Juvenile physiology, performance and migration behavior of triploid summer steelhead

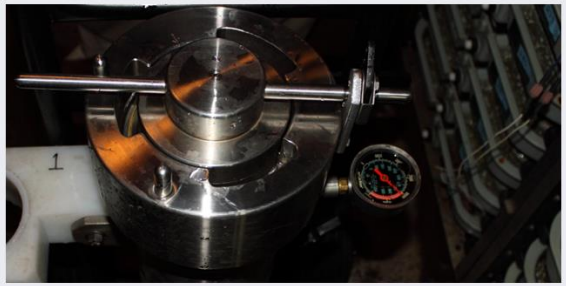
Marc A. Johnson[1] Thomas A. Friesen[1], Andrew H. Dittman[2], Paul M. Olmsted[1], David L. G. Noakes[3, 4], Ryan B. Couture[3], Carl B. Schreck[3], Thomas P. Quinn[5]

[1]Corvallis Research Laboratory, Oregon Department of Fish and Wildlife, Corvallis, Oregon, USA
[2]Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration Fisheries, Seattle, Washington, USA
[3]Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA
[4]Oregon Hatchery Research Center, Oregon Department of Fish and Wildlife, Alsea, Oregon, USA
[5]School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington, USA

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

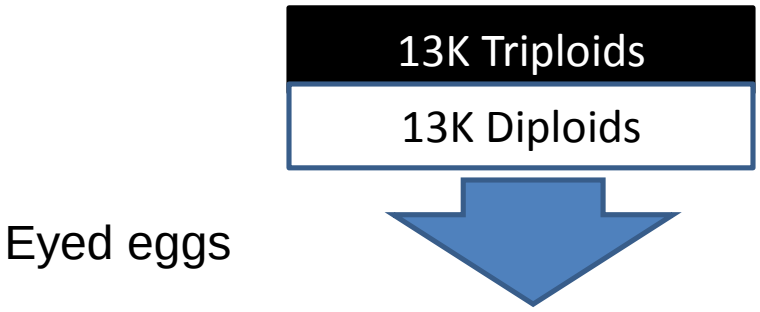
- Triploids fail to undergo meiosis and do not produce gametes
- Commonly used approach for trout and other resident species
- Anadromous species experience no/low adult returns
  - Why? Four hypotheses:
    1) Failure to outmigrate as juveniles
    2) High mortality at saltwater entry
    3) Failure 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*
		

