Steelhead Kelt Reconditioning and Reproductive Success Studies in the Columbia River Basin

Hatch,[1] D.R., D.E. Fast[2], W.J. Bosch[2], J.W. Blodgett[2], J.L.J. Trammell[2], A.L. Pierce, [1,3] S.R. Everett[4], R. Branstetter[1], J. Stephenson[1], A.P. Matala[1], N. Graham[1], and Z.L. Penney[1].

[1] Columbia River Inter-Tribal Fish Commission, Portland, OR
[2] Yakama Nation, Toppenish, WA
[3] University of Idaho, Moscow, ID
[4] Nez Perce Tribe, Lapwai, ID

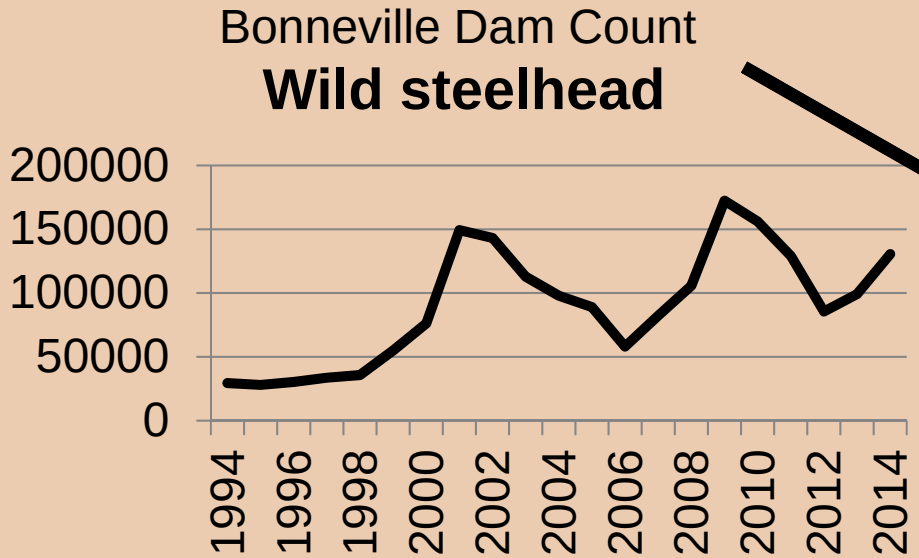
Presentation Outline

Project Goal: Attempt to enhance repeat spawner rates (iteroparity) in steelhead and address the following issues:

1. Define the problem / rationale for this effort
2. Summary of kelt reconditioning efforts in the Yakima and Snake rivers
3. Summary of physiology studies
4. Evaluations of reproductive success of reconditioned kelt steelhead
5. Effects of artificial reconditioning on homing of kelt steelhead
6. Genetic Stock Identification of the Snake River kelt steelhead population
7. Population recovery from the perspective of a reconditioning model

1. Define the Problem

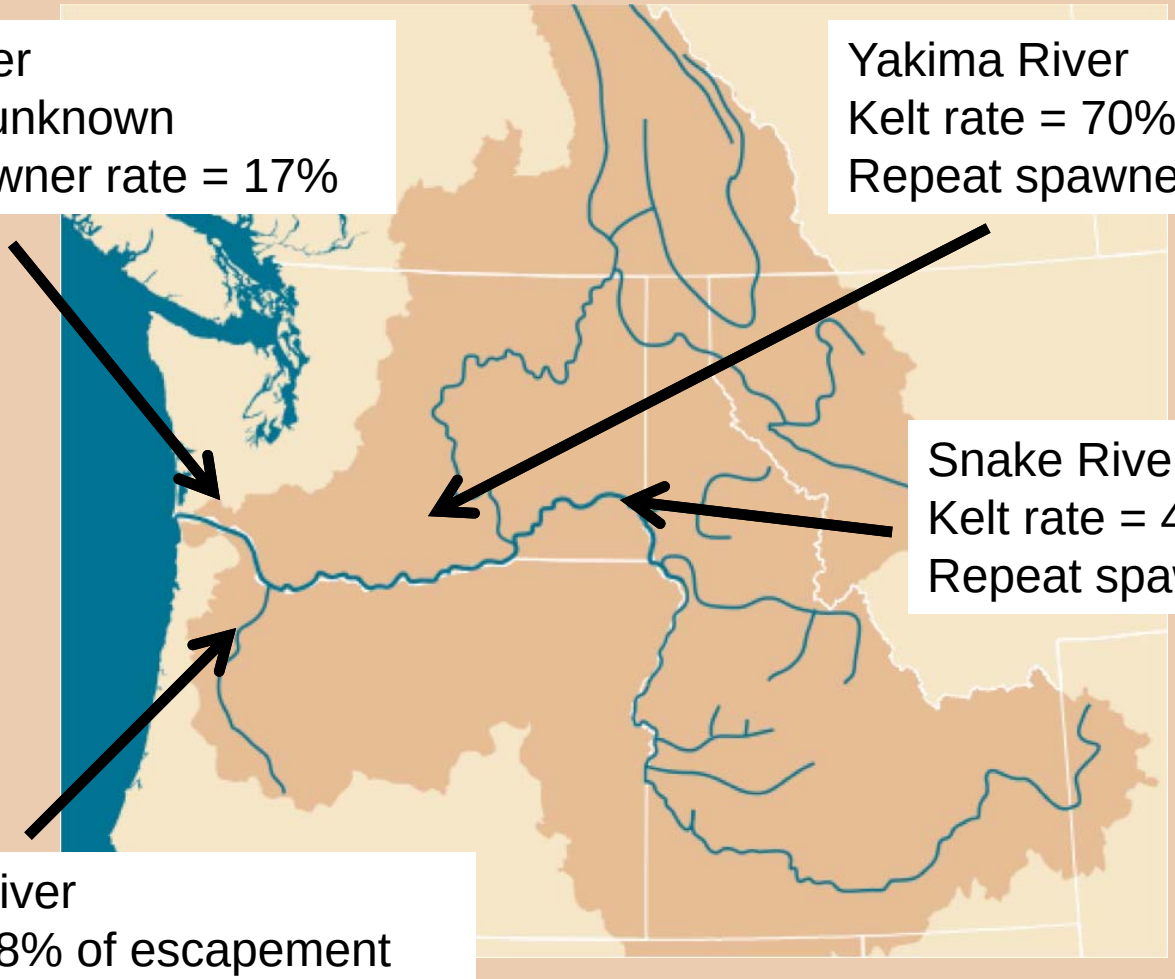
All steelhead upstream of Bonneville Dam in the Columbia River are listed Under the Endangered Species Act



