

Saltwater Readiness, Growth and Survival of Triploid Summer Steelhead

Marc A. Johnson^{1,2,3} Thomas A. Friesen¹, Andrew H. Dittman⁴,
Paul M. Olmsted¹, David L. G. Noakes^{2,3}, Ryan B. Couture³,
Carl B. Schreck², Thomas P. Quinn⁵

¹Corvallis Research Laboratory, Oregon Department of Fish and Wildlife, Corvallis, Oregon, USA

²Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA

³Oregon Hatchery Research Center, Oregon Department of Fish and Wildlife, Alsea, Oregon, USA

⁴Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration Fisheries, Seattle, Washington, USA

⁵School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington, USA



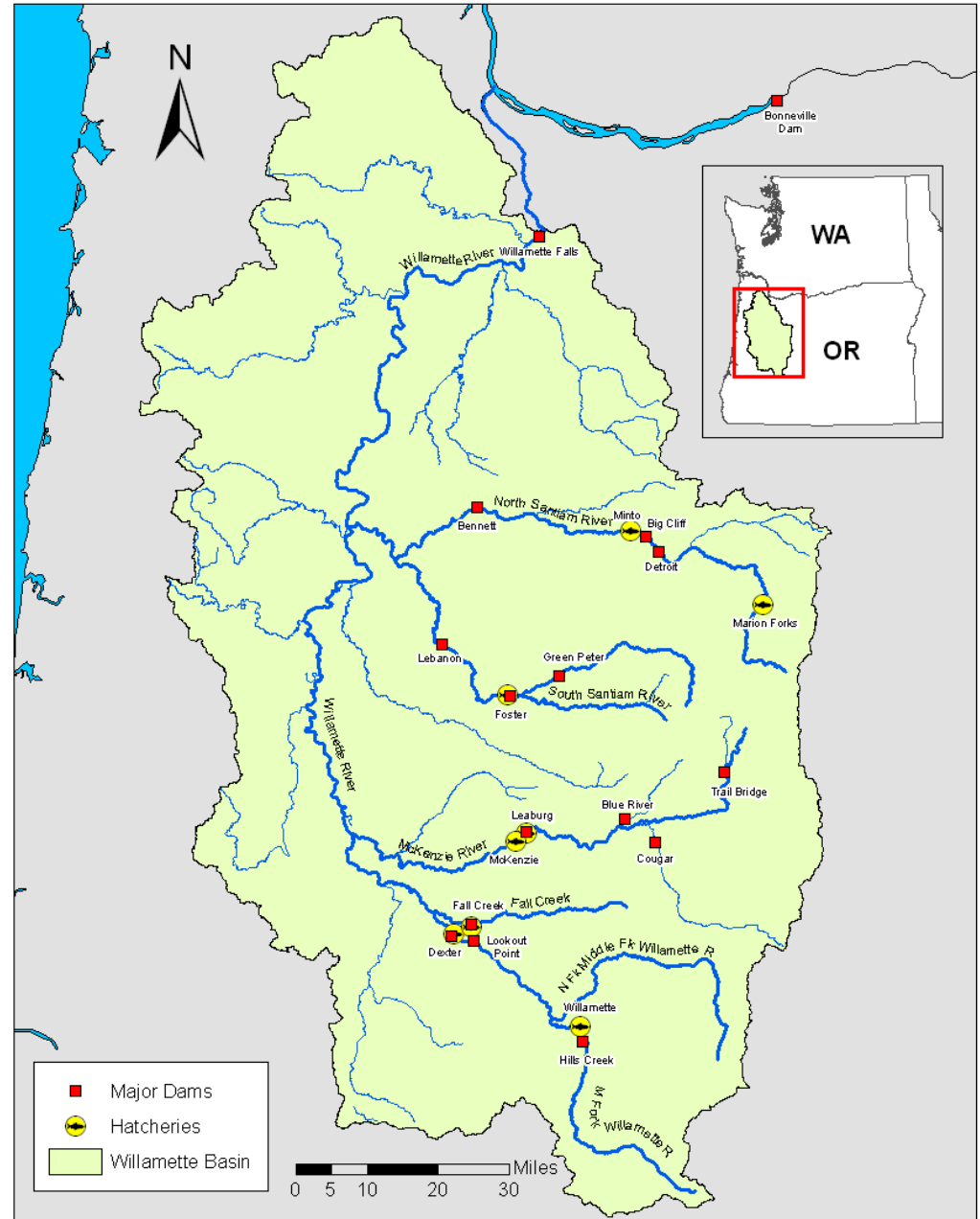
The Willamette River

- 19th in volume in U.S.
- 301 km mainstem
- Average 1,060 m³/s
- Flow is regulated by dams

