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Management Brief

Revised length categories and standard weight equation for Northern Pikeminnow

Nicholas S. Voss[1,]* and Michael C. Quist[2]

[1]Idaho Cooperative Fish and Wildlife Research Unit, Department of Fish and Wildlife Science, University of Idaho, Moscow, Idaho, USA
[2]U.S. Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit, Department of Fish and Wildlife Science, University of Idaho, Moscow, Idaho, USA

*Corresponding author: Nicholas S. Voss. Email: nvoss@uidaho.edu.

ABSTRACT

Objective: Length and weight indices (e.g., proportional size distribution, relative weight) provide standardized benchmarks that are useful for comparing groups of fish, identifying ecological interactions, and evaluating the effect of management actions. However, the current length categories and standard weight (W_s) equation for Northern Pikeminnow *Ptychocheilus oregonensis*, a species of important management focus in the Pacific Northwest, were developed using limited data, unclear methods, and no validation. As such, we sought to revise the length categories and W_s equation for Northern Pikeminnow.

Methods: We used the all-tackle world record to develop length categories for Northern Pikeminnow. We compiled data from 100,663 Northern Pikeminnow from 114 populations in Idaho, Montana, Oregon, Washington, and British Columbia to develop a revised W_s equation. Most fish were measured in fork length (FL), so we converted total lengths (TLs) to FLs using the equation $\text{TL} = -2.301 + 0.916(\text{FL})$; $r^2 = 0.998$. We used the regression line percentile, linear empirical percentile (EmP), and quadratic EmP methods to develop 50th percentile and 75th percentile W_s equations. We then assessed length-related biases in our W_s equations and the previously published equation.

Results: We propose minimum FLs of 17 cm (7 inches; stock), 26 cm (10 inches; quality), 35 cm (14 inches; preferred), 41 cm (16 inches; memorable), and 51 cm (20 inches; trophy) for proportional size distribution calculations. The previously published W_s equation exhibited substantial length-related biases according to the Willis and weighted empirical quartile method tests. The EmP 50th-percentile W_s equation was the only equation that we evaluated that did not exhibit length-related bias. The EmP 50th-percentile W_s equation was the best performing equation (i.e., no length-related bias detected). The equation is $\log_{10}(W_s) = -5.258 + 3.135(\text{FL})$, where W_s is in grams and FL is in millimeters. The equation is valid for Northern Pikeminnow 90–580 mm FL.

Conclusion: The length categories, length conversion, and W_s equation presented here will aid fisheries professionals in the study and management of Northern Pikeminnow populations.

KEYWORDS: body condition, length structure, management, population index, stock assessment

LAY SUMMARY

The Northern Pikeminnow is a species of considerable management focus in western North America. The standard length categories and validated standard weight equation provided here will assist in monitoring, research, and management efforts for this native species.

INTRODUCTION

Understanding patterns in the length and weight of fishes is foundational to fisheries management and conservation. Information on length structure provides insight on the commercial or recreational potential of a fishery, and monitoring changes in length structure can help scientists evaluate changes in abiotic factors, biotic interactions, or management actions (Neumann et al., 2012). When combined, length and weight data can be used to estimate standing crop or production of a fish population, yield of a fishery, and body condition of fishes (e.g., Blackwell et al., 2000; Haddon, 2011).

A variety of stock assessment indices have been created to summarize length and weight data (Neumann et al., 2012). For example, proportional size distribution (PSD) was developed to summarize length data using standard length categories (Anderson & Weithman, 1978; Gabelhouse, 1984; Willis et al., 1993) and relative weight (W_r) was developed to provide insight on body condition using a reference equation

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for the species (Blackwell et al., 2000; Neumann & Willis, 1995; Wege & Anderson, 1978). Although PSD and W_r are staples of sport fish management and research, the use of these benchmarks has led to their development and application to many nongame fishes (e.g., Bister et al., 2000; Black et al., 2021; Bonvechio & Bonvechio, 2021). Notably, managers of undesirable fishes frequently use PSD and W_r to evaluate population dynamics (e.g., DeBoer et al., 2018; Phelps & Willis, 2013), ontogenetic shifts in diet (e.g., Zollweg, 1998), and the effect of suppression programs, particularly when negative effects are size specific (e.g., piscivores) or compensatory growth is a concern (e.g., Knutsen & Ward, 1999; Porter, 2012; Takata et al., 2007). One species of particular management interest that bridges the definition of sport and nongame fish is the Northern Pikeminnow *Ptychocheilus oregonensis*.