1. Kelt steelhead availability (% of escapement) and repeat spawner rates (% of the run) in the Columbia Basin

Kalama River
Kelt rate is unknown
Repeat spawner rate = 17%

Yakima River
Kelt rate = 70% of escapement
Repeat spawner rate = 3.4%



Snake River
Kelt rate = 45% of escapement
Repeat spawner rate = 0.4%

Willamette River
Kelt rate is 58% of escapement
Repeat spawner rate = 1.3-12.4%

1. Approach

This project wants to leverage the iteroparous nature of steelhead into increasing the lifetime reproductive success of wild steelhead and assist with recovery. Kelt stage steelhead are abundant in the Columbia River, but repeat spawners are rare.

Successful iteroparity can increase individual lifetime reproductive success by two to three times relative to individuals adopting a semelparous strategy

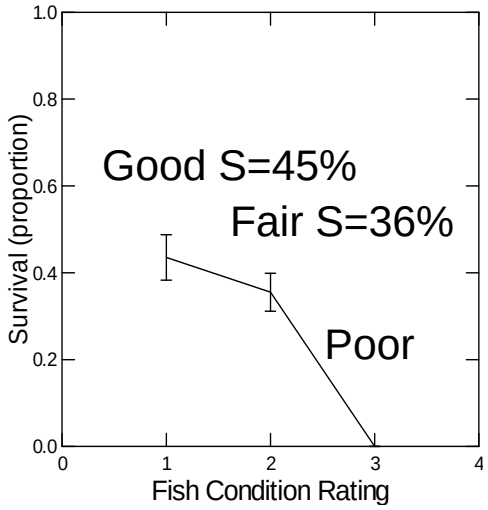
NOAA Biological Opinion for the Operating the Columbia River Hydro system calls for a 6% improvement in B-run steelhead population productivity by artificially reconditioning kelt steelhead and / or improving in-stream passage through the hydro system

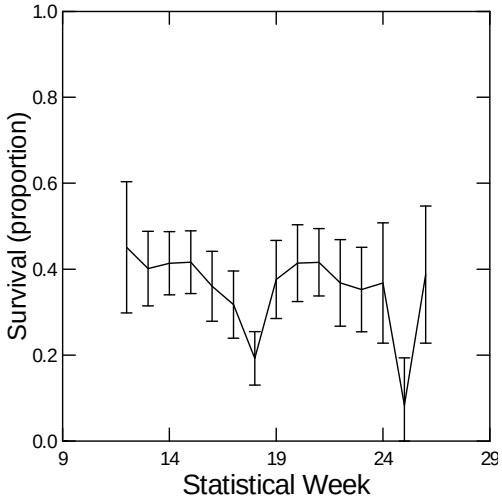
2. Kelt Reconditioning Process

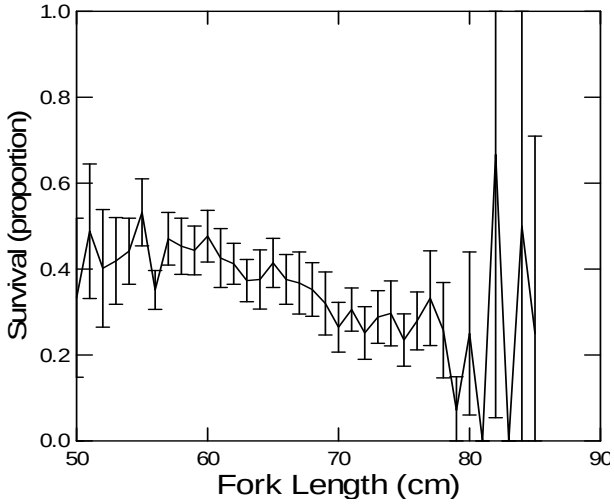
1. Collect downstream migrating kelts at weirs, or juvenile bypass systems in the spring.
2. Place kelt steelhead in large circular tanks. Apply standard fish culture practices.
3. Release reconditioned kelts in the fall.
4. Reconditioned kelts return to spawn with the natural run either the following spring (consecutive), or wait a year (skip).
5. Reproductive success is tested using genetic parentage analysis.