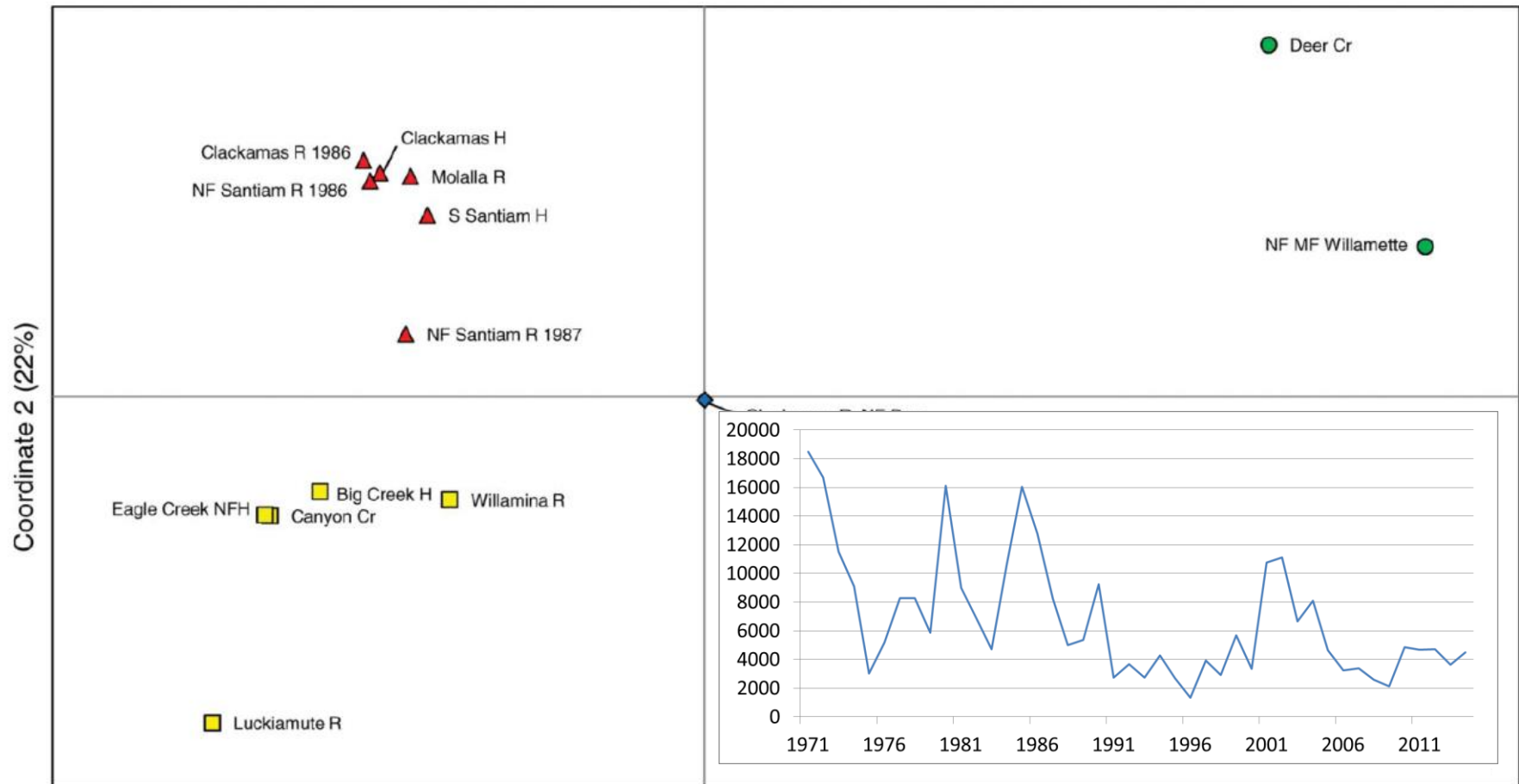


Native Salmonids

- *Prosopium williamsoni*
- *Salvelinus confluentus*
- *Oncorhynchus clarkii*
- *O. tshawytscha*
- *O. mykiss*