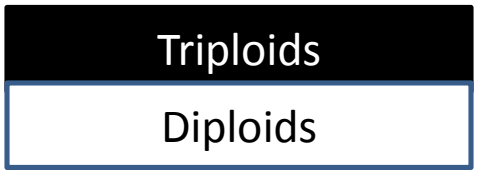
2013 cohort

- 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



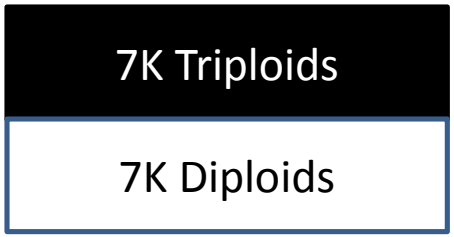
South Santiam Hatchery

Eyed eggs



OHRC

CWD

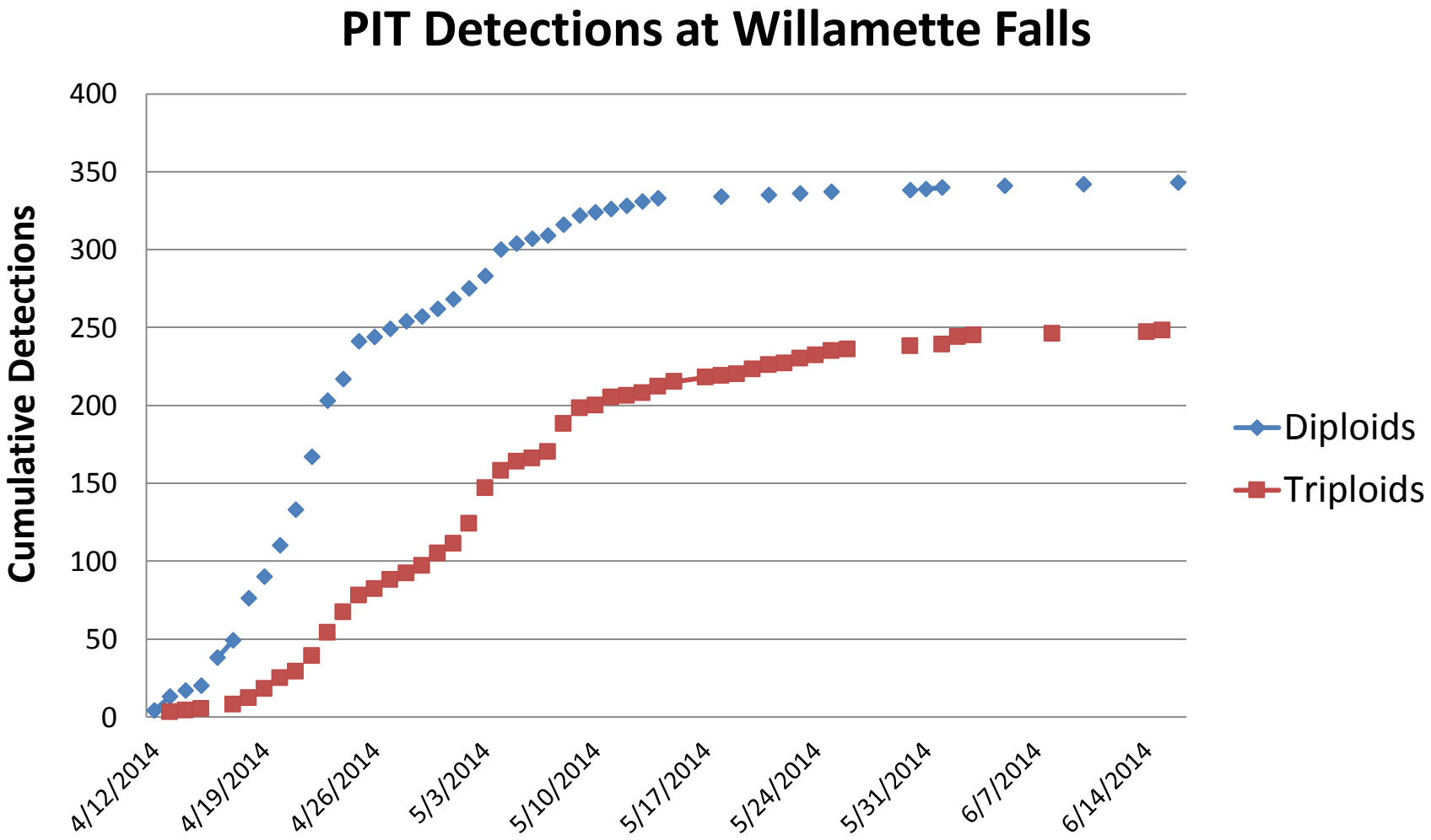


<u>South Santiam Hatchery:</u>
PIT tagged and released (3/14)
- juvenile outmigration
- adult return rates

<u>OHRC:</u>
Physiology sampling
- saltwater readiness
- imprinting signature

<u>Oregon Coast Aquarium:</u>
PIT tagged & reared in saltwater
- survival in saltwater
- growth in saltwater

