Estimates of Wenatchee Steelhead Spawners

Spawn Years 2004-2022

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Contents

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1 Goal

To compile all the steelhead redd data collected in the Wenatchee between 2004 and 2013, apply PIT tag based escapement estimates where appropriate and the single observer error model where appropriate to estimate the true number of steelhead redds and spawners in the Wenatchee each year. We've also compiled all of our work from 2014 - 2022, using the two-observer redd error model, to generate a complete time-series of our best estimates of hatchery and natural origin steelhead in the Wenatchee.

2 Methods

Various methods were applied depending on the year and reach. For most reaches and years, redd counts were adjusted based on the one-observer redd count error model developed in Murdoch et al. (2018). Some reaches were part of that study, and the census observer counts from that study were assumed to be the true number of redds. For the later years, within the tributaries, we applied the PIT tag-based escapement estimates described in Waterhouse et al. (2020). For a few tributaries with no redd surveys, an expansion factor was developed based on the proportion of fish estimated to spawn in those tributaries compared to the overall number of spawners in the Wenatchee (Table 1).

2.1 Redd Surveys

Redd surveys were divided into three different types of reaches: index reaches, non-index reaches, and no-error reaches (Table 2). For index reaches, we compiled the necessary covariates to run the one-observer redd net error model described in Murdoch et al. (2018). Any reach designated to use redd data that contained no data for a particular year was assumed to have zero redds for that year.

2.1.1 Index Reaches

To apply the redd observer error model to all index reaches, we needed to compile the necessary covariates for that model. These included depth, the mean CV of the thalweg, and the redd density (number of features visible per kilometer of stream). Depth was calculated from a relationship derived from flow gauges. This often resulted in the same depth being applied to all reaches within a particular stream (but not always). The mean CV of the thalweg was assumed to be constant through time. However, measurements for this metric had been conducted in the current P3 and P4 reaches, which make up the historic P3 (P2) reach, so the mean of the thalweg CVs across P3 and P4 was applied to P3 (P2).

For the redd density (redds / km), first the reach length needed to be compiled. Within the Peshastin, stretches where no surveys were conducted were dropped, and the index areas of the current P3 and P4 were combined into the historic P3 (P2) reach, while the non-index areas of the current P3 and P4 were combined into the historic non-index P4. To calculate the number of visible redds, we needed to estimate this based on the number of new redds counted during each survey, as only new redds were recorded in older data. To do so, we calculated average redd life, by stream and reach group, and applied that redd life to each new redd observed. This allowed us to estimate how many redds were visible during any given survey.

Redd life was collected in 5 streams. Only redds which were observed to disappear were included in this dataset (i.e. known redd life). For the non-mainstem tributaries, we calculated the mean and standard deviation of redd life. For the mainstem Wenatchee, we initially divided it into three different reach groups based on geomorphology: reaches W1-W5, W6-W9 and W10. Figure 1 shows the distribution of redd life by reach and reach group. However, there was no discernible difference in redd life between W10 and W6-W9, so those groups were lumped together. Table 3 shows the mean and standard deviation of redd life within each reach group.

Once the redds visible for each survey were compiled or estimated, the other covariates for the one-observer error model were attached to the dataset, and the net error of each survey was predicted (with uncertainty).

We did a quick comparison of how the predicted net error of this historic data compared to the observed net error calculated within the Murdoch et al. (2018) dataset (Figure 2). There were a few reaches with a net error below the range of values in Murdoch et al. (2018).

We also compared the covariates for this historic dataset against those observed in the Murdoch et al. (2018) study. The coefficients of the one-observer net error model are shown in Table 4. Figure 3 shows how the historic covariates compare those observed in the model dataset.

We used the Gaussian Area-Under-the-Curve (GAUC) method described in Murdoch et al. (2018) to estimate the number of redds using the number of new redds observed each survey, the mean of the estimated net

Table 1: Methods employed to calculate spawners within each reach, each year.

River	Reach	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Chiwaukum	U1	Expansion	Expansion	Expansion	Expansion	Expansion	Expansion	Expansion	PIT	PIT	PIT
Chiwawa	C1	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Chiwawa	C2	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Chumstick	-	Expansion	Expansion	Expansion	Expansion	Expansion	Expansion	Expansion	PIT	PIT	PIT
Icicle	I1	Redd	Redd	Redd	Redd	Redd	Redd	Truth	Truth	PIT	PIT
Little Wenatchee	L2	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Little Wenatchee	L3	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Mission	-	Expansion	Expansion	Expansion	Expansion	Expansion	Expansion	Expansion	Expansion	PIT	PIT
Nason	N1	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Nason	N2	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Nason	N3	Redd	Redd	Redd	Redd	Redd	Redd	Truth	PIT	PIT	PIT
Nason	N4	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Peshastin	P1	Redd	Redd	Redd	Redd	Redd	Redd	Truth	PIT	PIT	PIT
Peshastin	P3 (P2)	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Peshastin	P4	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
Wenatchee	W1	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd
Wenatchee	W10	Redd	Redd	Redd	Redd	Redd	Redd	Truth	Truth	Redd	Redd
Wenatchee	W2	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd
Wenatchee	W3	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd
Wenatchee	W4	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd
Wenatchee	W5	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd
Wenatchee	W6	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd
Wenatchee	W7	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd
Wenatchee	W8	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd	Redd
Wenatchee	W9	Redd	Redd	Redd	Redd	Redd	Redd	Truth	Truth	Truth	Redd
White River	H2	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT
White River	H3	Redd	Redd	Redd	Redd	Redd	Redd	Redd	PIT	PIT	PIT

Table 2: Number of reaches by type, and the percent of all reaches made up of that type.

Type	n	Percent
Index	101	47.0%
Non-Index	61	28.4%
No Error	53	24.7%

Table 3: Redd life mean and standard deviation by reach group.

Reach Group	Mean	SD
Chiwawa	25.9	13.6
Icicle	20.0	9.0
Nason	25.1	9.2
Peshastin	19.3	10.3
W1-W5	26.8	11.9
W6-W10	29.2	13.6

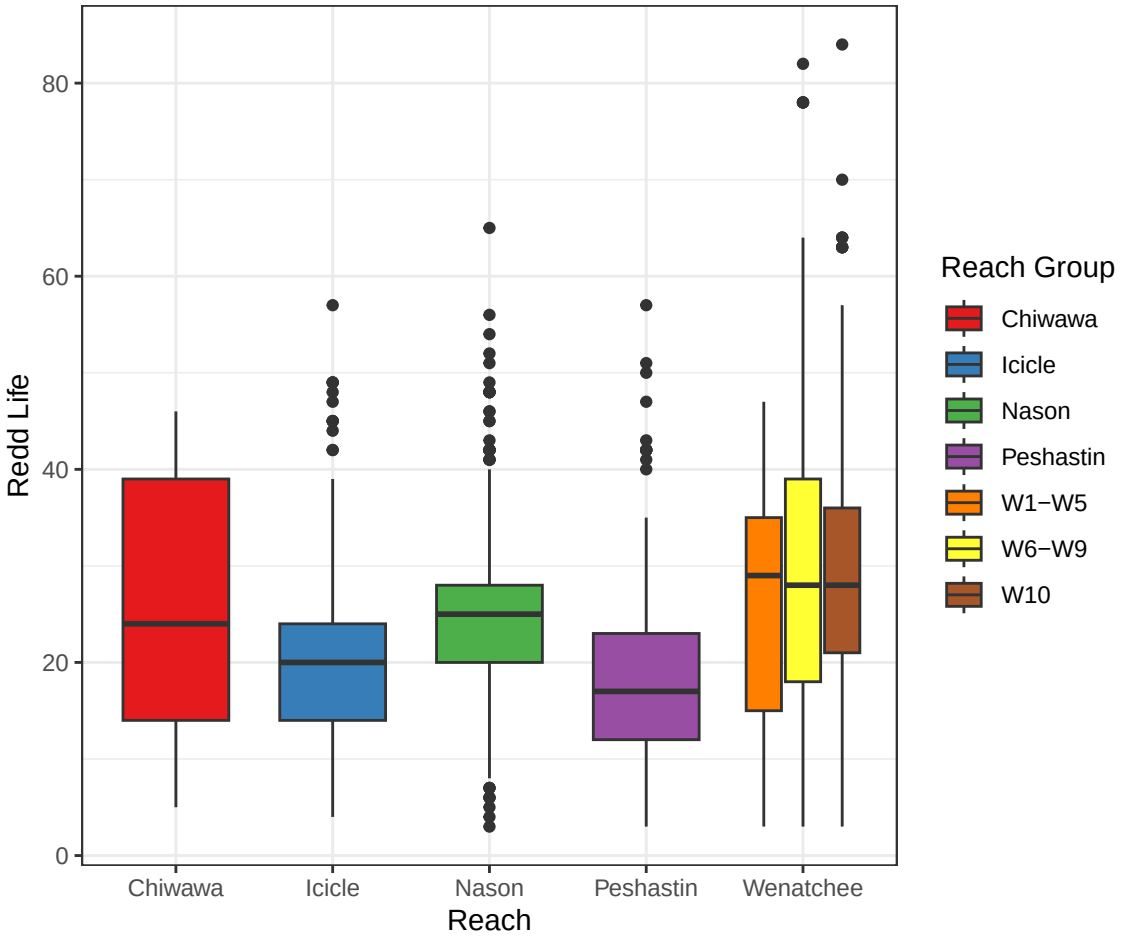

Figure 1: Boxplots of observed redd life by reach, colored by initial reach grouping.

