A Preliminary Summary of Ecological Effects and Fisheries Management Considerations Associated with the Removal of Powerdale Dam (Hood River, OR)

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Columbia Gorge Fisheries and Watershed Science Conference

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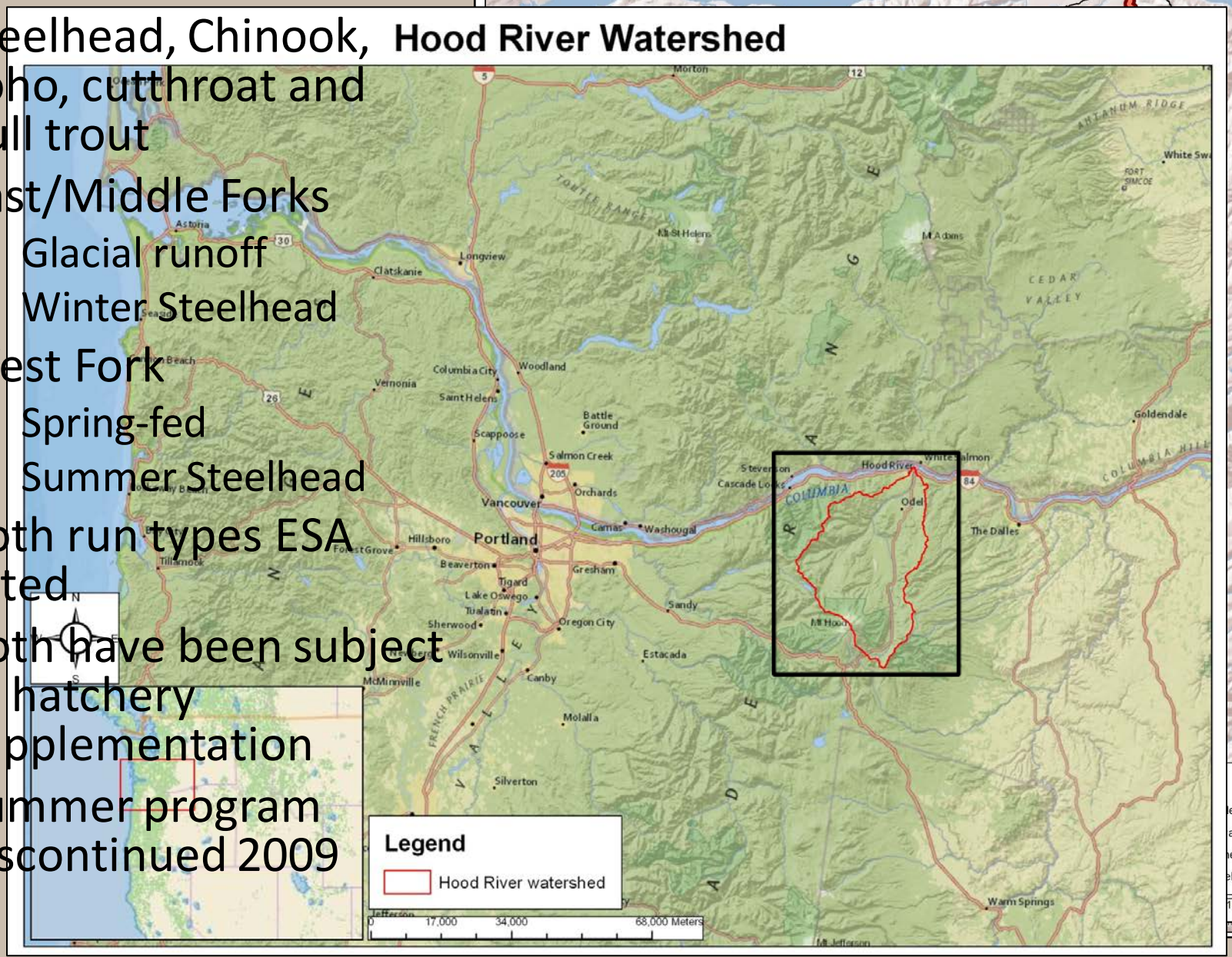
OREGON Fish & Wildlife

