2014 Snake River Kelt Management Plan

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Executive Summary

The 2014 Kelt Management Plan describes the current status of actions carried out to improve the survival of steelhead kelts in order to meet goals of increased spawner abundance defined in the 2008 FCRPS Biological Opinion (RPA Actions 33 and 42). The three major strategies to meet these goals are 1. Reconditioning or aquaculture based rehabilitation programs for post-spawn female steelhead, 2. Transportation of kelts through the hydrosystem via barge or truck, and 3. Hydrosystem actions to improve in-river migration.

In 2014, kelt collection for long-term reconditioning was expanded to existing tributary weirs, this allowed for improved availability of good condition B-run kelts. Collection at Lower Granite Dam (LGR) is currently a limiting factor for collection of kelts for long term reconditioning. Scoping of the redesign of the Lower Granite Juvenile Fish Facility in 2014 resulted in a recommendation for high velocity sort-by-size separation with a new adult salmon separator which would eliminate kelt passing to the juvenile separator and reduce amount of kelt handling. The Action Agencies will work to develop a low flow kelt outmigration and return spawner passage plan for Fish Passage Plan in conjunction with juvenile salmon and adult salmon passage survival modifications.

Several kelt related research studies supporting the major strategies should be highlighted. Hatch et al. (2014) concluded that one-year rematuration rates (consecutive as opposed to skip spawning) is lower in Snake River populations than in Yakima or Methow river populations, possibly due to B-run steelhead having a lower rate of consecutive spawning and lower water temperatures in the Clearwater River. Air spawned hatchery origin, and wild kelts from the SF Clearwater had the highest rematuration rates, suggesting that loss of energy during spawning and migration may delay maturation. A synthesis report evaluating hydrosystem survival of kelts through three lower Snake Dams in 2012/2013 concluded that kelts preferentially use surface passage weirs if the route is available and could be easily located; survival through surface weirs was 90%(2012) and 67%(2013) at LGR, averaged 95% at Little Goose Dam (LGS), and 98%(2012) and 92.7% (2013) at Lower Monumental Dam (LMN), and survival through turbines averaged 90% at LGR, 82% at LGS, and 74% at LMN (Harnish *et al. in review*). Larger fish, including many B-run kelts, showed lower survival rates through the Snake River and fish in poor condition fared far worse than good and fair condition adults. A test of survival during winter operations at McNary Dam estimated 48 hr survival rates of 97.7% via temporary spillway weir and 90.7% via turbines (Phipps and Heisey 2015). Keefer and Caudill (2014) evaluated migration histories of 53,282 steelhead detected at Bonneville Dam from 2000-2011 and detected 139 individuals initiating second spawning migrations. Among summer steelhead, half were consecutive spawners and half skip spawners and steelhead with a 1-ocean year pattern had higher rates of iteroparity than older steelhead with 2-ocean year pattern. The largest number of overwintering steelhead were distributed in the Lower Granite and Little Goose reservoirs, with the highest abundance of Clearwater River origin steelhead in these reservoirs (Keefer et al. 2014). Clearwater River fish made up 68% of steelhead overwintering in the FCRPS, followed by John Day origin steelhead (9%)."

Introduction and Background

The 2008 FCRPS Biological Opinion (BiOp) identified the capability among steelhead for iteroparity (repeat spawning) as an important life history strategy for increasing steelhead population abundance and stability. Two Reasonable and Prudent Alternatives (RPA Actions) laid out a set of actions to improve the survival and abundance of steelhead kelts, and in addition, preparation of an annual Kelt Management Plan was included among the five major BiOp hydro strategies. These two RPA Actions focus on a combination of hatchery (reconditioning) and hydrosystem operations at projects on the Lower Snake and Columbia Rivers to benefit Snake River B-run Steelhead (RPA Action 33), and hatchery operations to benefit upper and middle Columbia River Stocks (RPA Action 42). RPA Action 33 requires the U.S. Army Corps of Engineers (Corps) and the Bonneville Power Administration (BPA) to "prepare a Snake River Kelt Management Plan in coordination with NOAA Fisheries and the Regional Forum. BPA and the Corps will implement the plan to improve the productivity of interior basin B-run steelhead populations as identified in Sections 8.5." RPA Action 33 requires a Plan that will focus on the wild component of the B-run steelhead and should include:

1. Measures to increase the in-river survival of migrating kelts,
2. Potential for collection and transport (either with or without short-term reconditioning) of kelts to areas below Bonneville Dam,
3. Potential for long-term reconditioning as a tool to increase the number of viable females on the spawning grounds, and
4. Research as necessary to accomplish the plan elements.

RPA ACTION Action 42 requires Action Agency funding of steelhead kelt reconditioning programs for middle and upper Columbia River steelhead populations. RPA Action 42 requires:

1. Funding a program to recondition natural origin kelts for the Entiat, Methow and Okanogan subbasins (Upper Columbia) including capital construction, operation, and monitoring and evaluation costs; and
2. Funding a program to recondition natural origin kelts in the Yakima sub-basin (Mid-Columbia) including capital construction, implementation, and monitor and evaluation costs.

Coordinated expansion of infrastructure and aquaculture facilities in the Snake and Columbia Rivers, and lessons learned during early stages of the program have been beneficial for fulfilling both kelt RPA Actions. Research conducted in the middle Columbia River under RPA Action 42 pertaining to experimental development of techniques for reconditioning, monitoring of survival rates through the lower Columbia dams, and monitoring of kelt return rates has been helpful for successful implementation of the Snake River reconditioning program, planned under RPA Action 33. Progress towards meeting the objectives of RPA Action 42 is detailed in the annual reports for CRITFC's Kelt Reconditioning project (BPA project 2007-401-00 http://www.cbfish.org/Project.mvc/Display/2007-401-00). Unlike RPA Action 33, RPA Action 42 does not specify a numerical target for an increased number of returning steelhead spawners; it only mandates funding for hatchery based reconditioning programs that conserve and build genetic resources for the recovery of ESA listed steelhead populations in the Upper and Middle Columbia Distinct Populations Segments (DPS).

A variety of sources inform us on the repeat spawner rates for steelhead to different locations in the Columbia River Basin based on scale pattern analysis (IDFG unpublished) and tagging studies (Keefer et al. 2008; Hatch et al. 2015). Estimates of annual returns of repeat steelhead spawners vary from 2.9 – 9.0% for kelts tagged at lower Columbia River dams and from 0.05 – 1.2% for kelts for Snake River (Keefer et al. 2008; Hatch et al. 2015). Kelt relative return rates have been estimated for 9-10 years from the Yakima and Snake Rivers (Everett et al. 2015). Returns of additional in-river migrants tagged for the multiyear Colotelo et al. (2014) study should be available by 2015.

Idaho Department of Fish and Game has been collecting adult steelhead in cooperation with NOAA Fisheries staff at the Lower Granite Dam (LGR) fish ladder. Methods for the sampling effort can be found in Schrader et al. (2013). Sampling establishes stock abundance and composition estimates for steelhead runs above Lower Granite Dam using Genetic Stock Identification (GSI) techniques and age composition based on scale data. The sampling is focused on maiden spawners but also collects data on repeat spawners.

Trends in overall abundance and percent of repeat spawning steelhead over LGR have increased since SY2010 (Table 1). This LGR count combines A and B run steelhead. On average, 1.46% of the adult steelhead sampled at the LGR trap during SY2010-2013 were repeat spawners. The estimate of 2.8% percent repeat spawners in SY2013 is approaching historic levels as reported by Long (1937).

Nine GSI stocks have been identified containing repeat spawners in the LGR dataset from SY2010-2013 (Table 2). This includes all GSI stocks that are reported above LGR and these stocks are comprised of both A-run and B-run designated areas (Table 2). On all spawn years, A-run stocks such as the Grande Ronde and Upper Salmon have been the most abundant (Table 2). However, B-run were represented in three of the spawn years (Table 2). Since Grande Ronde stocks are found in higher abundance as maiden spawners it is logical that this stock would also be represented at a higher level for repeat spawners. Additional analysis carrying GSI stocks from maiden spawn year abundance to subsequent consecutive year and skip year repeat spawning would estimate a true repeat spawner occurrence by stock. Data being collected at LGR will provide this ability moving forward.

Table 1. Steelhead scale sample data and percent repeat spawners from Lower Granite Dam for spawn years 2010-2013. (IDFG)

Year	Total # Aged Samples	# Repeat Spawners	Percent of Repeats
SY2010	1747	13	0.744
SY2011	2051	21	1.024
SY2012	1816	22	1.211
SY2013	1856	53	2.856
Total:	7470	109	

Table 2. Repeat spawner steelhead abundance by genetic stock based upon systematic sampling at the Lower Granite Dam adult fish trap for spawn years 2010-2013. (IDFG)

Spawn Year	GenStock	# Repeat Spawners	Stock Proportion	Abundance Estimate	Proportion	L	U	P1
SY2010								
	Grande Ronde	5	0.385	111	0.381	90	132	18.9
	Imnaha	3	0.231	67	0.230	39	97	43.3
	Lower Clearwater	1	0.077	21	0.072	11	31	48.6
	Lower Sanke	2	0.154	45	0.155	30	61	34.6
	Upper Salmon	2	0.154	47	0.162	32	62	32.1
	Total:	13	1.000	291	1.000	249	332	14.3
SY2011								
	Grande Ronde	9	0.429	186	0.438	158	213	14.8
	Imnaha	3	0.143	72	0.169	51	93	29.3
	Lower Clearwater	1	0.048	17	0.040	9	26	51.4
	MFK Salmon	2	0.095	42	0.099	24	63	46
	NG	1	0.048	NA	NA	NA	NA	NA
	SFK Clearwater	1	0.048	18	0.042	10	27	47.6
	SFK Salmon	1	0.048	26	0.061	8	46	72.3
	Upper Salmon	3	0.143	64	0.151	47	84	28.9
	Total:	21	1.000	425	1.000	376	473	11.4
SY2012								
	Grande Ronde	4	0.182	84	0.167	66	102	21.5
	Imnaha	2	0.091	45	0.089	28	64	39.7
	Lower Salmon	2	0.091	42	0.083	23	62	46.7
	Lower Snake	2	0.091	39	0.077	25	55	38.2
	MFK Salmon	1	0.045	19	0.038	11	29	46.6
	SFK Clearwater	1	0.045	59	0.117	33	85	44.4
	SFK Salmon	3	0.136	66	0.131	42	89	35.8
	Upper Clearwater	2	0.091	48	0.095	25	75	51.7
	Upper Salmon	5	0.227	102	0.202	78	126	23.6
	Total:	22	1.000	504	1.000	442	564	12.1
SY2013								
	Grande Ronde	18	0.340	205	0.338	179	232	12.9
	Imnaha	2	0.038	28	0.046	18	40	38.7
	Lower Clearwater	2	0.038	19	0.031	11	27	42.9
	Lower Salmon	5	0.094	60	0.099	41	80	32.4
	Lower Snake	8	0.151	95	0.157	76	115	20.4
	MFK Salmon	5	0.094	55	0.091	42	70	25.3
	SFK Salmon	1	0.019	12	0.020	6	18	51.1
	Upper Clearwater	3	0.057	34	0.056	21	47	38.7
	Upper Salmon	9	0.170	99	0.163	82	118	18.2
	Total:	53	1.000	607	1.000	559	655	7.9

NOAA (2008) concluded that rates of productivity for upper Columbia River (UCR) naturally-reproducing steelhead populations must increase by 2 to 6 fold in order to escape imminent risk of extinction. Increasing the survival of kelts and their eventual return as repeat spawners can be considered one component in improving the abundance and productivity of ESA listed steelhead populations in the Snake River and Upper and Middle Columbia River. An analysis included in the 2008 FCRPS BiOp evaluated the likelihood of prospective actions for improving kelt survival and abundance, including transportation, kelt reconditioning, and in-stream passage improvements (e.g. spill-flow modifications) (Supplemental Comprehensive Analysis Steelhead Kelt Appendix- Bellerud et al. 2007). Given available data, the evaluation concluded that a combination of these actions could increase kelt returns enough to increase the number of returning Snake River B-run steelhead spawners to Lower Granite Dam by about 6%, or in the 0.4 –9% range depending on the strategies adopted. Increasing repeat spawning steelhead in a population will benefit the population ecologically by providing a buffer for predation and harvest mortality, and through contribution of marine derived nutrients to streams as well as additional production contributions, increasing the life-time reproductive success and commensurately productivity of individuals that successfully repeat spawn.