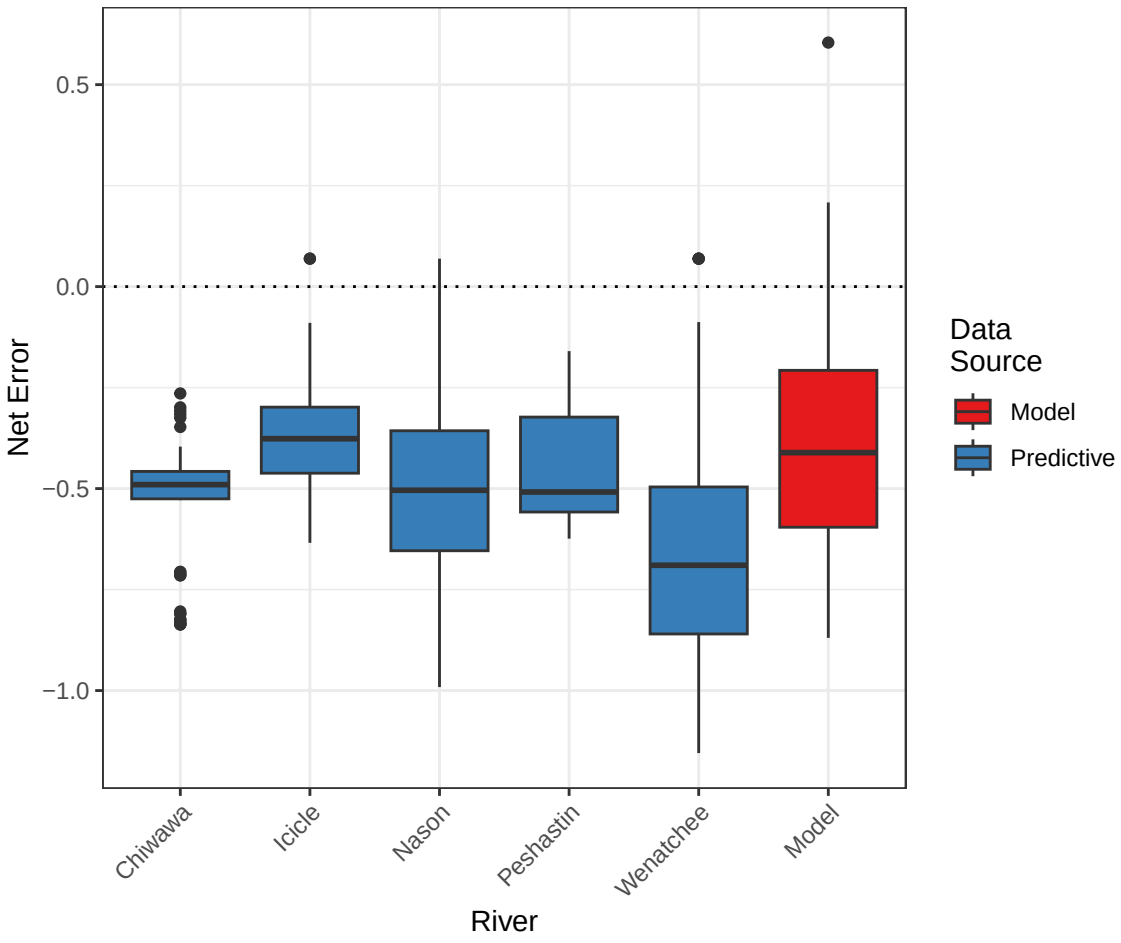

Figure 2: Boxplots of estimated net error, by river, compared with the net errors observed in the redd observer error model.

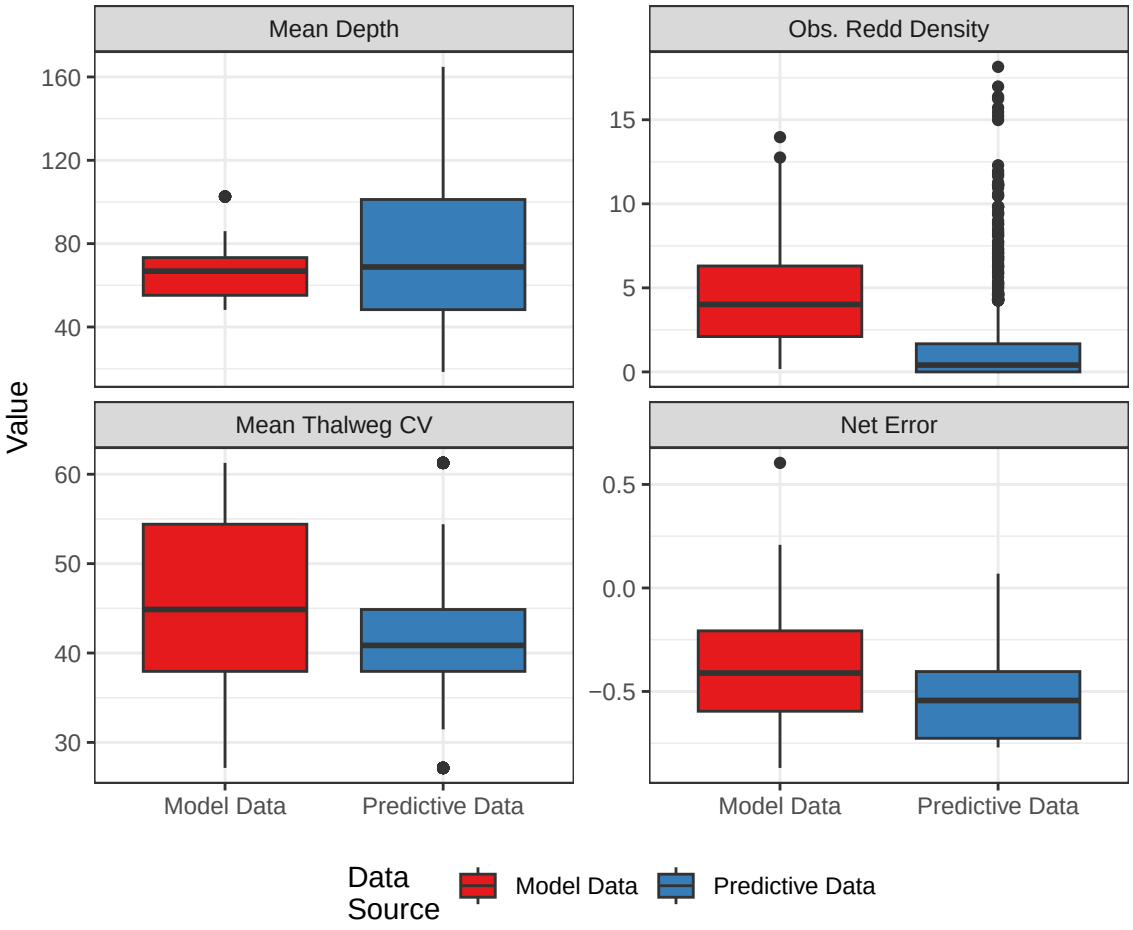

Figure 3: Boxplots showing distribution of covariates and estimated net error between the model data from Murdoch et al. (2018) in red and the predictive data used in this analysis in blue.

Table 4: Net error one-observer model covariates and coefficients.

Term	Estimate	Std Error
(Intercept)	-0.382	0.023
Obs. Redd Density	0.146	0.026
Mean Depth	-0.094	0.023
Mean Thalweg CV	-0.005	0.026

error for that reach and the mean of the estimated net error standard error for that reach. If a reach failed to contain a minimum number of observed redds (2), or a minimum number of non-zero surveys (3), or the GAUC model failed to converge, then the number of redds was estimated by dividing the total number of observed redds by the mean estimated net error.

In addition, if the estimated net error was below a threshold of -0.77, we borrowed the net error estimate from the closest upstream index reach, as the initial estimate was deemed inappropriate. That threshold was defined by the 5th quantile of observed net error in the Murdoch et al. (2018) study. If the net error in the closest upstream reach was also below this threshold, we fixed the net error in the reach to be -0.77.