2. Summary of Reconditioning efforts in the Yakima and Snake rivers

Location	Years	N	S	Potential Benefit relative to fish left in river (survival/return rate)
Yakima	16	9,208	40%	14 x
Snake	4	520	35%	113 x







Hatch et al. 2013. NAJFM 33:615-625.

2. Summary of Reconditioning efforts in the Yakima River

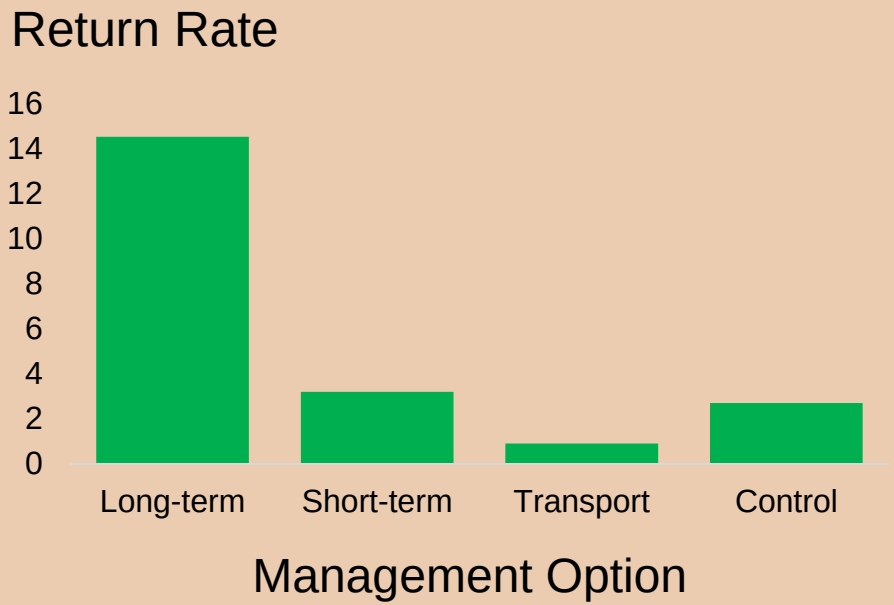
Collect downstream migrating kelts:

Control – PIT tag and release and systematic sample.

Transport – PIT tag, transport and release below Bonneville Dam. Timed with kelt run.

Short-term – PIT tag, place in tanks and feed for 6-8 weeks, then transport below Bonneville Dam. Timed with kelt run.

Long-term – PIT tag, place in tanks and feed for 5-6 months, then release back in river. Timed with the returning run.



Trammell et al. In-press. NAJFM 33.

3. Summary of Physiology Studies

Studies applying physiological tools to kelt reconditioning began in 2009, and have addressed the general areas of:

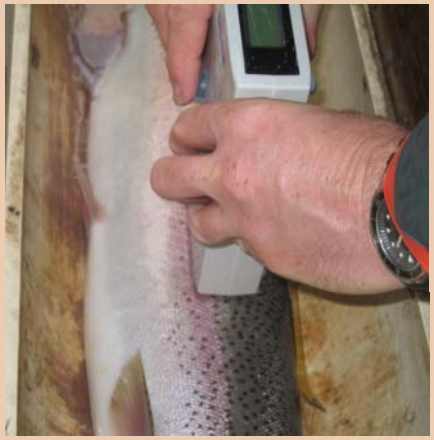
- describing the energetic and physiological status of kelts,
- understanding alternative life histories in post-spawning fish,
- assessing reproductive performance in reconditioned fish as compared to maiden spawners; and,
- improving survival and health of reconditioned fish.

The focus has been on female kelts, due to the preponderance of females in kelt collections, the higher survival rate of females, and the greater importance of females to productivity.

3. Summary of Physiology Studies

Energetic and physiological status of kelts

- Energy was progressively depleted from early migration to the kelt stage. Muscle lipids were used more rapidly than muscle protein
- Muscle lipid use appeared to slow during fall and winter
- Liver lipid stores were depleted more rapidly than muscle stores and saturated and monounsaturated fatty acids were depleted more rapidly than polyunsaturated fatty acids, which may reflect conservation of polyunsaturated fatty acids due to their role in cell membrane structure and function
- At the kelt stage, fish rated as in better condition based on visual appearance had greater energy reserves, consistent with findings on survival in captive reconditioning and natural repeat spawning rates