Oncorhynchus mykiss in the Upper Willamette River



◆ Late Winter-run, E Tribes

← Native

● Rainbow Trout

← Native

■ Early Winter-run and W Tribes

← Introduced

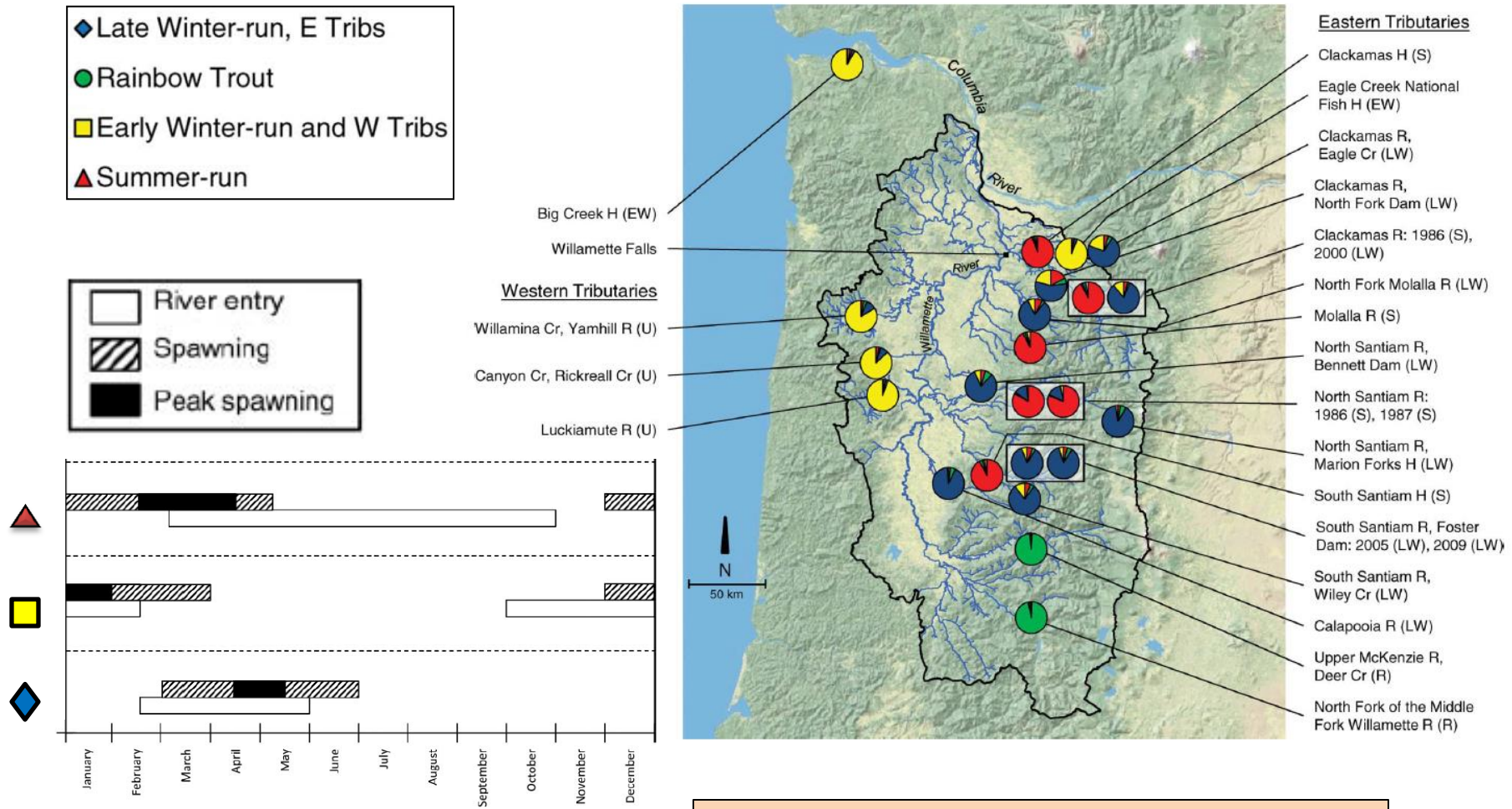
▲ Summer-run

← Introduced

Coordinate 1 (40%)

Van Doornik et al. (2014) *Transactions of the American Fisheries Society* 144:150-162

Oncorhynchus mykiss in the Upper Willamette River

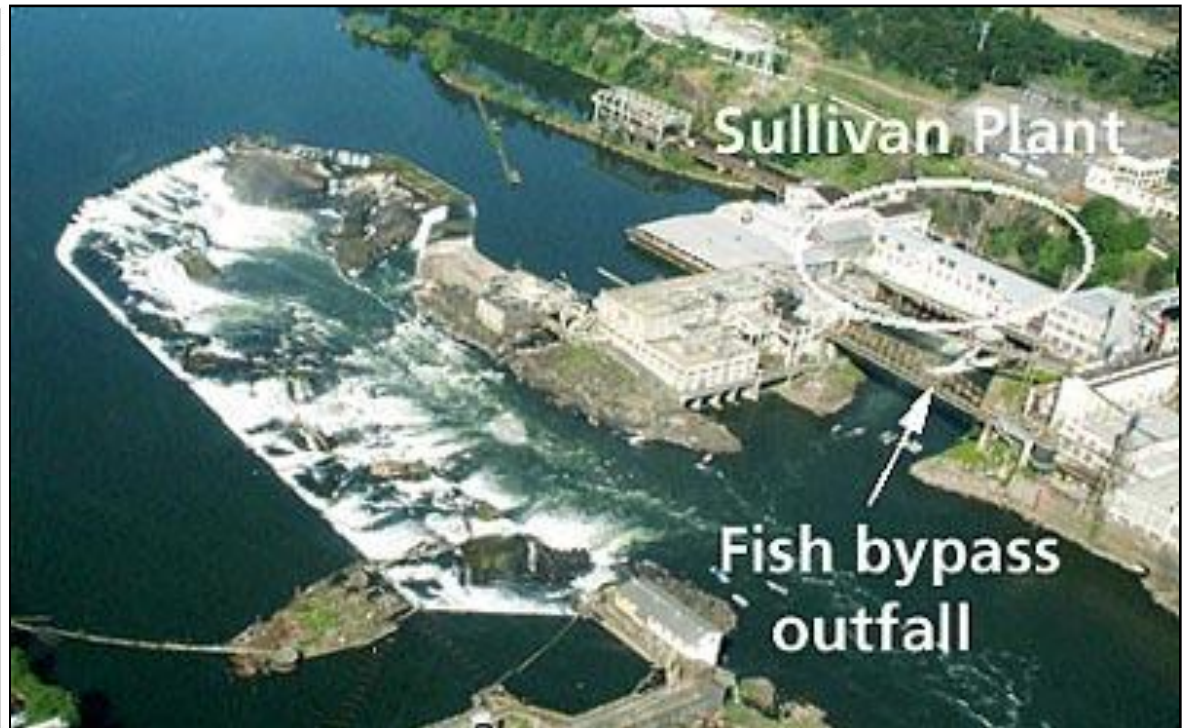
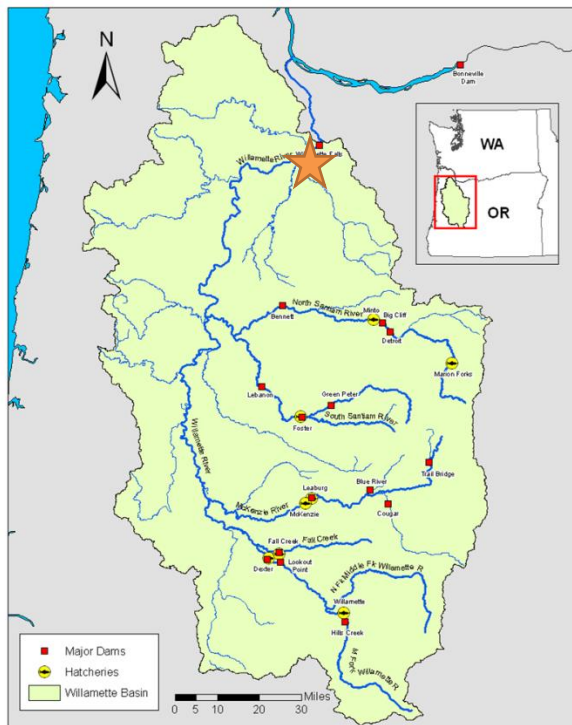


Van Doornik et al. (2014) *Transactions of the American Fisheries Society* 144:150-162