Three BiOp strategies to improve steelhead productivity

Three strategies to specifically improve b-run steelhead lifetime productivity are being evaluated. In years when large numbers of kelts that are in good condition can be collected, kelt reconditioning could likely meet the BiOp goal of increasing b-run steelhead abundance by 6%. Enhanced in-river migration strategies have resulted in marginal increases of repeat spawners that are annually consistent. A prudent approach would be to collect and recondition as many kelt steelhead as possible, continue to make in-river improvements, and in years when reconditioning facilities are at capacity implement a transport and release strategy.

Kelt Reconditioning Strategy

Kelt reconditioning is used as a means of increasing post-spawning survival and repeat spawning. This strategy includes two variations on reconditioning which are distinguished between length of time (short vs. long) that the post-spawned fish are held to aid their recovery. However, the reconditioning approach primarily being utilized is long-term reconditioning, which consists of holding post-spawned kelts for 6-10 months while they reinitiate feeding. A variable ratio of reconditioned females show positive growth rates and gonadal development after the first year (consecutive spawners), while other females required more than one year to remature (skip spawners). Data from 2013 showed that among hatchery origin kelts at Dworshak facility, 57% of females survived one year and 93% of the survivors rematured during the first year, while a second study at Yakima showed an average rate of consecutive year maturation of 56% between 2009-2014 (Everett et al. 2015). The only proposed transportation component would be that level of truck transport required to convey pre- and post-reconditioned kelts to and from the location of collection and release. Re-maturing kelts that have experienced long term reconditioning are released in the fall, typically in mid-to-late October, coincident with run-timing of adult steelhead migrating into upper Columbia tributaries as stream temperatures are declining.

Reconditioned fish are typically released near or downstream of their collection location so that they may over-winter and return to spawning locations on their own volition.

Short-term reconditioning is conducted over the 3-12 weeks needed for kelts to initiate post-spawn feeding, followed by transportation of kelts around mainstem hydro projects for release into the Columbia River downstream of Bonneville Dam and maturation in the Pacific Ocean (Branstetter et al. 2007). Short term reconditioning is currently less commonly implemented in the Snake River, although it may play a role in the transportation strategy for dry years.

Baseline success rates (kelt ocean return) for short and long term reconditioning are detailed in the 2009-10 KMP (http://www.salmonrecovery.gov/Files/Hatchery/2009-2010%20Kelt%20Plan_Final%20Draft.pdf).

The 2012-13 Kelt Management Plan presents extensive research results from the first five years of the reconditioning program sponsored by Nez Perce Tribe/CRITFC, as facilities were developed and significant progress was made in aquaculture techniques. Both the per capita success rate, and kelt capacity at key facilities is substantially larger than five years ago. The Action Agencies reason that the Long Term Reconditioning strategy has the potential to meet or exceed the 6% increased B-run steelhead abundance goal in years when kelt collections are high. However, in years with low kelt collection availability, this technique may not meet BiOp goals. (http://www.salmonrecovery.gov/Files/Hatchery/2012%20Snake%20River%20Kelt%20Management%20Plan_Final.pdf)

Enhanced In-river Migration Strategy

This strategy includes operational or structural modifications to hydro facilities that create conditions which could enhance survival rates of kelts passing a hydro facility. These modifications may physically guide or passively attract kelts towards either a collection-passage system or spillways. Perhaps the most important category of structural modification has been installation of surface passage weirs and sluiceways, which was completed for the eight FCRPS dams between LGR and BON in 2009. Subsequent monitoring has broadly indicated that kelts and adult steelhead are effectively finding these routes and experiencing high downstream survival rates through the route. The Action Agencies reason that as currently configured the enhanced in-river migration strategy solely would likely not meet BiOp goals, but could increase repeat spawners above the base period. In addition, a winter spill operation through the Dalles Ice and Trash Sluiceway was initiated in 2010 after identification of The Dalles Dam as a site of elevated fallback of overwintering steelhead with potential for increased mortality through the turbine route.

Collection and Transportation Strategy

Transportation of kelts around the hydro-system is hypothesized as a means of increasing kelt survival and iteroparity of natural populations by decreasing dam and reservoir passage mortality and conserving the already taxed energy reserves of emigrating kelts (Wertheimer and Evans, 2005). This strategy involves the collection and transportation of kelts by either barge or tank truck around the mainstem hydro projects, prior to release downstream of Bonneville Dam. Once kelts are collected, they can be transported and released or held for reconditioning. Reconditioning has produced much higher return rates than transport and release (Hatch et al. 2013b), thus the Action Agencies are currently recommending that collected kelts be retained for reconditioning until hatchery capacity is reached.

Following the installation of surface passage routes at all lower Columbia and lower Snake dams, the rate of passage through bypass systems where kelts are available for capture systematically decreased. At Lower Granite Dam, only 7% of kelts are accessible for collection at the bypass facility during periods of spill, and 22% of kelts during the weeks before initiation of spill on April 10th of each year (Dygert 2007, FPP). The total number of kelts collected in mainstem and tributary locations remains a limiting factor for the reconditioning, and transportation strategies, and also limits the number of kelts which may be tagged and monitored during in-river outmigration and for other research.

Kelt Master Plan Summary

The Nez Perce Tribe and CRITFC are working on development of the Snake River Basin Steelhead Kelt Reconditioning Facility Master Plan. This plan will evaluate alternatives for location and design of a kelt reconditioning facility.

Objectives of the 2014 KMP

The Kelt Management Plan for 2014-2015 is intended to evaluate progress of the three major strategies towards meeting the goals laid out in the 2008 FCRPS BiOp, and to provide an annual status update including recent research results and near-term planning for key infrastructure. The BiOp states that a Kelt Management Plan should be prepared every year, along with annual progress reports citing the status of project implementations and milestones. In addition to describing implementation of BiOp Actions (33 and 42) this Plan will also coordinate approaches with those implemented in the kelt reconditioning programs that were committed to under the 2008 Fish Accords with the Three Lower River Treaty Tribes and the Columbia River Inter-Tribal Fish Commission (CRITFC). Starting with the original framework introduced in the 2009-2010 plan, subsequent annual plans have progressed using approaches of adaptive management.

http://www.salmonrecovery.gov/Hatchery/KeltReconditioning.aspx

Evaluation of 2014 Progress for three BiOp strategies

The winter operation of the ice and trash sluiceway at The Dalles Dam for the benefit of overwintering steelhead has been continued annually since 2008. A benefit analysis for B-run Snake River steelhead based on 2008-2010 research at the dam allowed the Action Agencies to conclude that by extending the operating season to include December 1-15 and March 1-April 9, a 0.9 percent increase in adult returns would be realized. There was no implementation of kelt transportation in 2014.

Reconditioning efforts focused on B-run hatchery kelts have been developed and implemented at Dworshak NFH. In Dec. 2014, 37 natural origin female B-run kelts from the reconditioning program were released at Hamilton Island.

Current status and research results

Strategy 1: Long term reconditioning

The Kelt Steelhead Reconditioning and Reproductive Success Evaluation Project is a research, monitoring, and evaluation (RM&E) category project funded through the Columbia Basin Fish Accords. The project studies and evaluates two broad topics with respect to post-spawn steelhead, first it assesses reconditioning processes and strategies, and second, it measures reproductive success of artificially reconditioned kelt steelhead. It associates with RPA Actions 33 and 64 in the Federal Columbia River Power System Biological Opinion. RPA Action 33 requires the Action Agencies to develop, in cooperation with regional salmon managers, and to then implement a Snake River steelhead kelt management plan designed to provide at least a 6% improvement in B-run population productivity. Toward that goal, a variety of approaches are being tested and implemented including passage improvements and reconditioning kelt stage steelhead. Research on reconditioning and reproductive success of kelt steelhead sponsored under the project contributed 5 papers to the published literature in 2014. The team presented 14 project presentations in 2014.

Kelt stage steelhead were collected at the Chandler Juvenile Monitoring Facility (CJMF) adjacent to Prosser Hatchery on the Yakima River, the separator screen in the juvenile bypass system at Lower Granite Dam, and at the weir on Fish Creek (Lochsa River). Snake River B-run steelhead were collected at Lower Granite Dam and Fish Creek and reconditioned at Dworshak National Fish Hatchery (DNFH). Survival (from collection to October) of long-term reconditioned kelt steelhead was 61% and 30% for fish at Prosser and DNFH, respectively.

The kelt run at Lower Granite Dam was characterized using Genetic Stock Identification (GSI) from tissue samples of 4,171 natural-origin kelts and 2,288 hatchery-origin kelts collected from 2009-13. A total of 192 unique SNP loci (Hess et al. 2012) were pared to 188 loci following exclusion of a sex determining marker, and three *O. clarkii* hybrid determining markers, to be used for genetic stock identification analysis specific to the Snake River Basin. A description of SNP marker panels, laboratory and genotyping methodologies, and descriptive statistics used to evaluate assignment power and to conduct GSI analyses are described in detail in Hess et al. (2012) and Ackerman et al. (2012). Estimated stock proportions for natural-origin kelts are given in Table (1) and for hatchery-origin kelts in Table (2).

