Appendix C – Habitat Capacity Requirements

Introduction

Appendix C describes a series of approaches to determine life-stage-specific capacity requirements for spring-summer run Chinook salmon (hereafter Chinook salmon) and summer-run steelhead (hereafter steelhead) under two conditions: 1) contemporary adult escapement and 2) adult escapement accompanying proposed de-listing criteria (NOAA 2017). The goal is to estimate the maximum redd capacity, summer parr rearing capacity, and over-winter presmolt capacity necessary to support both conditions. The primary challenge associated with this initiative arises from the fact that observations of productivity and survival from one life stage to the next are only recently available and are therefore the product of heavily modified habitat and management actions, such as hatchery production. Additionally, data availability varies among the three targeted watersheds.

The following options to estimate capacity requirements were considered:

1. Using empirical observations of adult escapement, redd production, and life-stage-specific juvenile abundance.
2. Applying a time-series process model to estimate and remove sampling error from productivity estimates.
3. Applying a generalized model of survival combining empirical data and literature values.

Initially, each of the three options (Empirical Observation Model, Time-Series Process Model, and Generalized Capacity Model) were explored for Chinook salmon in the Upper Salmon, Pahsimeroi, and Lemhi Rivers to evaluate their utility. Ultimately, we chose to use the third approach, the Generalized Capacity Model, and that model was then applied to both species, and further, to all eight watersheds in the Upper Salmon River Subbasin (Upper Salmon River, Valley Creek, Yankee Fork Salmon River, East Fork Salmon River, Pahsimeroi River, Lemhi River, North Fork Salmon River, Panther Creek).

Empirical Observation Model

A time series of Chinook salmon adult escapement and juvenile production data are available for the Upper Salmon, Pahsimeroi, and Lemhi Rivers. The Sawtooth Hatchery, located on the Upper Salmon River, operates an adult weir for broodstock collection, enabling a precise estimate of adults released upstream to spawn. Similarly, the Pahsimeroi Hatchery operates an adult weir for broodstock collection on the lower Pahsimeroi River, also enabling a precise estimate of adults released upstream to spawn. Further, the Idaho Department of Fish and Game operates one rotary screw trap (RST) in the Upper Salmon River, one RST in the lower Pahsimeroi River, and three RSTs within the Lemhi River to estimate juvenile productions. The adult escapement data and juvenile production data can be combined to monitor productivity in those areas. We queried the Idaho Fish and Wildlife Information System (IFWIS) to compile data from the year 2000 onward at these facilities (Supplemental Table C-1 and Supplemental Table C-2).

A shorter time series of data are available for Lemhi River Chinook salmon at the population level. Adult escapement estimates are generated by tagging natural-origin adult Chinook salmon with passive integrated transponder (PIT) tags as they migrate past Lower Granite Dam and then subsequent detection of those adults as they pass in-stream PIT tag detection systems (IPTDS) located in the lower Lemhi River (ISEMP/CHaMP 2017). These data are available since 2010. We paired adult escapement data with juvenile abundance data generated from the three RSTs operated in the Lemhi River watershed, beginning in 2008 (Supplemental Table C-3).

These data summaries illuminate differences among the Upper Salmon, Pahsimeroi, and Lemhi River Chinook salmon populations. First, adult escapement into the Upper Salmon and Pahsimeroi Rivers is managed, manifesting in a lower percentage of female escapement relative to the Lemhi River (Table C-1). Second, most Chinook salmon juveniles pass RSTs in the Upper Salmon and Pahsimeroi Rivers as fry and parr, whereas most juvenile production in the Lemhi passes the lowest RST (L3A0) as presmolts and smolts (Table C-1). Differences in the observed emigration timing between the Upper Salmon and Pahsimeroi Rivers relative to the Lemhi River are likely a function of the proximity of the RSTs to Chinook salmon spawning areas. Lastly, the average number of redds per female spawner (Table C-1) differs among the three locations. It is unclear whether these differences are a result of observation error or a function of larger differences in pre-spawning mortality.

Table C-1. Mean percentage of total escapement composed of females and subsequent mean productivity for the Upper Salmon, Pahsimeroi, and Lemhi Rivers

Location	% Female	Redds/Female	% Fry	% Parr	% Presmolt	% Smolt
Upper Salmon	36%	0.7	26%	31%	33%	10%
Pahsimeroi	45%	0.9	32%	7%	48%	12%
Lemhi	49%	1.5	0%	2%	70%	28%

Given the uncertainty about the mechanisms underlying productivity differences among the three populations, we did not attempt to develop a joint model of capacity requirements based on empirical data.