The Northern Pikeminnow is a cyprinid native to western North America that is the focus of substantial attention by fishery managers and anglers. The native distribution of Northern Pikeminnow extends from the Pacific coast east to the Rocky Mountains in western Montana and from Nevada north to British Columbia (Sigler & Zaroban, 2018; Wydoski & Whitney, 2003). The Northern Pikeminnow is a habitat generalist but is most common in low-velocity habitats in large rivers, lakes, and reservoirs. Consequently, dam constructions throughout the 20th century increased the abundance of Northern Pikeminnow in many main-stem rivers, where it is an important piscivore (Knutsen & Ward, 1999; Petersen & Ward, 1999; Wydoski & Whitney, 2003). The negative influence of Northern Pikeminnow on more socioeconomically valuable species led to its classification as an undesirable nongame "trash" fish in the 20th century and the establishment of numerous removal efforts (Scott & Crossman, 1973; Wydoski & Whitney, 2003). For instance, the Northern Pikeminnow Sport-Reward Program was established in 1990 on the lower Columbia and Snake rivers (Washington–Oregon) to reduce predation of Northern Pikeminnow >275 mm on juvenile Pacific salmon *Oncorhynchus* spp. and steelhead *O. mykiss* (Beamesderfer et al., 1996; Winther et al., 2024). The program provides a monetary reward to anglers who harvest Northern Pikeminnow, and over 5.2 million fish have been returned to the program to date. Efforts to remove Northern Pikeminnow are not limited to systems with anadromous fishes. For instance, the Idaho Department of Fish and Game has removed over 1 million Northern Pikeminnow from Lake Cascade, Idaho, since the late 1950s in an effort to reduce predation on Yellow Perch *Perca flavescens* (Janssen et al., 2011; Welsh, 1975). However, the size, aggression, and status of Northern Pikeminnow as a native species have also led to increased appreciation among anglers, and multiple U.S. states now maintain state records. The considerable management and angler focus on Northern Pikeminnow in the Pacific Northwest demands that robust and transferable stock assessment indices (i.e., PSD, W_r) are available.

Calculations of PSD and W_r require valid standard length categories (i.e., stock; quality, preferred, memorable, and trophy) and standard weight (W_s) equations. However, the only stock assessment indices available for Northern Pikeminnow contain considerable methodological issues. For example, Beamesderfer and Rieman (1988) provide the only available length categories for Northern Pikeminnow, but they only defined stock (250 mm) and quality (380 mm) lengths. Furthermore, whether the lengths pertain to fork length (FL) or total length (TL) was not specified by the authors, but the proposed lengths are assumed by Neumann et al. (2012) to be FLs because that is what was measured from fish in the study. Establishing standard length categories follows an accepted process where percentages of the all-tackle world-record length are used to establish minimum length limits (Gabelhouse, 1984; Neumann et al., 2012). In situations where world-record lengths are not available or not representative (e.g., Black et al., 2021), lengths based on fish in a data set encompassing the distribution of the species have also been used. Willis et al. (1993) also encouraged the development of separate English and metric units rather than converting from English to metric. The stock and quality lengths provided by Beamesderfer and Rieman (1988) for Northern Pikeminnow are also concerning because the world-record length was not used and the methodology for arriving at the lengths was not described. Furthermore, no length categories beyond quality length are provided, the length measurement (FL or TL) is unclear, and only metric values are provided. As such, a full suite of standard length categories developed using accepted methodology is needed for Northern Pikeminnow.

A W_s equation for Northern Pikeminnow was developed by Parker et al. (1995), but was developed inappropriately and embedded in a larger population study in the lower Columbia and Snake rivers, Washington–Oregon. The methodology associated with developing W_s equations is even more structured than for length categories and has been the focus of debate in the literature (Froese, 2006; Gerow, 2010, 2011; Gerow et al., 2005; Ranney, 2018; Ranney et al., 2010, 2011). For example, the regression line percentile (RLP) technique was the most widely used method for developing W_s equations and uses the 75th percentile of mean weights estimated among populations as the basis for the W_s equation (Murphy et al., 1990; Neumann et al., 2012). However, Gerow et al. (2005) found that W_s equations developed using RLP techniques often exhibited length-related bias. The authors proposed that empirical percentile (EmP) methods based on percentiles of observed weights be used instead of the RLP method. The original EmP technique is based on the 75th percentile of the observed weights by 10-mm length increments, whereas the RLP technique uses predicted weights from regression models. The best technique has not been fully resolved because the best method to produce W_s equations appears to vary by species (e.g., Black et al., 2021; Ogle & Winfield, 2009; Ranney et al., 2010).