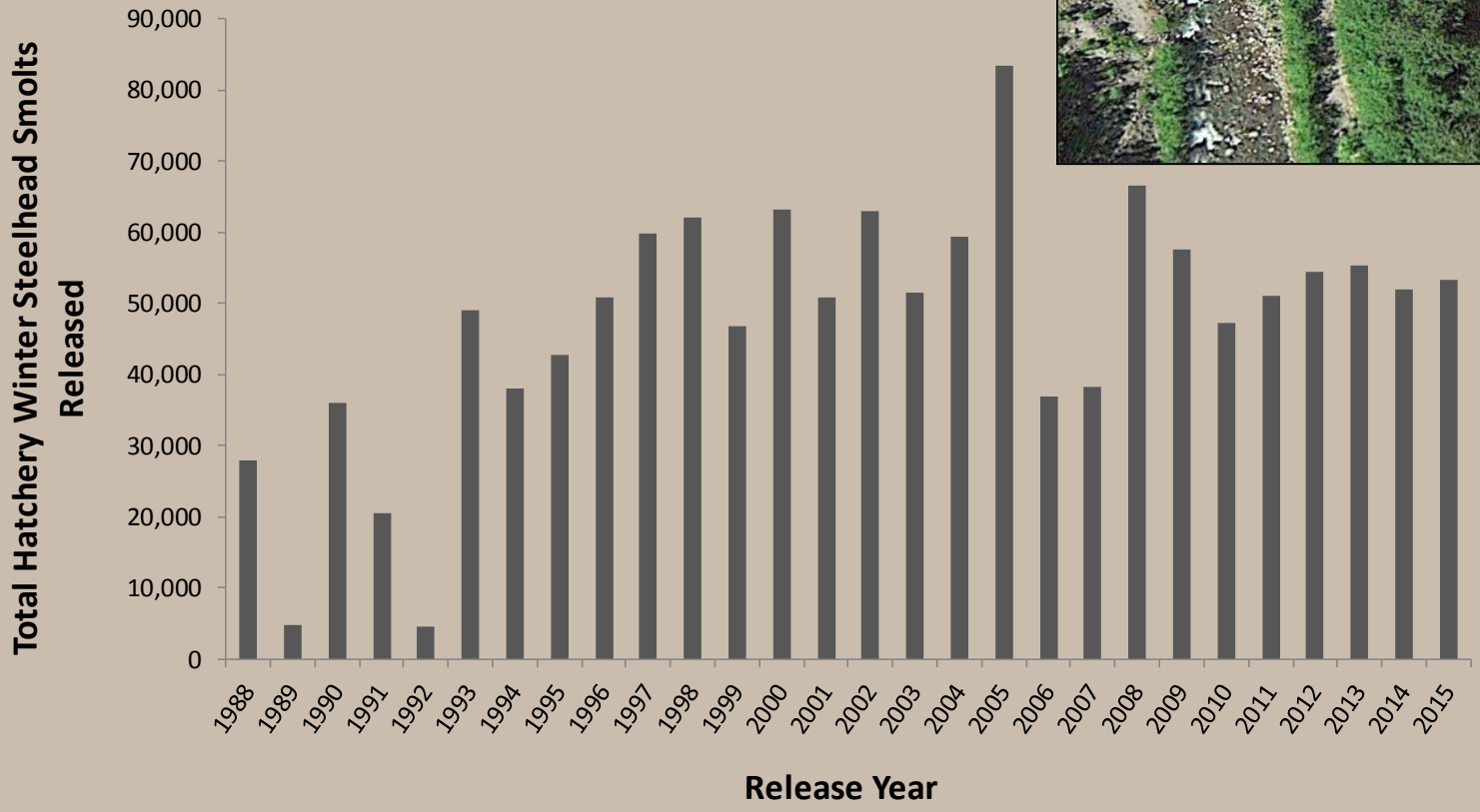
Study Area

- Steep Gradient
- Highly variable flow
- Steelhead, Chinook, coho, cutthroat and bull trout
- East/Middle Forks
  - Glacial runoff
  - Winter Steelhead
- West Fork
  - Spring-fed
  - Summer Steelhead
- Both run types ESA listed
- Both have been subject to hatchery supplementation
- Summer program discontinued 2009



Hood River Winter Steelhead Hatchery Supplementation Program

- Currently classified as an integrated program
- Mean release total (1988 – 2015) = 47,402
- Released as Age 1 Smolts
- “Volitional” release



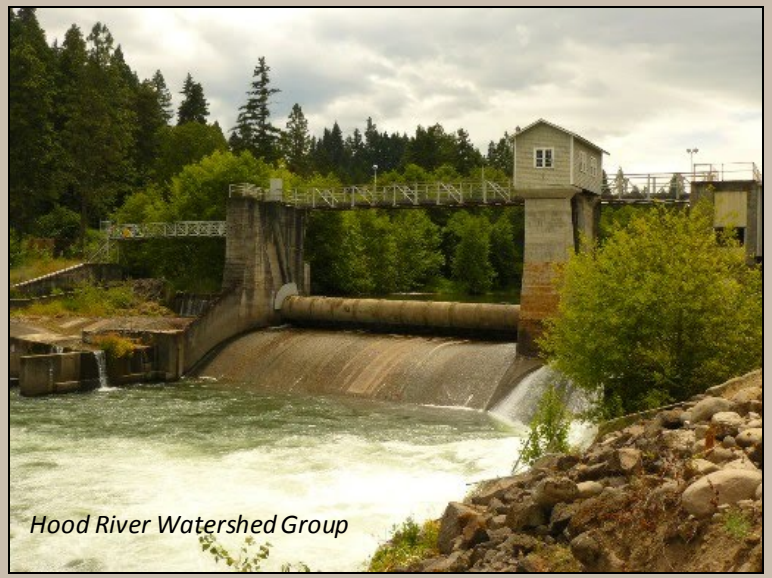
Powerdale Dam

- Constructed in 1923 and operated by Pacific Power and Light Company (now PacifiCorps)

- Dam located at river mile 4.5; Powerhouse at river mile ~1.3

- Produced electricity to support orchards and farms of Hood River Valley

- Complete fish passage barrier- adults passed through ladder daily



Fish Passage

• Fish ladder and upstream trap installed during original construction; updated trapping facility built 1995-1997

• Fish ladder owned by Bonneville Power Administration and operated by ODFW and Confederated Tribes of Warm Springs

• Every fish that passed above dam was recorded

Negative Effects of Dam

- Adult delayed migration, targeted by sport anglers
- Greater spill from west bank may have masked attraction flow to fish ladder
- Water diverted, at times, may have precluded fish passage in 3.2 miles between dam and powerhouse and altered fish habitat
- Limited passage/connectivity for juveniles
- Inadequately screened diversion channels potentially trapped downstream migrating fish

Powerdale Dam Removal—2010

7 July 2010. All three photos were taken from a permanent "photodoc" stand on the East bank. This view shows initial phases of decommissioning, with dam still in place.