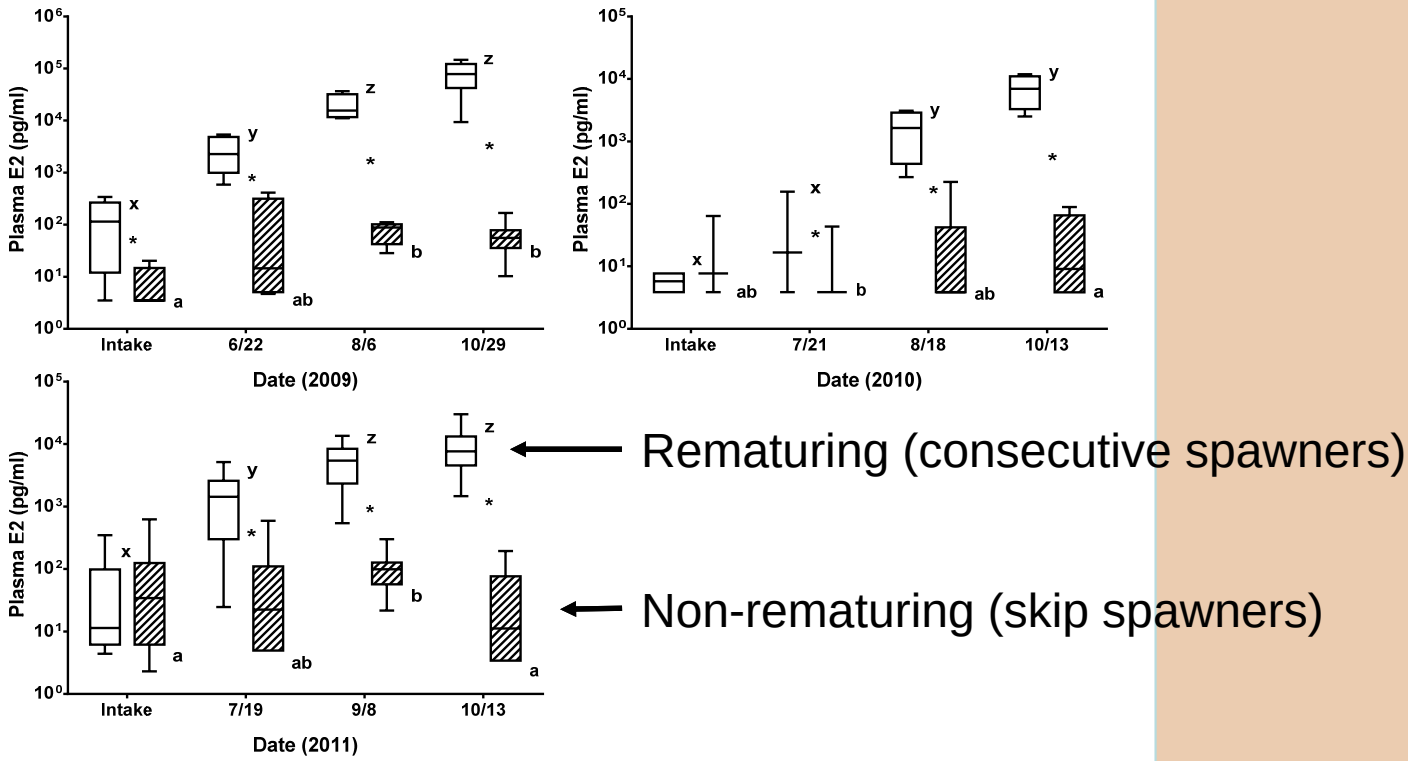


Buelow and Moffitt 2015. Ecology of Freshwater Fish 24:112-122.
Caldwell et al. 2013. General and Comparative Endocrinology 194:124-132.
Caldwell et al. 2014. PLoS One 9 e85700.
Penney and Moffitt 2014. Reviews in Fish Biology and Fisheries 24:781-801.
Penney and Moffitt 2014. TAFS 143:399-413.
Penney and Moffitt 2015. Journal of Fish Biology 86:105-120.

3. Summary of Physiology Studies

Alternative Life Histories

Plasma estradiol (E2) levels from intake to release in serially sampled rematuring (open bars) non-rematuring (striped bars) female PFH kelts.