Genetic characterization of smolts

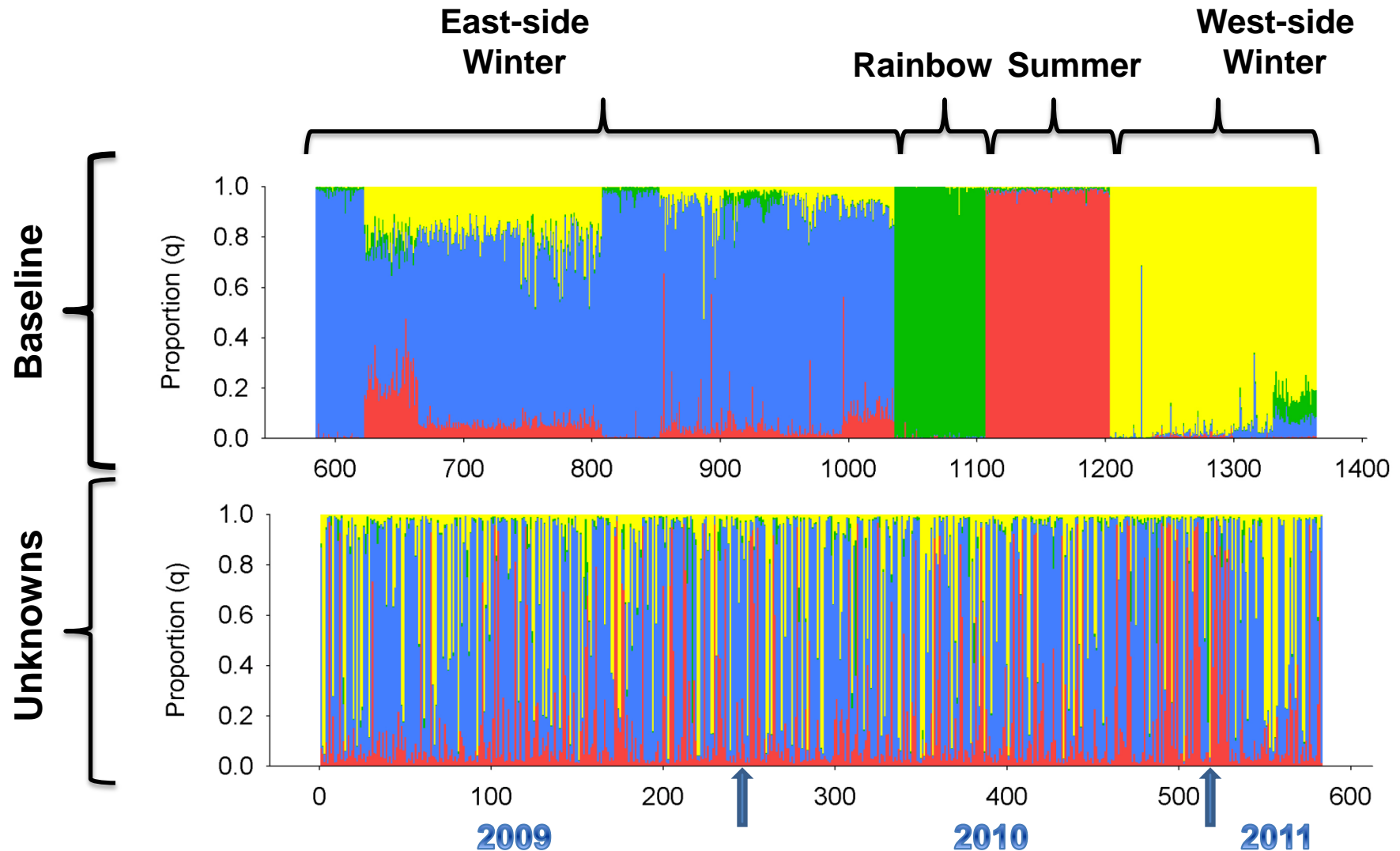
Estimate the proportion of summer steelhead among naturally produced* *O. mykiss* smolts sampled at Willamette Falls

Estimate the proportion of summer steelhead hybrids among naturally produced* *O. mykiss* smolts sampled at Willamette Falls

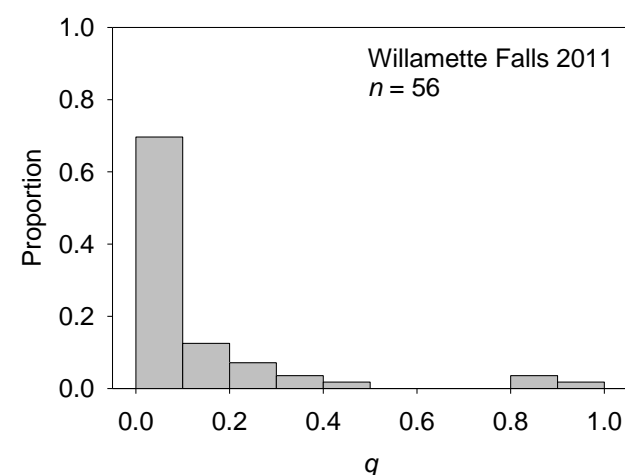
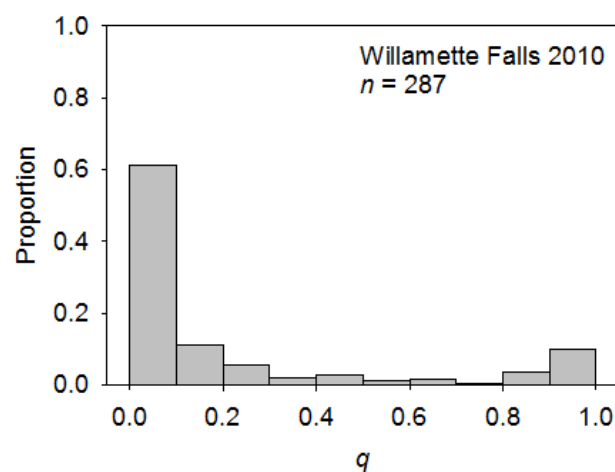
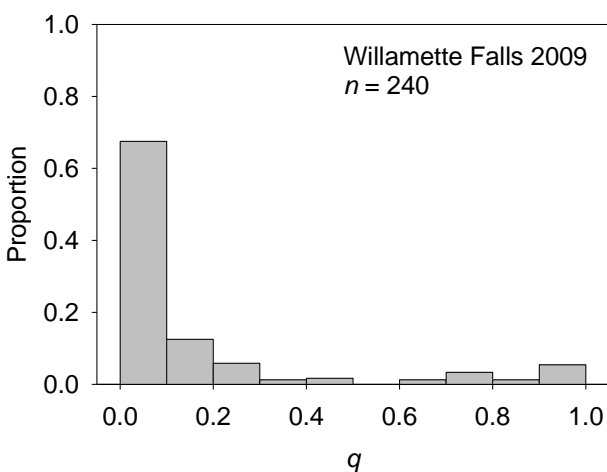