2.1.2 Census Reaches

Reaches that were surveyed as part of the Murdoch et al. (2018) study had census counts attached to them. Just like Murdoch et al. (2018), we assumed these census counts were accurate and without error. We summed the census counts by year, river and reach.

2.1.3 Non-Index Reaches

First we ensured that all non-index reaches had an index reach associated with them that contained data for that year. We found that the non-index reaches W5 and W6 were associated with the index reach W6, but the index W6 failed to contain data in 2004 and 2005. Therefore, we re-assigned the index reach to be W8 (the next upstream reach) for those instances.

We then assumed the single redd survey in the non-index reach occurred post peak spawning, and merely divided the number of observed redds in the non-index reach by the estimate of net error from the associated index reach. This is potentially a conservative estimate of redds, since it's possible additional redds were constructed in the non-index reaches after the surveys were conducted. However, without additional surveys in non-index reaches, this may be the most accurate method.

2.1.4 Total Redds

For all the reaches surveyed for redds each year, we can add the estimates of redds up across all reaches to estimate total redds in the Wenatchee. In calculating the standard error, 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 could result in an underestimate of standard error (i.e. uncertainty) at the stream scale. Different streams (and therefore reaches in different streams) were assumed to be independent. Because the correlation was estimated from

weekly surveys, only correlations between index reaches within a stream were calculated (non-index reaches were assumed to be independent).

2.2 Redds to Spawners

To translate estimates of redds to estimates of spawners by origin, we need data on the fish / redd to move from redds to total spawners and the proportion of hatchery origin spawners (pHOS) to split total spawners into hatchery and natural origin. The fish / redd estimate comes from the sex ratio, assuming one redd per female (Males / Females + 1). The sex ratio was determined using fish collected for broodstock from 2004-2006, fish sampled at Dryden from 2007 - 2010, and PIT tags from Priest (used in the DABOM model) detected in the Wenatchee subbasin from 2011 on. When using PIT tags, we used PIT tags detected in specific areas to generate more spatially refined fish/redd estimates (e.g. using tags detected in the lower or upper areas of the mainstem Wenatchee, and applying those estimates to the corresponding reaches).

2.3 Tributary Spawners

From 2011 onwards, we used the DABOM model to estimate tributary spawners. We assumed that every fish that escaped into a tributary was a successful spawner. Because counts at Priest Rapids dam have been questionable in recent years, we used DABOM estimates calculated based on counts at Rock Island dam for 2016, 2017, 2019 - 2022 (estimates in 2018 were very similar regardless of whether Priest or Rock Island counts were used, so we used Priest that year).

This process also allowed us to compile the redd and spawner estimates from 2014-2022, which utilized the two-observer redd observer error model from Murdoch et al. (2018) for the mainstem spawners (redd counts) and PIT-tag based estimates of escapement to all the tributaries. This includes some redds counted in tributaries downstream of the PIT tag arrays. For these, we assumed no observer error, and applied the fish/redd and pHOS estimate from that tributary based on observed PIT tags in that tributary.

2.4 Expansion

For some tributaries that never had redd surveys, but do have PIT tag arrays (Chiwaukum, Chumstick and Mission), we estimated the portion of the hatchery and natural origin spawners that were estimated in those tributaries for 2012 - 2022, excluding 2020 because our estimates of mainstem spawners in 2020 were done with a different method due to COVID preventing redd surveys from occurring. We calculated the mean proportion of spawners by tributary, across the years we had estimates for. Years when no PIT tags were detected in a particular tributaries were not included in that mean (since that may be an underestimate of the number of spawners in that tributary). The proportions were then summed across all three tributaries to estimate what proportion of the total run, by origin, that spawned in those tributaries.

We then expanded the estimates of spawners in the total Wenatchee basin for 2004-2010 by this proportion, to account for the fact that no redd surveys were conducted in those tributaries, and so any steelhead spawners there were missing from estimates in those years. We did not expand estimates for 2011-2013, except in one case, because we did have PIT tag estimates of escapement to those tributaries for those years. Because the PIT array in Mission Creek (MCL) was installed in October 2011, there were no PIT-tag based estimates of spawners in Mission for spawn year 2011 either, nor were there redd counts. For that year, we used the mean proportion of spawners estimated in Mission from 2012-2022 to expand the total estimate for the Wenatchee basin.

3 Results

3.1 Redd Estimates

Tables 5 and 6 show the estimate of total redds for every reach in every year.

Table 5: Estimates of redds (and SE) for all reaches in years 2004 - 2013. The method (Index, Non-Index or Census) and total number of observed redds is noted, as well as the mean net error (with standard error).

Year	River	Location	Reach	Method	Obs Redds	Err Est	Err SE	Redd Est	Redd SE
2004	Chiwawa	Chiwawa	Alder	No-Error	2	0.000	0.000	2	0.0
2004	Chiwawa	Chiwawa	Big Meadow	No-Error	9	0.000	0.000	9	0.0
2004	Chiwawa	Chiwawa	C1	Index	13	-0.770	0.078	57	24.5
2004	Chiwawa	Chiwawa	C2	Index	2	-0.770	0.078	9	3.0
2004	Chiwawa	Chiwawa	Chikamin	No-Error	1	0.000	0.000	1	0.0
2004	Chiwawa	Chiwawa	Clear	No-Error	38	0.000	0.000	38	0.0
2004	Icicle	Icicle	I1	Index	23	-0.539	0.049	50	20.3
2004	Nason	Nason	N1	Index	15	-0.471	0.029	42	42.1
2004	Nason	Nason	N2	Non-Index	7	-0.471	0.029	13	0.7
2004	Nason	Nason	N3	Index	32	-0.471	0.029	62	10.9
2004	Nason	Nason	N4	Index	7	-0.471	0.029	13	0.7
2004	Nason	Nason	Unnamed	No-Error	3	0.000	0.000	3	0.0
2004	Peshastin	Peshastin	P1	Index	23	-0.537	0.044	50	11.8
2004	Peshastin	Peshastin	P3 (P2)	Index	10	-0.579	0.039	29	14.8
2004	Peshastin	Peshastin	Tronson	No-Error	2	0.000	0.000	2	0.0
2004	Wenatchee	Above_TUM	Beaver	No-Error	15	0.000	0.000	15	0.0
2004	Wenatchee	Below_TUM	W2	Index	1	-0.770	0.077	4	1.5
2004	Wenatchee	Below_TUM	W3	Non-Index	1	-0.770	0.077	4	1.5
2004	Wenatchee	Below_TUM	W5	Non-Index	1	0.000	0.000	1	0.0
2004	Wenatchee	Above_TUM	W8	Index	5	-0.770	0.077	22	9.1
2004	Wenatchee	Above_TUM	W9	Index	58	-0.770	0.077	254	97.0
2004	Wenatchee	Above_TUM	W10	Index	70	-0.770	0.077	306	144.7
2005	Chiwawa	Chiwawa	Alder	No-Error	14	0.000	0.000	14	0.0
2005	Chiwawa	Chiwawa	Big Meadow	No-Error	16	0.000	0.000	16	0.0
2005	Chiwawa	Chiwawa	C1	Index	97	-0.395	0.043	161	36.8
2005	Chiwawa	Chiwawa	C2	Index	2	-0.475	0.044	4	0.3
2005	Chiwawa	Chiwawa	Chikamin	No-Error	2	0.000	0.000	2	0.0
2005	Chiwawa	Chiwawa	Clear	No-Error	12	0.000	0.000	12	0.0
2005	Icicle	Icicle	I1	Index	8	-0.408	0.071	14	4.4
2005	Nason	Nason	N1	Index	65	-0.277	0.051	93	17.7
2005	Nason	Nason	N2	Non-Index	39	-0.180	0.071	48	4.1
2005	Nason	Nason	N3	Index	151	-0.156	0.070	184	44.2
2005	Nason	Nason	N4	Index	40	-0.091	0.085	48	17.8
2005	Nason	Nason	Roaring	No-Error	2	0.000	0.000	2	0.0
2005	Peshastin	Peshastin	Mill	No-Error	1	0.000	0.000	1	0.0
2005	Peshastin	Peshastin	P1	Index	34	-0.224	0.075	44	4.2
2005	Peshastin	Peshastin	P3 (P2)	Index	50	-0.268	0.074	86	18.5
2005	Peshastin	Peshastin	Tronson	No-Error	5	0.000	0.000	5	0.0
2005	White River	White River	H2	No-Error	1	0.000	0.000	1	0.0
2005	White River	White River	H3	No-Error	1	0.000	0.000	1	0.0
2005	Wenatchee	Above_TUM	Beaver	No-Error	3	0.000	0.000	3	0.0
2005	Wenatchee	Below_TUM	W1	Non-Index	4	-0.555	0.037	9	0.7
2005	Wenatchee	Below_TUM	W2	Index	16	-0.537	0.034	35	8.1
2005	Wenatchee	Below_TUM	W3	Non-Index	12	-0.555	0.037	27	2.2
2005	Wenatchee	Below_TUM	W5	Non-Index	2	0.000	0.000	2	0.0
2005	Wenatchee	Below_TUM	W6	Non-Index	6	0.000	0.000	6	0.0
2005	Wenatchee	Above_TUM	W8	Index	38	-0.440	0.044	68	22.1
2005	Wenatchee	Above_TUM	W9	Index	182	-0.322	0.038	271	83.9
2005	Wenatchee	Above_TUM	W10	Index	163	-0.246	0.059	218	41.0
2006	Chiwawa	Chiwawa	Big Meadow	No-Error	3	0.000	0.000	3	0.0

