

# Estimates of Wenatchee Steelhead Redds in 2018

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February 11, 2020

## Abstract

This report contains estimates of total steelhead redds in the Wenatchee, after accounting for observer bias.

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Table 1: Net error model covariates and coefficients.

Covariate	Estimate	Std. Error
(Intercept)	0.682	0.039
Obs. Redd Density	0.277	0.053
Mean Thalweg CV	-0.169	0.043
Mean Discharge	0.116	0.048
Log Surveyor Exp.	0.115	0.042

## 1 Introduction

Redd counts are an established method to provide an index of adult spawners (Gallagher et al. 2007). In the Wenatchee subbasin, index reaches are surveyed weekly during the steelhead spawning season (Mar 12, 2018 - Jun 11, 2018) and non-index reaches are surveyed once during the peak spawning period. The goal of this work is to:

1. Predict observer net error, using the model described in Murdoch et al. (2018).
2. Use estimates of observer net error rates and the mean survey interval to estimate the number of redds in each index reach, using a Gaussian area under the curve (GAUC) technique described in Millar et al. (2012) and Murdoch et al. (2018).
3. Estimate the total number of redds in the non-index reaches by adjusting the observed counts with the estimated net error where possible.
4. Sum the total number of estimated redds for the entire Wenatchee subbasin.

## 2 Methods

### 2.1 Net Error Model

The net error ( $NE$ ) for a reach  $i$  is defined as

$$NE_i = \frac{F_i}{V_i}$$

where  $F_i$  is the number of redds the surveyor reported and  $V_i$  is the true number of redds in the reach. Therefore, if we have an estimate of net error ( $\hat{NE}_i$ ), we can calculate the true number of redds based on that estimate and the number of redds the surveyor reported:

$$V_i = \frac{F_i}{\hat{NE}_i} \quad (1)$$

The model for observer net error is fully described in Murdoch et al. (2018). It uses covariates of the log of observer experience, mean discharge, the observed redd density and mean thalweg CV as a proxy for channel complexity. After normalizing these covariates, the model coefficients are shown in Table 1. The response, net error, is scaled such that estimates of net error less than 1 suggest more errors of omission, while estimates greater than 1 suggest more errors of commission. An estimate of net error equal to one would indicate the observed count equals the true number of redds.

### 2.2 Data

Redd counts were conducted on a nearly weekly basis for index reaches, and once during the peak spawning period for non-index reaches. The covariates in the observer error model of Murdoch et al. (2018) were