14 October 2010. At this time, the dam has just been removed, revegetation done, and the channel reconstructed. Note comparatively low position of the channel bottom.

4 May 2011. Recent photo showing the results of winter runoff and channel re-adjustment. Note accumulation of 10+ feet of new material and new island at right. The new channel is still providing fish passage

Images courtesy of the Hood River Watershed Group

Powerdale Dam Removal—2010

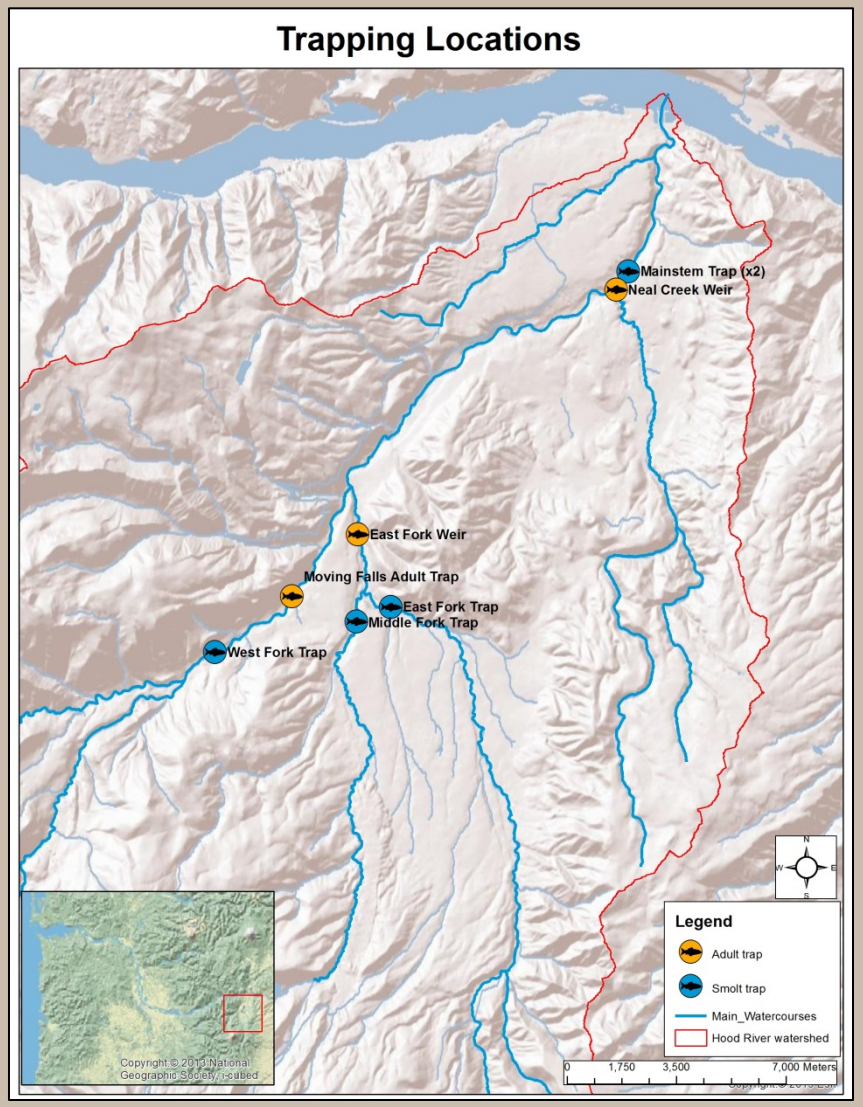
Google Earth


METHODS
SIMMS

PIT tagging

- Wild
  - PIT tag virtually all wild salmonids (since fall 2004)
    - 4 trap sites, 6 traps
- Hatchery
  - CTWSRO ≈ 10%
    - ≈ 5K Winter Steelhead
  - ODFW ≈ 1% – 5% (Steelhead)