*Unmarked; all hatchery steelhead in the upper Willamette R. are adipose fin clipped

Ancestry of Naturally-produced Smolts



Summer Steelhead: Natural Production & Introgression

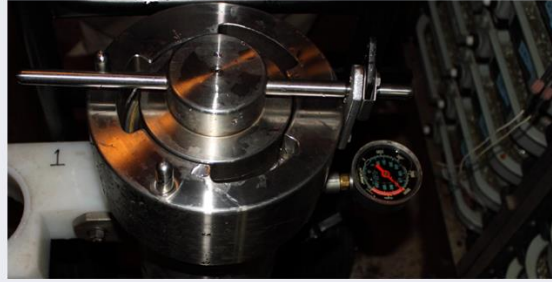


Year	Location	n	S	EW	RB	WW	SxWW	SxEW	SxRB	WWxEW	WWxRB	EWxRB	3x Hybrid
2009	Willamette Falls	240	19	126	1	34	1	23	1	31	0	1	3
2010	Willamette Falls	287	39	144	1	37	4	29	0	25	0	3	5
2011	Willamette Falls	56	3	29	0	13	1	3	0	5	0	0	2
Percent of Total			10.5	51.3	0.3	14.4	1.0	9.4	0.2	10.5	0.0	0.7	1.7

Ploidy manipulation can be used to sterilize and genetically contain cultured fish

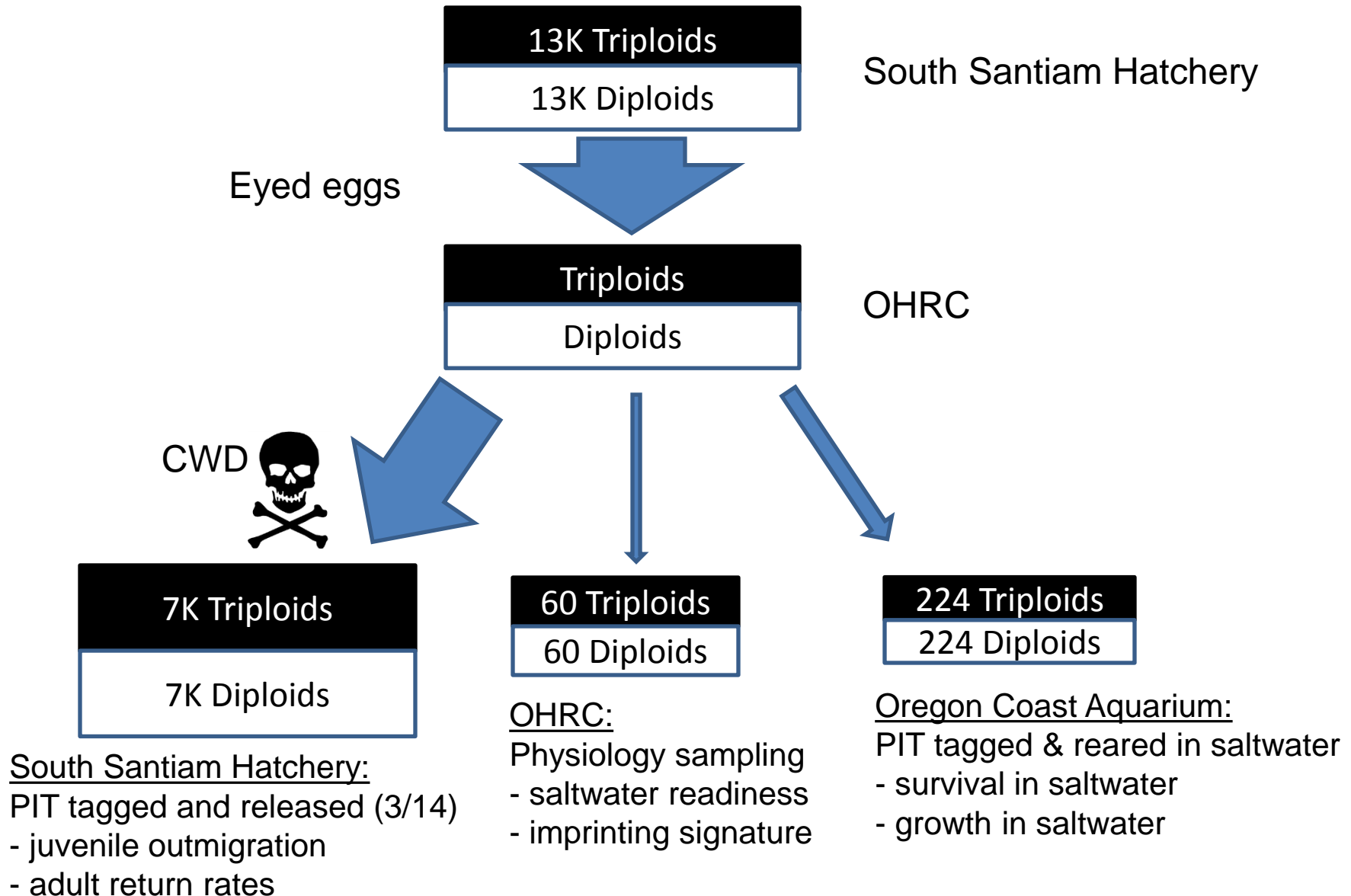
- Triploids fail to undergo meiosis and do not produce gametes
- Commonly used approach for trout and other resident species
- Anadromous species experience no/low adult returns
 - Why? Four hypotheses:
 - 1) Failure to outmigrate as juveniles
 - 2) High mortality at saltwater entry
 - 3) Failure to properly imprint and return to natal sites
 - 4) No physiological cues (i.e. gonad maturation) to return