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Table 5: Estimates of redds (and SE) for all reaches in years 2004 - 2013. The method (Index, Non-Index or Census) and total number of observed redds is noted, as well as the mean net error (with standard error). *(continued)*

Year	River	Location	Reach	Method	Obs Redds	Err Est	Err SE	Redd Est	Redd SE
2006	Chiwawa	Chiwawa	C1	Index	8	-0.510	0.042	16	2.6
2006	Chiwawa	Chiwawa	Chikamin	No-Error	1	0.000	0.000	1	0.0
2006	Chiwawa	Chiwawa	Clear	No-Error	7	0.000	0.000	7	0.0
2006	Icicle	Icicle	I1	Index	41	-0.322	0.066	61	25.1
2006	Nason	Nason	N1	Index	5	-0.559	0.039	12	4.6
2006	Nason	Nason	N2	Non-Index	2	-0.467	0.053	4	0.4
2006	Nason	Nason	N3	Index	32	-0.433	0.049	56	6.1
2006	Nason	Nason	N4	Index	7	-0.265	0.059	10	1.3
2006	Nason	Nason	Unnamed	No-Error	3	0.000	0.000	3	0.0
2006	Peshastin	Peshastin	P1	Index	20	-0.537	0.045	43	23.0
2006	Peshastin	Peshastin	P3 (P2)	Index	18	-0.604	0.040	48	17.3
2006	Wenatchee	Below_TUM	W1	Non-Index	2	-0.670	0.046	6	0.9
2006	Wenatchee	Below_TUM	W2	Index	5	-0.661	0.045	15	5.8
2006	Wenatchee	Below_TUM	W3	Non-Index	5	-0.670	0.046	15	2.1
2006	Wenatchee	Below_TUM	W5	Non-Index	1	-0.668	0.054	3	0.5
2006	Wenatchee	Below_TUM	W6	Index	7	-0.668	0.054	22	12.3
2006	Wenatchee	Above_TUM	W8	Index	12	-0.687	0.059	39	11.1
2006	Wenatchee	Above_TUM	W9	Index	43	-0.548	0.035	95	34.0
2006	Wenatchee	Above_TUM	W10	Index	79	-0.538	0.047	177	56.8
2007	Chiwawa	Chiwawa	C1	Index	3	-0.708	0.057	10	2.0
2007	Chiwawa	Chiwawa	Clear	No-Error	8	0.000	0.000	8	0.0
2007	Icicle	Icicle	I1	Index	6	-0.521	0.056	13	4.6
2007	Nason	Nason	N1	Index	10	-0.514	0.033	21	9.7
2007	Nason	Nason	N2	Non-Index	10	-0.514	0.033	21	1.4
2007	Nason	Nason	N3	Index	24	-0.514	0.033	50	8.4
2007	Nason	Nason	N4	Index	5	-0.514	0.033	10	3.8
2007	Peshastin	Peshastin	P1	Index	6	-0.525	0.044	13	2.2
2007	Peshastin	Peshastin	P3 (P2)	Index	22	-0.536	0.037	59	25.6
2007	White River	White River	H3	No-Error	1	0.000	0.000	1	0.0
2007	Wenatchee	Below_TUM	W2	Index	0	0.000	0.000	0	0.0
2007	Wenatchee	Below_TUM	W6	Index	2	-0.770	0.075	9	2.8
2007	Wenatchee	Above_TUM	W9	Index	10	-0.770	0.075	44	19.1
2007	Wenatchee	Above_TUM	W10	Index	34	-0.770	0.075	149	56.4
2008	Chiwawa	Chiwawa	C1	Index	9	-0.303	0.072	13	1.3
2008	Chiwawa	Chiwawa	Clear	No-Error	2	0.000	0.000	2	0.0
2008	Icicle	Icicle	I1	Index	34	-0.206	0.086	43	9.7
2008	Nason	Nason	N1	Index	13	-0.461	0.037	24	8.2
2008	Nason	Nason	N2	Non-Index	22	-0.427	0.059	38	4.0
2008	Nason	Nason	N3	Index	27	-0.421	0.059	51	27.8
2008	Nason	Nason	N3	Non-Index	4	-0.427	0.059	7	0.7
2008	Nason	Nason	N4	Index	14	-0.152	0.066	17	4.0
2008	Nason	Nason	N4	Non-Index	1	-0.274	0.069	1	0.1
2008	Nason	Nason	Unnamed	No-Error	1	0.000	0.000	1	0.0
2008	Peshastin	Peshastin	Mill	No-Error	1	0.000	0.000	1	0.0
2008	Peshastin	Peshastin	P1	Index	32	-0.257	0.066	43	10.5
2008	Peshastin	Peshastin	P3 (P2)	Index	16	-0.333	0.064	24	7.1
2008	Peshastin	Peshastin	P4	Non-Index	3	-0.342	0.065	5	0.5
2008	White River	White River	Napeequa	No-Error	1	0.000	0.000	1	0.0
2008	Wenatchee	Below_TUM	W1	Non-Index	1	-0.407	0.056	2	0.2
2008	Wenatchee	Below_TUM	W2	Index	3	-0.393	0.055	5	0.4
2008	Wenatchee	Below_TUM	W2	Non-Index	1	-0.407	0.056	2	0.2
2008	Wenatchee	Below_TUM	W3	Non-Index	5	-0.407	0.056	8	0.8
2008	Wenatchee	Below_TUM	W5	Non-Index	2	-0.419	0.043	3	0.3
2008	Wenatchee	Below_TUM	W6	Index	5	-0.397	0.041	8	3.1
2008	Wenatchee	Below_TUM	W6	Non-Index	10	-0.419	0.043	17	1.3
2008	Wenatchee	Above_TUM	W8	Index	6	-0.431	0.054	11	2.9
2008	Wenatchee	Above_TUM	W9	Index	6	-0.377	0.064	10	3.1
2008	Wenatchee	Above_TUM	W10	Index	46	-0.306	0.046	67	12.4

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Table 5: Estimates of redds (and SE) for all reaches in years 2004 - 2013. The method (Index, Non-Index or Census) and total number of observed redds is noted, as well as the mean net error (with standard error). *(continued)*

