Columbia River Basin Steelhead Kelt Reconditioning: Reproductive Development, Energy Stores, and Post-Release Migration of Long-Term Reconditioned Female Kelts in the Yakima River

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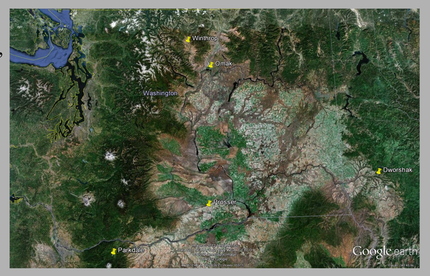
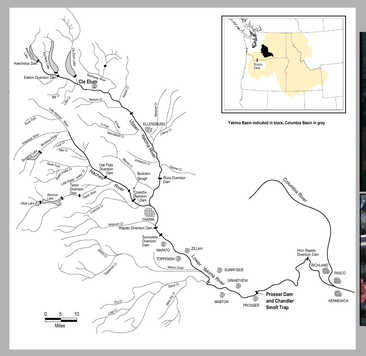
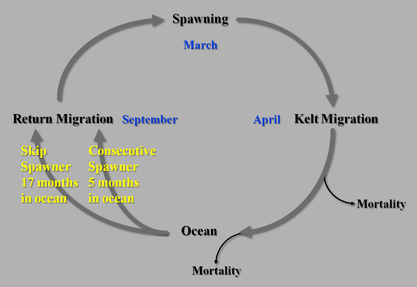
Introduction and Background

Unlike Pacific salmon, anadromous steelhead do not necessarily die after spawning. Instead, a large proportion of Columbia River Basin steelhead attempt outmigration. Downstream migrating fish are termed "kelts." Under current conditions, kelt survival to repeat spawning is poor. Projects are underway throughout the Columbia River Basin to capture and recondition steelhead kelts (right). The goal is to release reconditioned fish into rivers in the fall to spawn naturally.



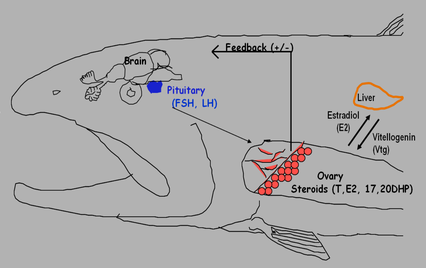
The largest kelt reconditioning project in the Columbia River Basin is at Prosser, Washington, on the Yakima River (below). An average of 885 kelts are collected each spring, of which 93% are female. All of the steelhead in the Yakima river are wild origin ESA-listed fish. Fish are treated for diseases and parasites, and fed krill and pellets over the summer. An average of 38% of fish taken for reconditioning survive to release in the fall.





In the natural environment, post-reproductive steelhead have two major life history trajectories (left). Some fish return the fall of the year of their outmigration, having spent less than a year in the ocean. These fish are termed consecutive spawners. Other fish return a year later, and are termed skip spawners. Post-reproductive life history trajectory is thought to be determined by energetic status at seasonally defined critical periods.

In fishes, reproductive development is controlled by the reproductive endocrine axis (right). During maturation or rematuration in females, plasma levels of the female steroid estradiol and the egg protein vitellogenin increase. Therefore, these factors can be used to monitor reproductive development.



Objectives

Using nonlethal techniques, we aimed to:

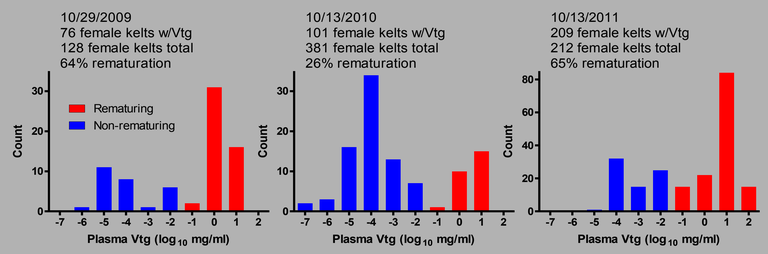
- Determine the maturation status of reconditioned female kelts released from Prosser.
- Establish methods for assessing maturation status of female kelts prior to release.
- Evaluate factors associated with maturation status at release.
- Explore relationships between maturation status at release and post-release migration.

Methods

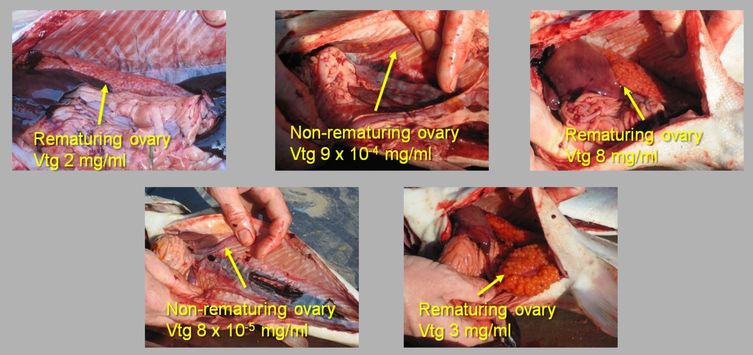
- Fish were blood sampled at release and the indicated dates.
- Plasma vitellogenin concentrations were assayed using a rainbow trout vitellogenin ELISA kit (Biosense, Cayman Chemical, Ann Arbor, MI).
- Plasma estradiol concentrations were determined by radioimmunoassay after solvent extraction (Coat-A-Count Estradiol, Diagnostic Products, Los Angeles, CA).
- Muscle lipid levels were non-lethally measured using a Distell Fish Fatmeter (Distell Inc., West Lothian, Scotland).
- Post-release upriver migration was monitored by PIT tag detection at Prosser dam. Fish are released approximately 1 km downstream from Prosser dam.