Table 3. Estimated stock proportions for natural-origin (NOR) kelts sampled at LGR during outmigration years 2009 through 2013. *Results are given in reference to all kelt assignments (all), and only the assignments that exceeded an 80% probability threshold (p>80). Assignments are the total number observed (n) and corresponding stock proportion (%) for each year as defined by reporting group.*

	assigned reporting group										
	LSNAKE	LOCLWR	SFCLWR	UPCLWR	GRROND	IMNAHA	LOSALM	SFSALM	MFSALM	UPSALM	total
all (n)											
2009	18	18	5	9	46	24	23	11	49	62	265
2010	90	81	24	35	192	151	54	38	121	438	1224
2011	89	87	31	52	255	140	54	43	128	234	1113
2012	121	119	37	43	286	114	59	28	104	217	1128
2013	39	39	8	17	108	51	27	10	37	105	441
overall	357	344	105	156	887	480	217	130	439	1056	4171
all (%)											
2009	0.07	0.07	0.02	0.03	0.17	0.09	0.09	0.04	0.18	0.23	---
2010	0.07	0.07	0.02	0.03	0.16	0.12	0.04	0.03	0.10	0.36	---
2011	0.08	0.08	0.03	0.05	0.23	0.13	0.05	0.04	0.12	0.21	---
2012	0.11	0.11	0.03	0.04	0.25	0.10	0.05	0.02	0.09	0.19	---
2013	0.09	0.09	0.02	0.04	0.24	0.12	0.06	0.02	0.08	0.24	---
overall	0.09	0.08	0.03	0.04	0.21	0.12	0.05	0.03	0.11	0.25	---
***p*>80 (n)**											
2009	0	2	4	7	12	15	6	5	35	31	117
2010	12	12	19	25	55	73	12	27	96	251	582
2011	4	21	24	37	85	66	11	29	96	96	469
2012	19	32	28	24	79	48	13	15	67	79	404
2013	4	11	6	13	33	18	4	7	22	48	166
overall	39	78	81	106	264	220	46	83	316	505	1738
***p*>80 (%)**											
2009	0.00	0.02	0.03	0.06	0.10	0.13	0.05	0.04	0.30	0.26	---
2010	0.02	0.02	0.03	0.04	0.09	0.13	0.02	0.05	0.16	0.43	---
2011	0.01	0.04	0.05	0.08	0.18	0.14	0.02	0.06	0.20	0.20	---
2012	0.05	0.08	0.07	0.06	0.20	0.12	0.03	0.04	0.17	0.20	---
2013	0.02	0.07	0.04	0.08	0.20	0.11	0.02	0.04	0.13	0.29	---
overall	0.02	0.04	0.05	0.06	0.15	0.13	0.03	0.05	0.18	0.29	---

Table 4. Estimated stock proportions for hatchery-origin (HAT) kelts sampled at LGD during outmigration years 2009 through 2013. *Results are given in reference to all kelt assignments (all), and only the assignments that exceeded an 80% probability threshold (p>80). Assignments are the total number observed (n) and corresponding stock proportion (%) for each year as defined by reporting group.*

	assigned reporting group										
	LSNAKE	LOCLWR	SFCLWR	UPCLWR	GRROND	IMNAHA	LOSALM	SFSALM	MFSALM	UPSALM	total
all (n)											
2009	2	2	9	0	4	2	1	0	1	20	41
2010	11	12	5	8	31	22	16	5	15	68	193
2011	42	54	45	22	64	52	30	0	21	268	598
2012	66	32	88	19	134	61	26	3	16	571	1016
2013	25	23	38	6	35	32	18	1	3	259	440
overall	146	123	185	55	268	169	91	9	56	1186	2288
all (%)											
2009	0.05	0.05	0.22	0.00	0.10	0.05	0.02	0.00	0.02	0.49	---
2010	0.06	0.06	0.03	0.04	0.16	0.11	0.08	0.03	0.08	0.35	---
2011	0.07	0.09	0.08	0.04	0.11	0.09	0.05	0.00	0.04	0.45	---
2012	0.06	0.03	0.09	0.02	0.13	0.06	0.03	0.00	0.02	0.56	---
2013	0.06	0.05	0.09	0.01	0.08	0.07	0.04	0.00	0.01	0.59	---
overall	0.06	0.05	0.08	0.02	0.12	0.07	0.04	0.00	0.02	0.52	---
***p*>80 (n)**											
2009	0	0	9	0	1	2	0	0	1	13	26
2010	0	2	2	7	10	11	6	4	13	35	90
2011	2	1	25	2	6	5	1	0	2	107	151
2012	4	6	72	6	26	34	1	2	4	332	487
2013	2	2	28	2	7	14	1	0	0	147	203
overall	8	11	136	17	50	66	9	6	20	634	957
***p*>80 (%)**											
2009	0.00	0.00	0.35	0.00	0.04	0.08	0.00	0.00	0.04	0.50	---
2010	0.00	0.02	0.02	0.08	0.11	0.12	0.07	0.04	0.14	0.39	---
2011	0.01	0.01	0.17	0.01	0.04	0.03	0.01	0.00	0.01	0.71	---
2012	0.01	0.01	0.15	0.01	0.05	0.07	0.00	0.00	0.01	0.68	---
2013	0.01	0.01	0.14	0.01	0.03	0.07	0.00	0.00	0.00	0.72	---
overall	0.01	0.01	0.14	0.02	0.05	0.07	0.01	0.01	0.02	0.66	---

Assigned reporting groups from with B-run steelhead components include the South Fork Clearwater (SFCLWR), Upper Clearwater (UPCLWR), South Fork Salmon River (SFSALM), and Middle Fork Salmon River (MFSLM). These reporting groups represented 20% of the natural-origin kelts and 13% of the hatchery-origin kelts reviewing all samples and restricting the reporting to only assignments that exceeded an 80% probability threshold the B-run reporting groups represented 34% of the natural-origin and 19% of the hatchery-origin kelts. This indicates that a reasonable abundance of kelt steelhead from B-run reporting groups are available for collection and reconditioning at Lower Granite Dam.

It is now well established that some female steelhead kelts remature after a summer of reconditioning, whereas other fish do not, and that plasma estradiol level from mid-August onward indicates maturation status. Evidence in both steelhead kelts and post-spawning rainbow trout suggests that the decision to remature is made early, before mid-July for kelts and during the 10 weeks after spawning in rainbow trout (Bromage, et al. 1992; Caldwell et al. 2013; Caldwell et al. 2014; Hatch, et al. 2013a). Plasma estradiol levels in rematuring and non-rematuring kelts for 2013 and 2014 at Prosser, Winthrop, and Dworshak were similar to previous years (Figs 1-3). Maturation rates at Prosser were in the range observed during previous years. Maturation rates at Prosser and Winthrop were comparable (2013 62.8% and 66.6%, respectively; 2014 46.0% and 53.4%, respectively). Maturation rates decreased from 2013 to 2014 at all three locations. This suggests that pre-capture environmental conditions common to the three projects may influence maturation rate. However, additional data is and analysis is required before conclusions can be drawn on this topic.

Maturation rates at Dworshak were lower than at the other two projects. There are a number of possible reasons for this difference. The Dworshak project reconditions both wild and hatchery origin B-run kelts, selected on the basis of body size. These fish spend two or more winters in the ocean before their maiden spawning, indicating that initial maturation (puberty) is delayed relative to typical steelhead. It is possible that rematuration schedules are similarly delayed. Steelhead in the Skeena and Nass systems in British Columbia have a life history similar to Snake River B-run steelhead. A substantial proportion of natural repeat spawners was found in these systems, however, all of them spent at least a full year in the ocean, indicating that they all had a skip spawning life history (Moore et al. 2014). In a previous report, only one of 25 Skeena female repeat spawners followed a consecutive spawning life history; 24 of 25 were skip spawners (Chudyk 1976). Thus, B-run steelhead may have an inherently low maturation rate as consecutive spawners. In addition, water temperatures at Dworshak are lower than at the other two projects, due to different water sources. Colder water temperatures may restrict growth and suppress rematuration. Finally, differences in feeding and disease treatment protocols may have resulted in less favorable growth conditions at Dworshak. Further investigation is required to examine these possibilities.

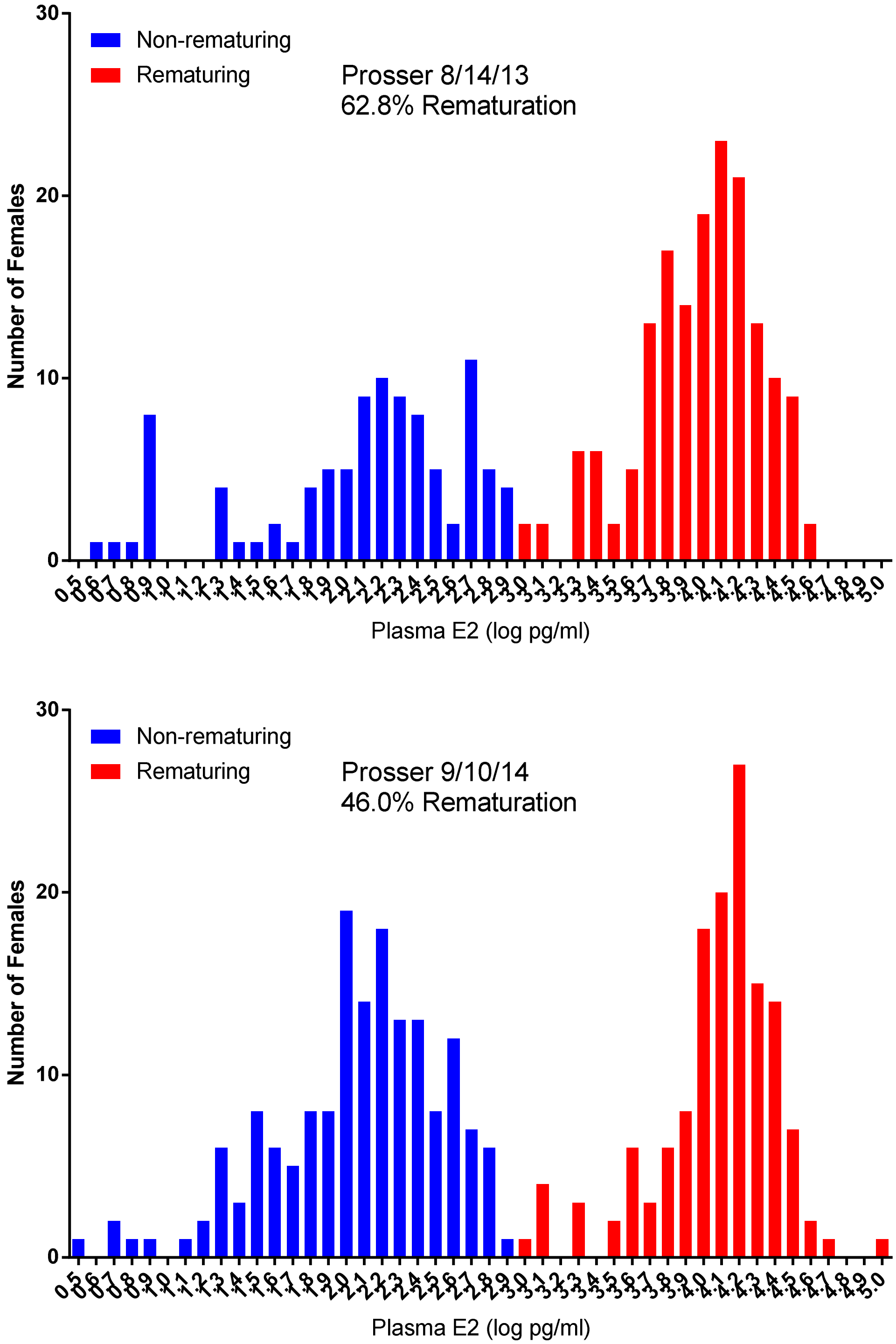

Figure 1: Plasma estradiol levels in female kelts in the reconditioning program at Prosser, Washington in 2013 and 2014.