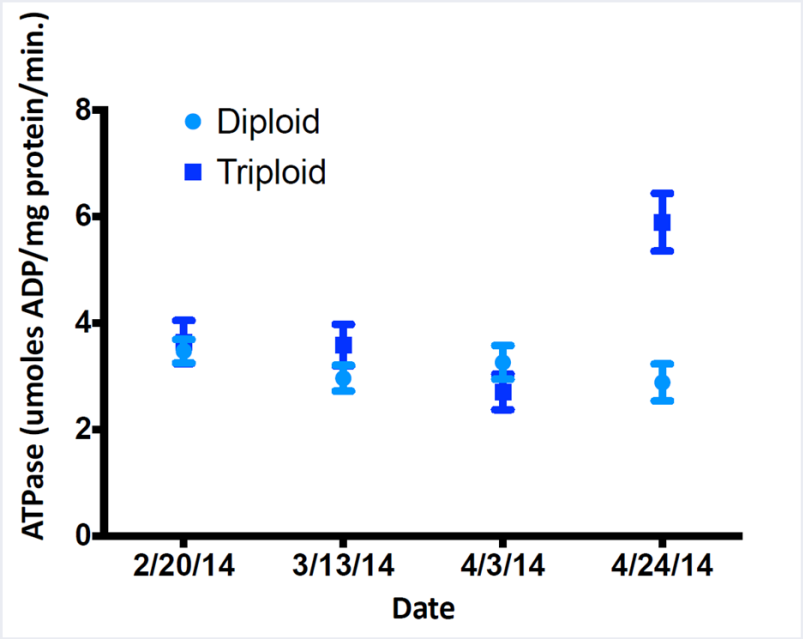
Juvenile outmigration



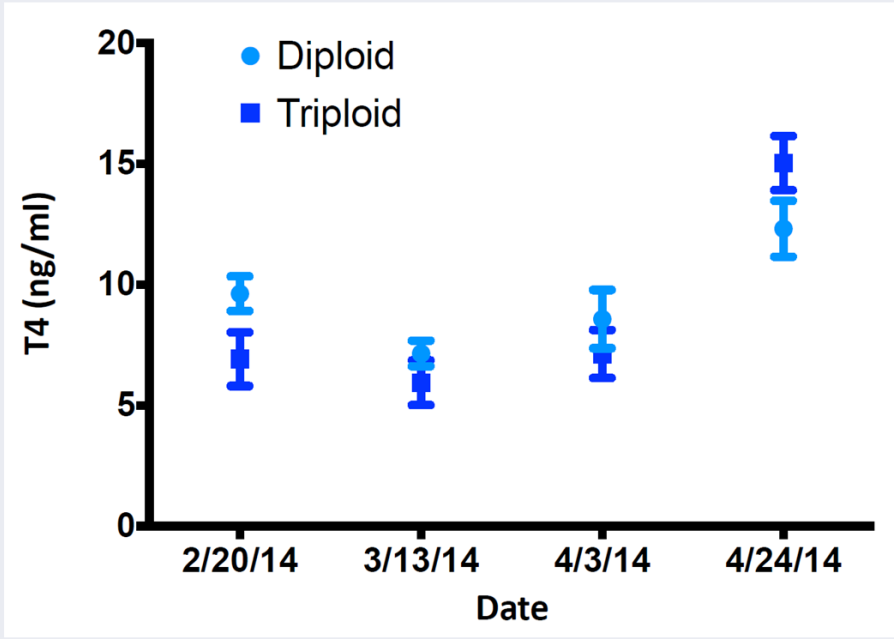
- Total 248 PIT detections of triploids, and 343 detections of diploids
- Triploid outmigration success was 72.3% that of diploids.

Physiology during Parr-Smolt Transformation

Gill ATPase



Thyroxine (T4)