Regardless of which technique produces the least bias, the W_s equation for Northern Pikeminnow provided by Parker et al. (1995) was seemingly developed haphazardly and the opaque methods raise questions about its validity (as noted by Blackwell et al., 2000). The equation was developed using the RLP method but was embedded in a larger study focused on population characteristics of Northern Pikeminnow in reservoirs in the lower Snake and Columbia rivers (Parker et al., 1995). The equation appears to have been created using survey data from their study area, but data from across the distribution of the species are needed to develop a W_s equation (Neumann et al., 2012; Ranney et al., 2010). The number of fish and number of populations that were used to develop the

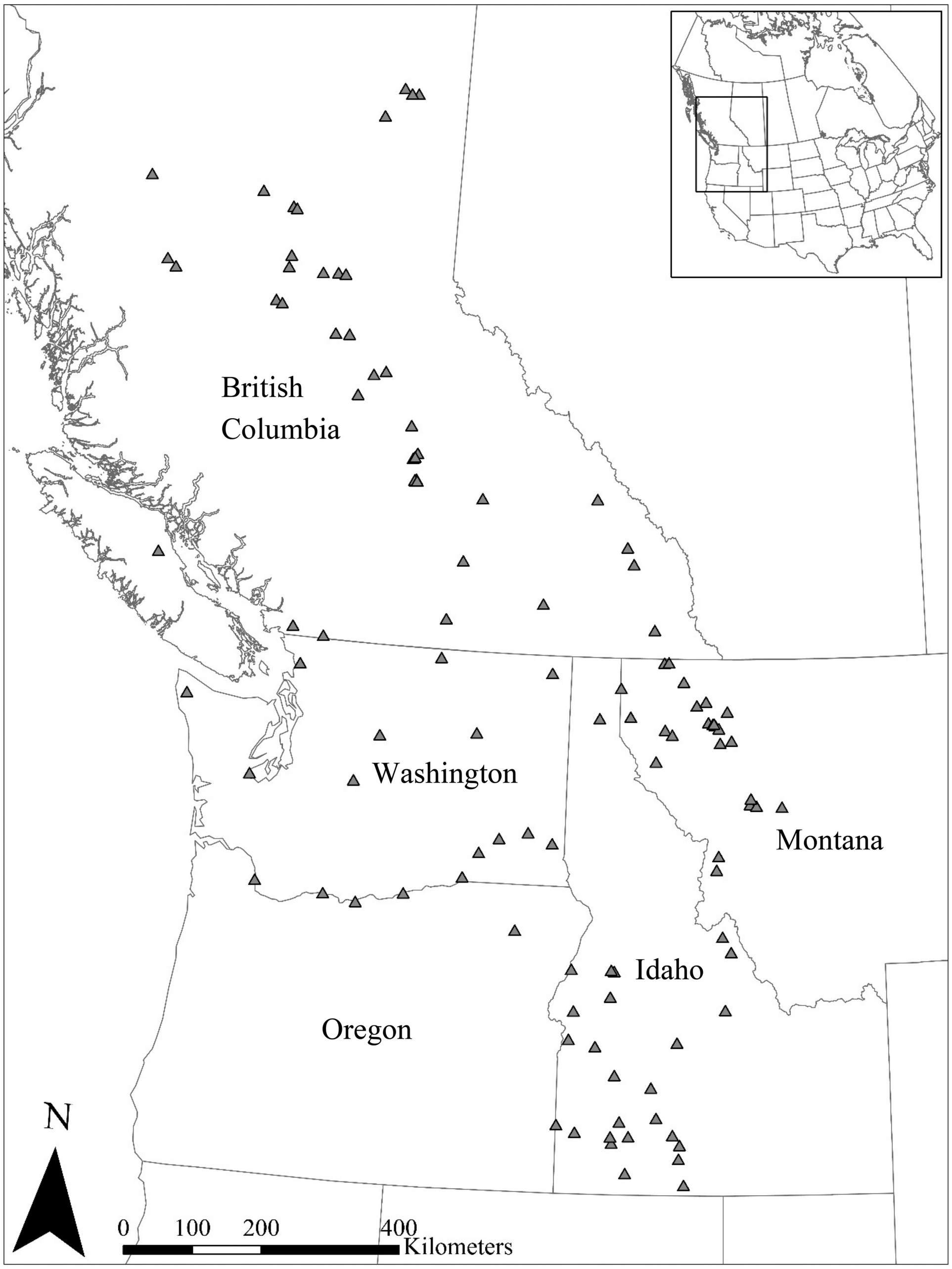

Figure 1. Map of populations (triangles) included in the developmental and validation data sets used to create a revised standard weight equation for Northern Pikeminnow.

equation are also unknown. Furthermore, no assessment of length-related bias was ever presented, and the minimum and maximum lengths across which the equation is valid were never stated (Parker et al., 1995). The equation has been used in numerous reports and publications over the past three decades (e.g., Knutsen & Ward, 1999; Lott et al., 2020; Porter, 2012; Takata et al., 2007; Zollweg, 1998) and remains in standard textbooks (Neumann et al., 2012) and software packages (Ogle et al., 2023) without warning as to the serious methodological issues with its development. Given the continued use of these stock assessment indices, the objective of this study was to develop a robust W_s equation and full set of length categories for Northern Pikeminnow. This study provides managers with stock assessment indices that are suitable for evaluating Northern Pikeminnow populations and their response to management actions across western North America.