Production of Triploid Steelhead

Broodstock*Eggs under Pressure**Triploid Steelhead*

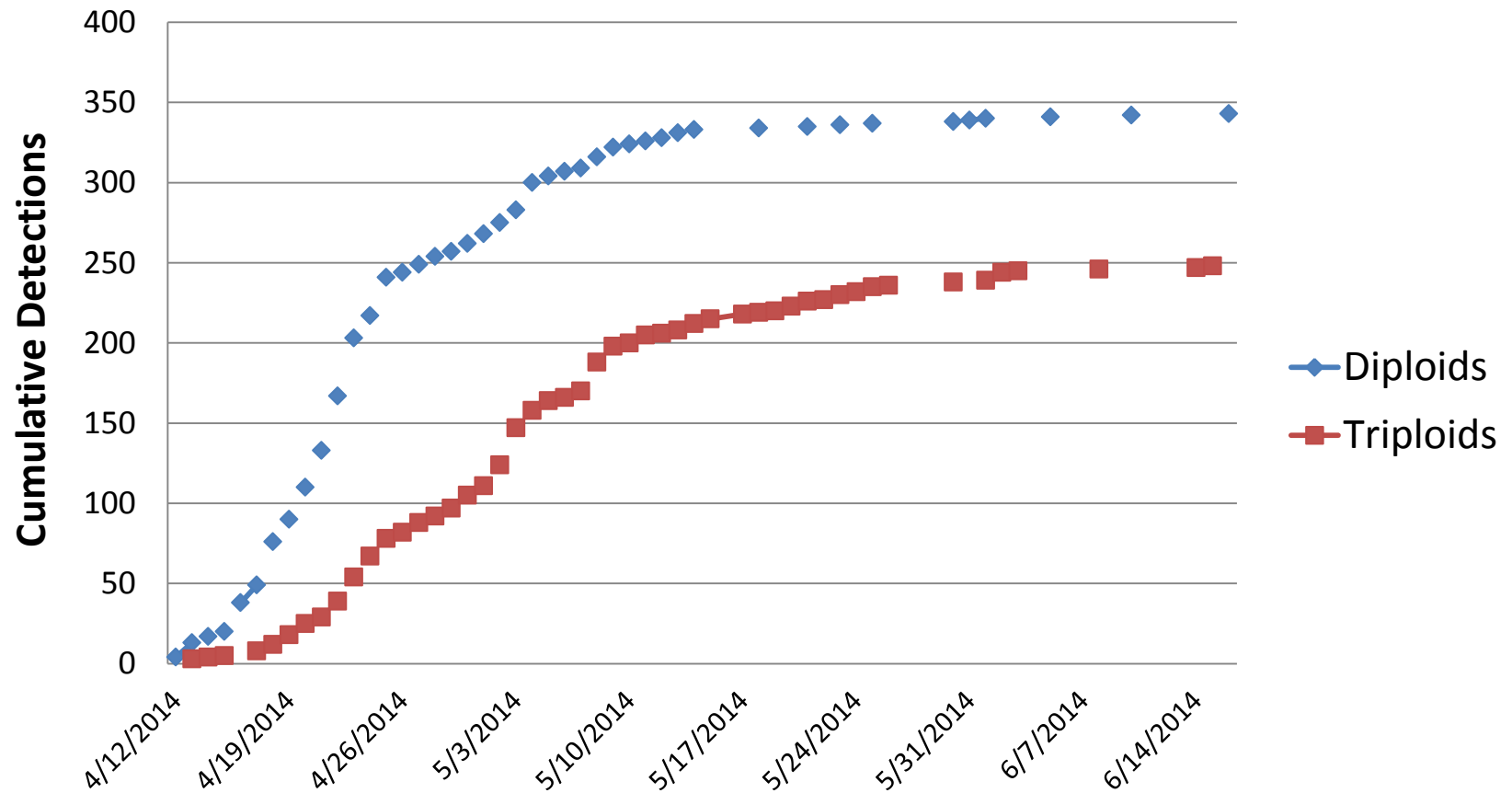
2013 cohort

- 8 families of South Santiam summer steelhead spawned (1:1 matings)
- Each fertilized egg lot split in half
 - Treated (triploids)
 - 5 minutes of 10,000 PSI at 22 minutes post fertilization
 - Untreated (diploids)
 - Result = full sibling treatments and controls