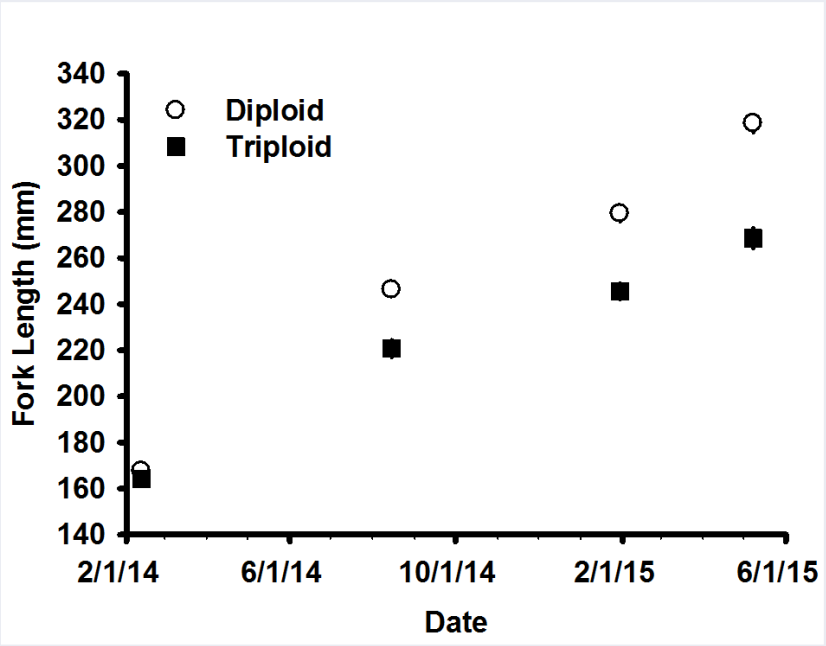


Significant (P = 0.002) seasonal increase in gill ATPase among juvenile triploid steelhead, not observed in diploids (interaction *Ploidy* x *Date*, $P < 0.001$).

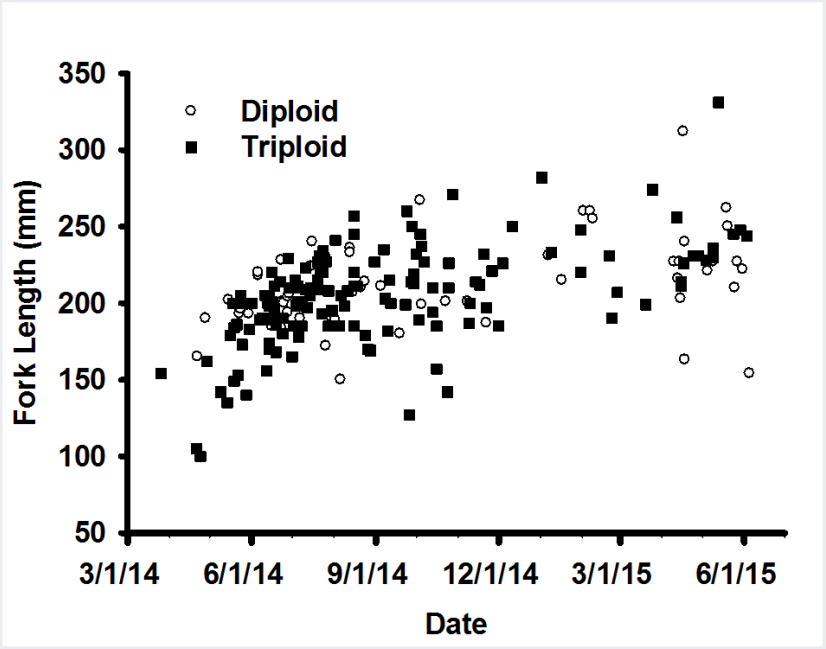
Thyroxine levels increased in both diploid and triploid steelhead ($P < 0.001$), with no significant difference between ploidy groups (interaction *Ploidy* x *Date* , P = 0.351).