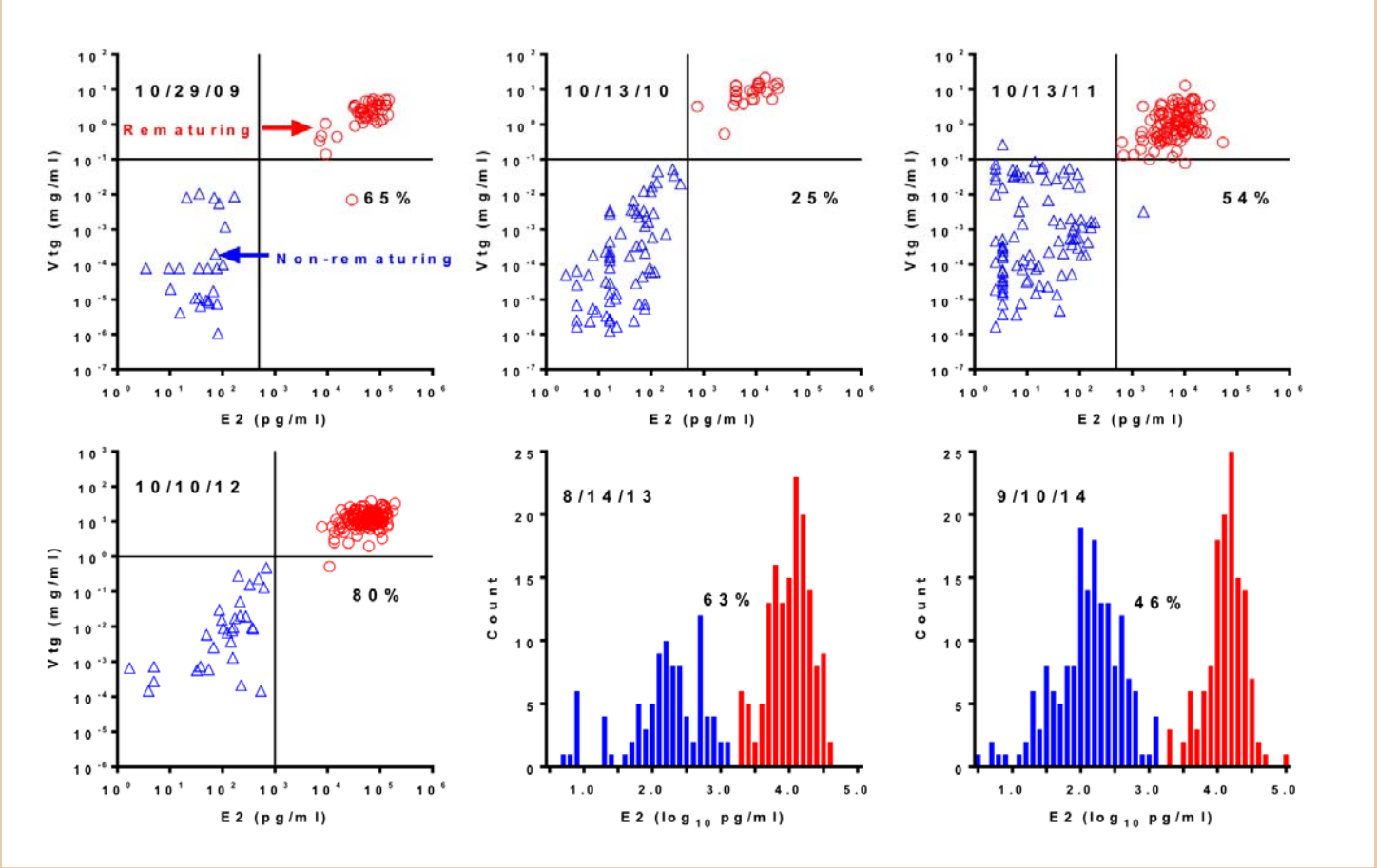


3. Summary of Physiology Studies

Alternative Life Histories

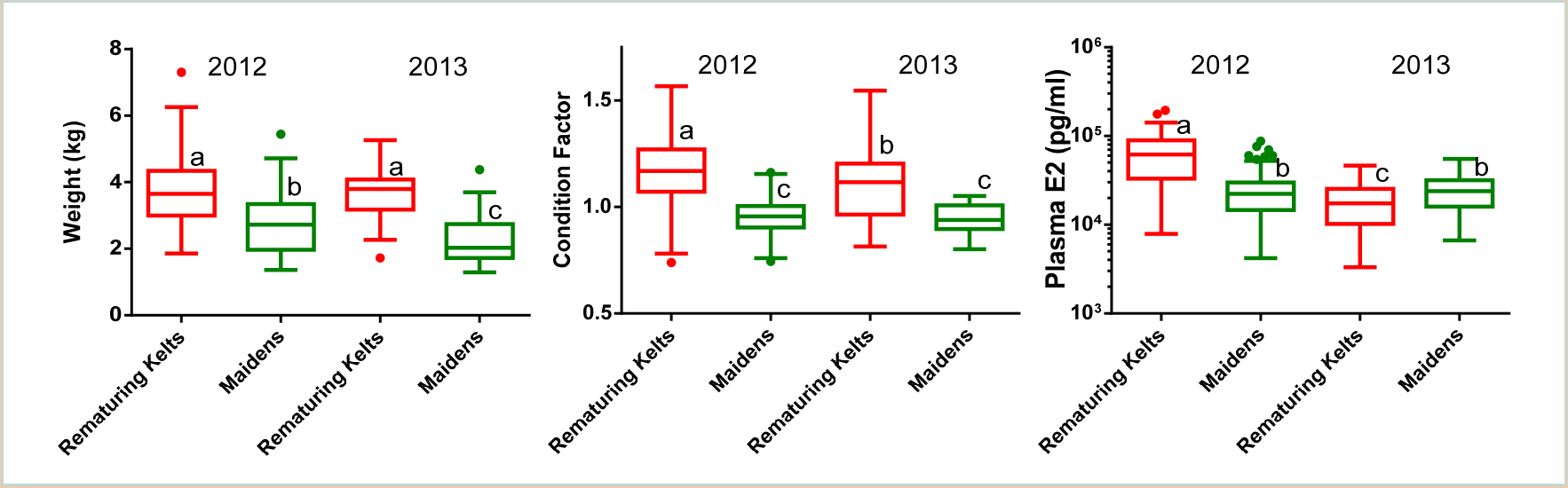
Maturation status of female kelts based on a release or earlier blood sample.