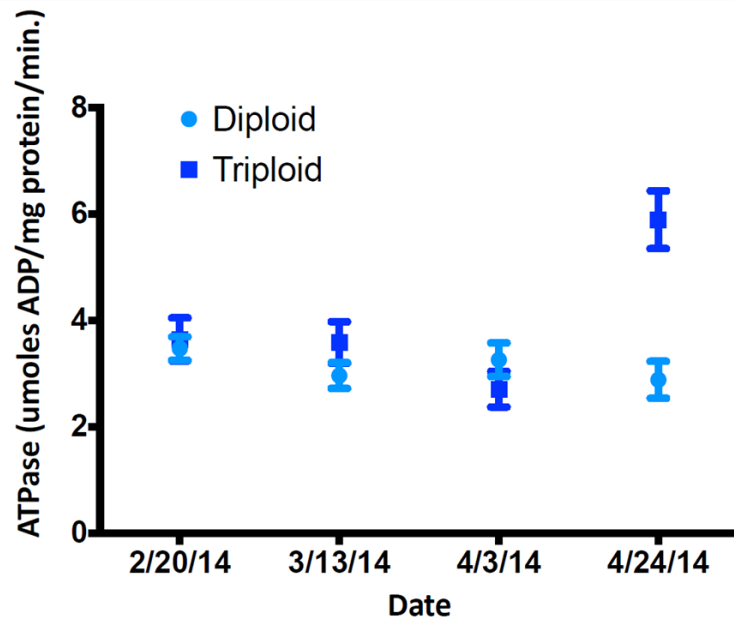
Juvenile outmigration

PIT Detections at Willamette Falls

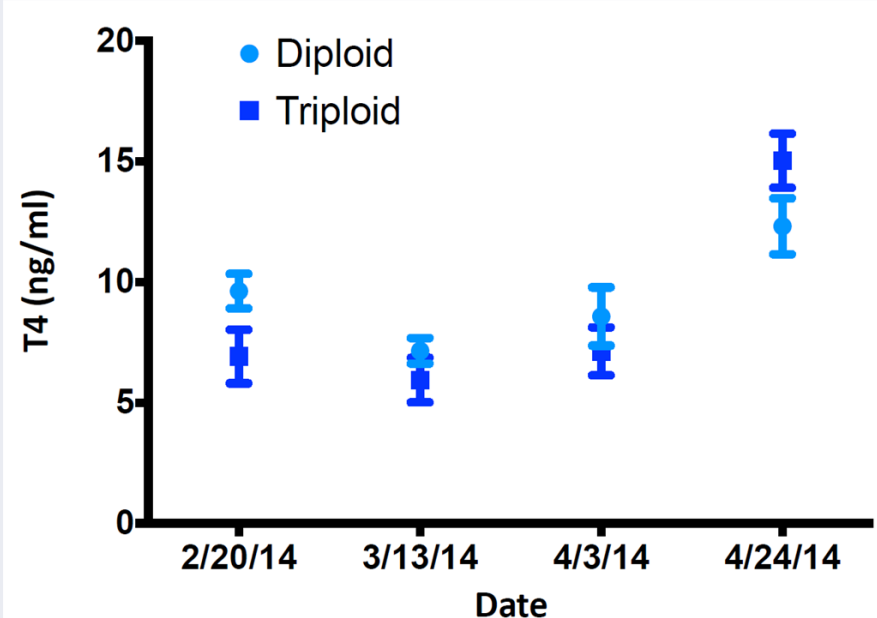


Physiology during Parr-Smolt Transformation

Gill ATPase



Thyroxine (T4)

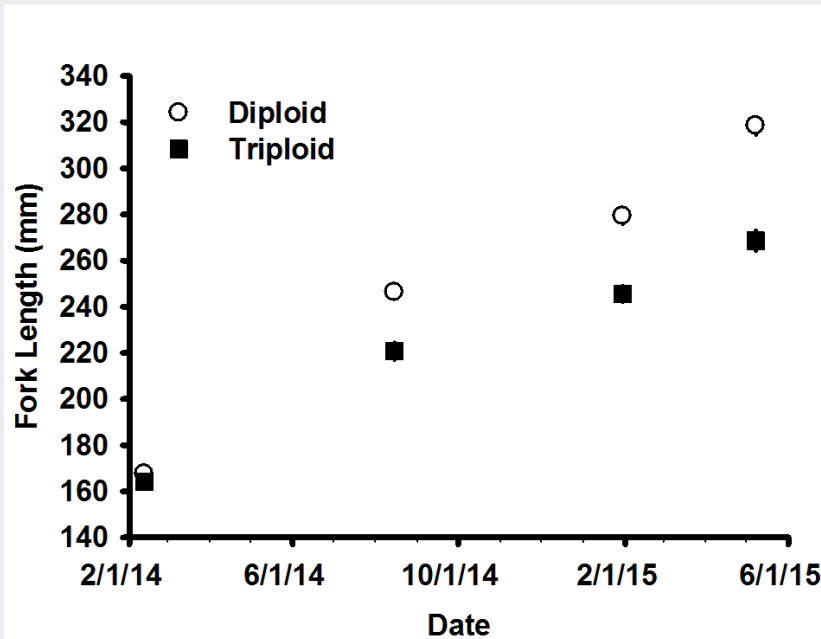


Significant ($P = 0.002$) seasonal increase in gill ATPase among juvenile triploid steelhead, not observed in diploids (interaction *Ploidy* x *Date*, $P < 0.001$).