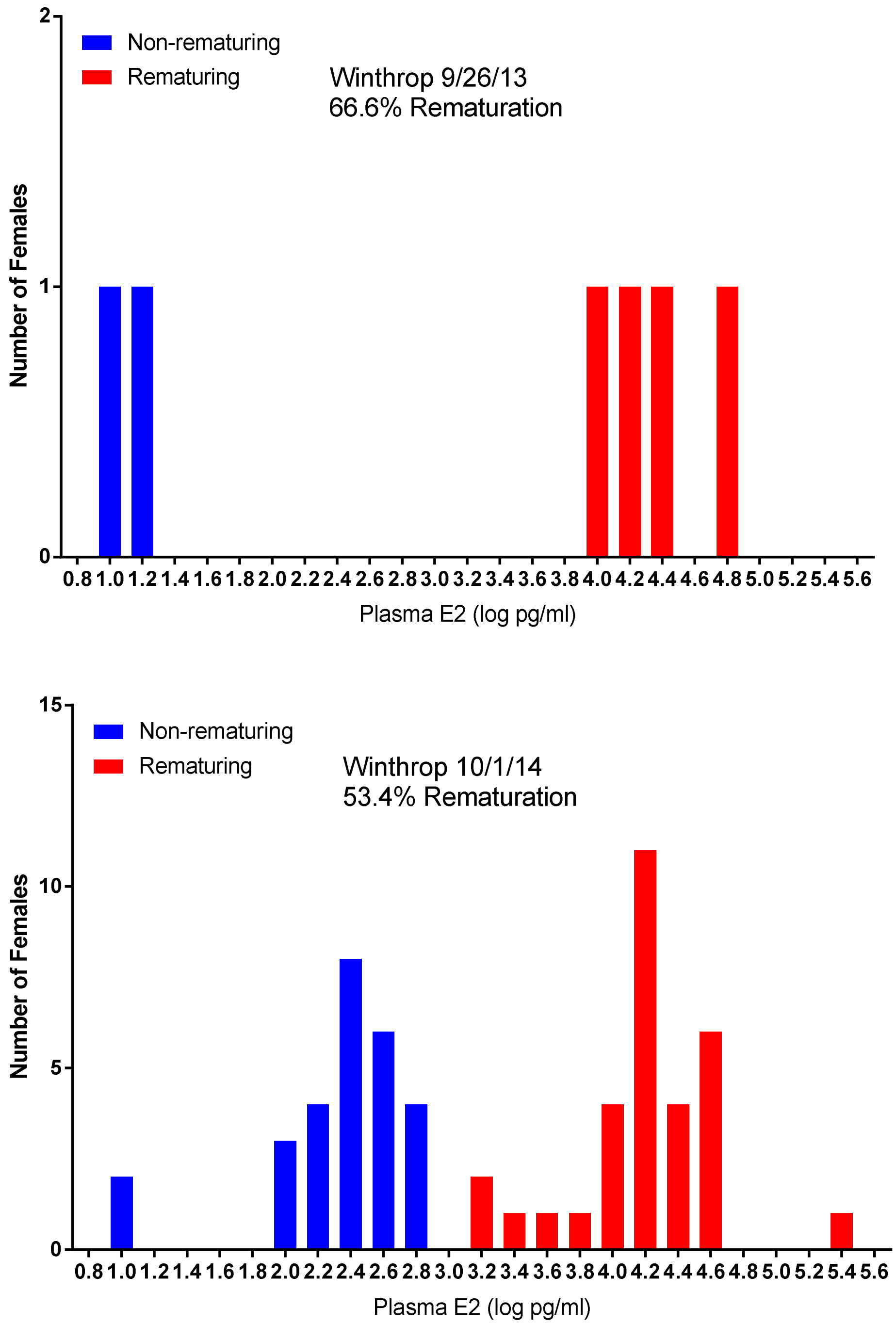

Figure 2: Plasma estradiol levels in female kelts in the reconditioning program at Winthrop, Washington in 2013 and 2014.

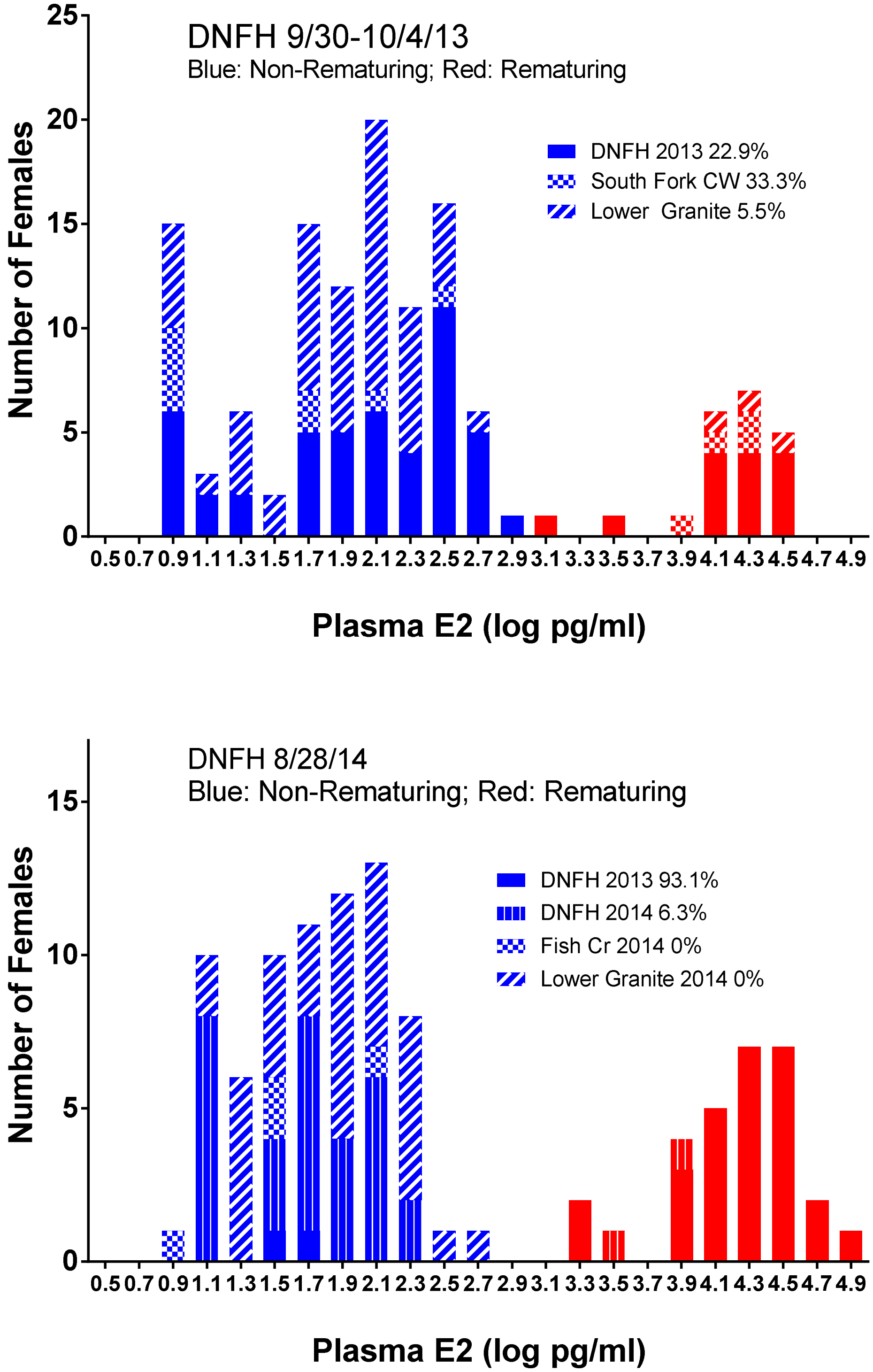

Figure 3: Plasma estradiol levels in female kelts in the reconditioning program at Dworshak National Fish Hatchery, Idaho in 2013 and 2014.

Among fish held at Dworshak, air spawned wild kelts from the South Fork of the Clearwater (2013) and air spawned hatchery origin kelts had the highest rematuration rates. This suggests that energy expenditure during spawning and post-spawning migration may suppress maturation. Obtaining kelts as close as possible to spawning is expected to result in increased maturation rates. Air spawned kelts from the South Fork of the Clearwater River localized broodstock program, and kelts collected from tributary weirs such as Fish Creek on the Lochsa River are highly desirable to achieve project goals.

We compared repeat spawner movements against any previous historical detections that they may have had as maiden fish to evaluate fidelity of repeat spawners to previous spawning area (repeat homing) in the Yakima River. We found that movement patterns where consistent with previous years PIT-tag observations in 2012/13 for both groups of repeat spawners (radio and PIT tagged only). The sample size was small (12) but preliminary evidence would suggest that repeat spawning fidelity is established even after artificial kelt reconditioning is conducted. The only major difference we found is that they did take longer in the natal spawning stream than in 2013, which was between 16-49 days longer. We believe that this is caused from environmental variability from differences in stream flow from year to year and with the additional possibility of variance in mate selection timing.

At Dworshak National Fish Hatchery we evaluated egg quality and reproductive parameters in hatchery origin maiden female steelhead and reconditioned kelt. Survival and maturation of hatchery origin kelts was much lower in 2014 than 2013. This was likely a result of fish being in poorer condition at intake, 2014 was a low run year for Clearwater steelhead. It was difficult to obtain fish for our studies due to concerns about the hatchery meeting its egg take requirements, and fish were obtained late in the season. Many of these fish had been sorted repeatedly using CO_2 anesthesia before they were air spawned. In addition, several problems with our formalin treatment system during the spring likely increased mortality. Maturation percentage as consecutive spawners for air-spawned hatchery origin kelts at DNFH has ranged from 80% (2012 spawn year, 4 of 5 fish), to 22% (2013 spawn year), to 6% (2014 spawn year). Both pre-capture and culture conditions likely play a role in determining maturation percentage. Culture conditions have been variable between years. For example, in 2012, fish were placed on effluent water due to a problem with the water line supplying the kelt tanks, resulting in high mortality. Even in the Prosser reconditioning project, where culture conditions are constant, rematuration rates range from 25% to 80%. More data is required before any conclusions can be drawn regarding typical survival and rematuration rates for hatchery origin kelts.

Encouragingly, the maturation rate for 2013 fish held for an additional year (skip spawners) was high (93.1%). This suggests that depletion of energy reserves due to the demands of migration, ovarian development, and spawning suppresses rematuration in kelts. Consistent with this idea, muscle lipid levels in 2013 kelts that deferred spawning were higher than those of 2014 kelts at intake.