Year	River	Location	Reach	Method	Obs Redds	Err Est	Err SE	Redd Est	Redd SE
2008	Wenatchee	Above_TUM	W10	Non-Index	1	-0.383	0.064	2	0.2
2009	Chiwawa	Chiwawa	Big Meadow	No-Error	3	0.000	0.000	3	0.0
2009	Chiwawa	Chiwawa	C1	Index	17	-0.438	0.049	31	8.9
2009	Chiwawa	Chiwawa	C1	Non-Index	12	-0.445	0.049	22	1.9
2009	Chiwawa	Chiwawa	C2	Non-Index	3	-0.445	0.049	5	0.5
2009	Chiwawa	Chiwawa	Chikamin	No-Error	2	0.000	0.000	2	0.0
2009	Chiwawa	Chiwawa	Clear	No-Error	2	0.000	0.000	2	0.0
2009	Icicle	Icicle	I1	Index	102	-0.181	0.074	125	26.0
2009	Nason	Nason	N1	Index	24	-0.524	0.033	51	10.3
2009	Nason	Nason	N2	Non-Index	6	-0.485	0.051	12	1.2
2009	Nason	Nason	N3	Index	37	-0.466	0.049	73	16.5
2009	Nason	Nason	N3	Non-Index	8	-0.485	0.051	16	1.5
2009	Nason	Nason	N4	Index	18	-0.244	0.059	24	4.0
2009	Nason	Nason	N4	Non-Index	2	-0.319	0.061	3	0.3
2009	Peshastin	Peshastin	P1	Index	21	-0.503	0.043	43	16.1
2009	Peshastin	Peshastin	P1	Non-Index	3	-0.503	0.043	6	0.5
2009	Peshastin	Peshastin	P3 (P2)	Index	6	-0.543	0.038	13	2.4
2009	Peshastin	Peshastin	P4	Non-Index	1	-0.553	0.040	2	0.2
2009	Wenatchee	Below_TUM	W2	Index	18	-0.537	0.034	40	12.8
2009	Wenatchee	Below_TUM	W2	Non-Index	4	-0.552	0.036	9	0.7
2009	Wenatchee	Below_TUM	W3	Non-Index	8	-0.552	0.036	18	1.4
2009	Wenatchee	Below_TUM	W5	Non-Index	0	0.000	0.000	0	0.0
2009	Wenatchee	Below_TUM	W6	Index	16	-0.526	0.038	34	6.6
2009	Wenatchee	Below_TUM	W6	Non-Index	5	-0.608	0.043	13	1.4
2009	Wenatchee	Below_TUM	W7	Non-Index	3	0.000	0.000	3	0.0
2009	Wenatchee	Above_TUM	W8	Index	16	-0.624	0.049	44	12.3
2009	Wenatchee	Above_TUM	W8	Non-Index	1	-0.633	0.050	3	0.4
2009	Wenatchee	Above_TUM	W9	Index	76	-0.492	0.034	150	50.1
2009	Wenatchee	Above_TUM	W9	Non-Index	8	-0.492	0.034	16	1.1
2009	Wenatchee	Above_TUM	W10	Index	94	-0.476	0.040	182	27.2
2010	Chiwawa	Chiwawa	Alder	No-Error	8	0.000	0.000	8	0.0
2010	Chiwawa	Chiwawa	Big Meadow	No-Error	3	0.000	0.000	3	0.0
2010	Chiwawa	Chiwawa	C1	Index	23	-0.475	0.043	45	9.5
2010	Chiwawa	Chiwawa	C1	Non-Index	13	-0.480	0.043	25	2.1
2010	Chiwawa	Chiwawa	C2	Index	1	-0.490	0.043	2	0.2
2010	Chiwawa	Chiwawa	C2	Non-Index	3	-0.480	0.043	6	0.5
2010	Chiwawa	Chiwawa	Chikamin	No-Error	11	0.000	0.000	11	0.0
2010	Chiwawa	Chiwawa	Clear	No-Error	12	0.000	0.000	12	0.0
2010	Icicle	Icicle	I1	Census	114	0.000	0.000	114	0.0
2010	Icicle	Icicle	I1	Non-Index	4	0.000	0.000	4	0.0
2010	Little Wenatchee	Little Wenatchee	L2	No-Error	2	0.000	0.000	2	0.0
2010	Little Wenatchee	Little Wenatchee	L3	No-Error	2	0.000	0.000	2	0.0
2010	Nason	Nason	N1	Index	28	-0.644	0.048	79	17.7
2010	Nason	Nason	N1	Non-Index	2	-0.663	0.049	6	0.9
2010	Nason	Nason	N2	Index	16	-0.661	0.052	47	12.4
2010	Nason	Nason	N2	Non-Index	37	0.000	0.000	37	0.0
2010	Nason	Nason	N3	Census	154	0.000	0.000	154	0.0
2010	Nason	Nason	N4	Index	23	-0.059	0.078	24	5.3
2010	Nason	Nason	N4	Non-Index	5	-0.168	0.077	6	0.6
2010	Nason	Nason	Whitepine	No-Error	1	0.000	0.000	1	0.0
2010	Peshastin	Peshastin	P1	Census	63	0.000	0.000	63	0.0
2010	Peshastin	Peshastin	P1	Non-Index	4	0.000	0.000	4	0.0
2010	Peshastin	Peshastin	P3 (P2)	Index	22	-0.443	0.037	39	2.6
2010	Peshastin	Peshastin	P4	Non-Index	35	-0.500	0.042	70	5.9
2010	Peshastin	Peshastin	Tronson	No-Error	3	0.000	0.000	3	0.0
2010	White River	White River	H2	No-Error	3	0.000	0.000	3	0.0
2010	Wenatchee	Above_TUM	Beaver	No-Error	2	0.000	0.000	2	0.0
2010	Wenatchee	Above_TUM	Chiwaukum	No-Error	1	0.000	0.000	1	0.0

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Table 5: Estimates of redds (and SE) for all reaches in years 2004 - 2013. The method (Index, Non-Index or Census) and total number of observed redds is noted, as well as the mean net error (with standard error). *(continued)*

Year	River	Location	Reach	Method	Obs Redds	Err Est	Err SE	Redd Est	Redd SE
2010	Wenatchee	Below_TUM	W1	Non-Index	6	-0.577	0.036	14	1.2
2010	Wenatchee	Below_TUM	W2	Index	23	-0.572	0.036	129	408.7
2010	Wenatchee	Below_TUM	W2	Non-Index	3	-0.577	0.036	7	0.6
2010	Wenatchee	Below_TUM	W3	Non-Index	4	-0.577	0.036	9	0.8
2010	Wenatchee	Below_TUM	W6	Index	36	-0.377	0.057	61	19.7
2010	Wenatchee	Below_TUM	W6	Non-Index	12	-0.470	0.056	23	2.4
2010	Wenatchee	Above_TUM	W8	Index	7	-0.710	0.058	24	4.9
2010	Wenatchee	Above_TUM	W9	Census	108	0.000	0.000	108	0.0
2010	Wenatchee	Above_TUM	W9	Non-Index	5	0.000	0.000	5	0.0
2010	Wenatchee	Above_TUM	W10	Census	139	0.000	0.000	139	0.0
2010	Wenatchee	Above_TUM	W10	Non-Index	12	0.000	0.000	12	0.0
2011	Icicle	Icicle	I1	Census	175	0.000	0.000	175	0.0
2011	Wenatchee	Above_TUM	Beaver	No-Error	2	0.000	0.000	2	0.0
2011	Wenatchee	Below_TUM	W1	Non-Index	6	-0.756	0.067	25	6.7
2011	Wenatchee	Below_TUM	W2	Index	22	-0.749	0.066	88	41.1
2011	Wenatchee	Below_TUM	W2	Non-Index	17	-0.756	0.067	70	19.0
2011	Wenatchee	Below_TUM	W3	Non-Index	2	-0.756	0.067	8	2.2
2011	Wenatchee	Below_TUM	W6	Index	31	-0.442	0.120	56	13.5
2011	Wenatchee	Below_TUM	W6	Non-Index	30	-0.647	0.113	85	27.1
2011	Wenatchee	Above_TUM	W8	Index	3	-0.442	0.120	5	1.2
2011	Wenatchee	Above_TUM	W9	Census	78	0.000	0.000	78	0.0
2011	Wenatchee	Above_TUM	W10	Census	66	0.000	0.000	66	0.0
2012	Wenatchee	Above_TUM	Beaver	No-Error	2	0.000	0.000	2	0.0
2012	Wenatchee	Below_TUM	W2	Index	1	-0.739	0.057	4	0.8
2012	Wenatchee	Below_TUM	W2	Non-Index	5	-0.746	0.058	20	4.5
2012	Wenatchee	Below_TUM	W3	Non-Index	1	-0.746	0.058	4	0.9
2012	Wenatchee	Below_TUM	W6	Index	1	-0.547	0.064	2	0.3
2012	Wenatchee	Above_TUM	W8	Index	0	0.000	0.000	0	0.0
2012	Wenatchee	Above_TUM	W9	Census	35	0.000	0.000	35	0.0
2012	Wenatchee	Above_TUM	W10	Index	92	-0.547	0.064	205	62.4
2013	Wenatchee	Above_TUM	Beaver	No-Error	1	0.000	0.000	1	0.0
2013	Wenatchee	Below_TUM	W1	Non-Index	3	-0.728	0.106	11	4.3
2013	Wenatchee	Below_TUM	W2	Index	26	-0.728	0.106	96	40.7
2013	Wenatchee	Below_TUM	W3	Non-Index	13	-0.728	0.106	48	18.7
2013	Wenatchee	Below_TUM	W5	Non-Index	3	-0.728	0.106	11	4.3
2013	Wenatchee	Below_TUM	W6	Index	4	-0.728	0.106	15	5.8
2013	Wenatchee	Below_TUM	W6	Non-Index	6	-0.728	0.106	22	8.6
2013	Wenatchee	Above_TUM	W8	Index	6	-0.728	0.106	22	8.6
2013	Wenatchee	Above_TUM	W9	Index	79	-0.742	0.067	307	93.2
2013	Wenatchee	Above_TUM	W10	Index	84	-0.728	0.106	309	137.4

Table 6: Estimates of redds (and SE) for all reaches in more recent years where redds were observed. The method (Index, Non-Index) and total number of observed redds is noted, as well as the mean net error (with standard error).