Time-Series Process Model

As described in the prior section, productivity data differ among Chinook salmon in the Upper Salmon, Pahsimeroi, and Lemhi Rivers. One of the most obvious differences among the three locations is the timing of juvenile emigration. Given the earlier relative age of juvenile Chinook salmon emigrants in the Upper Salmon and Pahsimeroi Rivers (i.e., juveniles tend to emigrate as fry and parr), estimating juvenile abundance in natal habitat is difficult. Here, we describe a simple model of the freshwater portion of the life cycle for Chinook salmon and fit the model using data from the Lemhi River basin. This is a minimal, empirical model, including only those life stages for which abundance or survival can be directly observed: spawners, parr, and smolts (operationally defined as juvenile emigrants passing Lower Granite Dam). It is assumed that all juveniles that survive to the smolt stage emigrate past Lower Granite Dam as yearlings. The spatial scale is the entire Lemhi River basin; we do not distinguish among subbasins or reaches, and thus there is no dispersal or movement beyond the direct migration implicit in the parr-to-smolt transition.

Transitions between successive life stages within the time-series process model are described by a Beverton-Holt model fit using data from the Lemhi River basin. Specifically, the Beverton-Holt model provides information regarding life-stage-specific abundance, intrinsic productivity, and the life-stage-specific required capacity (not to be confused with carrying capacity). Required capacity is the life-stage-specific capacity required to support a given level of adult escapement, whereas carrying capacity is the life-stage-specific abundance that the habitat can support. To estimate the parameters in the spawner-to-parr and parr-to-smolt Beverton-Holt functions, we require observations of abundance (spawner or parr), transition probabilities (e.g., survival), or both, along with estimates of observation uncertainty.

Estimates of smolt emigration abundance in the model do not rely directly on empirical estimates from the Lemhi River, because a large fraction of total juvenile emigration in the Lemhi occurs during the fall at the presmolt life stage. Instead, survival estimates of parr tagged during the summer prior to outmigration and until passing Lower Granite Dam the following spring are used, regardless of whether they reared within or outside of the Lemhi River watershed. These overall parr-to-Lower Granite Dam survival estimates and associated standard errors are produced using TribPIT (Lady et al. 2014), which models a cohort of juveniles following the same migration route, albeit potentially at different times. In this case, cohorts consist of parr tagged in Hayden Creek and in the upper Lemhi River, respectively.

Total parr abundance is defined as the sum of abundance estimates from Hayden Creek and the mainstem Lemhi River. Basin-wide parr-to-smolt survival is estimated by resampling distributions describing annual survival in Hayden Creek and the upper mainstem Lemhi River. Note that temporally comprehensive estimates of parr abundance in the upper and lower mainstem Lemhi River are not available, nor do we have cohorts of PIT-tagged parr residing in the lower mainstem. In the absence of such information, we assume the survival of parr from the upper mainstem Lemhi River is representative of those throughout the mainstem. Finally, we use independent estimates of parr capacity as an informative prior to help constrain the model fits. These estimates are derived from the quantile regression forest (QRF) models described in Appendix B that predict parr capacity as a function of habitat covariates.

Results

Model diagnostics suggested a reasonable model fit. Figure C-1 shows the posterior distributions of stage-specific intrinsic productivity and capacity, and Figure C-2 and Figure C-3 show the Beverton-Holt spawner-to-parr and parr-to-smolt relationships.