Plasma estradiol level indicated maturation status of female kelts by 8/9/13, indicated that reproductive trajectory is set before this date. This is similar to results from the kelt reconditioning project at Prosser, Washington, showing that reproductive trajectory is determined within the first few months after intake (Branstetter et al. 2011; Hatch et al. 2013a; Hatch et al. 2012). Estradiol levels increased in both rematuring and non-rematuring females from 8/9/13 to 10/3/13. Estradiol level increases to a peak approximately 6 months before spawning in rainbow trout (Prat, et al. 1996; Tyler and Sumpter 1996; Tyler et al. 1990). The increase in non-rematuring fish may be due to the presence of a dummy cycle (Taylor, et al. 2008).

Muscle lipid levels were significantly higher in rematuring versus non-rematuring kelts in October, consistent with the association between high muscle lipid levels and rematuration that has been found at Prosser (Hatch 2013, Hatch 2012). Levels increased in non-rematuring kelts and decreased in rematuring kelts as spawning time approached, resulting in significantly higher muscle lipid levels in non-rematuring kelts by February. The decrease in muscle lipid stores in rematuring fish is likely due to mobilization to support ovarian development. During exogenous vitellogenesis, which occurs during the final six months of ovarian development, stored lipids are mobilized and transported to the ovary, where they are incorporated into the eggs (Lubzens, et al. 2010; Tyler and Sumpter 1996). Non-rematuring kelts increased lipid levels to much higher than kelts at intake in the spring, which may account for the much higher rematuration percentage of fish held for a second year.

The spawn timing of consecutive spawning reconditioned kelts was slightly earlier (1.5 weeks) than their maiden spawning, although this difference was not significant. Atlantic salmon repeat spawners have been found to ascend rivers earlier than maiden spawners (Niemela, et al. 2006b). Results of the present study suggest that spawn timing was not substantially altered by artificial reconditioning. Fecundity increased with length in both maidens and consecutive spawning kelts, as expected (Quinn 2005; Quinn et al. 2011). No difference in the length-fecundity relationship was detected between maidens and reconditioned kelts, however, the sample size for reconditioned kelts was low. The significantly greater fecundity and egg size of consecutive spawning kelts (1.23 and 1.19 fold maiden levels, respectively), suggests that reconditioned kelts have greater productivity than maidens. The greater fecundity of Atlantic salmon repeat spawners results in a disproportionate contribution to population productivity (Halttunen 2011; Moore et al. 1995; Niemela, et al. 2006a). Alternate spawning reconditioned kelts are expected to have even higher fecundity than consecutive spawning fish. Fertilization success in consecutive repeat spawning reconditioned kelts was not significantly different from maiden spawners. Thus, there is no indication that artificial reconditioning decreases egg quality. Median fertilization success was 92% in maiden spawners and 96% in consecutive spawning reconditioned kelts. Fertilization percentages of 80% and greater are considered to indicate good egg quality in commercial rainbow trout egg production for aquaculture, and egg lots with less than 80% fertilization are considered to be sub-fertile (Stoddard et al. 2005). No reconditioned kelts and few maiden fish were sub-fertile.

We attempted to identify factors measured at intake into reconditioning associated with reproductive trajectory. We expected size (length, weight or mass-length residuals), body condition (K), and/or muscle lipid levels to be significantly different at intake between fish that spawned and fish that deferred, based on a condition-dependent life history strategy. However, none of these factors differed significantly between spawning and deferring fish. Moreover, none of these factors were found to be significant predictors of maturity in multiple linear regression models. It is possible that this is a result of the coarse resolution of our measurements and our limited sample size. However, the possibilities also remain that 1) reproductive trajectory depends on aspects of physiological condition at intake that were not captured in our measurements, or 2) reproductive trajectory does not depend on condition at intake. Further study is required to investigate these possibilities.

In contrast to the lack of any detectable effect of factors measured at intake on reproductive trajectory, growth rate during reconditioning was elevated in rematuring fish from intake to August. This is before ovarian growth would be expected to substantially contribute to increases in weight. In a multiple linear regression model, specific growth rate from intake to August was the strongest predictor of maturation. Muscle lipid stores were also elevated in rematuring fish in October compared with non-rematuring fish. Elevated growth rates and increased late summer to fall muscle lipid levels have been consistently found in rematuring Prosser kelts. The consistent and strong association of growth rate and maturation suggests that 1) increased growth rate stimulates maturation, and/or 2) maturation stimulates growth. Evidence exists for both of these possibilities. Growth rate has been found to greatly impact divergent maturation within populations of other salmonids, such as Chinook (Shearer, et al. 2006), and body growth has been found to influence oocyte development rate during the critical period for initiation of maturation in Coho (Campbell, et al. 2006a; Campbell et al. 2006b). In rainbow trout, elevations in growth rate and plasma levels of insulin-like growth factor-1 (Igf-1) were found in rematuring fish, and preceded increases in plasma levels of reproductive steroids (Taylor et al. 2008). Igf-1 is a growth stimulatory metabolic hormone (Picha, et al. 2008). On the other hand, reproductive steroids and other gonadal factors stimulate growth in fishes (Bhatta, et al. 2012).

We continued our evaluation of reproductive success of reconditioned kelt steelhead released into the Yakima River using parentage analysis. The largest numbers of parentage assignments to date were seen in the 2013 brood year analysis. This year's analysis also included pre-spawn maidens for the first time, helping to provide a total of 137 progeny assignments. Of these, at least 23 are attributed to a spawning event following successful reconditioning of a kelt. Two additional offspring assigned to a reconditioned kelt, but at longer (93 and 98mm) that could also be attributed to the first time spawning event for these fish.

The presence of progeny show that reconditioned kelts are able to successfully spawn in the wild. While relative reproductive success of pre-spawn maidens was greater than that of reconditioned kelts, any spawning by a reconditioned kelt is additive to the population and should be considered a success.

The vast majority of adults in this study had zero offspring assignments, but this was not unexpected as the number of adults interrogated is a fraction of the anadromous population and does not account for the large resident component in the Yakima River Basin. We were able to assign 26.7% of the juveniles collected to at least 1 adult anadromous steelhead, indicating that we are sampling in areas where steelhead spawning has occurred. Increasing this percentage would be desirable, but may not be feasible given our sampling structure. However, 26.7% may be adequate for relative reproductive success purposes, and we are planning to increase the juvenile sample numbers in the future.

Future sampling will continue to focus on age-0 fish in areas that spawning was expected to have occurred. For 2013, at least one progeny was seen for all locations except Willy Dick Creek in the Toppenish drainage. If no progeny are detected for this site in 2014, it will likely be excluded in 2015.

Sampling efforts in 2014 will include a component that targets areas that radio tagged kelts are suspected to have spawned in. Sampling efforts in 2015 will increase the number of samples taken from areas associated with anadromous sampling. Although we will still lack the ability to account for the resident population, and will still not genotype the majority of the anadromous adults, it is hoped that the increase in juvenile sampling will provide adequate data for statistical analysis.

A model was developed for the purpose of examining population recovery from the perspective of the kelt reconditioning program. The model mimics iteroparity in ways explicit to body condition, reconditioning, and release method. We have shown that kelts contribute up to 10% of spawning if sufficient kelts are captured and reconditioned. This is obvious from the raw data on success and survival rates, but speculation on the relative benefit of capture and reconditioning has remained elusive. This modeling tool provides the means to examine several questions regarding potential avenues for recovery, and management options for doing so.

The model was parameterized with constant rates obtained from tagging data, constant rates estimated from a Ricker spawner to smolt recruitment function model fitting, and constant survival rates obtained from fitting the population model to spawner returns. The rates being constant, the best fitting model would necessarily not fit all the data perfectly. Given that there was a systematic increase in spawning abundance during the period of time that the population model was used to fit the spawning abundance data, the best fit resulted in overestimation of spawners in the 1990's, and an underestimation of spawners between 2000 and 2013. As a result of the recent underestimation, the projected spawning abundance is potentially biased low. This could be for a number of reasons. First, it's possible that survival rate have been better than average in recent years. This seems like a likely scenario since empirical spawning numbers have increased despite smolt numbers being constant or declining since 2000. This is consistent with recent population increases in Columbia River salmonid populations, and points to improved mainstem or ocean survival conditions. If an argument can be made that model projections relying on the constant rates are underestimating spawning abundance in recent years, and if the cause of this is that smolt to adult survival is higher than average currently, then it stands to reason that performance measures are conservative if based on this model parameterization. The obvious solution is to characterize the cause of the systematic change in survival so that the bias can be accounted for, but for the meantime it's reasonable to conclude that the benefits of kelt reconditioning are being underestimated since the returns rate is biased low.

The model remains in development, but efforts in 2014 have resulted in significant advancement of the quantitative validation of the model. Despite not having full age structure implemented, we have been able to demonstrate a useful comparison of production levels with simple alteration of a key parameter: the kelt capture rate. This same type of comparison can be implemented on other key variables, such as pre-spawn mortality, repeat kelt rate, sensitivity of Ricker production parameters to environmental variation, sensitivity of kelt survival to body condition, and sensitivity of body condition to environmental conditions and density.

We remain cautious about our results because the we are at a relatively early stage of statistical model validation, and we have not incorporated the full suite of empirical data that could be brought to bear on this analysis, but the model has shown promise that it can be used to evaluate kelt management strategies in conjunction with broader spawning and rearing mechanisms of production and survival.

Strategy 2: Transportation

We are developing a spreadsheet model of management scenarios to address “what if” simulations. This model will be completed during the first half of 2015.

Strategy 3: Enhanced in-river migration

McNary Dam adult steelhead survival In February 2015, there are plans to estimate passage efficiency of turbine and surface weir routes at McNary Dam with hydroacoustics using steelhead released in the forebay and permitted to volitionally migrate downstream.

The Bonneville Dam PH2 corner collector was opened nearly one month early (March 17, 2014) in an effort to provide a safer route of passage for early-migrating steelhead kelts, primarily originating from the lower Columbia River.

The ice and trash sluiceway at The Dalles Dam and the corner collector at Bonneville Dam were operated prior to the use of the spillway at any time the projects were required to involuntarily spill due to high flows before the normal March 1 start in the Fish Passage Plan. Involuntary spill through the surface passage routes at Bonneville and The Dalles dams is prioritized before operation of the less efficient spillways for adult steelhead that need to return to natal streams upon overwintering or kelt returning to the ocean after spawning.

In 2012 and 2013, Pacific Northwest National Laboratory conducted a study that summarized the passage proportions and route-specific survival rates of downriver migrating steelhead kelts that passed through Federal Columbia River Power System (FCRPS) dams (Colotelo et al. 2013; Colotelo et al. 2014). To accomplish this, a total of 811 steelhead kelts were tagged with Juvenile Salmon Acoustic Telemetry System (JSATS) transmitters in order to estimate individual passage route rates and survival, as well as reach survivals to the estuary downriver of Bonneville Dam. In 2014, PNNL initiated a diagnostic evaluation of the Colotelo et al. JSATS studies in order to elucidate possible cause of the decrease in passage percent and route survival between the higher flow year 2012 and the lower flow year 2013 (Table 5) (Harnish *et al. in review*).

