Estimates of Methow Steelhead Redds and Spawners

Spawn Year 2022

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Abstract

This report contains estimates of total steelhead redds in the Methow, after accounting for observer error. It also includes estimates of spawners, as well as prespawn mortality.

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1 Introduction

Redd counts are an established method to provide an index of adult spawners (Gallagher et al. 2007). In the Methow subbasin, index reaches are surveyed weekly during the steelhead spawning season (Mar 09, 2022 - May 11, 2022) 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 Methow subbasin.
5. Translate the estimated number of redds into estimates of spawners, by origin.

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:

$$V_i = \frac{F_i}{\hat{NE_i}} \tag{1}$$

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.

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

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 collected during each survey. The covariate of mean thalweg CV was calculated based on all measurements taken within a reach across years (assuming this covariate does not vary through time within a reach). They were compared with the covariates contained in the model data set, as well as the estimates of net error (Figure 1).

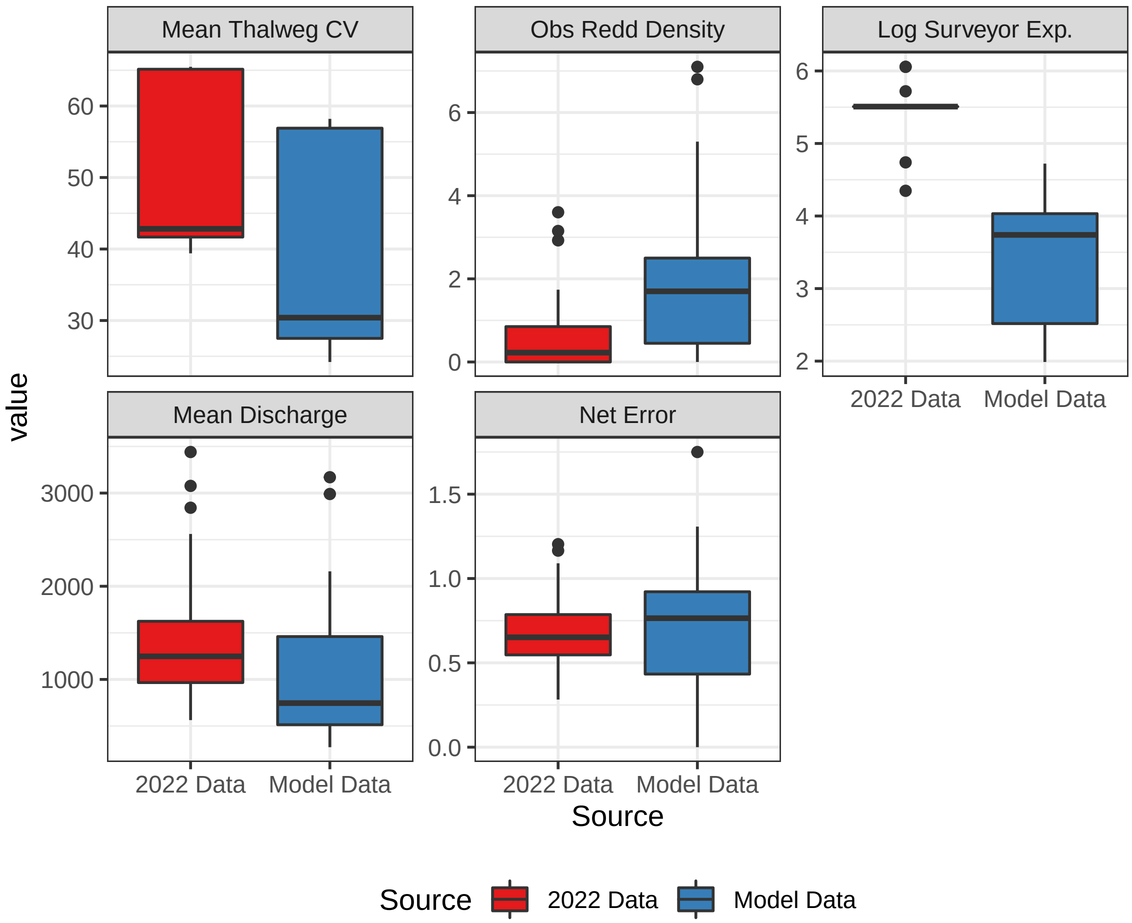

Figure 1: Net error covariate values from the original study the predicted reaches in this report.