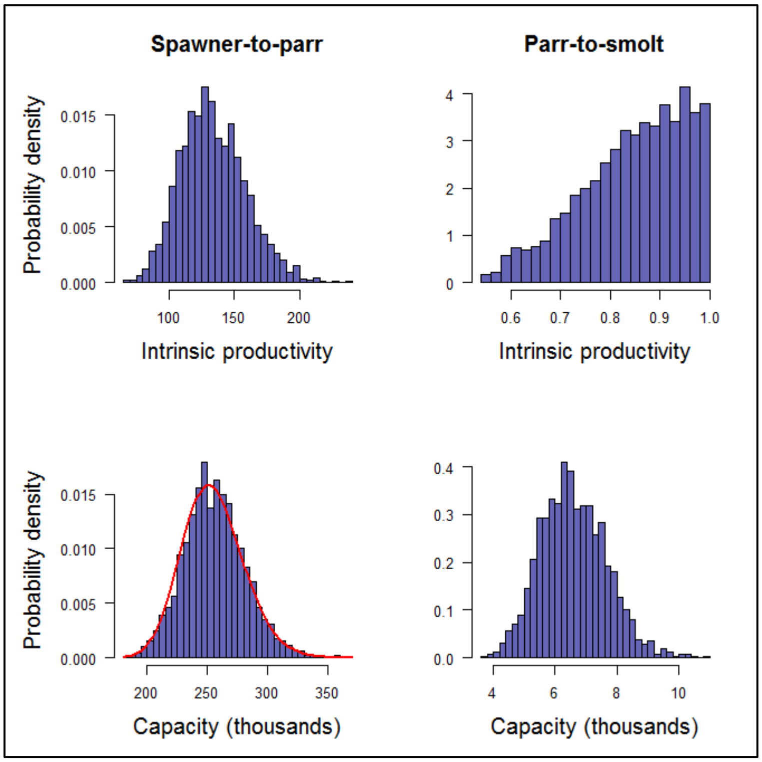

Figure C-1. Spawner to parr, parr to smolt, intrinsic productivity and capacity

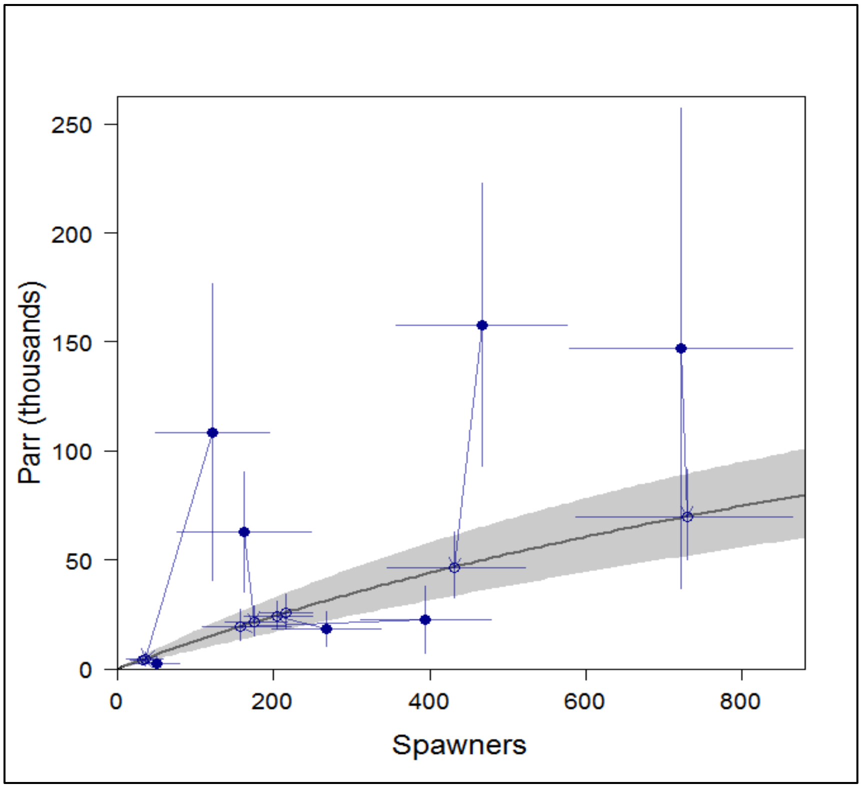

Figure C-2. Beverton-Holt spawner to parr productivity

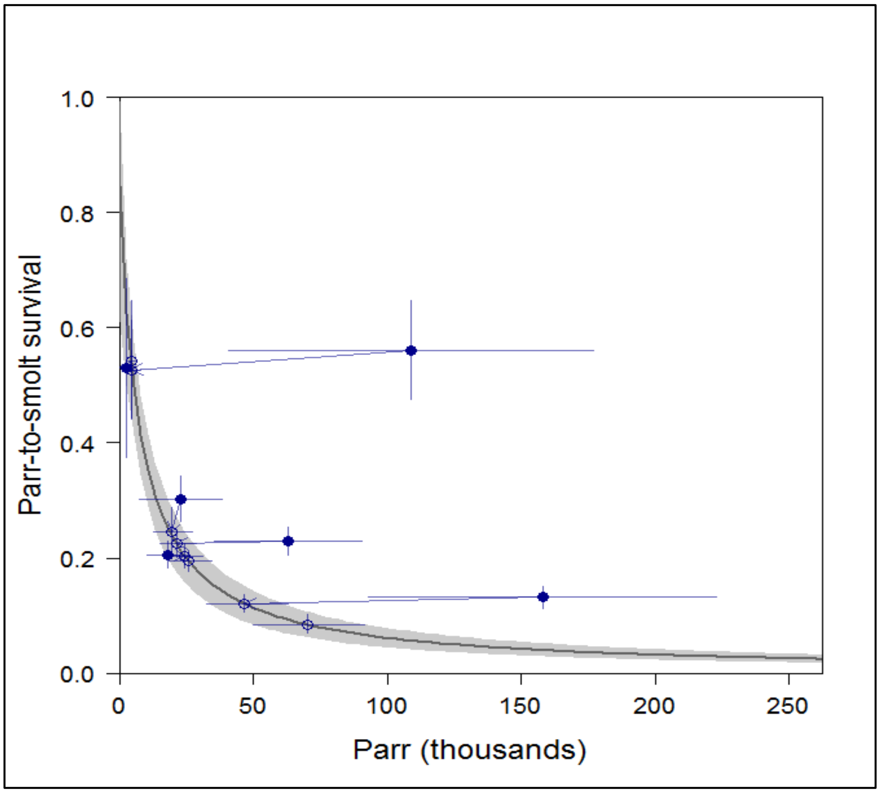

Figure C-3. Beverton-Holt parr to smolt relationship

In Figure C-1, the informative prior for capacity is shown in red; clearly, the posterior is determined entirely by the prior. Given that the posterior estimates of capacity are so closely related to the prior, we tested the sensitivity of other parameter estimates to starting values for capacity. Results suggest that the remaining parameters are quite robust to variations in capacity. In Figure C-2 and Figure C-3, data are shown as filled circles with approximate 95 percent confidence intervals, based on the observation error variances. Arrows connect each observation to the corresponding estimated “true” value (open circle) show with 95 percent posterior credible intervals.

Clearly, the largest deviations between observed and fitted values are in parr abundance (Figure C-2), which has the largest relative observation uncertainty. The model attributes three exceptionally high values to measurement error, producing a much more conservative estimate of the slope of the spawner-to-parr relationship at low spawner abundance (i.e., intrinsic productivity). It is also clear why the prior on parr capacity is so informative; the model does not think any of the observed escapements have come close to saturating the system with parr.

The same downward shift in the observed parr abundances is also evident in the parr-to-smolt survival plot (Figure C-3). Because the models for the two-stage transitions are coupled, they use the same estimated “true” parr values. This ensures internal consistency through the entire spawner-to-smolt model. In contrast to the spawner-to-parr