Year	River	Location	Reach	Method	Obs Redds	Err Est	Err SE	Redd Est	Redd SE
2014	Wenatchee	Below Tumwater	W2	Index	4	0.039	0.280	4	1.0
2014	Wenatchee	Below Tumwater	W3	Non-Index	2	0.000	0.000	2	0.0
2014	Wenatchee	Below Tumwater	W6	Index	25	0.096	0.384	23	9.1
2014	Wenatchee	Above Tumwater	W8	Index	4	-0.244	0.191	8	15.4
2014	Wenatchee	Above Tumwater	W9	Index	46	-0.110	0.222	52	14.9
2014	Chiwawa	Tributaries	C1	Tributary	5	0.000	0.000	5	0.0

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Table 6: Estimates of redds (and SE) for all reaches in more recent years where redds were observed. The method (Index, Non-Index) and total number of observed redds is noted, as well as the mean net error (with standard error). *(continued)*

Year	River	Location	Reach	Method	Obs Redds	Err Est	Err SE	Redd Est	Redd SE
2014	Peshastin	Tributaries	P1	Tributary	5	0.000	0.000	5	0.0
2014	Wenatchee	Above Tumwater	W10	Index	16	-0.132	0.163	19	6.0
2015	Wenatchee	Below Tumwater	W2	Index	2	-0.297	0.178	3	0.7
2015	Wenatchee	Below Tumwater	W3	Non-Index	1	0.000	0.000	1	0.0
2015	Wenatchee	Below Tumwater	W5	Non-Index	5	-0.186	0.097	6	0.7
2015	Wenatchee	Below Tumwater	W6	Index	54	0.156	0.591	47	25.5
2015	Wenatchee	Above Tumwater	W8	Index	9	-0.241	0.154	12	4.1
2015	Wenatchee	Above Tumwater	W9	Non-Index	4	-0.390	0.076	7	0.8
2015	Wenatchee	Above Tumwater	W9	Index	81	-0.072	0.157	87	22.2
2015	Chiwawa	Tributaries	C1	Tributary	1	0.000	0.000	1	0.0
2015	Nason	Tributaries	N1	Tributary	1	0.000	0.000	1	0.0
2015	Peshastin	Tributaries	P1	Tributary	1	0.000	0.000	1	0.0
2015	Wenatchee	Above Tumwater	W10	Non-Index	3	-0.123	0.081	3	0.3
2015	Wenatchee	Above Tumwater	W10	Index	99	0.058	0.244	94	29.6
2016	Wenatchee	Below Tumwater	W6	Index	11	0.027	0.287	11	4.9
2016	Wenatchee	Above Tumwater	W8	Index	1	-0.001	0.316	1	0.3
2016	Wenatchee	Above Tumwater	W9	Non-Index	3	0.000	0.000	3	0.0
2016	Wenatchee	Above Tumwater	W9	Index	23	-0.044	0.263	26	10.4
2016	Wenatchee	Above Tumwater	W10	Non-Index	2	0.000	0.000	2	0.0
2016	Wenatchee	Above Tumwater	W10	Index	72	-0.058	0.206	77	28.4
2017	Wenatchee	Below Tumwater	W2	Index	1	0.054	0.470	1	0.4
2017	Wenatchee	Below Tumwater	W6	Index	8	-0.092	0.186	9	3.0
2017	Wenatchee	Above Tumwater	W8	Index	2	-0.464	0.169	4	1.2
2017	Wenatchee	Above Tumwater	W9	Non-Index	1	-0.377	0.181	2	0.5
2017	Wenatchee	Above Tumwater	W9	Index	38	-0.393	0.162	63	22.6
2017	Nason	Tributaries	N1	Tributary	1	0.000	0.000	1	0.0
2017	Peshastin	Tributaries	P1	Tributary	1	0.000	0.000	1	0.0
2017	Wenatchee	Above Tumwater	W10	Non-Index	2	-0.355	0.166	3	0.8
2017	Wenatchee	Above Tumwater	W10	Index	38	-0.263	0.187	52	17.0
2018	Wenatchee	Below Tumwater	W6	Index	2	-0.093	0.186	2	0.5
2018	Wenatchee	Above Tumwater	W8	Index	1	-0.349	0.225	2	0.5
2018	Wenatchee	Above Tumwater	W9	Index	8	-0.414	0.144	14	6.3
2018	Peshastin	Tributaries	P1	Tributary	1	0.000	0.000	1	0.0
2018	Wenatchee	Above Tumwater	W10	Index	16	-0.066	0.196	17	5.9
2019	Wenatchee	Below Tumwater	W6	Index	5	0.036	0.207	5	2.3
2019	Wenatchee	Above Tumwater	W8	Index	1	-0.401	0.180	2	0.5
2019	Wenatchee	Above Tumwater	W9	Non-Index	1	-0.121	0.196	1	0.3
2019	Wenatchee	Above Tumwater	W9	Index	18	-0.126	0.209	21	7.5
2019	Peshastin	Tributaries	P1	Tributary	1	0.000	0.000	1	0.0
2019	Wenatchee	Above Tumwater	W10	Non-Index	2	0.000	0.000	2	0.0
2019	Wenatchee	Above Tumwater	W10	Index	25	-0.120	0.159	28	7.6
2021	Wenatchee	Below Tumwater	W6	Index	2	0.089	0.337	2	0.6
2021	Wenatchee	Above Tumwater	W9	Non-Index	2	-0.150	0.223	2	0.6
2021	Wenatchee	Above Tumwater	W9	Index	35	-0.318	0.184	51	13.8
2021	Chiwawa	Tributaries	C1	Tributary	1	0.000	0.000	1	0.0
2021	Wenatchee	Above Tumwater	W10	Non-Index	3	-0.002	0.131	3	0.4

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Table 6: Estimates of redds (and SE) for all reaches in more recent years where redds were observed. The method (Index, Non-Index) and total number of observed redds is noted, as well as the mean net error (with standard error). *(continued)*

Year	River	Location	Reach	Method	Obs Redds	Err Est	Err SE	Redd Est	Redd SE
2021	Wenatchee	Above Tumwater	W10	Index	58	-0.119	0.162	68	16.7
2022	Wenatchee	Below Tumwater	W6	Index	4	-0.085	0.175	4	2.1
2022	Wenatchee	Above Tumwater	W8	Index	2	-0.520	0.139	4	1.2
2022	Wenatchee	Above Tumwater	W9	Index	4	-0.428	0.145	7	1.9
2022	Wenatchee	Above Tumwater	W10	Non-Index	1	0.003	0.115	1	0.1
2022	Wenatchee	Above Tumwater	W10	Index	4	-0.420	0.088	9	6.4

3.2 Spawner Estimates

Table 7 shows the estimates of spawners for areas with redd counts from 2004-2013. This includes the total of observed redds, the mean observer net error, estimates of redds, and the fish/redd and pHOS estimates that were used to calculate hatchery and natural origin spawners from estimates of redds.

Table 7: Estimates of spawners, by origin, based on redd, fish/redd and pHOS estimates.

Year	N Rchs	Redd Obs	Redd Est	Redd SE	FpR	FpR SE	Phos	Phos SE	Spawn Est	Spawn SE	HOS Spwn	HOS SE	NOS Spwn	NOS SE
2004	22	338	986	183.6	2.58	0.22	0.608	0.033	2,547	494.2	1,549	305.4	998	200.9
2005	27	966	1,375	116.8	1.65	0.09	0.545	0.034	2,263	203.2	1,234	118.2	1,029	101.0
2006	20	301	636	91.3	1.75	0.11	0.492	0.035	1,110	163.7	547	83.4	563	85.8
2007	14	141	408	77.9	1.95	0.22	0.821	0.043	796	159.8	653	132.6	143	34.7
2008	21	266	406	36.3	2.34	0.15	0.699	0.025	951	89.5	665	63.5	286	29.2
2009	21	516	945	71.0	1.74	0.10	0.785	0.027	1,643	131.9	1,291	105.9	353	36.0
2010	28	950	1,304	410.0	2.17	0.13	0.598	0.027	2,832	893.5	1,694	535.5	1,138	360.5
2011	9	432	658	54.9	1.61	0.11	0.692	0.049	989	80.5	693	72.3	296	41.3
2012	7	137	272	62.6	1.68	0.15	0.621	0.055	479	116.1	315	79.2	164	42.3
2013	9	225	842	172.7	1.62	0.14	0.742	0.050	1,414	305.6	1,077	239.2	337	79.9

3.3 PIT Estimates

Table 8 shows the PIT-tag based estimates of escapement to particular tributaries in selected years. These years are to be combined with redd-based spawner estimates.

Table 8: Estimates of spawners by origin (with standard error), split out by tributary and year.