Those covariates in the observer error model were collected during each survey in 2022, 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 redds 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 redds can be marked, and therefore the GAUC model can be fit to new redds only. The equivalent of stream life thus the difference between survey numbers which can be fixed at 1. We applied the average net error from all the surveys when redds were visible, so as to not bias the estimate from early weeks when no redds were found, and the observed redd density was zero.

For non-index reaches, which were surveyed only once during peak spawning, the estimate of total redds was calculated by dividing the observed redds by the estimate of net error associated with that survey (Eq. (1)). This assumes that no redds were washed out before the non-index survey, and that no new redds appeared after that survey. As the number of redds observed in the non-index reaches ranged from 8 to 24, 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 redds 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 redds. 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 redds 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.

2.4 Estimating Spawners

Estimates of escapement to various tributaries in the Methow were made using a Dam Adult Branch Occupancy Model (DABOM) (Waterhouse et al. 2020) based on PIT tag detections of fish tagged at Priest Rapids dam. All fish that escaped to the various tributaries were assumed to be spawners (i.e. prespawn mortality only occurs in the mainstem).

To convert estimates of redds in mainstem areas into estimates of natural and hatchery spawners, the estimates of redds were multiplied by a fish per redd (FpR) estimate and then by the proportion of hatchery or wild fish. The fish per redd estimate was based on PIT tags from the branching patch-occupancy model observed to move into the lower mainstem Methow, but not into tributaries (between PTAGIS sites LMR and MRW). FpR was calculated as the ratio of male to female fish, plus 1. Reaches MRW1 - MRW8 are all in the lower mainstem Methow below Winthrop. Similarly, the proportion of hatchery and natural origin fish was calculated from the same group of PIT tags for areas in the mainstem, and the various tributaries.

2.5 Prespawn Mortality

After translating estimates of redds to estimates of spawners by origin, we can then compare the spawner estimates to escapement estimates made using PIT tags, and estimate a prespawn mortality rate. Taking the total PIT-tag based escapement estimate, by origin, to the Methow, we then subtract any fish removed for broodstock or surplus, as well as any deaths due to harvest (Table 2), and then subtract the total estimate of spawners, including the tributaries, to provide an estimate of how many fish succumbed to prespawn mortality. Dividing that number by the total escapement estimate provides an estimate of the prespawn mortality rate, by origin, across the entire Methow population.

If either origin had a higher estimates of spawners compared to escapement, we fixed our prespawn mortality estimate at 0, reflecting a very low level of prespawn mortality. There is uncertainty in both the escapement and spawner estimates, which could explain why these types of scenarios could arise.

Table 2: Known number of fish removed at for surplus or broodstock, or due to harvest, by origin.

Source	Hatchery	Natural
Methow mainstem	163	95
DCPUD to Wells	5	0
Twisp weir	12	10
WNFH hatchery trap	0	0

Table 3: 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
Methow	MRW1	Non-Index	0.53	0.201	8	15	3	0.202
Methow	MRW2	Index	0.461	0.377	19	46	26	0.565
Methow	MRW3	Non-Index	0.86	0.133	24	28	3.7	0.133
Methow	MRW4	Index	0.943	0.122	20	21	4.6	0.219
Methow	MRW5	Non-Index	0.788	0.154	9	11	1.8	0.16
Methow	MRW6	Index	0.81	0.166	8	10	2.9	0.29
Methow	MRW7	Non-Index	0.691	0.253	17	25	6.2	0.249
Methow	MRW8	Index	0.674	0.2	4	6	3.2	0.525

3 Results

3.1 Redd estimates

The estimated net error, observed redds and estimates of redds at the reach scale are shown in Table 3. Plots of the new redds and the GAUC fit to those data are shown in Figure 2. The results are summarized by major areas and population scale in Table 4.

3.2 Spawner Estimates

Demographic data about sex and origin were derived from the PIT tags detected within each area (Table 5.

Parameter estimates for fish / redd and proportion hatchery based on this PIT tag data are shown in Table 6.

Table 7 shows estimates of spawners by origin within each reach of the lower Methow. Combining those adjusted redd-based estimates of spawners with PIT tag-based estimates of spawners in the tributaries, Table 8 shows a summary of spawners by origin across various areas including the lower Methow mainstem and each tributary, as well as the population as a whole.