Growth in Saltwater

Mean fork lengths of the living



Fork lengths of the dead

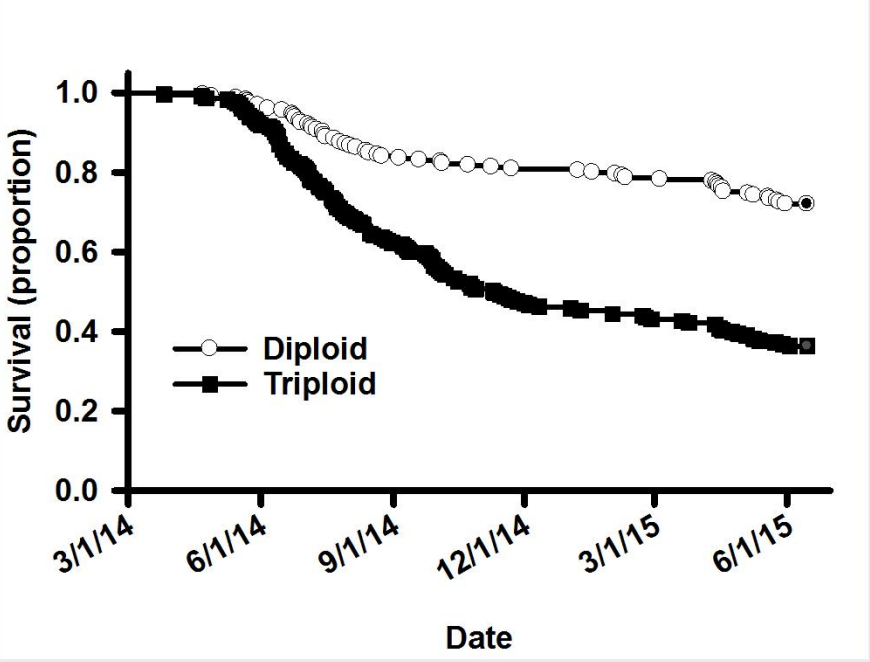


On February 12, 2014, the fork lengths of triploid steelhead (mean 164 mm) were not significantly different ($P = 0.23$) from those of diploids (mean 168 mm).

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



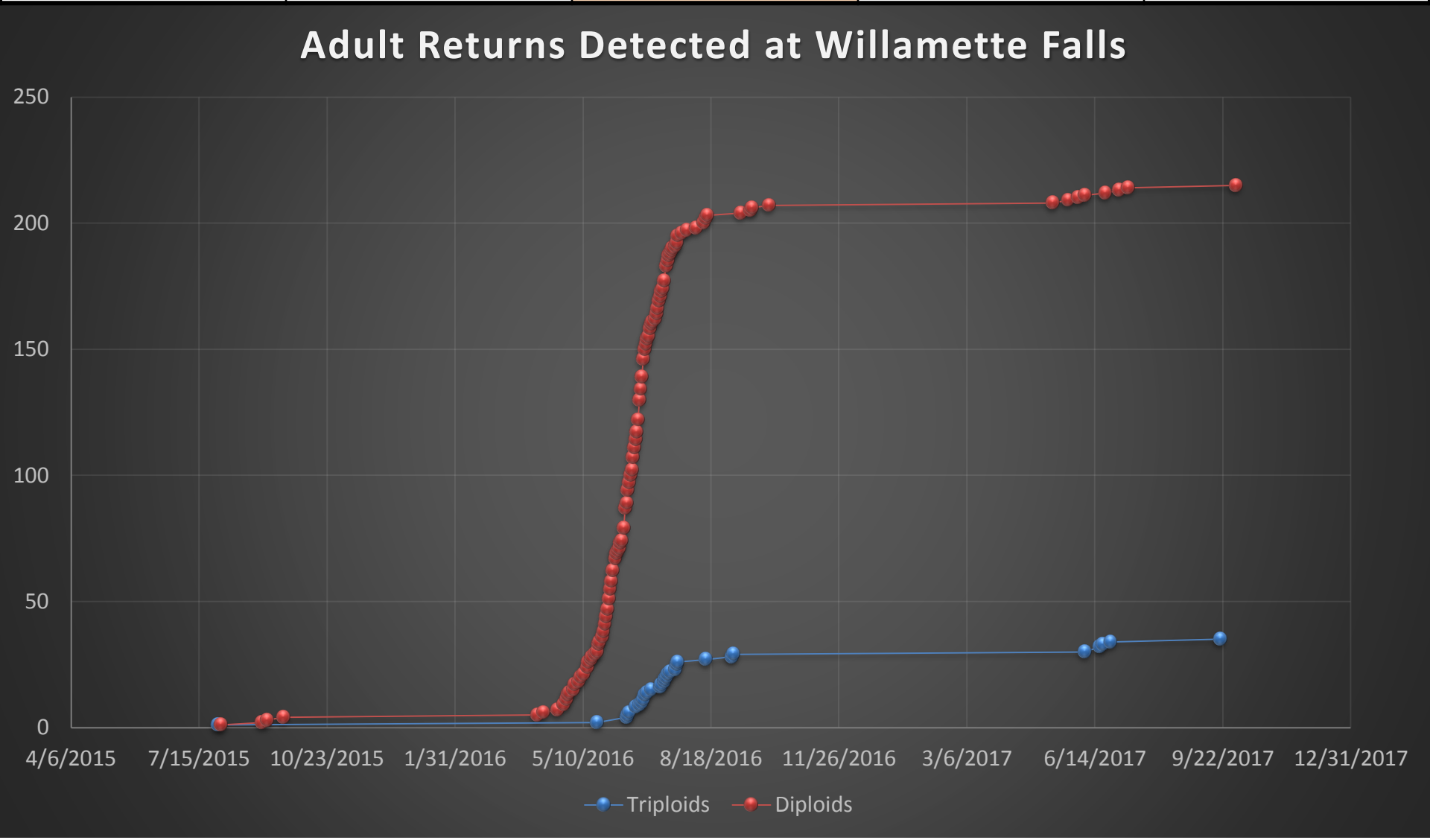
Lessons learned: "Bloat"