relationship, there is not much evidence of density dependence in the parr-to-smolt transition, based on the raw data. After shrinkage of the measurement errors, however, a relationship emerges with intrinsic productivity (i.e., maximum survival) around 0.84. This seems reasonable by comparison with the range of realized parr-to-smolt survival.

Conclusions

Although the time-series process model offers a statistically rigorous means to model density-dependent productivity, the data necessary to populate the model are limited to Chinook salmon in the Lemhi River and are only available for 8 years. Given uncertainty about the transferability of this model to Chinook salmon populations in the Upper Salmon River and Pahsimeroi River populations (and populations elsewhere in the Upper Salmon River subbasin), and further, to steelhead populations, we are hesitant to use this approach.

Generalized Capacity Model

A combination of empirical and literature-based abundance and survival estimates were used as a final approach for estimating life-stage specific capacity requirements.

Chinook salmon

The Chinook salmon model operated under the assumption that, in the absence of weirs, sex ratios in the Upper Salmon and Pahsimeroi Rivers would approximate those observed in the Lemhi River. Further, the model assumed that, on average, each escaping female would produce one redd, based on observations by Bjornn (1978), and corresponding to the combined mean number of redds constructed by females averaged across the Upper Salmon, Pahsimeroi, and Lemhi Rivers (Table C-2). Chinook salmon fecundity values in the model approximated those observed at Sawtooth Hatchery (Snider et al. 2005), and egg-to-parr survival reflected those reported by Petrosky et al. (1989). Finally, the weighted mean transition probability of parr-to-presmolt were generated from empirical data in the Lemhi River (ISEMP/CHaMP 2017).