E2: estradiol; Vtg: vitellogenin



3. Summary of Physiology Studies

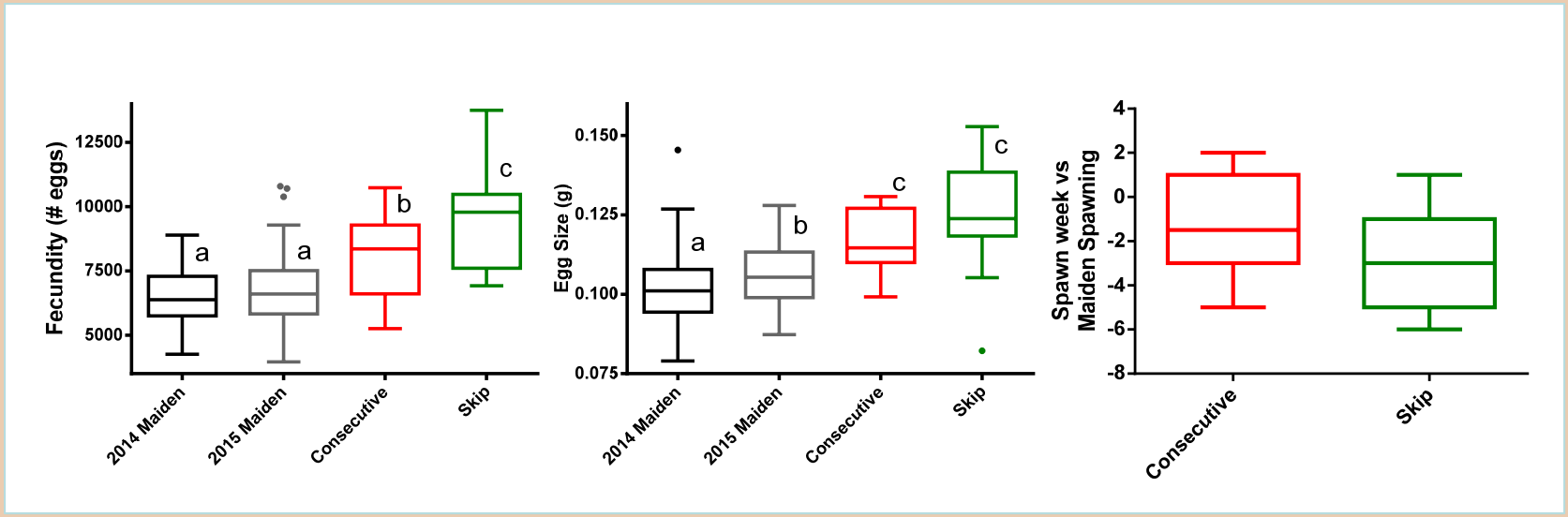
Reproductive Performance of Maiden and Reconditioned Kelts (wild fish)
Body size, Fulton's condition factor, and plasma estradiol levels in rematuring reconditioned female Prosser Fish Hatchery steelhead kelts and maiden females sampled during upstream migration at the Prosser Denil ladder in October (Yakima River).



3. Summary of Physiology Studies

Reproductive Performance of Maiden and Reconditioned Kelts (hatchery fish)

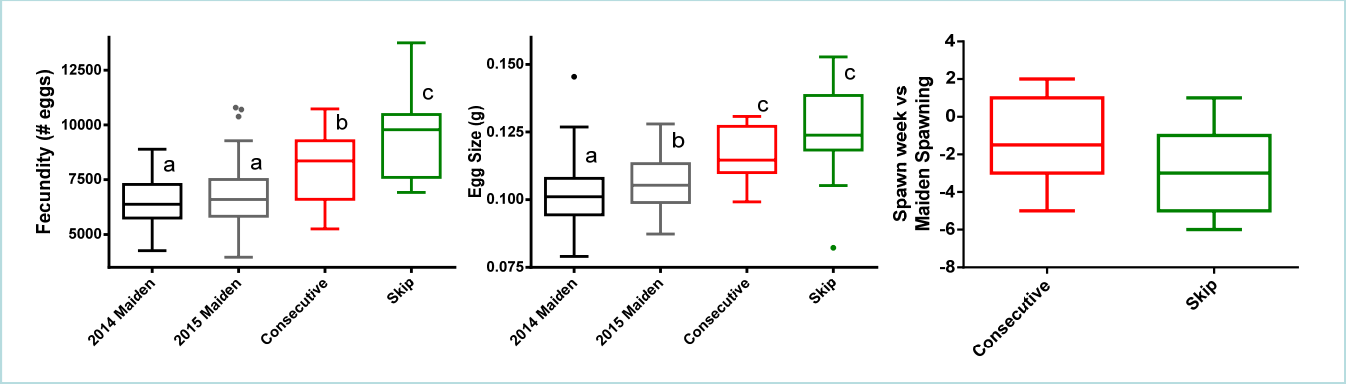
Fecundity, egg weight, and spawn date fidelity in consecutive and skip spawning reconditioned kelts versus maiden spawners Dworshak National Fish Hatchery.



4. Evaluations of Reproductive Success of Reconditioned Kelt Steelhead

We have evaluated reproductive success of reconditioned kelt steelhead at a variety of scales due in part to the difficult in obtaining these types of data in natural streams.

1. As reported earlier in a hatchery setting: evaluate reproductive performance of maiden fish, recondition them and compare performance as repeat spawners. Results to date show that fecundity and egg size were greater in reconditioned consecutive spawners versus maidens, and increased further in skip spawners, indicating that kelts should produce more offspring that survive at a higher rate than maidens.



4. Evaluations of Reproductive Success of Reconditioned Kelt Steelhead

We have evaluated reproductive success of reconditioned kelt steelhead at a variety of scales due in part to the difficult in obtaining these types of data in natural streams.

2. In a river setting, we are evaluating reproductive performance of maiden and reconditioned kelt steelhead using parentage analysis to identify juveniles produced by each group. Results to date are encouraging and indicate that lifetime reproductive success of reconditioned kelt steelhead is about double that of maiden fish.