Harnish, RA, AH Colotelo, X Li, KD Ham, and ZD Deng. December 2014 Draft. In Review. Factors affecting route selection and survival of steelhead kelt at Snake River dams in 2012 and 2013. Prepared by Pacific Northwest National Laboratory, Report # PNNL-23941,Richland, WA for the US Army Corps of Engineers, Walla Walla District, Walla Walla, WA.

Table 5. Passage route proportions and survival estimated at LGR, LGO, and LMN in 2012 and 2013

		2012					2013				
Dam	Measure	n	Traditional Spill	Spillway Weir	Turbine	JBS	n	Traditional Spill	Spillway Weir	Turbine	JBS
LGR	Passage Percent	124	25.80%	57.30%	6.50%	5.60%	144	12.50%	79.90%	1.40%	4.90%
	Survival (SE)		0.906 (0.052)	0.901 (0.035)	0.875 (0.117)	0.857 (0.132)		0.706 (0.111)	0.667 (0.046)	1.000 (0.000)	0.333 (0.193)
LGO	Passage Percent	288	24.70%	60.80%	4.50%	10.10%	365	15.60%	71.00%	5.20%	6.80%
	Survival (SE)		0.943 (0.028)	0.967 (0.014)	0.779 (0.119)	0.966 (0.034)		0.821 (0.051)	0.937 (0.015)	0.842 (0.084)	0.880 (0.065)
LMN	Passage Percent	258	20.50%	68.00%	4.60%	6.90%	294	16.00%	71.10%	6.80%	5.40%
	Survival (SE)		0.926 (0.036)	0.983 (0.010)	0.583 (0.142)	1.000 (0.000)		0.826 (0.056)	0.927 (0.018)	0.842 (0.084)	0.938 (0.061)

Bayesian model averaging of multivariable logistic regression models was used to identify the environmental, temporal, operational, individual, and behavioral variables that had the highest probability of influencing the route of passage and the route-specific survival probabilities for kelts that passed Lower Granite (LGR), Little Goose (LGS), and Lower Monumental (LMN) dams in 2012 and 2013. The posterior probabilities of the best models for predicting route of passage ranged from 0.106 for traditional spill at LMN to 0.720 for turbine passage at LGS. Generally, the behavior (depth and near-dam searching activity) of kelts in the forebay appeared to have the greatest influence on their route of passage. Shallower-migrating kelts had a higher probability of passing via the weir and deeper-migrating kelts had a higher probability of passing via the JBS and turbines than other routes. Kelts that displayed a higher level of near-dam searching activity had a higher probability of passing via the spillway weir and those that did less near-dam searching had a higher probability of passing via the JBS and turbines. The side of the river in which kelts approached the dam and dam operations also affected route of passage. Dam operations and the size and condition of kelts were found to have the greatest effect on route-specific survival probabilities for fish that passed via the spillway at LGS. That is, longer kelts and those in fair condition had a lower probability of survival for fish that passed via the spillway weir. The survival of spillway weir- and deep-spill passed kelts was positively correlated with the percent of the total discharge that passed through turbine unit 4. Too few kelts passed through the traditional spill, JBS, and turbine units to evaluate survival through these routes.

Phipps, J and PG Heisey. 2015. Direct Injury and Survival of Adult Steelhead Passing Over a Spillway Weir and Through a Turbine at McNary Dam. Prepared by Normadeau Associates, Drummond, PA for US Army Corps of Engineers, Walla Walla District, Walla Walla, WA.

All previous FCRPS hydrosystem passage rate and survival studies for kelt have indicated that surface weir passage during relatively average or above average flow years outperforms other routes. However, no adult steelhead survival studies have been performed to elucidate the direct benefits of surface spill passage to steelhead survival compared to alternate routes.
steelhead raises powerhouse passage concern. Temporary Spillway Weirs (TSWs) have been installed at MCN to benefit juvenile salmonids. An increasing proportion of adult steelhead have been observed passing through the TSW by kelt and overwintering prespawn steelhead in the spring. Juvenile salmonids HI-Z tag direct survival estimates through spill and bypass systems have been higher (median 98.6% for 222 tests) than those for turbine (median 95.9% for 167 tests). Generalized assumption that these high direct survival estimates could be applicable to adult salmonids have not been verified. Survival estimate (1 and 48 h) of TSW and Turbine passed fish were 97.7 and 90.7%, respectively. The Malady Free (MF) rate estimates were 97.7 and 92.7% for the TSW and Turbine passed fish, respectively. Desired precision (ε) $\leq \pm 0.05$; 95% of the time was met for all survival estimates. TSW survival was significantly higher than turbine survival; malady rates were not significantly different. Qualitative evidence that mortality of turbine passed fish was size related. Injuries to turbine passed fish were severe and consisted primarily of severance or decapitation

O'Connor, RR, JL Maenhout, AF Evans, D Thompson, S McCutcheon, A Hopkins, ML Taper, C Frantz, Q Payton, and F Loge. 2015. Lower Granite Dam juvenile fish collection channel prototype overflow weir and enlarged orifice biological evaluation, 2014. Prepared by University of California, Davis, Davis, CA, Blue Leaf Environmental, Ellensburg, WA, Real Time Research Inc, Bend, OR, and Biomark, Boise, ID for US Army Corps of Engineers, Walla Walla District, Walla Walla, WA.

This second year study was performed to confirm findings of year one that the most biological beneficial prototype passage structure that passes juvenile and adult salmon and juvenile lamprey from the gatewell to and through the collection channel at Lower Granite Dam would be the enlarged 14 inch orifice compared to the existing 10 inch orifices and an overflow weir. The study was designed to evaluate differences in travel times and fish injury rates between the prototype structures. Adult steelhead kelt (n=92) were PIT-tagged, photographed to access external health metrics, and then released from May 2-May 21. Equivalent Orifice passage efficiency (OPE) for steelhead kelt was 91.7% for kelt released during operation of the 14-inch orifice with its light ring on (some avoidance of artificial light compared to overhead ambient light) to 100% for all the other passage routes tested including the control. Travel times for adult steelhead kelt were similar, albeit slightly slower, than those of juvenile salmonids, with similar delay observe at the weir during the day. Steelhead kelt were only released during the day when adults typically move pass the dam, but moved through the Juvenile Bypass System (JBS) more quickly during operation of the 14-inch orifice. Kelt total travel times were highest during operation of the overflow weir. Time spent in the bypass channel accounted for a greater proportion of the total travel time for all passage routes (Figure xx). The rates and severity of injury among kelt released into prototype passage routes were low, with little effect of route or individual fish characteristics.

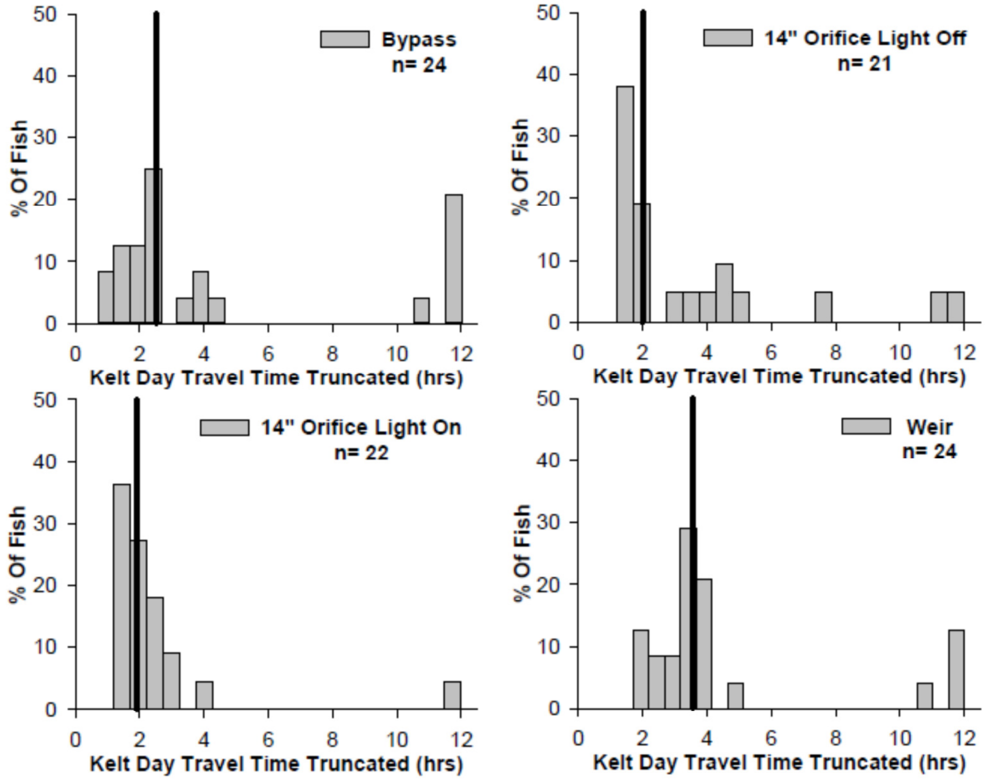

Figure 4. Travel times for steelhead kelts released into Gatewell 5A during spring 2014 block design operation of the sharp-crested weir, 14-inch orifice with light ring off, 14-inch orifice with light ring on, and directly into the bypass channel at Lower Granite Dam. All travel times greater than 12 hours were truncated to 12 hours to accommodate the operation schedule for each passge route in Gatewell 5A. Solid black line represents the 50th percentile.

Keefer, ML and CC Caudill. 2014. Estimating iteroparity in Columbia River steelhead using records archived in the Columbia River PIT Tag Information System (PTAGIS) database. Technical Report 2014-1. Prepared by University of Idaho, Moscow, ID for US Army Corps of Engineers, Walla Walla District, Walla Walla, WA.

Keefer and Caudill (2014) used steelhead PIT-tag detection data archived in the Columbia River PTAGIS database to estimate the incidence of repeat spawning migration (i.e., iteroparity) in the multi-stock metapopulation upstream from Bonneville Dam. They evaluated migration histories from 53,282 adult steelhead detected at Bonneville Dam over 11 adult migration years (2000-2010). The dataset included winter- and summer-run life history types, wild- and hatchery-origin fish, and were from a wide variety of populations and management groups.

In total, 7 winter steelhead and 132 summer steelhead were considered to have initiated a second spawning migration based on appropriately-timed detections at Bonneville Dam in two migration years. Six of the seven winter steelhead were consecutive year spawners and the seventh was a skip year spawner. The summer group was half consecutive spawners and half skip spawners. With all years combined, Bonneville-to-Bonneville iteroparity estimates for the primary life history×origin groups were: 2.78% (winter, wild), 0.44% (winter, hatchery), 0.56% (summer, wild), and 0.16% (summer, hatchery).