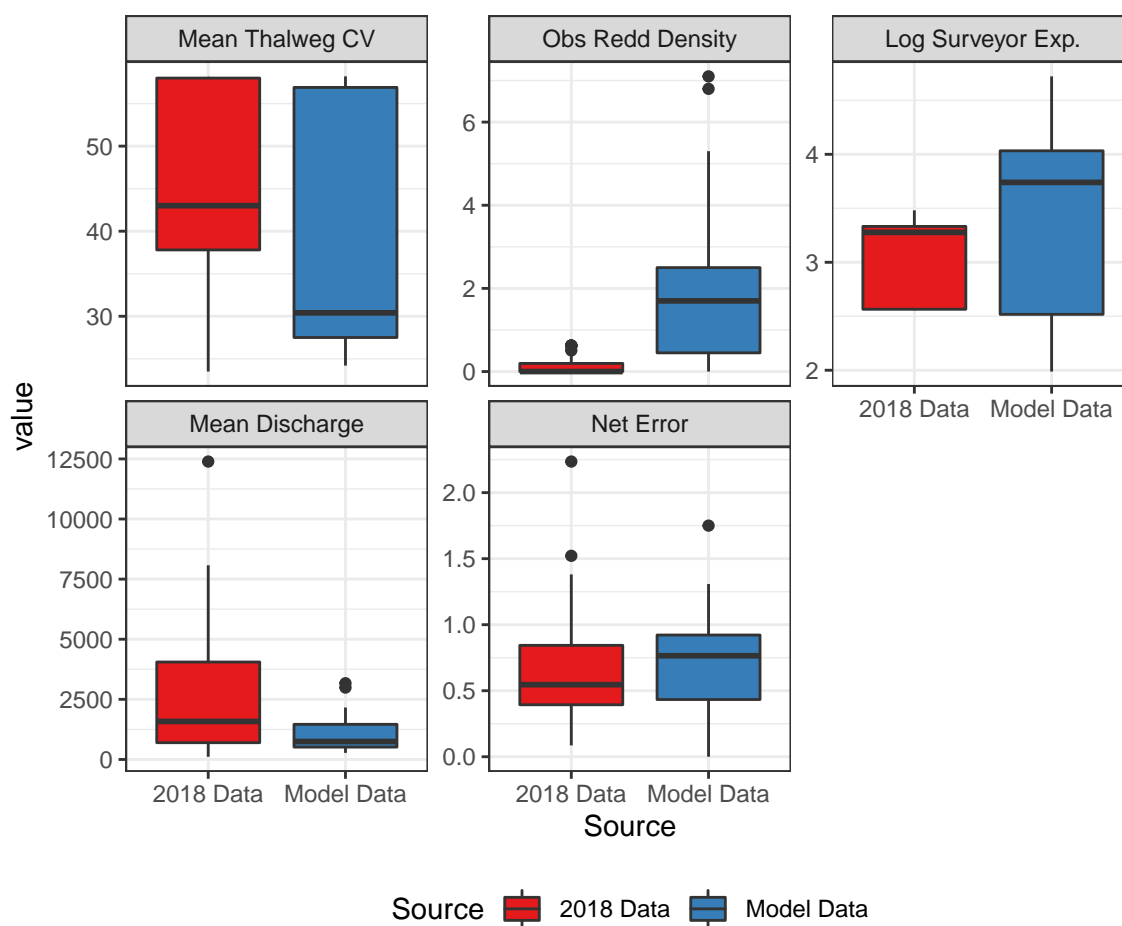


Figure 1: Net error covariate values from the original study the predicted reaches in this report.

collected during each survey. They were compared with the covariates contained in the model data set, as well as the estimates of net error (Figure 1).

Those covariates in the observer error model were collected during each survey in 2018, and predictions of net error were made for each survey. From these survey specific estimates of net error, a mean and standard error of net error was calculated for each reach. The standard deviation was calculated by taking the square root of the sum of the squared standard errors for all predictions within a reach.

## 2.3 Estimating Redds

Use of the GAUC methodology was limited to index reaches with a minimum of two reds and at least three weeks with at least one new redd found. For those reaches, we used the method described in Millar et al. (2012) and Murdoch et al. (2018). The GAUC model was developed with spawner counts in mind. As it is usually infeasible to mark every individual spawner, only total spawner counts can be used, and an estimate of average stream life must be utilized to translate total spawner days to total unique spawners. However, in adapting this for redd surveys, we note that individual reds can be marked, and therefore the GAUC model can be fit to new reds only. The equivalent of stream life thus the difference between survey numbers which can be fixed at 1.

For non-index reaches, which were surveyed only once during peak spawning, the estimate of total reds was calculated by dividing the observed reds by the estimate of net error associated with that survey (Eq. (1)). This assumes that no reds were washed out before the non-index survey, and that no new reds appeared after that survey. As the number of reds observed in the non-index reaches ranged from 0 to 0, any violation of this assumption should not affect the overall estimates very much. Any index reaches that did not meet the thresholds described above were treated as non-index reaches, and the total observed reds in those reaches were divided by the mean estimate of net error for each reach.

When summing reach-scale estimates to obtain estimates at the stream scale, an attempt was made to incorporate the fact that the reaches within a stream are not independent. Estimates of correlation between the reaches within a stream were made based on weekly observed reds. This method may not be perfect, since spawners could use certain reaches preferentially at different times in the season, but it may be the best we can do. Because correlations are often quite high between reaches, this is a better alternative than to naively assume the standard errors between reaches are independent of one another. These correlation estimates were combined with estimates of standard error at the reach scale to calculate a covariance matrix for the reaches within each stream, which was used when summing estimates of total reds to estimate the standard error at the stream scale. Failure to incorporate the correlations between reaches would result in an underestimate of standard error at the stream scales. Different streams (and therefore reaches in different streams) were assumed to be independent.

Table 2: Estimates of mean net error and redds for each reach.

River	Reach	Type	Net Error	Net Error CV	Observed Redds	Estimated Redds	Std. Err. Redds	Redds CV
Chiwawa	C1	Index	1	0	0	0	0	-
Nason	N1	Index	1	0	0	0	0	-
Peshastin	P1	Index	1	0	1	1	0	0
Wenatchee	W1	Non-Index	1	0	0	0	0	-
Wenatchee	W2	Non-Index	1	0	0	0	0	-
Wenatchee	W2	Index	0.736	0.238	0	0	0	-
Wenatchee	W3	Non-Index	1	0	0	0	0	-
Wenatchee	W4	Non-Index	1	0	0	0	0	-
Wenatchee	W5	Non-Index	1	0	0	0	0	-
Wenatchee	W6	Non-Index	0.925	0.223	0	0	0	-
Wenatchee	W6	Index	0.784	0.232	2	3	0.6	0.197
Wenatchee	W8	Index	0.484	0.301	1	2	0.6	0.31
Wenatchee	W9	Non-Index	1.055	0.225	0	0	0	-
Wenatchee	W9	Index	0.779	0.2	8	10	4.5	0.454
Wenatchee	W10	Non-Index	0.558	0.301	0	0	0	-
Wenatchee	W10	Index	0.472	0.357	16	34	15.3	0.449

Table 3: Estimate of redds for each stream

River	Index	# Reaches	Observed Redds	Estimated Redds	Std. Err. Redds	Redds CV
Chiwawa	Y	1	0	0	0	-
Nason	Y	1	0	0	0	-
Peshastin	Y	1	1	1	0	0
Wenatchee	N	8	0	0	0	-
Wenatchee	Y	5	27	49	13.2	0.27
<b>Total</b>	<b>-</b>	<b>16</b>	<b>28</b>	<b>50</b>	<b>13.2</b>	<b>0.265</b>

## 3 Results

### 3.1 Redd estimates

The estimated net error, observed redds and estimates of redds at the reach scale are shown in Table 2. Plots of the new redds and the GAUC fit to those data are shown in Figure 2. The results are summarized at the stream and population scale in Table 3.