Biomark



NOAA NWFSC

Smolt Abundance and Survival

p5

p5

p4

p3

p2

p1

Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Legend

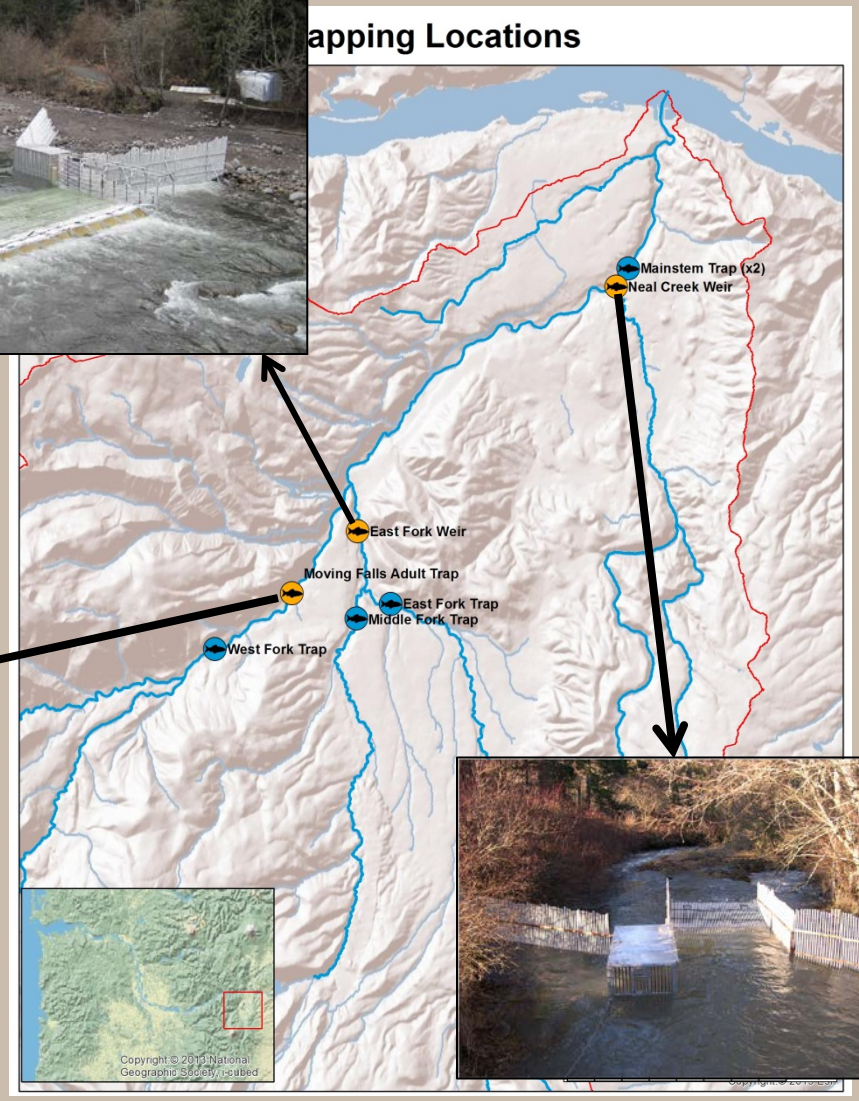
CJS_points

Hood River watershed

- Abundance: $\hat{N} = (C)/p2$
- Survival: Cormack Jolly-Seber
  (Program MARK; length, flow covariates)