METHODS

Standard length categories

We obtained information on the FL of the world-record Northern Pikeminnow from the International Game Fish Association (IGFA; Dania Beach, Florida). We used FL because it tends to be the most common measurement used for Northern Pikeminnow and appears to be exclusively used in British Columbia, Washington, and Oregon, where most active management of Northern Pikeminnow occurs (e.g., Winther et al., 2024). Criteria described in Gabelhouse (1984) were used to establish the minimum FL of Northern Pikeminnow for each of the five-cell length categories (i.e., stock, quality, memorable, preferred, and trophy) in both metric and English units.

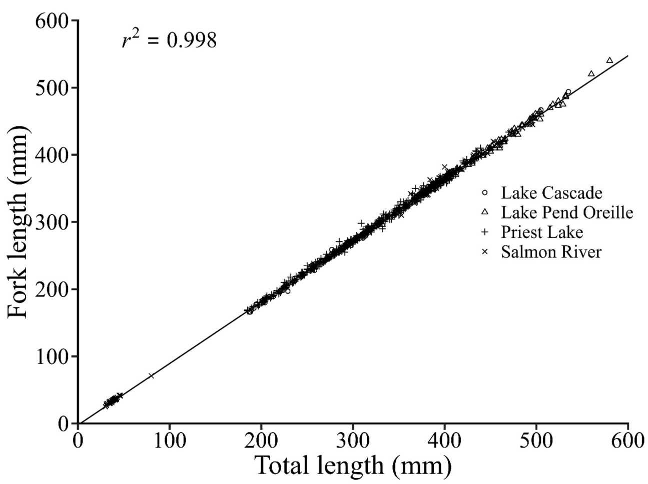

Figure 2. Total length (mm) to fork length (mm) relationship for Northern Pikeminnow based on double-measured fish from four populations in Idaho. The solid line denotes the simple linear regression that was used to convert the total length measurements to fork length measurements.

Standard weight equation

Length and weight data from Northern Pikeminnow in Idaho, Oregon, Washington, Montana, and British Columbia were acquired from state, provincial, federal, and university scientists (Figure 1). We were unable to secure data from Alberta and Nevada, where the species has a limited distribution. Scientists were asked to provide information on TL, FL, weight, sex, date sampled, water body sampled ("population"), sampling technique used, and coordinates of collection. All measurements were in millimeters, and all weights were in grams. All populations sampled by Parker et al. (1995) were present in our data set. All TLs (46% of individuals) were converted to FL using a simple linear regression of TL to FL fit to 810 individuals from four populations in Idaho that were double-measured by the Idaho Department of Fish and Game at our request. Although the number of populations was limited, data from double-measured fish were otherwise unavailable and the fit of the resulting equation ($TL = -2.301 + 0.916[FL]$; $r^2 = 0.998$; Figure 2) indicated that the relationship was consistent and adequately explained by the regression. Next, fish sampled in June were removed to minimize the influence of mature gonads and spawning on length–weight relationships (Sigler & Zaroban, 2018; Wydoski & Whitney, 2003). Clear outliers (e.g., incorrectly entered data) were removed by plotting and regressing $\log_{10}$(FL) against $\log_{10}$(weight) for each population; individuals that exceeded the 99% prediction interval for each population were considered outliers and removed (Bister et al., 2000; Black et al., 2021;