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, $P < 0.001$).

Ultimately triploid survivorship was 43% that of diploid controls.

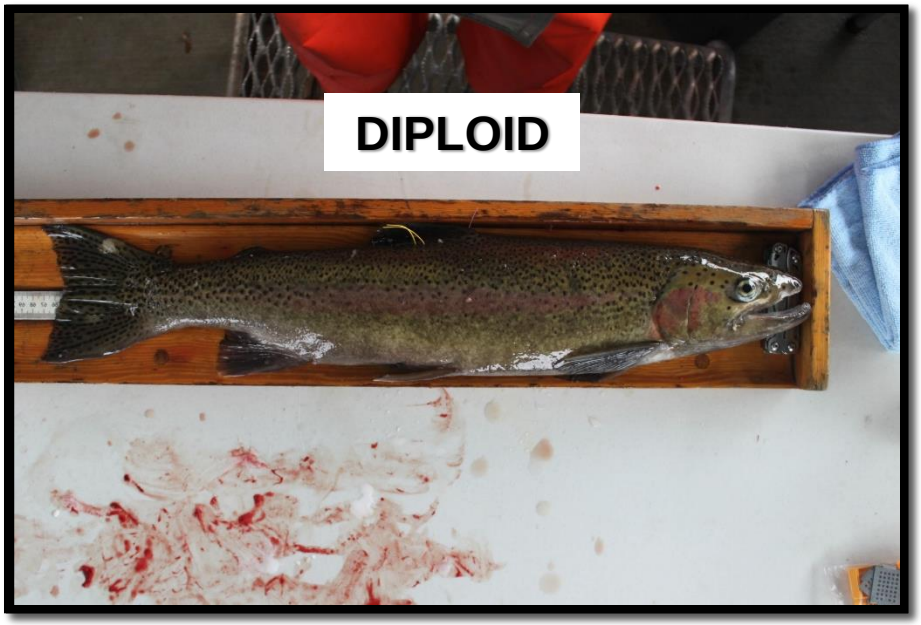


Triploid:Diploid return rate = 35:215

Triploid return rate was 16.3% that of diploid controls

Adult Returns

- Confirmed triploidy with flow cytometry
- Compared gonad development between groups



- Returning adult triploids: only males
- Under-developed gonads in triploids

Summary of Findings

- Triploids under-performed with respect to:
  - Outmigration
  - Growth
  - Early saltwater survival
  - Adult sex ratio; only male triploids returned

- Low adult returns (16.3% of control group)

- Use of triploidy to genetically manage anadromous salmonids must address detrimental treatment effects at multiple life stages

Acknowledgments

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

Questions?