Year	River	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2011	Chiwaukum	19	30	17.58	21.80
2011	Chiwawa	54	186	26.08	47.32
2011	Chumstick	104	114	36.81	39.74
2011	Icicle	0	0	0.00	0.00
2011	Little Wenatchee	0	26	0.00	16.48
2011	Mission	0	0	0.00	0.00
2011	Nason	217	184	47.72	44.47
2011	Peshastin	44	106	25.11	37.91
2011	White River	0	0	0.00	0.00
2012	Chiwaukum	19	54	12.31	19.92

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Table 8: Estimates of spawners by origin (with standard error), split out by tributary and year. *(continued)*

Year	River	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2012	Chiwawa	165	125	36.31	31.38
2012	Chumstick	91	56	26.22	19.85
2012	Icicle	48	112	18.96	28.51
2012	Little Wenatchee	11	0	9.30	0.00
2012	Mission	48	70	19.10	22.79
2012	Nason	168	144	34.08	31.34
2012	Peshastin	20	236	12.40	41.14
2012	White River	0	11	0.00	9.05
2013	Chiwaukum	0	33	0.00	18.56
2013	Chiwawa	109	105	29.63	28.79
2013	Chumstick	40	11	17.47	9.33
2013	Icicle	59	65	20.09	20.48
2013	Little Wenatchee	0	0	0.00	0.00
2013	Mission	33	25	15.86	13.62
2013	Nason	97	144	25.31	30.83
2013	Peshastin	12	138	9.74	30.14
2013	White River	0	0	0.00	0.00
2014	Chiwaukum	16	35	10.41	15.28
2014	Chiwawa	96	129	24.62	29.22
2014	Chumstick	10	74	9.07	21.98
2014	Icicle	41	72	16.18	21.57
2014	Little Wenatchee	0	0	0.00	0.00
2014	Mission	41	71	16.13	21.84
2014	Nason	138	164	29.35	32.92
2014	Peshastin	11	192	8.96	34.63
2014	White River	0	0	0.00	0.00
2015	Chiwaukum	9	36	7.48	13.76
2015	Chiwawa	116	123	27.42	27.78
2015	Chumstick	9	30	7.70	13.33
2015	Icicle	30	61	12.69	18.25
2015	Little Wenatchee	0	0	0.00	0.00
2015	Mission	24	62	11.67	18.68
2015	Nason	49	200	16.67	32.87
2015	Peshastin	34	186	13.69	30.54
2015	White River	0	0	0.00	0.00
2016	Chiwaukum	12	80	10.45	35.24
2016	Chiwawa	96	47	34.54	22.10
2016	Chumstick	48	85	17.49	24.83
2016	Icicle	22	90	11.77	23.82
2016	Little Wenatchee	0	0	0.00	0.00
2016	Mission	18	35	13.36	18.08
2016	Nason	70	74	27.89	29.12
2016	Peshastin	0	185	0.00	36.32
2016	White River	0	12	0.00	14.14
2017	Chiwaukum	0	0	0.00	0.00
2017	Chiwawa	35	17	20.43	11.67
2017	Chumstick	0	18	0.00	12.48
2017	Icicle	29	16	14.07	10.16

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Table 8: Estimates of spawners by origin (with standard error), split out by tributary and year. *(continued)*

Year	River	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2017	Little Wenatchee	0	0	0.00	0.00
2017	Mission	18	30	11.56	15.02
2017	Nason	38	37	15.81	14.74
2017	Peshastin	0	58	0.00	20.38
2017	White River	0	0	0.00	0.00
2018	Chiwaukum	12	21	8.61	12.11
2018	Chiwawa	31	26	13.08	11.45
2018	Chumstick	7	12	6.58	8.06
2018	Icicle	20	46	9.18	14.34
2018	Little Wenatchee	0	6	0.00	5.02
2018	Mission	0	54	0.00	15.12
2018	Nason	37	33	12.47	12.08
2018	Peshastin	0	83	0.00	19.37
2018	White River	6	0	5.50	0.00
2019	Chiwaukum	0	0	0.00	0.00
2019	Chiwawa	45	31	17.57	13.93
2019	Chumstick	11	11	10.94	9.88
2019	Icicle	33	10	14.14	8.24
2019	Little Wenatchee	0	0	0.00	0.00
2019	Mission	10	17	9.75	11.11
2019	Nason	27	16	12.62	9.89
2019	Peshastin	11	68	9.21	22.20
2019	White River	0	0	0.00	0.00
2020	Chiwaukum	0	38	0.00	17.38
2020	Chiwawa	34	40	15.52	18.77
2020	Chumstick	0	52	0.00	19.10
2020	Icicle	28	51	13.82	19.08
2020	Little Wenatchee	0	9	0.00	7.61
2020	Mission	23	52	12.71	19.28
2020	Nason	29	44	13.14	17.24
2020	Peshastin	10	107	8.07	26.77
2020	White River	0	0	0.00	0.00
2021	Chiwaukum	26	37	19.13	22.78
2021	Chiwawa	127	104	36.15	31.33
2021	Chumstick	0	71	0.00	26.69
2021	Icicle	24	75	15.32	26.15
2021	Little Wenatchee	0	0	0.00	0.00
2021	Mission	0	43	0.00	20.46
2021	Nason	32	129	17.51	34.67
2021	Peshastin	16	159	12.88	40.18
2021	White River	0	12	0.00	10.77
2022	Chiwaukum	10	21	9.77	14.68
2022	Chiwawa	0	25	0.00	19.59
2022	Chumstick	0	22	0.00	14.46
2022	Icicle	19	79	13.00	27.41
2022	Little Wenatchee	0	0	0.00	0.00
2022	Mission	13	15	11.46	12.26
2022	Nason	0	41	0.00	19.03

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Table 8: Estimates of spawners by origin (with standard error), split out by tributary and year. *(continued)*

Year	River	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2022	Peshastin	14	70	12.35	25.65
2022	White River	0	0	0.00	0.00

3.4 Spawners by Tributary

Table 9 shows estimates of spawners, by origin, broken down by river for 2004 - 2013. These include mainstem Wenatchee estimates as well.

Table 9: Estimates of spawners in the Wenatchee by tributary and mainstem areas, based on redd surveys and PIT tag estimates for certain tributaries.

Year	River	Method	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2004	Chiwawa	Redd	182	117	43.0	28.7
2004	Icicle	Redd	79	51	32.8	21.4
2004	Nason	Redd	209	135	71.6	46.9
2004	Peshastin	Redd	127	82	32.4	21.5
2004	Wenatchee	Redd	952	613	290.1	190.9
2005	Chiwawa	Redd	188	156	36.6	31.2
2005	Icicle	Redd	13	10	4.1	3.4
2005	Nason	Redd	337	281	53.8	46.4
2005	Peshastin	Redd	122	102	19.9	17.1
2005	Wenatchee	Redd	574	478	96.5	82.3
2005	White River	Redd	2	1	0.2	0.1
2006	Chiwawa	Redd	23	24	3.1	3.2
2006	Icicle	Redd	52	54	22.1	22.8
2006	Nason	Redd	73	75	9.6	9.8
2006	Peshastin	Redd	78	81	33.2	34.2
2006	Wenatchee	Redd	320	330	72.6	74.6
2007	Chiwawa	Redd	29	6	4.8	1.8
2007	Icicle	Redd	21	5	7.8	2.0
2007	Nason	Redd	163	36	29.4	10.6
2007	Peshastin	Redd	115	25	46.5	11.8
2007	Wenatchee	Redd	323	71	120.3	30.8
2007	White River	Redd	2	0	0.2	0.1
2008	Chiwawa	Redd	25	11	2.8	1.4
2008	Icicle	Redd	70	30	16.6	7.5
2008	Nason	Redd	228	98	51.1	23.2
2008	Peshastin	Redd	120	52	22.5	10.4
2008	Wenatchee	Redd	221	95	25.2	12.1
2008	White River	Redd	2	1	0.1	0.1
2009	Chiwawa	Redd	89	24	13.7	4.8
2009	Icicle	Redd	171	47	37.2	11.6
2009	Nason	Redd	244	67	31.7	11.8
2009	Peshastin	Redd	87	24	23.0	6.9
2009	Wenatchee	Redd	699	191	90.1	30.8
2010	Chiwawa	Redd	146	98	16.5	12.1

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Table 9: Estimates of spawners in the Wenatchee by tributary and mainstem areas, based on redd surveys and PIT tag estimates for certain tributaries. *(continued)*