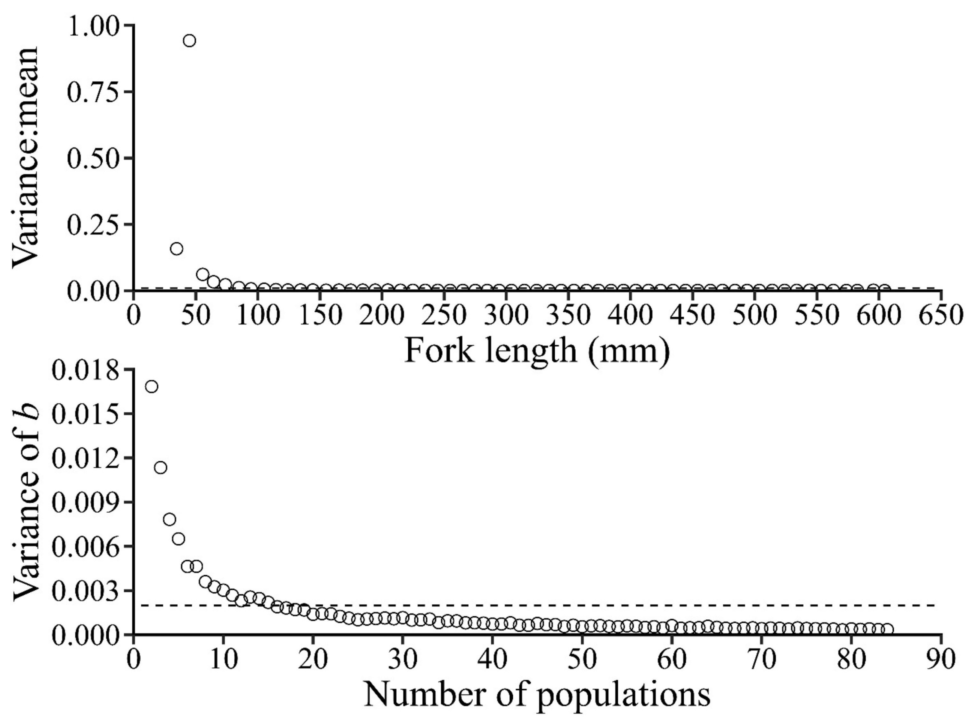

Figure 3. Variance-to-mean ratio of $\log_{10}$(weight) by fork length (FL) at 10-mm intervals for Northern Pikeminnow in the developmental data set (top panel). The horizontal dashed line indicates the cutoff value of 0.01 that was used to determine the minimum FL to include in the model. The bottom panel displays the results of a bootstrap analysis that was used to identify the minimum number of populations in the development data set required to fit a valid standard weight equation for Northern Pikeminnow. The horizontal dashed line denotes the minimum acceptable variance (0.002) of the slope of the $\log_{10}$(weight)–$\log_{10}$(FL) relationship (b) among randomly sampled populations in the developmental data set.

Table 1. Number of populations and number of individual fish in each 10-mm length-class (fork length) in the developmental data set used to develop the revised standard weight equation for Northern Pikeminnow. Length-classes marked with an asterisk (*) were not used in estimating the standard weight equation.

Length-class (mm)	Populations	Individuals	Length-class (mm)	Populations	Individuals
20*	1	2	320	44	2,168
30*	4	29	330	50	2,170
40*	15	37	340	46	2,041
50*	16	271	350	44	1,953
60*	26	272	360	46	1,956
70*	26	264	370	43	1,705
80*	35	267	380	43	1,672
90	40	314	390	48	1,624
100	41	441	400	40	1,553
110	44	811	410	46	1,481
120	44	733	420	42	1,441
130	49	601	430	41	1,439
140	48	608	440	41	1,330
150	57	683	450	45	1,184
160	60	1,003	460	38	1,167
170	57	1,290	470	39	955
180	58	1,487	480	35	728
190	52	1,769	490	32	607
200	58	1,643	500	34	430
210	53	1,672	510	28	289
220	59	1,728	520	23	158
230	57	1,959	530	21	122
240	56	2,014	540	22	85
250	53	1,991	550	13	40
260	49	1,964	560	8	19
270	50	2,000	570	13	23
280	51	2,007	580	4	5
290	53	1,911	590	3	4
300	52	2,091	600	4	5
310	48	2,077	700*	1	1

Ogle & Winfield, 2009). This resulted in 1% of Northern Pikeminnow being removed from the data set. Next, populations with less than 20 fish sampled were removed from the data set. Populations were also removed if the coefficient of determination from a regression of $\log_{10}$(FL) on $\log_{10}$(weight) was less than 0.90 or if the slope (b) was beyond 2.5–3.5 (Black et al., 2021; Ogle & Winfield, 2009). Lastly, we regressed the estimated intercepts ($\log_{10}[a]$) against the estimated slopes for each water body and sampling technique to identify any divergent patterns among populations. The population sampled in Teslin Lake (British Columbia) in 1968 exhibited both an unusually low b and unusually large fish (e.g., six individuals longer than the IGFA world record). We suspected that this unlikely combination of attributes was a result of TL measurements that were incorrectly reported as FL. As such, we excluded Teslin Lake from the data set.

We randomly partitioned our data into "developmental" and "validation" data sets at a 2:3 ratio. The developmental data set was used to compute W_s equations, and the validation data set was used to evaluate equations and test for length-related bias (Black et al., 2021; Gerow et al., 2005; Ogle & Winfield, 2009). Populations with <500 individuals sampled or 1 year of sampling were randomly assigned at the population level. Populations with ≥500 individuals sampled across multiple years were split and randomly assigned by year. We used two-sample t-tests to assess differences in mean slope and intercept values between the developmental and validation data sets (Black et al., 2021; Ogle & Winfield, 2009). A bootstrap simulation was used to estimate the number of populations required for a robust W_s equation from the developmental data set (Brown & Murphy, 1996). Specifically, a given number of slopes from $\log_{10}$(FL) against $\log_{10}$(weight) regressions (by population) were randomly selected with replacement for 300 iterations and the sample variance of selected slopes was computed. The number of randomly selected slopes was increased incrementally from 2 to 84 populations and the minimum number of populations required to achieve a sample variance <0.002 was defined as the minimum required to compute a robust W_s equation (Brown & Murphy, 1996).