Table C-2. Parameter values used to estimate life-stage specific capacity requirements for the Upper Salmon, Pahsimeroi, and Lemhi Rivers

Parameter	Value	Source
Female Ratio	0.49	IDFG/ISEMP
Redds/Female	1	Bjornn (1978)
Fecundity	5,290	Snider et al. (2005)
Egg:Parr	0.29	Petrosky, Everson, and Holubetz (1989)
Parr: Presmolt	0.41	Lemhi Empirical

Life-stage-specific habitat capacity requirements cannot be estimated without making assumptions regarding the fraction of juvenile Chinook salmon expected to emigrate from natal habitat as fry and parr. Many of the habitat changes that influence capacity and behavior existed prior to the time series of juvenile observation data. It is therefore unclear whether fry and parr emigration rates observed in recent years for the Upper Salmon and Pahsimeroi Rivers are a natural condition. For the purposes of calculating capacity requirement, the model assumed that natural rates of fry or parr emigration were historically negligible. Further, it is assumed that when habitat capacity is sufficient, rates of presmolt emigration are negligible, as observed by Bjornn (1971). They reported fall presmolt emigration rates as low as 6.7 percent. Taken together, these parameters and assumptions (Table C-2) can be used to estimate the expected number of redds, summer parr, and presmolts expected given a specified adult escapement and negligible density-dependence.

Expected parr (summer) and presmolt (winter) abundances were calculated based on both the mean and maximum observed adult escapement among recent (contemporary) data to estimate current capacity requirements. For the Upper Salmon and Pahsimeroi Rivers, the mean and maximum escapement was based on observed adult escapement since 2010. For the Lemhi River, parr and presmolt abundance estimates were calculated based on the mean and maximum observed adult escapement since 2010. Further, using the parameters in Table C-2, we applied the generalized capacity model to the remaining five populations in the Upper Salmon River Subbasin. Mean and maximum observed adult escapement in Valley Creek (2010 to 2015), Yankee Fork Salmon River (2012 to 2015), and East Fork Salmon River (2010 to 2015) were based on IPTDS located in those rivers. For the North Fork Salmon River (1991 to 2017) and Panther Creek (2001- to 2017), mean and maximum adult escapement estimates were based on redd counts and estimates of fish-per-redd for those systems (Personal Communication, Matt Belnap, Idaho Department of Fish and Game). We then calculated expected capacity requirements to support adult escapement targets identified in NOAA (2017) de-listing criteria (Supplemental Table C-4 to Supplemental Table C-11).

Steelhead

We used the generalized capacity model framework that was first developed for Chinook salmon in the Upper Salmon River Subbasin and applied that framework to steelhead in the subbasin. For steelhead, sex ratios were estimated from all adult steelhead that were PIT-tagged at Lower Granite Dam and later detected at IPTDS in the Upper Salmon River Subbasin (Powell et al. 2017). IPTDS used to estimate sex ratios were located in the following areas: Upper Salmon River (above Redfish Lake), Valley Creek, Yankee Fork Salmon River, upper mainstem Salmon River, East Fork Salmon River, Pahsimeroi River, Lemhi River, and Carmen Creek. Further, the model assumed that, on average, each escaping female would produce 0.89 redds based on observations by Jonasson et al. (2016) for steelhead in Deer Creek, Grande Ronde River, Oregon. Steelhead fecundity values in the model approximated those observed at the Sawtooth and Pahsimeroi hatcheries (Personal Communication, Steve Pomerleau and Todd Garlie, Idaho Department of Fish and Game). Finally, egg-to-parr survival and parr-to-smolt survival were derived from McHugh et al. (2017). Parameters used in the steelhead generalized capacity model are summarized in Table C-3.

Table C-3. Parameter values used to estimate life-stage specific capacity requirements for the Upper Salmon, Pahsimeroi, and Lemhi Rivers

Parameter	Value	Source
Female Ratio	0.62	Powell et al. (2017)
Redds/Female	0.89	Jonasson et al. (2016)
Fecundity	4,926	IDFG, Personal Communication
Egg:Parr	0.13	McHugh et al. 2017
Parr: Presmolt	0.36	McHugh et al. 2017

Similar to the Chinook generalized capacity model, expected summer parr and winter juvenile abundances were calculated based on both the mean and maximum observed adult escapement among recent (contemporary) data to estimate current capacity requirements. For Valley Creek (2010- to 2015) and Lemhi River (2010 to 2015), mean and maximum observed adult escapement were based on IPTDS located in those rivers. Escapement data for Panther Creek, North Fork Salmon River, and Pahsimeroi River were all available from 2011 to 2015 from run reconstruction efforts across the Snake River Basin (e.g., Stark et al. 2017). For the East Fork Salmon River (2012 to 2015) and Upper Salmon River (2010 to 2015), escapement estimates were from weirs at hatchery facilities in those locations. Escapement estimates in the Yankee Fork Salmon River (2012 to 2015) were based on a weir and IPTDS located in the lower river. We then calculated expected capacity requirements to support adult escapement targets identified in NOAA (2017) de-listing criteria (Supplemental Table C-12 to

Supplemental Table C-19). Note that for steelhead, the Upper Salmon (above Redfish Lake), Valley Creek, and Yankee Fork Salmon groups are all located within the Upper Salmon mainstem Technical Recovery Team (TRT) population (NOAA 2017). To calculate expected capacity requirements for those watersheds, we multiplied the total adult escapement target for that population (1,000) by the percentage of available stream length within the steelhead domain in those watersheds (Table C-4).