3.3 Prespawn Mortality

The estimates of overall prespawn mortality within the Methow population, by origin, are shown in Table 9.

Table 4: Estimate of redds in lower mainstem Methow, and any tributaries surveyed.

River	Location	Type	# Reaches	Observed Redds	Estimated Redds	Std. Err. Redds	Redds CV
Methow	Lower Methow	Index	4	51	83	26.8	0.322
Methow	Lower Methow	Non-Index	4	58	79	8.1	0.102
Total	**-**	**-**	**8**	**109**	**162**	**27.9**	**0.172**

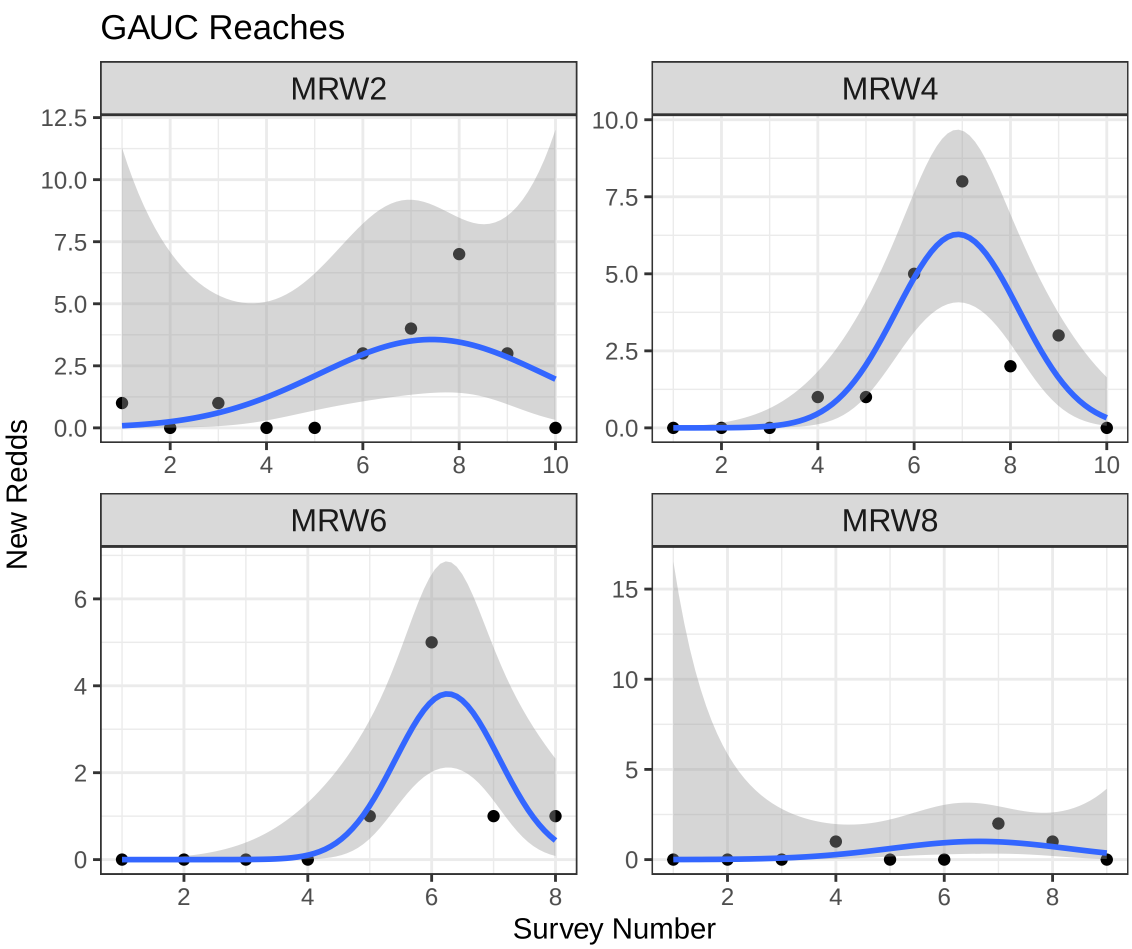

Figure 2: Plots of observed redd counts (black dots) through time for each qualifying index reach, and the fitted curve from the GAUC model (blue line) with associated uncertainty (gray).