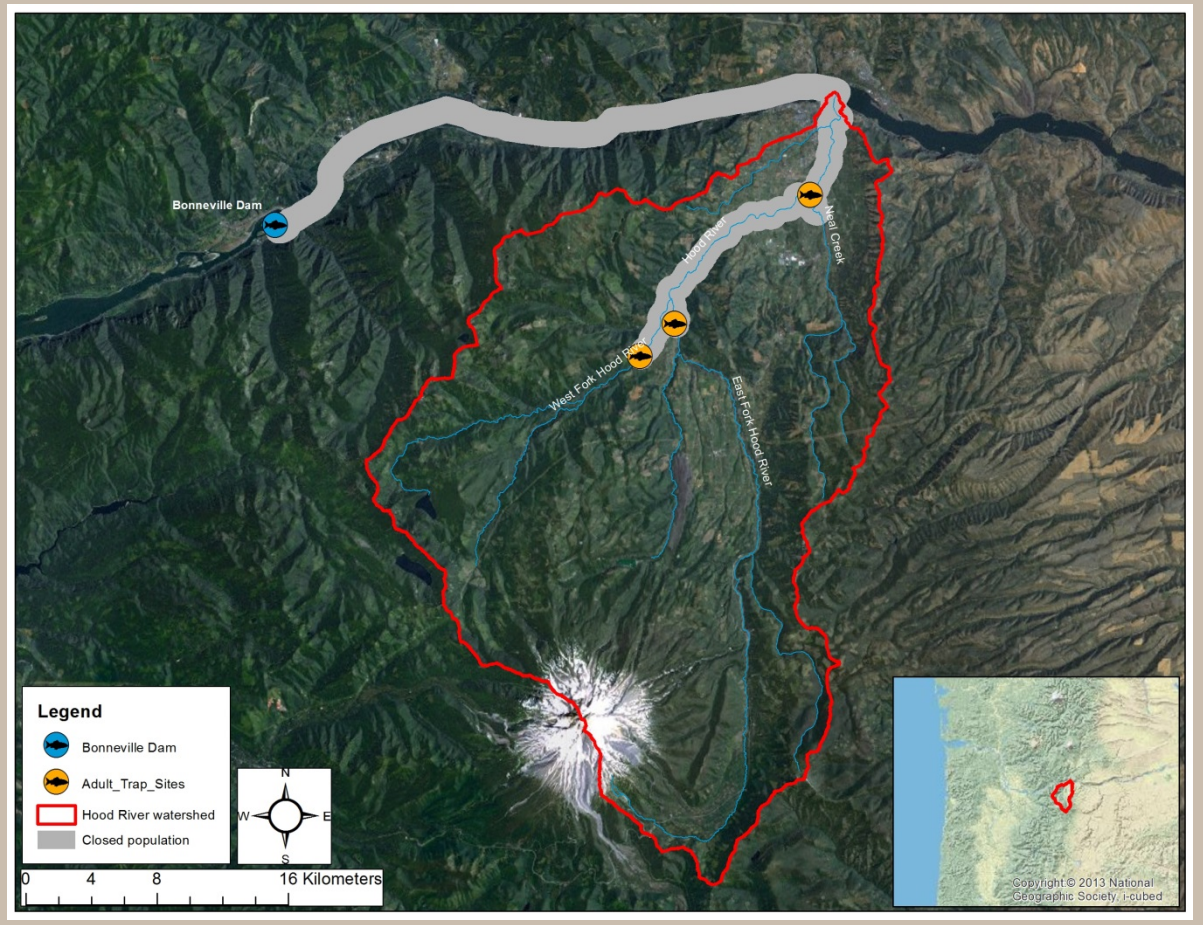
Adults: Post-Dam Removal

- East Fork Weir
- Neal Creek Weir
- Moving Falls



Adult Escapement: M-R

- Lincoln-Petersen (with Chapman's modification) where:
  - ***M*** = previously PIT tagged species *x*, run type *y*, and origin *z* detected at the adult Bonneville Dam interrogation facilities
  - ***C*** = the total marked and unmarked species *x*, run type *y*, and origin *z* captured at the adult weir facilities within the Hood River basin
  - ***R*** = the total number of recaptures within the second capture group (***C***)
  - $\hat{N}$ = estimated number of adults of species *x*, run type *y*, and origin *z* returning to Bonneville Dam