Year	River	Method	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2010	Icicle	Redd	153	103	11.3	9.1
2010	Little Wenatchee	Redd	5	3	0.4	0.3
2010	Nason	Redd	460	309	44.5	33.5
2010	Peshastin	Redd	233	156	19.0	14.9
2010	Wenatchee	Redd	694	466	533.0	358.3
2010	White River	Redd	4	3	0.3	0.2
2011	Chiwaukum	PIT	19	30	17.6	21.8
2011	Chiwawa	PIT	54	186	26.1	47.3
2011	Chumstick	PIT	104	114	36.8	39.7
2011	Icicle	Redd	188	125	12.0	10.0
2011	Little Wenatchee	PIT	0	26	0.0	16.5
2011	Nason	PIT	217	184	47.7	44.5
2011	Peshastin	PIT	44	106	25.1	37.9
2011	Wenatchee	Redd	504	172	71.3	40.0
2011	White River	PIT	0	0	0.0	0.0
2012	Chiwaukum	PIT	19	54	12.3	19.9
2012	Chiwawa	PIT	165	125	36.3	31.4
2012	Chumstick	PIT	91	56	26.2	19.9
2012	Icicle	PIT	48	112	19.0	28.5
2012	Little Wenatchee	PIT	11	0	9.3	0.0
2012	Mission	PIT	48	70	19.1	22.8
2012	Nason	PIT	168	144	34.1	31.3
2012	Peshastin	PIT	20	236	12.4	41.1
2012	Wenatchee	Redd	315	164	79.2	42.3
2012	White River	PIT	0	11	0.0	9.1
2013	Chiwaukum	PIT	0	33	0.0	18.6
2013	Chiwawa	PIT	109	105	29.6	28.8
2013	Chumstick	PIT	40	11	17.5	9.3
2013	Icicle	PIT	59	65	20.1	20.5
2013	Little Wenatchee	PIT	0	0	0.0	0.0
2013	Mission	PIT	33	25	15.9	13.6
2013	Nason	PIT	97	144	25.3	30.8
2013	Peshastin	PIT	12	138	9.7	30.1
2013	Wenatchee	Redd	1,077	337	239.2	79.9
2013	White River	PIT	0	0	0.0	0.0

3.5 Initial Total Spawners

Table 10 shows the initial estimates, by origin, of spawners in the Wenatchee population for spawn years 2004-2013. This only includes areas surveyed for redds or that had PIT tag escapement estimates (some tributaries in 2011-2013). Some of those areas had the redd surveys replaced by PIT tag escapement estimates in later years.

Table 10: Initial estimates of total spawners in the Wenatchee basin, based on redd surveys and PIT tag estimates for certain tributaries.

Year	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2004	1,549	998	305.4	200.9
2005	1,234	1,029	118.2	101.0
2006	547	563	83.4	85.8
2007	653	143	132.6	34.7
2008	665	286	63.5	29.2
2009	1,291	353	105.9	36.0
2010	1,694	1,138	535.5	360.5
2011	1,131	942	102.4	98.4
2012	885	972	102.7	87.5
2013	1,427	858	244.5	100.6

3.6 Expansion

Table 11 shows the proportion of the overall number of spawners in 2012-2022 (except 2020) estimated to be in Chiwaukum, Chumstick and Mission creeks. These are the proportions used to expand older estimates (pre-2011) of total spawners by origin. That table also shows the mean proportion of spawners in Mission Creek alone, from 2012-2022. That proportion was used to expand estimates in 2011 of total spawners by origin.

Table 11: Mean proportion of total spawners within the Wenatchee basin estimated to have moved into Chiwaukum, Chumstick and Mission creeks, by origin, with standard error. Year column corresponds to spawn years those expansions were used. Proportion in 2011 is only for Mission Creek.

Year	HOS Prop	NOS Prop	HOS Prop SE	NOS Prop SE
2004 - 2010	0.191	0.210	0.079	0.058
2011	0.080	0.081	0.056	0.036

3.7 Final Total Spawners

Table 12 shows final estimates of spawners, by origin and year, for 2004-2013. This includes expanding the estimates in Table 10 by the expansion factors from Table 11 to account for the unmonitored tributaries during this time period.

Table 12: Final estimates of total spawners in the Wenatchee basin, based on redd surveys, PIT tag estimates for certain tributaries and expanded for tributaries without redd surveys, for years 2004 - 2013.

Year	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2004	1,915	1,264	443.1	280.7
2005	1,526	1,303	235.5	177.0
2006	676	714	131.6	127.6
2007	807	181	190.8	47.1
2008	822	363	126.7	50.2
2009	1,595	447	233.3	61.9
2010	2,095	1,441	708.9	476.1
2011	1,229	1,025	137.8	115.7
2012	885	972	102.7	87.5
2013	1,427	858	244.5	100.6

Table 13 extends Table 12 to include the more recent years of spawner estimates, displaying the complete time-series to date of total steelhead spawners, by origin, in the Wenatchee basin. Figure 4 graphs the same time-series, with 95% confidence intervals.

Table 13: Final estimates of total spawners in the Wenatchee basin, based on redd surveys, PIT tag estimates for certain tributaries and expanded for tributaries without redd surveys.

Year	HOS Spwn	NOS Spwn	HOS SE	NOS SE
2004	1,915	1,264	443.1	280.7
2005	1,526	1,303	235.5	177.0
2006	676	714	131.6	127.6
2007	807	181	190.8	47.1
2008	822	363	126.7	50.2
2009	1,595	447	233.3	61.9
2010	2,095	1,441	708.9	476.1
2011	1,229	1,025	137.8	115.7
2012	885	972	102.7	87.5
2013	1,427	858	244.5	100.6
2014	491	829	55.9	71.8
2015	612	833	71.0	67.1
2016	391	698	61.2	78.7
2017	223	256	39.0	39.7
2018	149	314	25.4	37.3
2019	179	212	32.7	35.1
2020	124	509	52.4	99.4
2021	317	708	51.9	80.6
2022	85	323	25.3	54.6

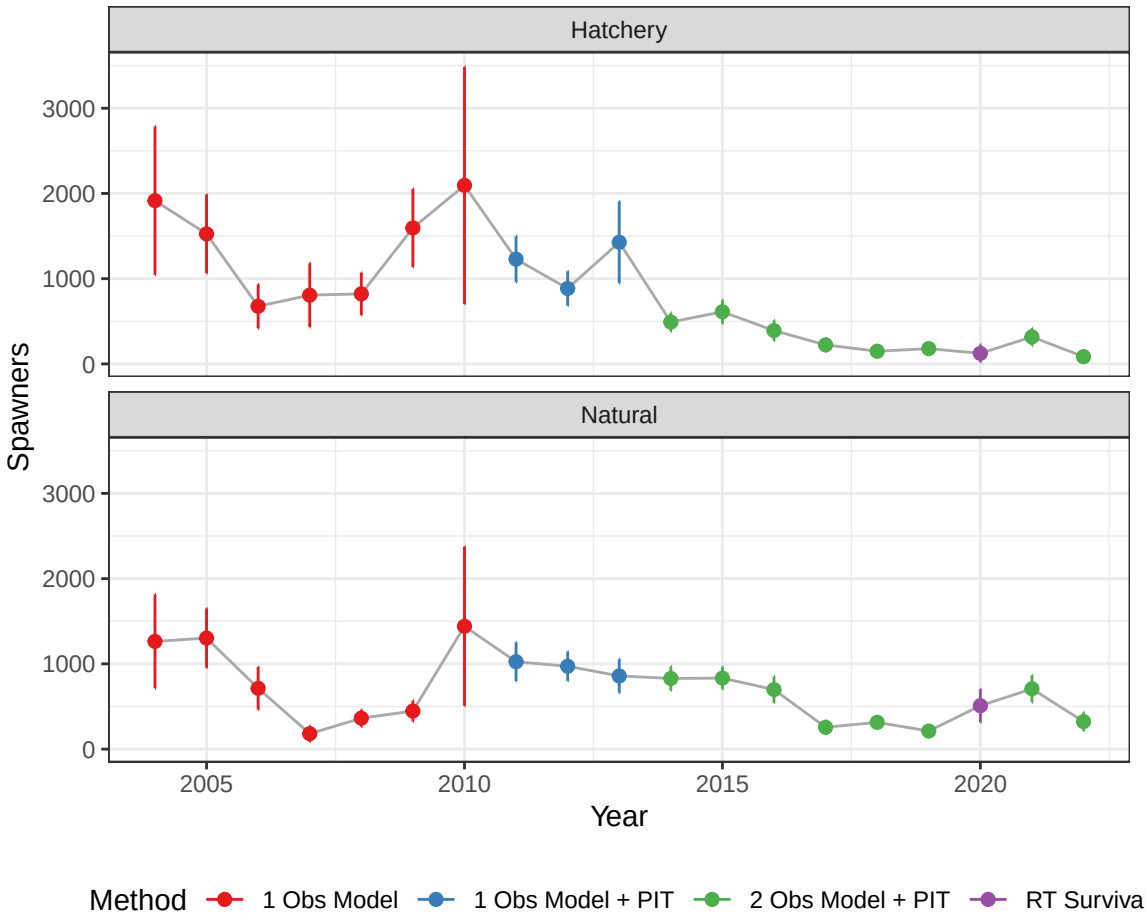

Figure 4: Time-series of spawner estimates, facted by origin. Colors show the estimation method. Error bars show the 95% confidence intervals.

4 References

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