4. Evaluations of Reproductive Success of Reconditioned Kelt Steelhead

Number and percentage of parents detected in each class, average number of progeny assigned to an individual, relative reproductive success (RRS), and lifetime reproductive success (LRS) for each group of individuals. Data collected in 2013 and 2014 in Yakima River tributaries. This is an index due to incomplete sampling.

		Parents			Progeny				
		Genotyped	Detected		Genotyped	Assigned			
	Class	N	N	%	N	N	Per	RRS	LRS
♂		312	16	5.1%	312	33	0.11	1.00	
♂		78	10	12.8%	78	27	0.35	3.27	
♂		24	4	16.7%	24	9	0.38	3.55	6.82
		905	33	5.6%	905	101	0.17	1.00	
♀		625	55	10.1%	625	128	0.23	1.37	
		321	17	6.0%	321	33	0.12	0.69	2.06

Columbia River Inter-Tribal Fish Commission

4. Evaluations of Reproductive Success of Reconditioned Kelt Steelhead

We have evaluated reproductive success of reconditioned kelt steelhead at a variety of scales due in part to the difficulty in obtaining these types of data in natural streams.

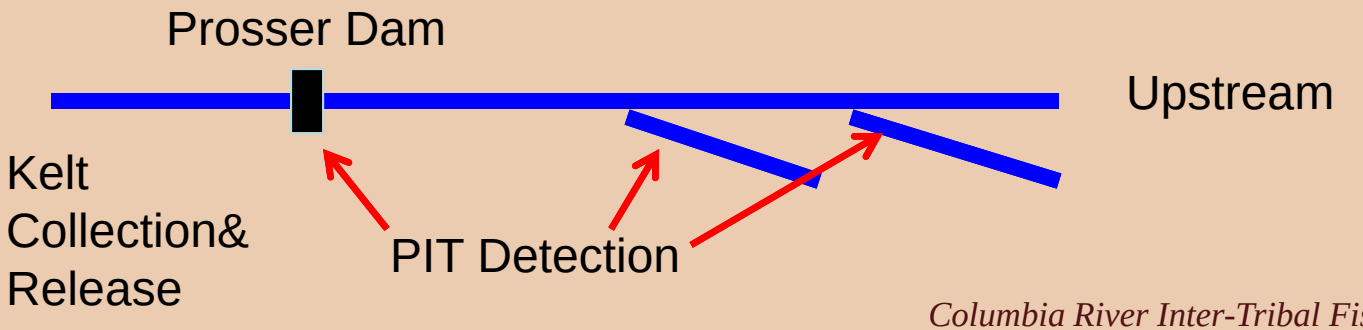
3. We placed 15 reconditioned kelt steelhead in an artificial spawning channel to evaluate spawning performance. This study is still very preliminary, but we have collected over 4,000 juveniles from the channel and will use parentage analysis to match them to parents.

5. Effects of Artificial Reconditioning on Homing of Kelt Steelhead

A number of data sources provide details of spawning locations of maiden steelhead. Sources include In-stream PIT arrays, radio tracking, trap capture, and fish ladder PIT detection. Conclusive evidence for homing was found in fish histories with both maiden and repeat spawning events located.

5. Effects of Artificial Reconditioning on Homing of Kelt Steelhead

	Conclusive Evidence for Homing				Consistent with Homing		
Location	A. Maiden/ Repeat Spawner Tag Detection	B. Repeat Spawner Tag Detection + GSI conformation	C. Conclusive Homing total A+B		D. Repeat spawner PIT Detection at Prosser	E. Post Spawn Repeat Spawner Recaptured at CJFF	F. Consistent with homing, some fish are in both D and E
Yakima R	27	200	227		561	103	629
Omak Cr	11	-	11		-	-	-
Total	38	200	238		561	103	629



Summary

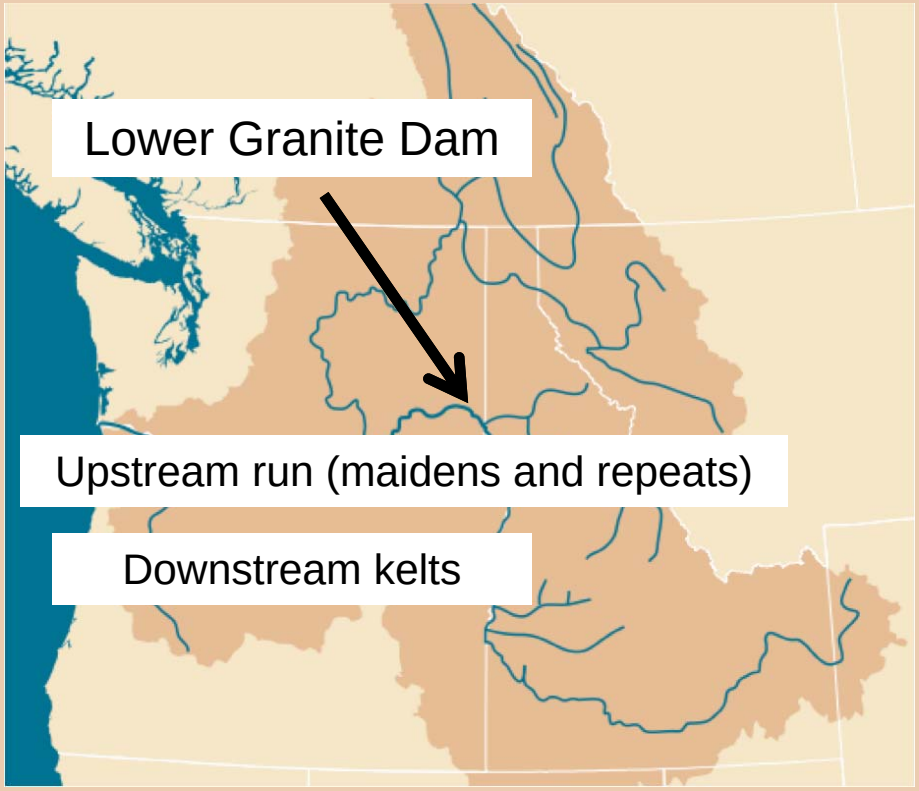
1. Columbia River steelhead populations are listed under ESA and need novel recovery strategies
2. There is a relatively large abundance of kelt steelhead in the Columbia River even in the upper most areas
3. In general, repeat spawning steelhead make up a very small proportion of the spawning run
4. Increasing repeat spawners in steelhead populations can have many positive effects on populations including increasing; genetic diversity, lifetime fecundity, and fitness since genes are distributed across generations
5. Long-term reconditioning kelt steelhead provides 5 to over 100 times more repeat spawners than leaving the fish in the river
6. Physiology studies have provided us with a much better understanding of energetic and physiological status of kelts, improved our understanding of alternative life histories in post-spawning fish, and improved survival and health of reconditioned fish.