Table C-4. Available stream length within the steelhead domain for the Upper Salmon (above Redfish Lake), Valley Creek, and Yankee Fork watersheds within the Upper Salmon mainstem

Watershed	Stream Length (km)	Stream Length (%)
Upper Salmon (above Redfish Lake)	195.3	48.0%
Valley Creek	99.9	24.6%
Yankee Fork	111.3	27.4%

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Supplementary Tables to Appendix C

Empirical Observation Model

Supplemental Table C-1. Adult escapement, redd counts, and juvenile production data for Chinook salmon in the Upper Salmon River (Sawtooth Weir and Rotary Screw Trap).

Year	Escapement	Females	Redds	Females/Redd	Redds/Female	Fry	Parr	Presmolt	Smolt
2000	553	168	126	1.33	0.75	18,674	24,538	35,289	28,096
2001	1304	484	275	1.76	0.57	158,479	120,538	44,452	28,182
2002	1419	663	378	1.75	0.57	213,696	74,005	119,332	34,049
2003	775	400	227	1.76	0.57	50,533	62,877	74,409	47,435
2004	748	267	139	1.92	0.52	41,511	79,575	98,146	17,682
2005	457	186	144	1.29	0.77	25,713	121,373	136,300	12,010
2006	441	128	93	1.38	0.73	12,959	16,293	96,331	9,964
2007	215	64	48	1.33	0.75	N/A	27,500	47,483	5,728
2008	592	118	99	1.20	0.84	11,640	41,787	29,245	12,015
2009	447	166	103	1.61	0.62	45,619	31,640	58,200	15,270
2010	771	189	164	1.15	0.87	5,662	96,413	34,307	8,386
2011	657	228	118	1.93	0.52	N/A	76,712	62,954	13,481
2012	816	284	215	1.32	0.76	20,425	36,377	48,528	29,701
2013	413	73	58	1.26	0.79	5,289	12,106	7,719	5,240
2014	705	268	141	1.90	0.53	17,546	18,872	14,717	5,904
2015	399	121	73	1.66	0.60	14,908	30,451	23,907	N/A
2016	438	229	125	1.83	0.55	N/A	N/A	N/A	N/A
Mean	656	237	149	1.6	0.7	45,904	54,441	58,207	18,210
Maximum	1,419	663	378	1.9	0.9	213,696	121,373	136,300	47,435

Supplemental Table C-2. Adult escapement, redd counts, and juvenile production data for Chinook salmon in the Pahsimeroi River (Pahsimeroi Weir and Rotary Screw Trap).

Year	Escapement	Females	Redds	Females/Redd	Redds/Female	Fry	Parr	Presmolt	Smolt
2000	105	48	51	0.95	1.05	7,595	336	5,274	4,083
2001	329	168	173	0.97	1.03	20,202	8,904	27,272	6,189
2002	322	174	125	1.39	0.72	12,681	162	26,232	3,433
2003	822	439	354	1.24	0.81	28,560	1,069	36,908	6,187
2004	517	251	235	1.07	0.94	16,229	1,003	13,026	6,731
2005	681	356	273	1.30	0.77	26,449	446	45,619	6,595
2006	186	94	64	1.46	0.68	4,995	338	6,069	1,853
2007	166	72	77	0.94	1.07	2,443	747	9,863	1,080
2008	224	92	82	1.13	0.89	5,034	N/A	13,217	4,090
2009	338	159	199	0.80	1.25	15,543	2,747	24,672	7,934
2010	328	147	100	1.47	0.68	3,531	12,060	20,978	7,678
2011	436	209	113	1.85	0.54	15,946	5,513	22,001	8,253
2012	234	89	78	1.14	0.88	5,931	N/A	37,374	6,693
2013	387	74	56	1.32	0.76	6,377	2,209	5,991	3,486
2014	776	327	291	1.12	0.89	33,672	5,290	18,806	3,679
2015	580	186	172	1.08	0.92	11,578	2,426	11,226	N/A
Mean	402	180	153	1.2	0.9	13,548	3,089	20,283	5,198
Maximum	822	439	354	1.8	1.2	33,672	12,060	45,619	8,253

Supplemental Table C-3. Adult escapement, redd counts, and juvenile production data for Chinook salmon in the Lemhi River (Lower Lemhi IPTDS [LLR] and L3A0, LRW, and HYC Rotary Screw Traps).