Estimated length–weight relationships tend to exhibit the lowest precision and accuracy for the smallest and largest size-classes (Gerow et al., 2005; Neumann et al., 2012). As such, a suitable length distribution was developed prior to deriving the W_s equations. Minimum FL for all equations was established by identifying the smallest 10-mm length interval for which the variance-to-mean ratio of $\log_{10}$(weight) was <0.01 (Murphy et al., 1990). Maximum FL for all equations was established by identifying the largest 10-mm length interval containing fish from at least three populations (Gerow et al., 2005).

Standard weight equations were estimated using the RLP and EmP methods (Gerow et al., 2005; Murphy et al., 1990).

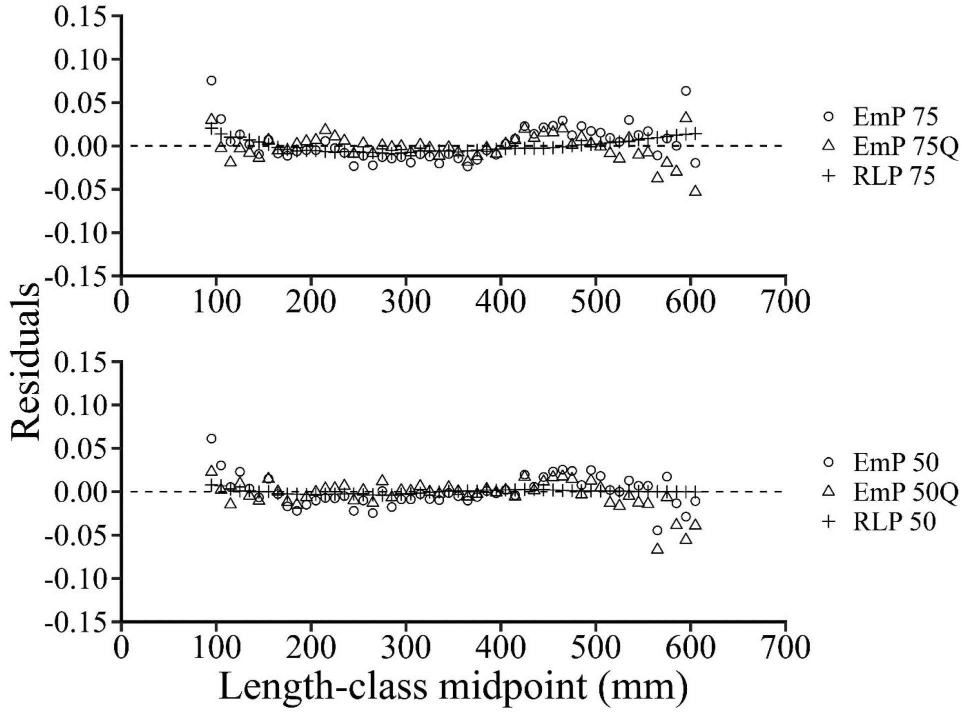

Figure 4. Residuals by 10-mm length-class (fork length) for candidate Northern Pikeminnow standard weight equations generated for the 75th percentile (top panel) and 50th percentile (bottom panel) using the linear empirical percentile (EmP), quadratic empirical percentile (EmP-Q), and regression line percentile (RLP) methods.

Table 2. Parameter estimates for Northern Pikeminnow standard weight (W_s) equations estimated using the regression line percentage (RLP), linear empirical percentage (EmP), and quadratic EmP (EmP_Q) methods (75 = 75th percentile; 50 = 50th percentile). RLP W_{s75} (Parker) denotes the previous W_s equation for Northern Pikeminnow (Parker et al., 1995). Length-related bias was assessed using the Willis and weighted empirical quartile method (EmpQ) tests.

	Parameters			Willis test			EmpQ test	
Equation	$\log_{10}(a)$	b_{linear}	$b_{quadratic}$	**Negative**	**Positive**	P	P_{linear}	$P_{quadratic}$
RLP W_{s75} (Parker)	−4.886	2.986	–	3	36	0.00	0.00	0.19
RLP W_{s75}	−5.176	3.110	–	13	27	0.04	0.00	0.00
EmP W_{s75}	−5.227	3.134	–	17	21	0.63	0.20	0.00
EmP W_{s75Q}	−3.448	1.633	0.314	18	18	1.00	0.20	0.01
RLP W_{s50}	−5.223	3.117	–	15	26	0.12	0.05	0.43
EmP W_{s50}	−5.258	3.135	–	17	21	0.63	0.85	0.23
EmP W_{s50Q}	−3.755	1.867	0.265	19	18	1.00	0.06	0.00

For both methods, linear equations for both the 75th (W_{s75}) and 50th (W_{s50}) percentiles were estimated because equations based on the 50th percentile may exhibit less length-related bias than the 75th percentile and some researchers may wish to summarize body condition relative to a median fish rather than an "above-average" fish (Ogle & Winfield, 2009). We also evaluated an additional quadratic equation for each percentile (W_{s75Q} and W_{s50Q}) using the quadratic EmP method (Gerow et al., 2005).