Results and Discussion

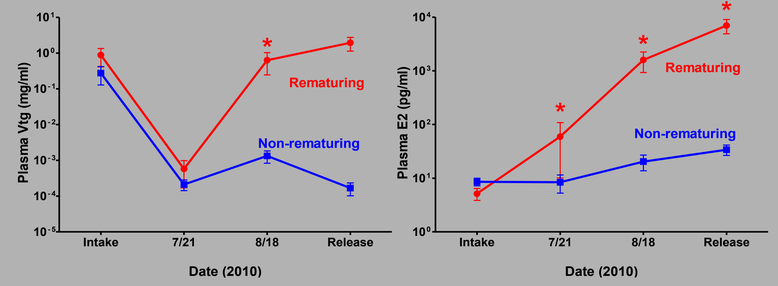
Plasma Vtg levels were bimodally distributed at release (below). The modes differed by 5 orders of magnitude. Female fish with Vtg ≥ 0.1 mg/ml were identified as rematuring. We hypothesize that rematuring fish are following a consecutive spawning and non-rematuring fish are following a skip spawning life history trajectory.



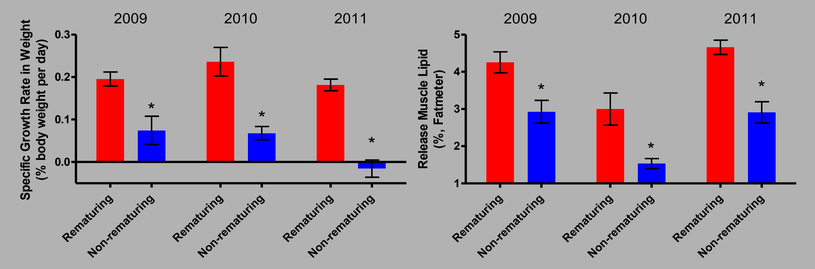
Prosser kelts are ESA-listed and cannot be lethally sampled to assess ovarian development. However, maturation status based on plasma Vtg level was correct in 5 mortalities that occurred after the 10/13/2010 sampling (below). Additional data are needed on fish near the 0.1 mg/ml Vtg cutoff.



In fish serially sampled in 2010, plasma Vtg indicated female maturation status by Aug 18 (below). Plasma estradiol (E2) also indicated female maturation status by Aug 18, and was significantly elevated in maturing fish on July 21. These results show that maturation status can be determined from a blood sample taken in August, enabling separate management of the consecutive spawning and skip spawning life history types. E2 may indicate maturation status earlier than Vtg.



Rematuring fish grew faster than non-rematuring fish over the reconditioning period, and had higher muscle lipid levels at release (below). This indicates that rematuration is associated with energetic status. However, it is not yet known whether positive energetic status caused rematuration, or vice versa.



Rematuring fish were more likely to be detected migrating upriver after release than non-rematuring fish (below). This suggests that rematuring fish were migrating in preparation to spawn. Non-rematuring fish were sometimes detected migrating upriver at Prosser dam 1 year after release, consistent with the possibility that these fish had migrated to the ocean, reconditioned, and returned as skip spawners.

	2009			2010			2011		
	Not Detected	Detected Oct '09-Mar '10	Detected Fall '10	Not Detected	Detected Oct '10-Mar '11	Detected Fall '11	Not Detected	Detected Oct '11-Mar '12	Detected Fall '12
Rematuring	**29**	**15**	**0**	**1**	**3**	**0**	**37**	**50**	**-**
Non-rematuring	**24**	**1**	**1**	**44**	**14**	**1**	**32**	**3**	**-**
Notes	Fisher's exact test p = 0.0062, skip spawner not included.			Most maturing females were kept for an experiment. Fisher's exact test p = 0.0591, skip spawner not included.			Fisher's exact test p < 0.0001, skip spawners have not returned yet.		

Conclusions and Questions

- The kelt project at Prosser produces both rematuring and non-rematuring females.
  - What determines rematuration and when?
- Maturation status can be determined from a blood sample in August.
  - What is the best strategy for allowing non-rematuring fish to contribute?
- Rematuration is associated with energetic status.
  - Will improving energetic status increase the rematuration rate?
- Rematuring fish show a migration pattern consistent with spawning.
  - How do rematuring reconditioned fish compare with maiden spawners?