At several geographic scales, wild steelhead had iteroparity estimates that were several times higher than those for hatchery steelhead. This was likely the result of more liberal harvest regulations for hatchery fish and the collection of hatchery adults for broodstock (i.e., limited survival to kelting). Younger steelhead (i.e., 1-sea, or 'A-group') tended to have higher iteroparity estimates than older steelhead (i.e., 2-sea, or 'B-group'), though this pattern was not universal across populations. Winter steelhead had higher iteroparity than summer steelhead, but there were no direct comparisons of life history groups within individual tributaries. Iteroparity rates for wild steelhead decreased as freshwater migration distance increased, presumably reflecting higher kelt mortality for interior Columbia and Snake River populations.

Annual iteroparity estimates for wild steelhead were positively correlated with river discharge during the kelt outmigration. After accounting for this effect, we found limited but indirect evidence that installation and increased operation of surface flow outlets (SFOs) at Columbia and Snake River dams may have contributed to increasing steelhead iteroparity rates during the study period. However, Keefer and Caudill (2014) also concluded that the PTAGIS dataset was not particularly well suited to address this management question because sample sizes in the response variable (repeat-spawners) were small in several years and there was high year-to-year variability in which steelhead populations were PIT- tagged. No management groups (e.g., wild steelhead from individual populations or Snake River 'B- group' steelhead) had sufficient numbers of PIT-tagged fish in all study years. Keefer and Caudill (2014) provide several recommendations for evaluating the efficacy of SFOs for increasing iteroparity beginning with increasing PIT-tagging of individual populations and management aggregate populations like B-run steelhead tributaries.

The PTAGIS-based iteroparity estimates do provide important baseline data, both as a time series of estimates for aggregated steelhead populations and as estimates for a range of individual management groups. These data can be used for future conservation and management initiatives for Columbia basin steelhead.

Keefer, ML, T Clabough, M Jepson, and C Caudill. 2014. FCRPS overwintering distribution and fallback behavior by adult steelhead radio-tagged at Bonneville Dam in 2013-2014. Letter Report. Prepared by University of Idaho, Moscow, ID for US Army Corps of Engineers, Walla Walla District, Walla Walla, WA.

Steelhead partially overwinter throughout the FCRPS cued by water temperature and photoperiod. Snake River fish have particularly diverse behaviors. Studies from 1996-2003 suggest that 10,000s steelhead overwinter in FCRPS during most years, comprising annual estimates of 7-20% of "successful" migrants of the whole steelhead run (Keefer et al. 2008). Late migrants are far more likely to overwinter with many nominal B-group Snake River fish represented. Motivation for the current study was the 2008

FCRPS BiOp RPA Actions to increase B-group survival and productivity through increasing kelt survival mechanisms of passage. 789 summer steelhead were radio-tagged at Bonneville Dam in 2013. The sample was weighted for later 'B-group' migrants to increase the number of fish with likelihood of FCRPS overwintering behaviors since later migrants were not adequately represented in the early studies (Keefer et al. 2008). Minimum FCRPS overwintering estimates were 7.7% for steelhead tagged in June to early August and 27.4% for those tagged in late September to mid-October. Estimates were higher (12.2% and 37.8% respectively) when excluding fish harvested in the main stem and those tagged fish that were unaccounted for. Overwintering steelhead were distributed throughout the FCRPS, but the largest numbers were in Little Goose and Lower Granite reservoirs; this distribution was due, in large part, to the abundance of Clearwater River fish in the sample. The FCRPS overwintering group was predominantly composed of Clearwater River steelhead (68%), followed by John Day River (9%), and Snake River upstream of Lower Granite reservoir (9%). The remaining overwintering fish were last detected at a variety of sites, including the Salmon (n=4), Grande Ronde (n=1), Imnaha (n=1), Tucannon (n=1), White Salmon (n=1), Hood (n=1), and Klickitat (n=1) rivers; 8% were last recorded at main stem sites. 95 steelhead fell back at Lower Columbia and Snake River dams 158 times between 1 November and 31 March with most frequent fallbacks during this time at The Dalles and McNary dams. Forebays were monitored with aerial antennas from early December through 1 April. Estimated fallback routes were: powerhouses (46%), spillways (18%), ice/trash sluiceways (10%), adult ladders (6%), and unknown (20%). Several steelhead that fell back in the winter held in or near the forebays for days to weeks during periods of no spill. More than half (56%) of pre-spawn steelhead that fell back from 1 November to 31 March were subsequently detected in potential spawning tributaries. 194 fallback events were recorded for 59 likely post-spawn steelhead kelts in April and May, 59 events at lower Columbia dams and 135 events at Snake River dams, mostly at Lower Granite and Little Goose dams.

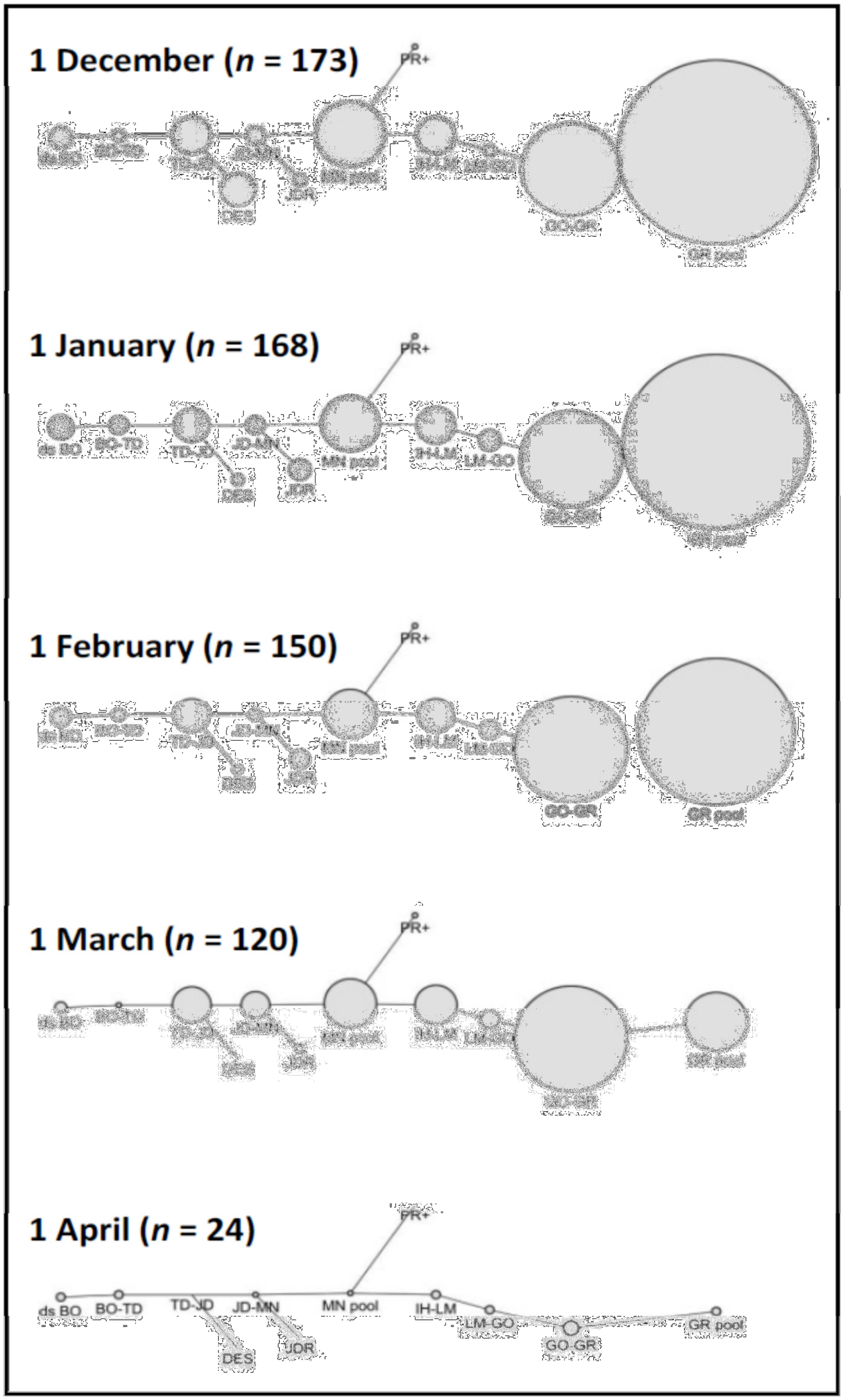

Figure 5. Estimated locations where overwintering radio-tagged steelhead were in the FCRPS on the first month from December 2013 to April 2014. Fish in the Deschutes and John Day rivers eventually migrated to other tributaries and so were included here. Circle size is scaled relative to abundance. Sample sizes decrease through time as steelhead enter tributaries.

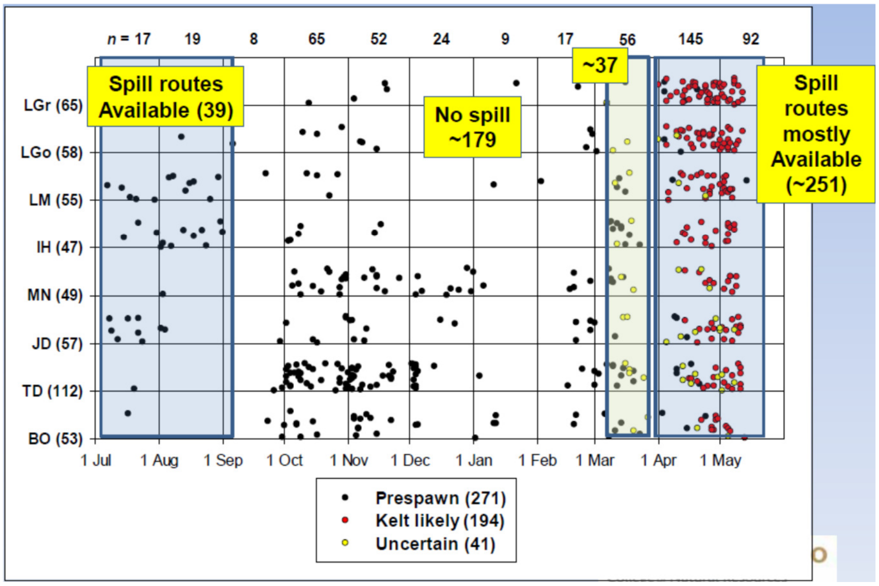

Figure 6. Estimated dates that radio-tagged steelhead fell back at dams in 2013-2014. Fallback events are color coded to represent likely steelhead reproductive status at the time of fallback and randomly jittered on the y-axis for each dam to better display the data. Two fallback events at Priest Rapids Dam and two Bonneville events in June are not shown.