We used residual analysis, the Willis method (Willis et al., 1991), and the weighted empirical quartile method (EmpQ; Gerow et al., 2004) to evaluate length-related bias in our W_s equations and the previous equation presented by Parker et al. (1995). Residual analysis involved visually examining model residuals in the developmental data set for obvious patterns. The Willis and EmpQ methods involved assessing the distribution of standardized mean weights (i.e., predicted relative weights) for fish in the validation data set by 10-mm length-class. The Willis method uses a chi-square test to identify whether the proportion of populations with a significant positive association between FL and estimated W_r was equal to the proportion of populations with a significant negative association (Willis et al., 1991). The EmpQ method assesses whether there is a significant linear or quadratic relationship between the length-class midpoint and the observed quantile (75th or 50th) mean weight for each 10-mm length-class (all populations) standardized by estimated W_s (Gerow et al., 2004). Here, linear and quadratic slope coefficients that are both not significantly different from zero ($\alpha = 0.05$) indicate minimal length-related bias. We used packages FSA (Ogle et al., 2023) and FSAWs (Ogle, 2025) in program R version 4.3.3 for all the analyses (R Core Team, 2024).

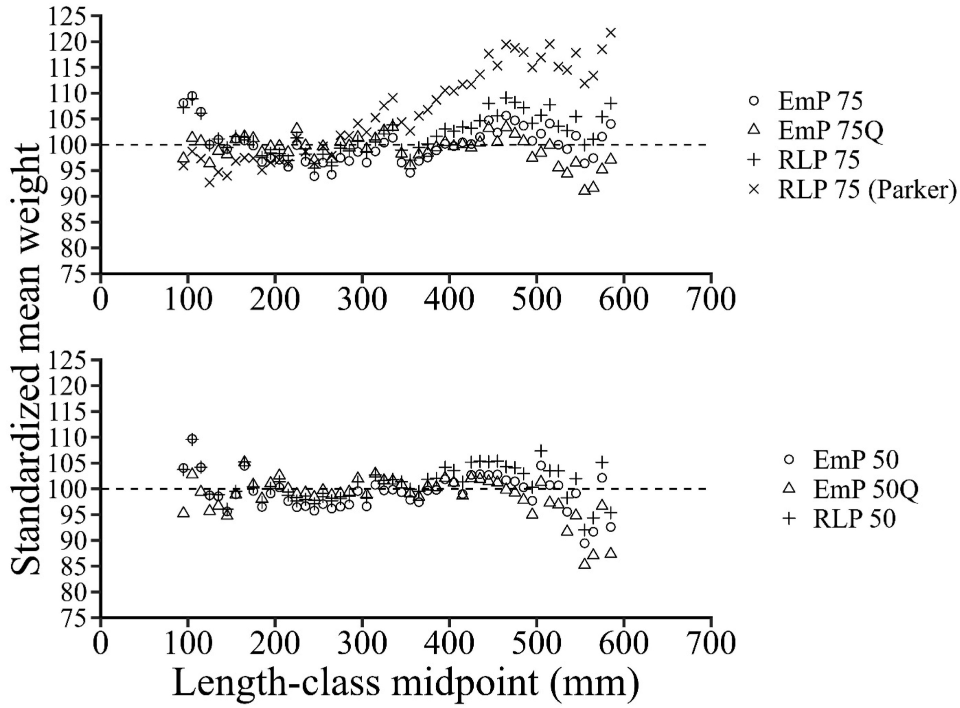

Figure 5. Distribution of observed quantile mean weight (g) by 10-mm length-class (fork length) in the Northern Pikeminnow validation data standardized by estimated standard weight based on equations generated for the 75th percentile (top panel) and 50th percentile (bottom panel) using the linear empirical percentile (EmP), quadratic empirical percentile (EmP-Q), and regression line percentile (RLP) methods. RLP 75 (Parker) denotes the 75th-percentile standardized mean weights that were generated using the previous standard weight equation for Northern Pikeminnow (Parker et al., 1995).

RESULTS AND DISCUSSION

The IGFA all-tackle world-record Northern Pikeminnow was 629 mm FL. Based on this length, the proposed minimum FLs are 17 cm (7 inches) for stock length, 26 cm (10 inches) for quality length, 35 cm (14 inches) for preferred length, 41 cm (16 inches) for memorable length, and 51 cm (20 inches) for trophy length. The proportional size distribution indices all varied widely among the populations in our data set (see online Supplementary Material, Table S1), indicating that the proposed minimum FLs were suitable for length structure comparisons.