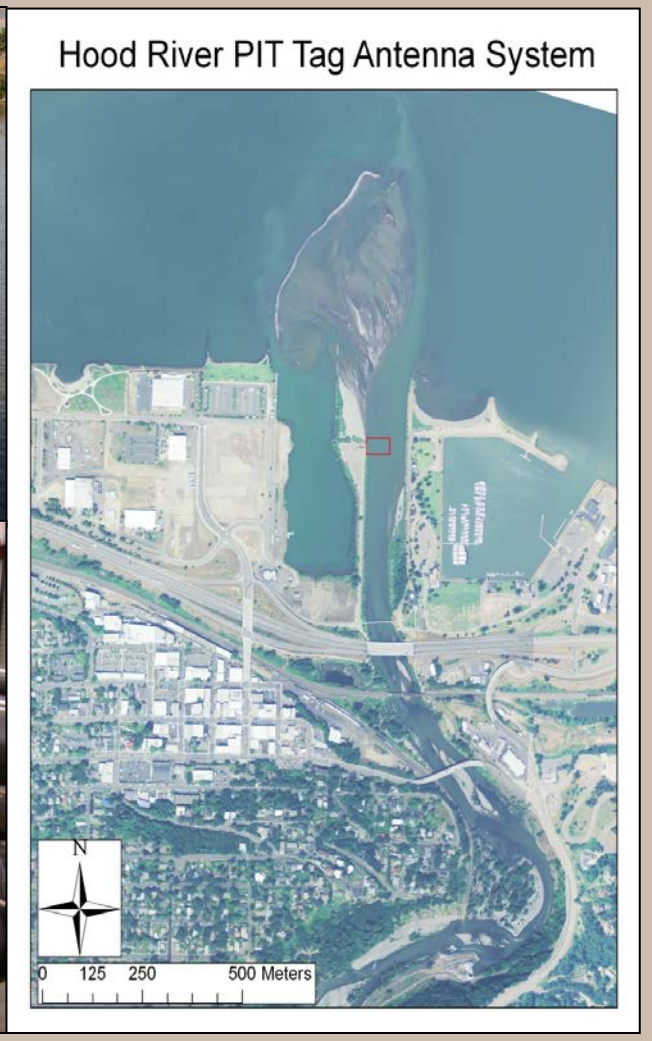


- *var* ($\hat{N}$) = *[(M+1) (C+1) (M- R) (C-R)] / [(R+1)^2 (R+2)]*

- **Very limited M group**

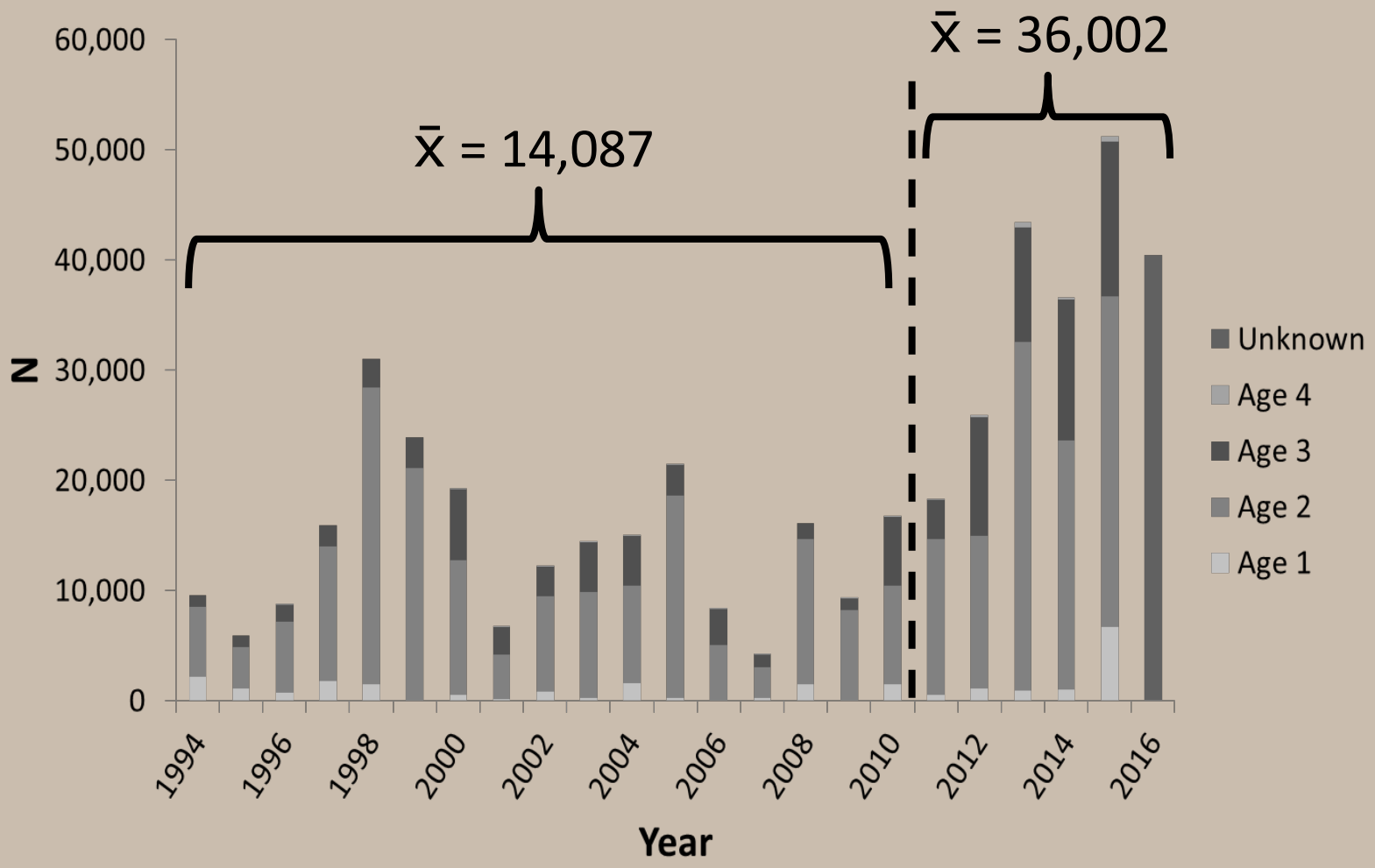
Closed population assumptions

- No deaths, births, immigration, emigration
- Modeled apparent survival (Bonneville ---> HR) using CJS open population model



JUVENILES

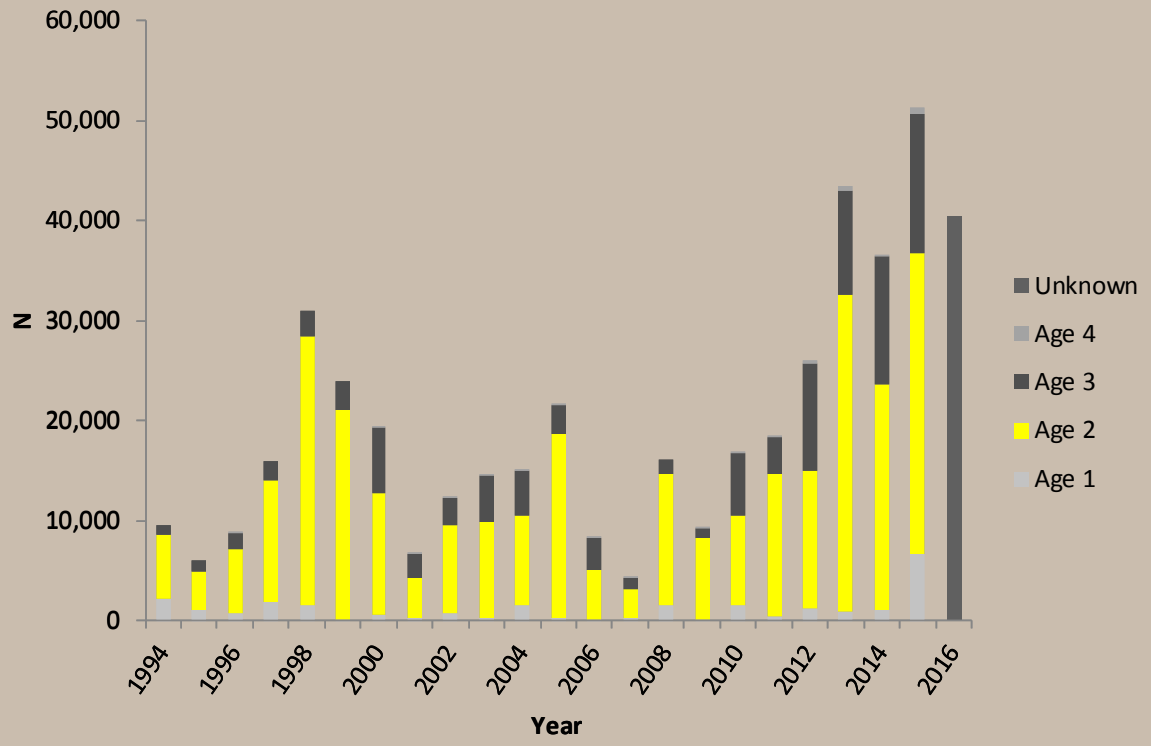
Smolt Abundance 1994 – 2016



- $p<0.00003$ ($\alpha=0.05$)

Smolt Production Multiple Regression Model

- Response variable
  - Abundance of wild age 2 smolts
- Predictor variables
  - Average flow rate during Sept 1 – Oct 15 the year prior to smolt migration
  - Average flow rate during April – May of brood year
  - Dam Removal
  - Proportion of non-smolts (FL<141mm) from hatchery release group
  - Total adult spawners during Brood Year
- Other predictor variables considered:
  - Average fork length of age 2 smolts
  - Smolt abundance of elder age class
  - Proportion of wild vs. hatchery spawners
  - Dec – April flow variance
  - % Residuals