Summary

7. Blood hormone assays are useful to classify consecutive and skip spawner steelhead.
8. There appears to be a reduction in the B-run steelhead composition between the maiden and kelt stage, but the B-run composition of repeat spawners is similar to the kelt composition
9. Reproductive success studies are underway at a variety of scales: hatchery analog, spawning channel, and natural river. Results are encouraging
10. Artificially reconditioned kelt steelhead appear to repeat home with high fidelity.

4. Genetic Stock Identification of Snake River Origin Kelts

We conducted GSI monitoring of kelt steelhead in the Snake River Basin of Washington, Oregon and Idaho from 2009 to 2014 in order to evaluate kelt stock proportions by region-of-origin and compared to other work with maiden and repeat spawners.



Assignments made to the highest ranked reporting group regardless of probability score.
Reporting groups included:

Grande Ronde
Imnaha
Lower Clearwater
Lower Salmon
Lower Snake
Upper Snake

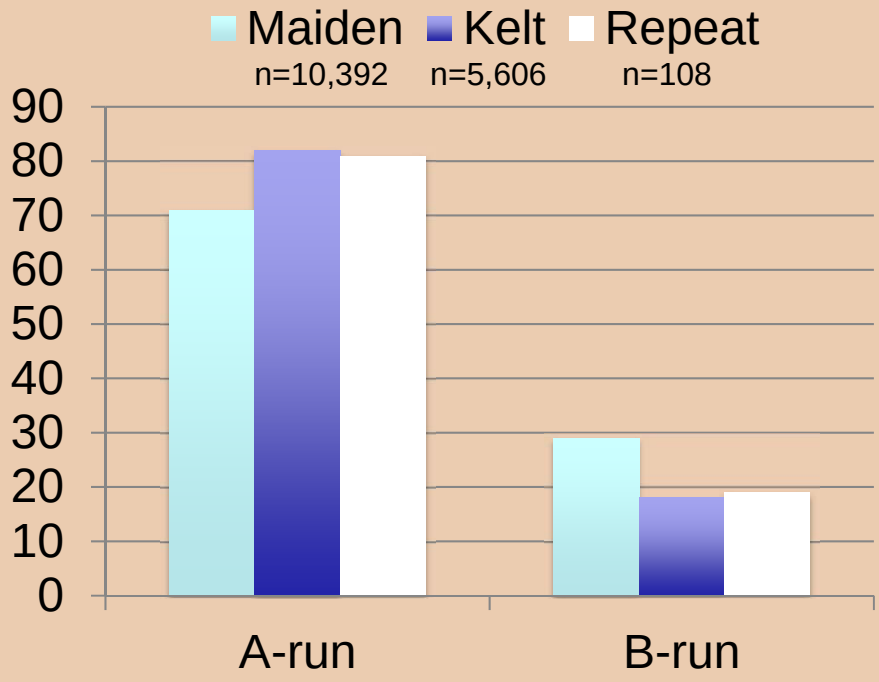
A run groups

Middle Fork Salmon
South Fork Salmon
Upper Clearwater
South Fork Clearwater

B run groups

4. Genetic Stock Identification of Snake River Origin Kelts

Run composition of maiden, kelt, and repeat spawner steelhead determined with GSI at Lower Granite Dam



Assignments made to the highest ranked reporting group regardless of probability score.

Reporting groups included:

Grande Ronde
Imnaha
Lower Clearwater
Lower Salmon
Lower Snake
Upper Snake

A run groups

Middle Fork Salmon
South Fork Salmon
Upper Clearwater
South Fork Clearwater

B run groups

Matala, A.P., D.R. Hatch, S. Everett, M. Ackerman, B. Bowersox, and S. Narum. In review. Genetic stock identification reveals regional distinctions in the biology and repeat spawning potential of emigrating kelt steelhead in the Snake River. ICES Special Addition.