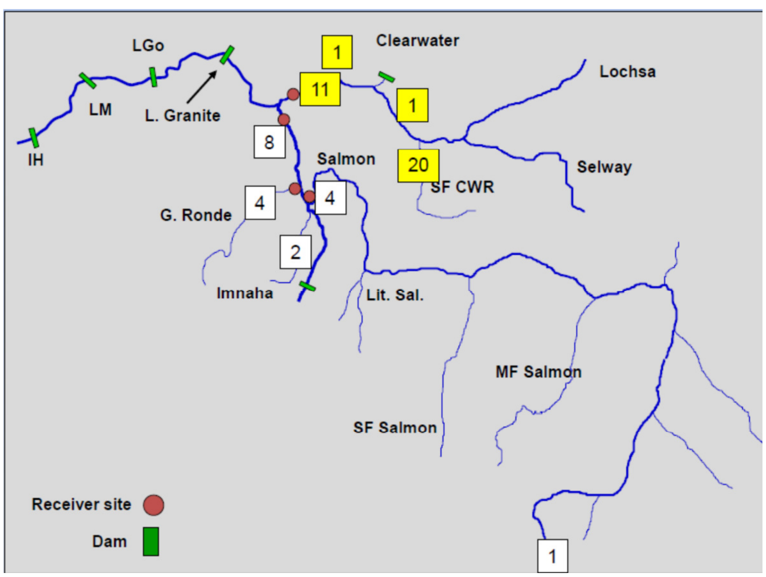

Figure 7. Locations of 52 fallback events of overwintering steelhead radiotagged in 2013-2014.

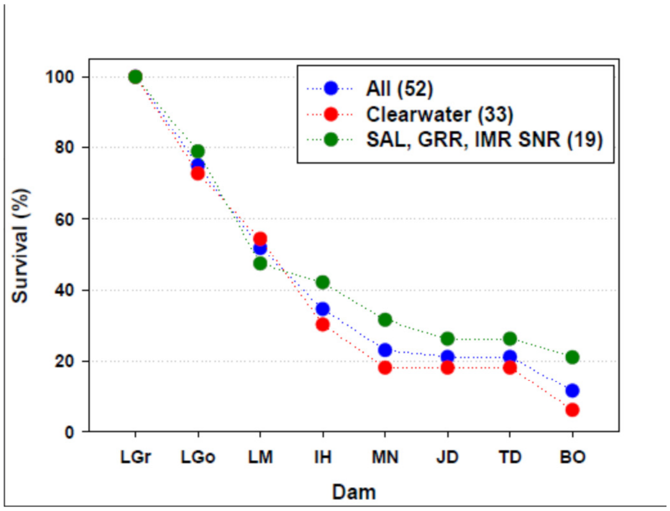

Figure 8. Cumulative survival rates of kelt tagged above Lower Granite Dam in the Clearwater River (red) and Salmon/Grande Ronde/Imnaha /Snake Rivers (green). ~10-20% of Snake River kelts survived to Bonneville dam, with an average travel time of 1-3 weeks among successful migrants. Attrition was highest in the lower Snake River. Kelts originating from the Clearwater River experienced lower survival rates than other Snake River groups.

Future Planning (2015-2018) for infrastructure and research

Strategy 1: Long term reconditioning

From an adaptive management standpoint in 2015, the experimental spawning channel at Cle Elum Hatchery will be available, so a proposal and study plan is currently being drafted to use the channel in an evaluation of reconditioned steelhead reproductive success. Additional components such as resident rainbow trout contribution and maiden steelhead reproductive success may also be added. We are also searching for potential stream locations to conduct a relative reproductive success study.

Four, 16 foot-circular tanks are used to recondition adult steelhead and the capacity of those tanks is about 200 adult steelhead, but varies depending on flow. Following implementation of the Master Plan, the ability to reach RPA Action 33's goal of a 6% increase in abundance at Lower Granite Dam will likely be limited by kelt collection, In 2015, collections will be made at the Lower Granite Dam juvenile bypass, and at the Fish Creek weir, a tributary of the Lochsa River, where an additional 75 fish should be collected. Future years (2016 +) will seek collections at additional tributary locations and a pilot study for collection and holding potential at Little Goose Dam, where approximately 100 good condition b-run kelts are observed annually. These additional collection locations should provide adequate abundance of kelt steelhead to meet the goal of RPA Action 33.

Strategy 2: Transportation

The 2014 Corps Fish Passage Plan (FPP) for the Lower Columbia and Lower Snake River hydropower projects (http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/2014/final/FPP14_Final_061314.pdf) calls for collection of post-spawn steelhead off the Lower Granite Separator for the Nez Perce reconditioning program. A similar number of a-run and b-run kelt, up to about 400 total, will be provided to CRITFC/NPT researchers at Dworshak Dam reconditioning facility, and remaining kelt will be PIT-tagged and released into tailwaters. There are currently no plans for transporting collected kelts to the estuary during years with average or high flow conditions, however in the next year, the Action Agencies will work to develop a low flow kelt outmigration and return spawner passage plan for the FPP in collaboration with juvenile salmon and adult salmon passage survival modifications.

Strategy 3: Enhanced in-river migration

In 2015 the Corps of Engineers research will finalize the diagnostic evaluation of the third year of the in-river kelt survival study (Colotelo et al. 2012, 2013, Harnish *et al. in review*). On conclusion of the study, they plan to update the survival rates and production metrics used in the 2008 BiOp (Bellerud et al. 2007), reflecting the current configuration of the hydrosystem with surface passage routes installed at the eight lower Snake and lower Columbia River dams. The results from the three year in-river survival study will also be used to develop a low flow contingency response plan for the Fish Passage Plan (FPP).

Lower Granite adult facility and kelt facility.
Scoping of the Corps' Juvenile Fish Facility Phase 2 design requirements for smolt transportation improvements began in 2014. Both the Transportation COP and the Lower Granite COP support the previous KMPs in strongly recommending new high velocity sort-by-size separation for juvenile salmon that would follow in the plumbing after an inline adult salmon and debris separator. The new adult salmon separator would eliminate kelt passing to the juvenile separator, thus reducing kelt handling for collection. Separated kelt would be water diverted and routed in a flume to circular tanks similar to those designed into the reconditioning facilities.

Assess the effect of low flow and corresponding warm upper surface passage water conditions on summer outmigrating kelt through Lower Granite reservoir and dam, specifically the later outmigrating B-run populations of the Clearwater River basin such as Fish Creek. A contingency plan should be developed for enhancing adult passage. The Corps will be working with NOAA Fisheries to verify operational scenarios and is looking at infrastructure improvements for 2015. Since the in-water construction of the Lower Granite adult ladder water source chimney at Diffuser 14 intake and the extended auxillary pipes to 68 feet deep has been delayed to the winter work window of January and February of 2016, the Corps has planned that all three auxillary adult ladder pumps will be operational, including a redesigned rental pump operation at Diffuser 14 intake installed by 1 July 2015. High ladder temperatures in late summer primarily impact impact maiden summer-run steelhead migrating in late August and September to overwintering holding areas above Lower Granite Dam, and the proportion of upriver migrating respawners that are migrating during the same period.

Limited availability of female wild b-run steelhead kelts at collection sites is a challenge. Condition of kelts collected in tributaries is typically better than among the group collected at mainstem dams and tributary collection may have the greatest potential for expansion. The technique of air spawning broodstock at hatcheries has allowed adult steelhead to remain in good condition, successfully go through rehabilitation, and reach maturity as kelts. Given the annual variability in returning steelhead spawners, and the declining capability to collect kelts at Lower Granite Dam due to factors such as spill operations, development of tributary collection should be addressed during redesign and planning of the Lower Granite bypass system in 2014-15. The Action Agencies recommend including size selective sorting capability, with an adult and debris separator. Adult collection efforts could be increased at Lower Monumental and Little Goose dams which currently can do size selective sorting at their bypass facilities.

Extend and enhance TDA sluiceway operations and other alternate non-turbine or bypass routes. An evaluation of operations during previous years may be necessary to estimate the expected benefits of alternative scenarios.

Adaptive Management - Synthesis of current status and future planning

The Action Agencies will need to continue research on further development of the benefits of kelt transportation and in-river operations alternatives. Therefore the below synthesis primarily focuses on kelt reconditioning.

There are several critical uncertainties associated with the kelt reconditioning project which we believe we are close to answering, however we must navigate some remaining challenges. In the Snake River Basin we are attempting to meet the goals of RPA Action 33 in the supplemental BiOp (NOAA 2014). Even though we do not currently operate a production level hatchery facility we have been close to reconditioning the number of fish designated in the RPA Action. We are collecting additional B-run kelts at sites including Fish Creek and South Fork Clearwater River. With the anticipated completion of the Snake River kelt master by the Nez Perce Tribe, the focus in the Snake will be on setting up a kelt reconditioning facility that will provide the Snake River Basin a consistent production of artificially reconditioned B and A- run repeat spawners .

Results from the genetic stock identification provide a reasonable level of confidence in evaluating which regions produce greater proportions of potentially iteroparous individuals. This is an important attribute contributing to population productivity and monitoring of the relative abundances of both A-run and B-run steelhead forms, and will inform specific management of each with important implications for conservation. Interestingly, the upper Salmon River region produces a disproportionate number of Snake River kelt steelhead, and is presumably an important factor in spawner abundance for that region. This result is mirrored among hatchery-origin fish. Underlying biological and behavior factors contributing to such discrepancies are not well understood but likely warrant further investigation. With more data including escapement comparisons, it may be possible to refine the confidence in estimated rates of iteroparity among regional groups. Hatchery-origin GSI results suggest this method may perform reasonably well for identifying proportions of kelts originating from specific hatchery programs. High relative rates of iteroparity (kelt proportions) among UPSALM hatcheries should be monitored closely and underlying causative factors explored.

To get a better measure of kelt reproductive capabilities we have opted to discontinue utilizing the site at Omak Creek and instead focus on utilizing the Cle Elum spawning channel, a semi-natural setting. We are testing the feasibility of the site this year to see if it is adequate for steelhead as it was previously used for spring Chinook to great success. If the site is feasible we propose expanding the project to observe maiden/repeat spawner and resident interactions.

Providing assistance to post-spawn steelhead in the forms of feed, and prophylactic measures may increase the probability that individual steelhead repeat spawn and contribute to population growth. We feel that this approach can improve steelhead populations by increasing the number of female spawners in basins with listed populations. Not only will increased spawner production reduce extinction probability through increased productivity (Seamons and Quinn 2010) but they also act as important living genetic reservoirs (Narum 2008). Having a genetically diverse population can help act to as a buffer against manmade and natural stochastic events.

While we recognize that reconditioning may not work everywhere primarily due to following limiting factors such as flashy stream hydrology combined with poor capture capabilities and/or shortage of water, rearing capacity, or simply lack of a sufficient operating budget. We believe that it can be utilized as an important tool in the right locations. We base this belief on our current evidence that artificially reconditioned repeat spawners are contributing to ESA-listed populations based on the parentage analysis results. To quantify exactly how much is a difficult proposition and remains to be determined, but the results of egg quality experiments at both Parkdale and Dworshak would suggest that they are doing so at rates that were similarly observed in Seamons and Quinn (2010). We have learned much about steelhead kelts since the inception of this program in 1999 and look forward to learn more from them and continue to work towards maintaining this important life history strategy of this species in the Columbia River Basin.

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