Model Selection

R (AICmodavg)

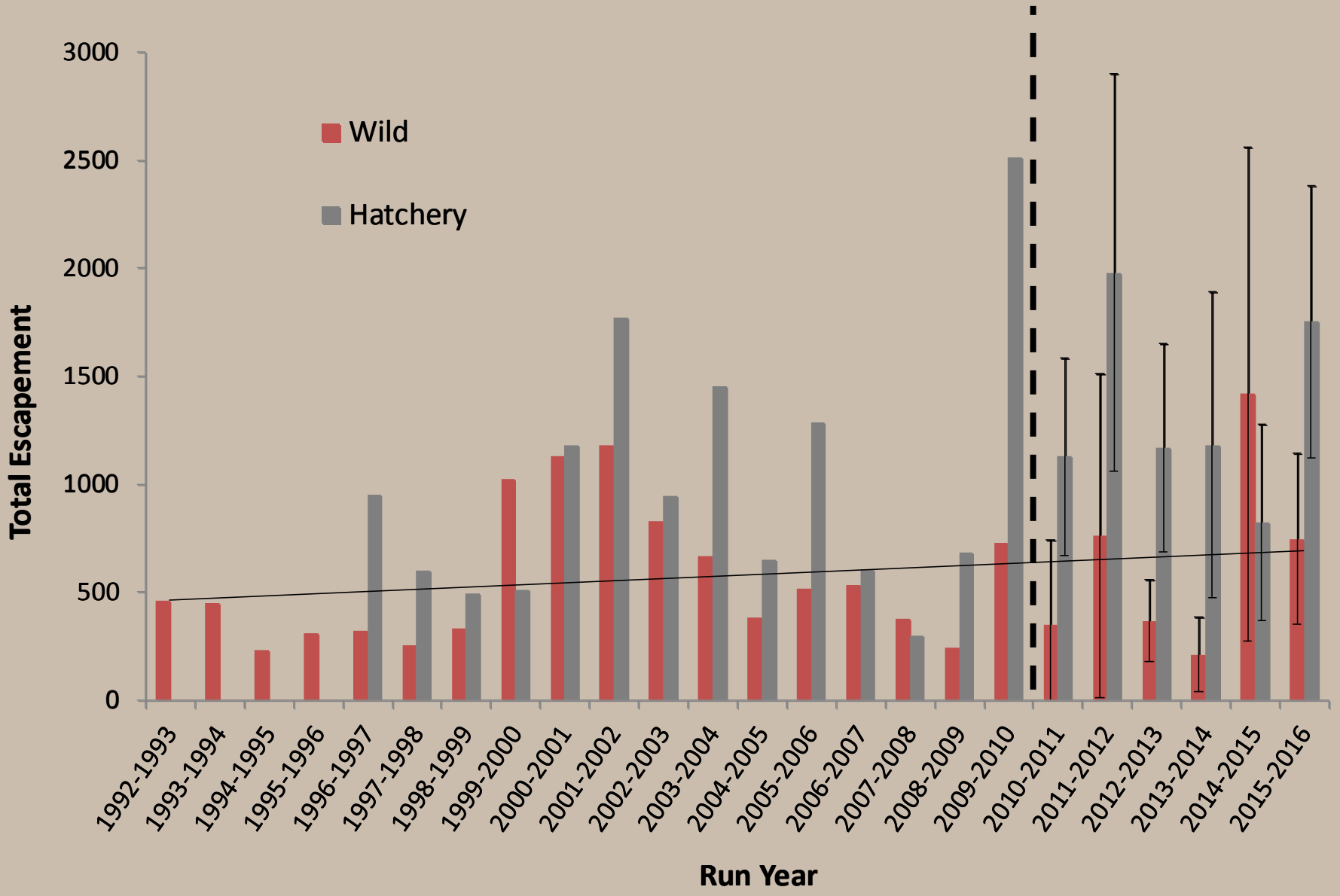
- Averaged top 3 models
- Dam removal most significant variable ($\alpha = 0.05$)
- Mean Apr – May flow during brood year near significance threshold
- Mean summer low flow also positively correlated with smolt production

Modnames	K	AICc	Delta_AICc	ModelLik	AICcWt	LL	Cum.Wt
MQBY+DAM	4	375.0264	0.000000	1.00000000	0.344989974	-181.9748	0.3449900
MSLQ+DAM	4	376.3886	1.362128	0.50607813	0.174591879	-182.6558	0.5195819
MSLQ+MQBY+DAM	5	376.7305	1.704100	0.42653963	0.147151895	-180.8653	0.6667337
MQBY	3	378.5655	3.539050	0.17041389	0.058791085	-185.4256	0.7255248
MQBY+PP+DAM	5	378.9037	3.877216	0.14390409	0.049645469	-181.9518	0.7751703
MSLQ+MQBY	4	379.0546	4.028165	0.13344277	0.046036416	-183.9888	0.8212067
MSLQ	3	379.2186	4.192183	0.12293598	0.042411679	-185.7522	0.8636184
MSLQ+PP+DAM	5	380.2177	5.191237	0.07459971	0.025736154	-182.6088	0.8893546
PP+DAM	4	380.2325	5.206007	0.07405084	0.025546797	-184.5778	0.9149013
MSLQ+PP	4	380.8785	5.852027	0.05361033	0.018495027	-184.9008	0.9333964
MQBY+PP	4	381.0020	5.975556	0.05039931	0.017387256	-184.9625	0.9507836
MSLQ+MQBY+PP+DAM	6	381.2348	6.208345	0.04486162	0.015476809	-180.7992	0.9662604
PP	3	381.5026	6.476132	0.03923971	0.013537308	-186.8941	0.9797977
Intercept only	2	381.8128	6.786328	0.03360220	0.011592420	-188.5064	0.9913902
MSLQ+MQBY+PP	5	382.4077	7.381221	0.02495676	0.008609831	-183.7038	1.0000000