Year	Escapement	Females	Redds	Females/ Redd	Redds/ Female	L3A0				LRW				HYC			
						Fry	Parr	Presmolt	Smolt	Fry	Parr	Presmolt	Smolt	Fry	Parr	Presmolt	Smolt
2008	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	15	5,905	1,143	N/A	22	10,590	1,172
2009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,796	4444	39,634	3,710	7,468	1,953	8,053	983
2010	156	51	126	0.4	2.4	N/A	N/A	N/A	N/A	799	783	18,818	2,654	13,763	1,657	16,739	826
2011	267	101	184	0.6	1.8	N/A	N/A	N/A	16,842	1,372	354	26,858	5,387	15,507	1,571	17,501	947
2012	83	N/A	98	N/A	N/A	0	0	15,307	6,519	445	461	6,128	5,167	16,447	665	9,476	1,468
2013	393	98	131	0.8	1.3	0	0	17,056	14,440	0	160	12,330	6,288	N/A	536	6,164	1,160
2014	464	269	288	0.9	1.1	0	2,878	56,436	19,816	21,971	2,428	40,978	15,226	59,431	1,617	15,178	732
2015	718	337	310	1.1	0.9	0	862	52,523	N/A	19,965	1,334	21,549	N/A	35,473	2,195	24,196	N/A
Mean	347	172	190	0.7	1.5	0	935	35,330	14,404	6,044	747	21,525	5,653	24,682	1,277	1,041	13,487
Max.	718	337	310	1.1	2.4	0	2,878	56,436	19,816	21,971	2,428	40,978	15,226	59,431	2,195	1,468	24,196

Generalized Capacity Model

Chinook salmon

Supplemental Table C-4. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for Chinook salmon in the Upper Salmon River. Recent capacity requirements are based on the mean and maximum estimated escapement to the Upper Salmon River, 2000-2016. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	**Recent**		**De-listing**
	Mean	**Maximum**	
Escapement	656	1,419	1,000
Redd	321	695	490
Eggs	1,700,372	3,678,497	2,592,100
Parr	493,108	1,066,764	751,709
Presmolt	199,793	432,221	304,570

Supplemental Table C-5. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for Chinook salmon in Valley Creek. Recent capacity requirements are based on the mean and maximum estimated escapement to Valley Creek, 2010-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	**Recent**		**De-listing**
	Mean	**Maximum**	
Escapement	506	739	500
Redd	248	362	245
Eggs	1,311,603	1,915,562	1,296,050
Parr	308,365	555,513	375,855
Presmolt	154,112	225,077	152,285

Supplemental Table C-6. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for Chinook salmon in the Yankee Fork Salmon River. Recent capacity requirements are based on the mean and maximum estimated escapement the Yankee Fork Salmon River, 2012-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	**Recent**		**De-listing**
	Mean	**Maximum**	
Escapement	248	343	500
Redd	121	168	245
Eggs	641,545	889,090	1,296,050
Parr	186,048	257,836	375,855
Presmolt	75,381	104,467	152,285

Supplemental Table C-7. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for Chinook salmon in the East Fork Salmon River. Recent capacity requirements are based on the mean and maximum estimated escapement to the East Fork Salmon River, 2010-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	283	343	1,000
Redd	139	168	490
Eggs	733,046	889,090	2,592,100
Parr	212,583	257,836	751,709
Presmolt	86,132	104,467	304,570

Supplemental Table C-8. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for Chinook salmon in the Pahsimeroi River. Recent capacity requirements are based on the mean and maximum estimated escapement to the Pahsimeroi River, 2000-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	402	822	1,000
Redd	197	403	490
Eggs	1,042,496	2,129,424	2,592,100
Parr	302,034	617,533	751,709
Presmolt	122,375	250,206	304,570

Supplemental Table C-9. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for Chinook salmon in the Lemhi River. Recent capacity requirements are based on the mean and maximum estimated escapement to the Lemhi River, 2010-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	347	718	2,000
Redd	170	352	980
Eggs	899,027	1,861,128	5,184,200
Parr	260,718	539,727	1,503,418
Presmolt	105,635	218,681	609,140