## 4 Discussion

Most of the covariates collected in 2018 were within the range of those in the model data set from Murdoch et al. (2018), leading to estimates of net error in a very similar range to the model dataset (Figure 1). However, most reaches did not meet the minimum thresholds of number of observed redds or number of weeks with at least one new redd observed, so we used the GAUC method in only two reaches.

## 5 Acknowledgements

The data for this report was collected by Washington Department of Fish and Wildlife. Development of the observer error model was done in collaboration with Andrew Murdoch, WDFW.

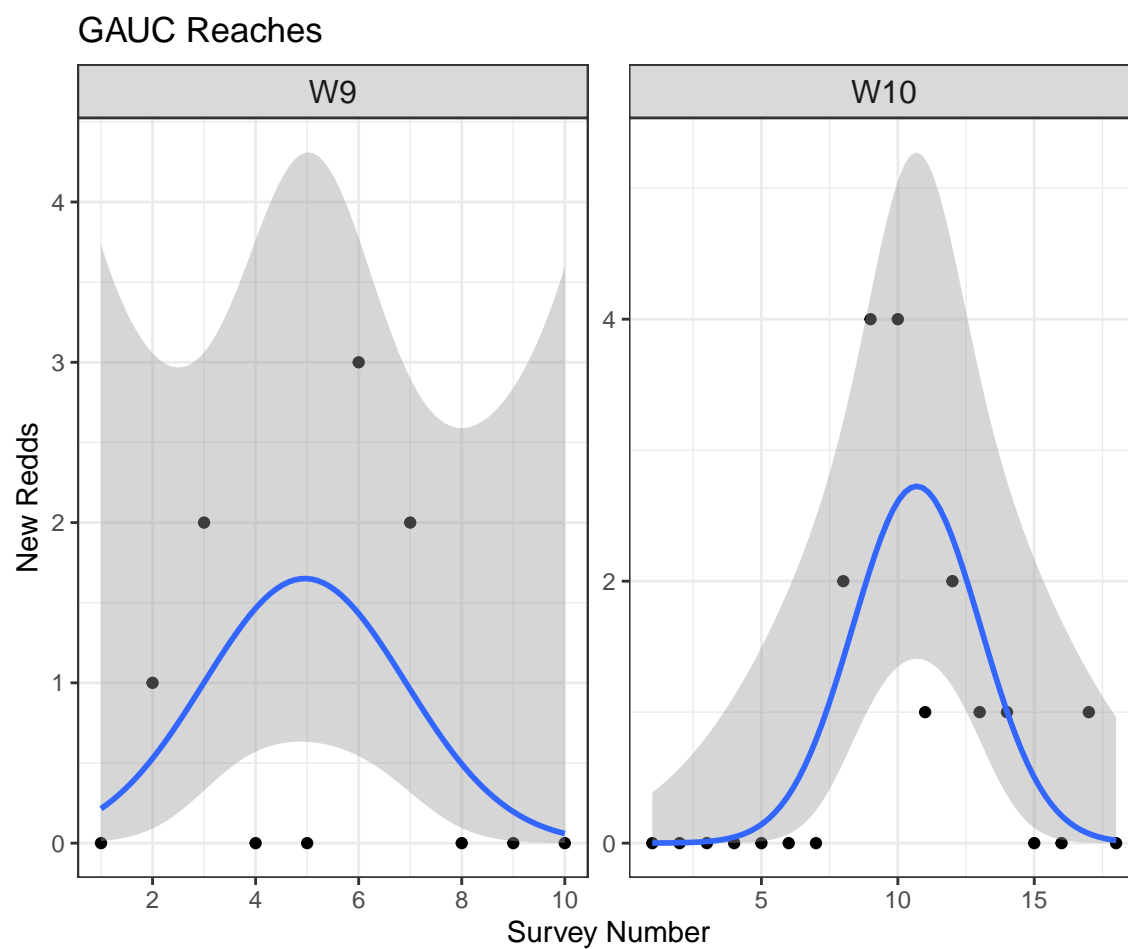


Figure 2: Plots of observed redd counts (black dots) through time for each qualifying index reach, and the fitted curve from the GAUC model (blue line) with associated uncertainty (gray).

## 6 References

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