Table 5: Number of PIT tags detected in each area by sex and origin.

Location	Sex	Natural	HOR-SN	HOR-C
Lower Methow	F	27	38	9
Lower Methow	M	4	10	2
Upper Methow	F	3	1	0
Upper Methow	M	1	0	0
Chewuch	F	8	3	1
Chewuch	M	1	1	0
Twisp	F	10	6	3
Twisp	M	1	0	2
Spring Creek	F	1	9	6
Spring Creek	M	0	5	1
Beaver	F	2	3	1
Beaver	M	0	0	0
Gold	F	2	4	0
Gold	M	0	2	0
Libby	F	0	2	0
Libby	M	0	0	0

Table 6: Fish per redd and hatchery / natural origin proportion estimates.

Location	Fish / redd	FpR Std. Error	Prop. Hatchery	Prop Std. Error
Lower Methow	1.216	0.06	0.656	0.05

Table 7: Estimates (CV) of spawners in lower Methow by reach and origin.

Location	Reach	Type	Total Spawners	Natural	HOR-SN	HOR-C
Lower Methow	MRW1	Non-Index	18 (0.21)	6 (0.25)	10 (0.23)	2 (0.35)
Lower Methow	MRW2	Index	56 (0.57)	19 (0.59)	30 (0.58)	7 (0.63)
Lower Methow	MRW3	Non-Index	34 (0.14)	12 (0.2)	18 (0.17)	4 (0.32)
Lower Methow	MRW4	Index	26 (0.22)	9 (0.27)	14 (0.24)	3 (0.36)
Lower Methow	MRW5	Non-Index	14 (0.17)	5 (0.22)	7 (0.19)	2 (0.33)
Lower Methow	MRW6	Index	11 (0.29)	4 (0.33)	6 (0.31)	1 (0.41)
Lower Methow	MRW7	Non-Index	30 (0.25)	10 (0.29)	16 (0.27)	4 (0.38)
Lower Methow	MRW8	Index	8 (0.53)	3 (0.55)	4 (0.54)	1 (0.6)
Lower Methow	**Total**	**-**	**197 (0.17)**	**68 (0.18)**	**105 (0.18)**	**24 (0.21)**

Table 8: Estimates (CV) of spawners by area and origin.

Location	Total Spawners	Natural	HOR-SN	HOR-C
Lower Methow	197 (0.17)	68 (0.18)	105 (0.18)	24 (0.21)
Beaver	59 (0.1)	20 (0.67)	29 (0.57)	10 (0.99)
Chewuch	122 (0.06)	74 (0.34)	38 (0.48)	10 (0.99)
Gold	82 (0.08)	23 (0.64)	59 (0.39)	0 (-)
Libby	26 (0.17)	0 (-)	26 (0.73)	0 (-)
Upper Methow	57 (0.11)	41 (0.59)	16 (1)	0 (-)
Spring Creek	207 (0.04)	14 (0.86)	129 (0.28)	64 (0.39)
Twisp	184 (0.04)	89 (0.3)	52 (0.4)	43 (0.44)
Total	**934 (0.04)**	**329 (0.16)**	**454 (0.14)**	**151 (0.23)**

Table 9: Methow prespawn mortality estimates. Includes estimates (standard error) of escapement, spawners, prespawn mortality, and standard error of this rate, separated by origin.

Origin	Escapement	Spawners	Prespawn Mortality	SE	CV
Natural	413 (69)	329 (52)	0.204	0.182	0.893
Hatchery	790 (89)	605 (72)	0.234	0.126	0.539

4 Discussion

Most of the covariates collected in 2022 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).

Natural origin steelhead PIT-tagged at Priest Rapids dam were not detected in Libby Creek this year, nor were HOR-C fish detected in Gold, Libby or the Upper Methow, leading to estimates of zero spawners for those origins in those tributaries (Table 8). Because these estimates are based on a sample of the entire Upper Columbia steelhead run, it's possible a handful of steelhead may have spawned in those tributaries, but it's potentially more likely that the estimate of zero steelhead spawners in those areas is correct.

5 Acknowledgements

The data for this report was collected by Washington Department of Fish and Wildlife.

6 References

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