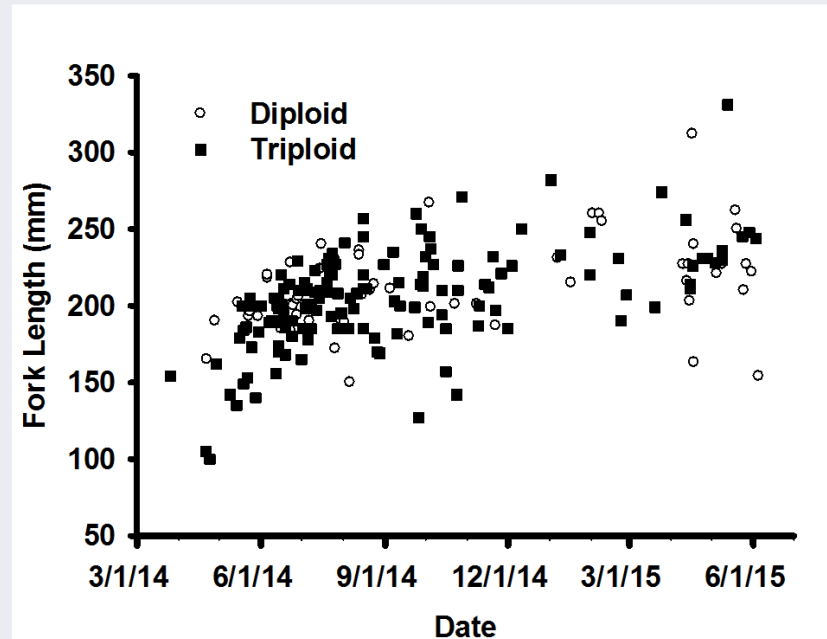
Thyroxine levels increased in both diploid and triploid steelhead ($P < 0.001$), with no significant difference between ploidy groups (interaction *Ploidy* x *Date*, $P = 0.351$).

Growth in Saltwater

Mean fork lengths of the living



Fork lengths of the dead

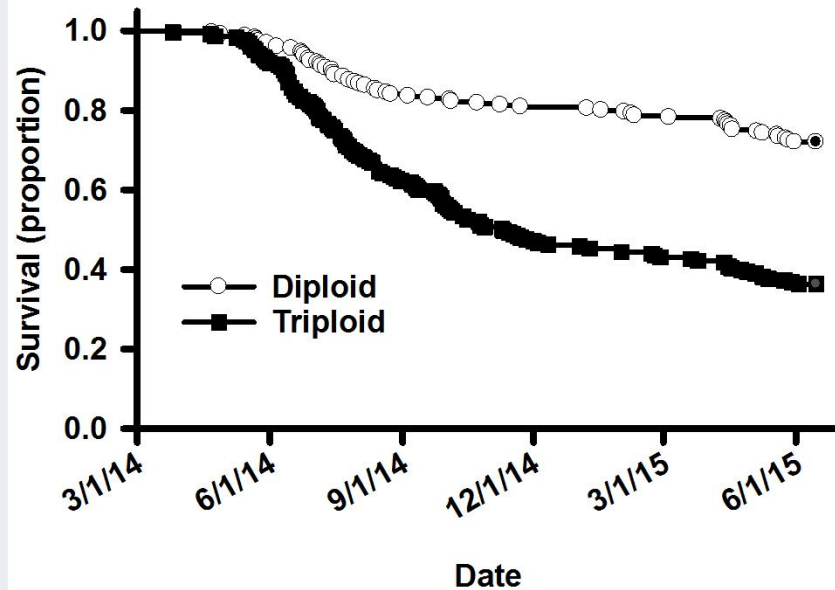


On February 12, 2014, the fork lengths of triploid steelhead (mean 164 mm) were not significantly different ($P = 0.23$) from those of diploids (mean 168 mm).

However, subsequent growth rates of diploids and triploids differed ($P < 0.001$) and by May 8, 2015, the mean fork length of surviving triploids (269 mm) was significantly less ($P < 0.001$) than the mean fork length of surviving diploids (318 mm).

Survival in Saltwater

Diploids outperform triploids



Lessons learned: "Bloat"



Above: A triploid with symptoms of "bloat".

We observed symptoms of "bloat" or "water belly" (Anderson 2006) associated with many diploid and, especially, triploid steelhead mortalities. Transition to a lower lipid, higher retention diet appeared to alleviate this issue.

Survivorship of triploid steelhead was significantly less than that of diploids (log rank = 61.73, df = 1, $P < 0.001$).

Summary of Findings

- Outmigration, growth and survival of juvenile triploid steelhead were all inferior to diploid controls
- These results may explain differences in adult return rates
- But triploids did not completely fail!
- First adult returns in 2016

introduction

methods

results

summary

questions

Acknowledgments

O. mykiss genetics

<i>Sampling</i>	<i>ODFW field crews, biologists and managers</i>	<i>Eric Bailey, Kirsten Schnurle, Luke Whitman, Brett Boyd, Greg Grenbemer & many more</i>
<i>Funding</i>	<i>USACE</i>	<i>David Griffith, Rich Piaskowski & David Leonhardt</i>
<i>Funding</i>	<i>ODFW Restoration and Enhancement Board</i>	
<i>DNA Sequencing</i>	<i>UC Davis</i>	<i>Sean O'Rourke, Omar Ali & Kayla Meza</i>

Triploid steelhead

<i>Rearing & husbandry</i>	<i>Oregon Coast Aquarium</i>	<i>Jim Burke, Kevin Clifford, Evonne Mochon-Collura and Meghan Marie</i>
<i>Rearing & husbandry</i>	<i>REU and PROMISE and Oregon Coast Community College students</i>	<i>Courtney Jackson, Sam Shry, Alessandra Jimenez, Meaghan Clark, Peter Snell, Bailey Stone, Erin Hanson, Mackenzie Mason, Brandon Bertilson and Claire Smith</i>
<i>Flow cytometry and fish health</i>	<i>ODFW</i>	<i>Craig Banner & Sarah Bjork</i>
<i>Physiology assays</i>	<i>University of Washington</i>	<i>Darran May & Paul Hoppe</i>
<i>Spawning, rearing, tagging</i>	<i>ODFW</i>	<i>Brett Boyd & staff at South Santiam Hatchery, Cam Sharpe & crew, OSU students, Association of Northwest Steelheaders</i>
<i>Funding</i>	<i>ODFW R&E Board, Fish Division</i>	

Questions?