The final data set used to develop and validate W_s equations included 100,663 Northern Pikeminnow sampled from 114 populations in Idaho, Montana, Oregon, Washington, and British Columbia between 1947 and 2024 (Figure 1). The developmental data set contained 62,294 individuals sampled from 84 populations between 1948 and 2024, and the validation data set contained 38,369 individuals sampled from 57 populations between 1947 and 2024 (Table S2). Significant differences in mean population-level b ($t = -0.84$, $P = 0.40$, df = 139) and $\log_{10}(a)$ ($t = 0.83$, $P = 0.40$, df = 139) were not detected between the developmental and validation data sets. The bootstrap simulation indicated that a minimum of 16 populations was needed to develop a robust W_s equation for Northern Pikeminnow (Figure 3). The minimum FL for our W_s equations was 90 mm based on variance-to-mean ratios (i.e., variance/mean FL < 0.01; Figure 3), and the maximum FL was 600 mm based on low sample size in the developmental data set (i.e., less than three populations; Table 1). Consequently, Northern Pikeminnow 90–600 mm FL were used to develop the W_s equations. However, the final W_s equation was only applicable to 90–580-mm fish due to the absence of individuals >580 mm in the validation data set.

The Willis test detected significant length-related biases in both the Parker et al. (1995) RLP W_{s75} equation and our RLP W_{s75} equation. The EmpQ test detected significant length-related biases in our RLP W_{s75}, EmP W_{s75}, EmP W_{s75Q}, RLP W_{s50}, and EmP W_{s50Q} equations (Table 2). The only W_s equation that did not exhibit a statistically significant length-related bias according to the Willis and EmpQ tests ($\alpha = 0.05$) was our Emp W_{s50} equation. Although our Emp W_{s50} equation exhibited minimal length-related bias, it tended to exhibit positive residuals and slightly underpredict W_r for the smallest length-classes (i.e., 90–130 mm; Figures 4 and 5). The residuals of all the other W_s equations also exhibited this pattern, indicating that it could reflect a true ontogenetic shift in morphology or resource allocation (Parker et al., 1995; Poe et al., 1991).

The results of our W_s analysis highlight the inadequacies of the previous equation published by Parker et al. (1995) and the importance of taking the time to develop robust W_s equations. By analyzing data from over 100 populations across the distribution of Northern Pikeminnow (spanning >14° latitude) rather than a restricted geographic area, we found that the data set presumably used by Parker et al. (1995) contained an inadequate number of populations ($n = 10$) to develop a W_s equation representative of the species (a minimum of 16 based on our analysis; Brown & Murphy, 1996; Neumann et al., 2012). We also found that the previous RLP

W_{s75} equation published by Parker et al. (1995) exhibited the greatest length-related biases of all the equations examined in our study. In contrast, we were able to use a newer approach (EmP; Gerow et al., 2005) to develop and validate an equation with minimal bias. We were also able to validate our equation for much smaller length-classes than Parker et al. (1995; 90 mm rather than a presumed minimum of 250 mm; Blackwell et al., 2000; Neumann et al., 2012), a limitation that previously prevented the use of W_s for investigations involving small-bodied Northern Pikeminnow (e.g., Marciniak, 2024). Lastly, our analysis provides full transparency regarding the statistical methods, performance, and limitations of our W_s equation, important details that were not available for the previous equation.

Relative weight is one tool among many that can be used to analyze patterns in fish length and weight. In particular, quantile regression is a flexible approach that allows multiple response curves to be fit to different quantiles of a length–weight relationship and allows curves to be compared in a single statistical framework (Cade et al., 2008, 2011; Ranney, 2018). Although often framed as an alternative to W_r (e.g., Cade & Gilham, 2024; Cade et al., 2008; Ranney, 2018), the interpretation of quantile regression results are typically anchored to individual groups of fish rather than the species as a whole (as with W_r; Blackwell et al., 2000; Neumann et al., 2012), and both approaches (i.e., W_r and quantile regression) may yield similar inferences when applied to the same data (e.g., Cade et al., 2011). Several remaining uncertainties also currently prevent quantile regression from being used to develop W_s equations. Specifically, the minimum sample size and minimum number of populations needed for a reference data set have not been resolved (Ranney, 2018), and the approach to defining minimum and maximum fish lengths remains unclear. Quantile regression is relatively new to the toolbox of fisheries science and may prove useful to fisheries professionals analyzing length and weight data. In the meantime, W_r remains the most widely used method for jointly summarizing length–weight data for fish, which demands that W_s equations are developed rigorously and transparently.

The Northern Pikeminnow is a native cyprinid that holds a prominent place in the management of fishes across northwestern North America. Considerable resources are dedicated to managing Northern Pikeminnow populations in the Pacific Northwest, suggesting that there is considerable opportunity to study how these populations function and respond to management actions. We hope that the revised W_s equation, length categories, and length conversion presented here will help facilitate future research and management of this prominent native piscivore.

SUPPLEMENTARY MATERIAL

Supplementary Material is available at *North American Journal of Fisheries Management* online.

DATA AVAILABILITY

The data used in this study are available from the corresponding author upon request.

ETHICS STATEMENT

All fish used in this study were handled following the protocols of the various states and provinces from which they were sampled.

FUNDING

Funding for this research was provided by the Idaho Cooperative Fish and Wildlife Research Unit.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest for this study.

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