Supplemental Table C-10. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for Chinook salmon in the North Fork Salmon River. Recent capacity requirements are based on the mean and maximum estimated escapement for the North Fork Salmon River, 1991-2017. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	55	208	500
Redd	27	102	245
Eggs	142,486	540,297	1,296,050
Parr	41,321	156,686	375,855
Presmolt	16,742	63,485	152,285

Supplemental Table C-11. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for Chinook salmon in Panther Creek. Recent capacity requirements are based on the mean and maximum estimated escapement for Panther Creek, 2001-2017. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	20	115	750
Redd	10	56	368
Eggs	51,616	297,210	1,944,075
Parr	14,969	86,191	563,782
Presmolt	6,065	34,922	228,427

Steelhead

Supplemental Table C-12. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for steelhead in the Upper Salmon River. Recent capacity requirements are based on the mean and maximum estimated escapement to the Upper Salmon River, 2010-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	92	154	480[1]
Redd	51	85	267
Eggs	251,959	420,995	1,313,402
Parr	33,826	56,519	176,324
Presmolt	12,131	20,269	63,235

[1] The de-listing escapement for the Upper Salmon River was determined by multiplying the de-listing goal for the entire upper mainstem Salmon River TRT population by the amount of available stream habitat in the Upper Salmon River relative to Valley Creek and the Yankee Fork Salmon River (Table C-4).

Supplemental Table C-13. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for steelhead in Valley Creek. Recent capacity requirements are based on the mean and maximum estimated escapement to Valley Creek, 2010-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	193	278	246
Redd	107	154	136
Eggs	526,244	759,978	671,833
Parr	70,648	102,027	90,194
Presmolt	25,336	36,590	32,346

[1] The de-listing escapement for Valley Creek was determined by multiplying the de-listing goal for the entire upper mainstem Salmon River TRT population by the amount of available stream habitat in Valley Creek relative to the Upper Salmon River and the Yankee Fork Salmon River (Table C-4).

Supplemental Table C-14. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for steelhead in the Yankee Fork Salmon River. Recent capacity requirements are based on the mean and maximum estimated escapement the Yankee Fork Salmon River, 2012-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	95	213	274
Redd	53	118	152
Eggs	260,388	582,285	748,498
Parr	34,957	78,172	100,486
Presmolt	12,537	28,035	36,037

[1]The de-listing escapement for the Yankee Fork Salmon River was determined by multiplying the de-listing goal for the entire upper mainstem Salmon River TRT population by the amount of available stream habitat in the Yankee Fork Salmon River relative to the Upper Salmon River and Valley Creek (Table C-4).

Supplemental Table C-15. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for steelhead in the East Fork Salmon River. Recent capacity requirements are based on the mean and maximum estimated escapement to the East Fork Salmon River, 2012-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	30	54	1,000
Redd	17	30	555
Eggs	82,695	147,622	2,733,733
Parr	11,102	19,818	367,004
Presmolt	3,981	7,107	131,618

Supplemental Table C-16. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for steelhead in the Pahsimeroi River. Recent capacity requirements are based on the mean and maximum estimated escapement to the Pahsimeroi River, 2011-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	1,156	1,614	1,000
Redd	641	896	555
Eggs	3,159,649	4,412,245	2,733,733
Parr	424,183	592,344	367,004
Presmolt	152,124	212,431	131,618

Supplemental Table C-17. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for steelhead in the Lemhi River. Recent capacity requirements are based on the mean and maximum estimated escapement to the Lemhi River, 2010-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	337	417	1,000
Redd	187	231	555
Eggs	920,357	1,139,967	2,733,733
Parr	123,558	153,041	367,004
Presmolt	44,311	54,885	131,618

Supplemental Table C-18. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for steelhead in the North Fork Salmon River. Recent capacity requirements are based on the mean and maximum estimated escapement for the North Fork Salmon River, 2011-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	252	349	500
Redd	140	194	277
Eggs	688,354	954,073	1,366,867
Parr	92,412	128,084	183,502
Presmolt	33,141	45,935	65,809

Supplemental Table C-19. Estimated redds, eggs, summer parr, and winter presmolt capacity requirements for steelhead in Panther Creek. Recent capacity requirements are based on the mean and maximum estimated escapement for Panther Creek, 2011-2015. De-listing capacity requirements are based on NOAA de-listing adult escapement targets.

Life Stage	Recent		De-listing
	Mean	Maximum	
Escapement	449	650	500
Redd	249	361	277
Eggs	1,226,353	1,776,927	1,366,867
Parr	164,638	238,552	183,502
Presmolt	59,044	85,551	65,809