table 2). The combination of all six Fatmeter readings along with length and weight measurements accurately predicted sex for

70.6% of females and 80.0% of males (Table 2). We found that the addition of Fatmeter readings to models with fish length and weight alone provided only modest improvements for predicting the sex of Lake Sturgeon. Predictions were substantially (approximately 10-30%) better if only "ripe" individuals were considered (Table 2).
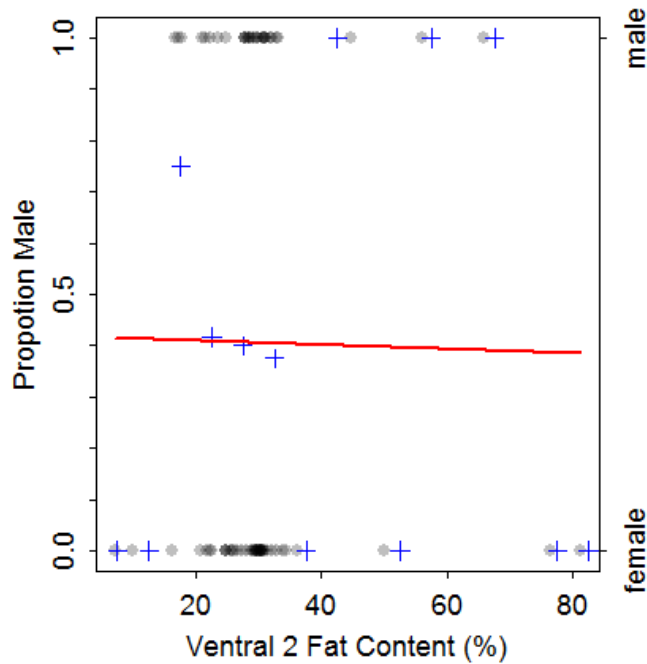

Figure 2: Logistic regression model for predicting sex from the second ventral (V2) Fatmeter readings as an example of the poor fit of individual logistic regression models.

Table 3. The percentage of correct predictions of sex for linear discriminant analysis models separated by known sex and model inputs for all Lake Sturgeon and only "ripe" Lake Sturgeon. Model inputs were all Fatmeter readings without fish length and weight (FM), all Fatmeter readings with fish length and weight (FM, LW), and only fish length and weight without Fatmeter readings (LW).

Sex	All Lake Sturgeon			Only "Ripe" Lake Sturgeon		
	FM	FM, LW	LW	FM	FM, LW	LW
Female	54.5%	70.6%	59.1%	71.4%	85.7%	78.6%
Male	50.0%	80.0%	73.3%	78.9%	89.5%	84.2%

Discussion:

The Fatmeter readings alone cannot be used to accurately predict the sex of Lake Sturgeon during the spearfishing harvest in Lake Winnebago. Models with length and weight alone (i.e., no Fatmeter readings) had better predictions than models with just the Fatmeter readings. Accuracy in the determination of Lake Sturgeon sex increased only slightly when Fatmeter readings were added to the models with length and weight.

Our analyses with only the ripe Lake Sturgeon was meant to create a situation that was, in our mind, a best case scenario for Fatmeter readings as these are the fish that would have the greatest separation in fat content due to the reproductive processes. Accuracy in sex determination in these tests increased substantially, but sex was still only accurately predicted for 70-80% of fish when using only Fatmeter measurements and Fatmeter measurements did not substantively increase the accuracy of prediction over models with only length and weight.

From these results, we conclude that the Fatmeter cannot replace the assessment of excised gonads to determine the sex of Lake Sturgeon during the Lake Winnebago spearfishing season. Fatmeter readings can be used to increase the predictive success of sex by 5-10% over just using the length and weight of the fish. However, this is not a significant increase in accuracy of predictions versus the cost of the unit.

Our results may have been adversely affected by several conditions in the field. This study was performed in adverse weather conditions, such as cold weather ($< 0°C$), that may have affected the accuracy of the Fatmeter. The cold weather may have led to

shorter battery life. If one of the readings was taken on a low battery then the microwaves that the Fatmeter uses to measure fat content may have been weaker and the reading would have been affected. The Lake Sturgeon in this study were harvested during a spearing season and, therefore, all sampled fish had puncture wounds that may have been a contributing factor to the poor accuracy of the Fatmeter. These conditions, however, are the conditions that are present during the Lake Winnebago Sturgeon spearing season and, thus, only further suggest that the Fatmeter cannot replace visually examination of the gonads to determine sex during this time.

Acknowledgments