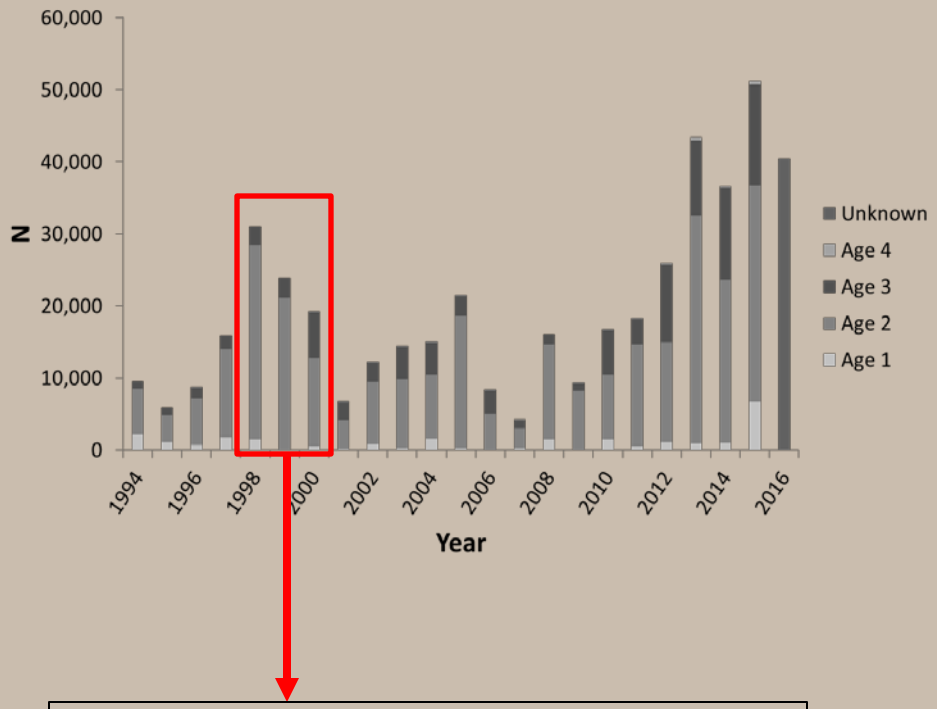
	Estimate	Std. Error	Adjusted SE	z value	Pr(>|z|)
(Intercept)	6641.602	7761.565	8375.171	0.793	0.4278
MQBY	9.727	4.597	4.988	1.95	0.0512
DAM	-9054.349	3568.313	3882.586	2.332	0.0197
MSLQ	27.253	16.709	18.085	1.507	0.1318

ADULTS

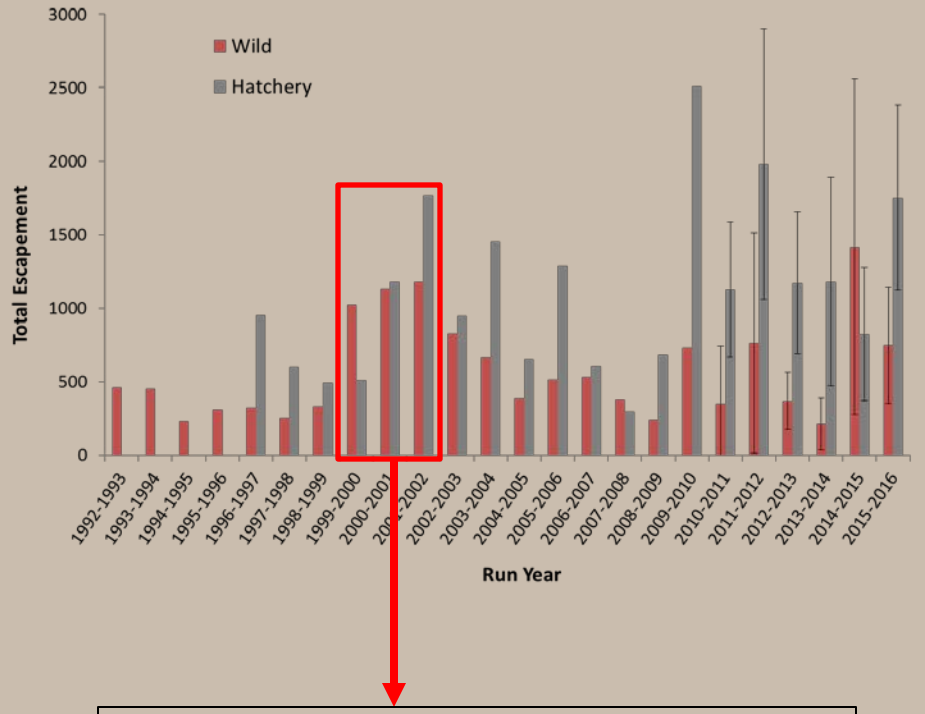
Winter steelhead escapement



Juvenile/Adult Production



- 1998 – 2000 Outmigration Years
- Mean N = 25,000

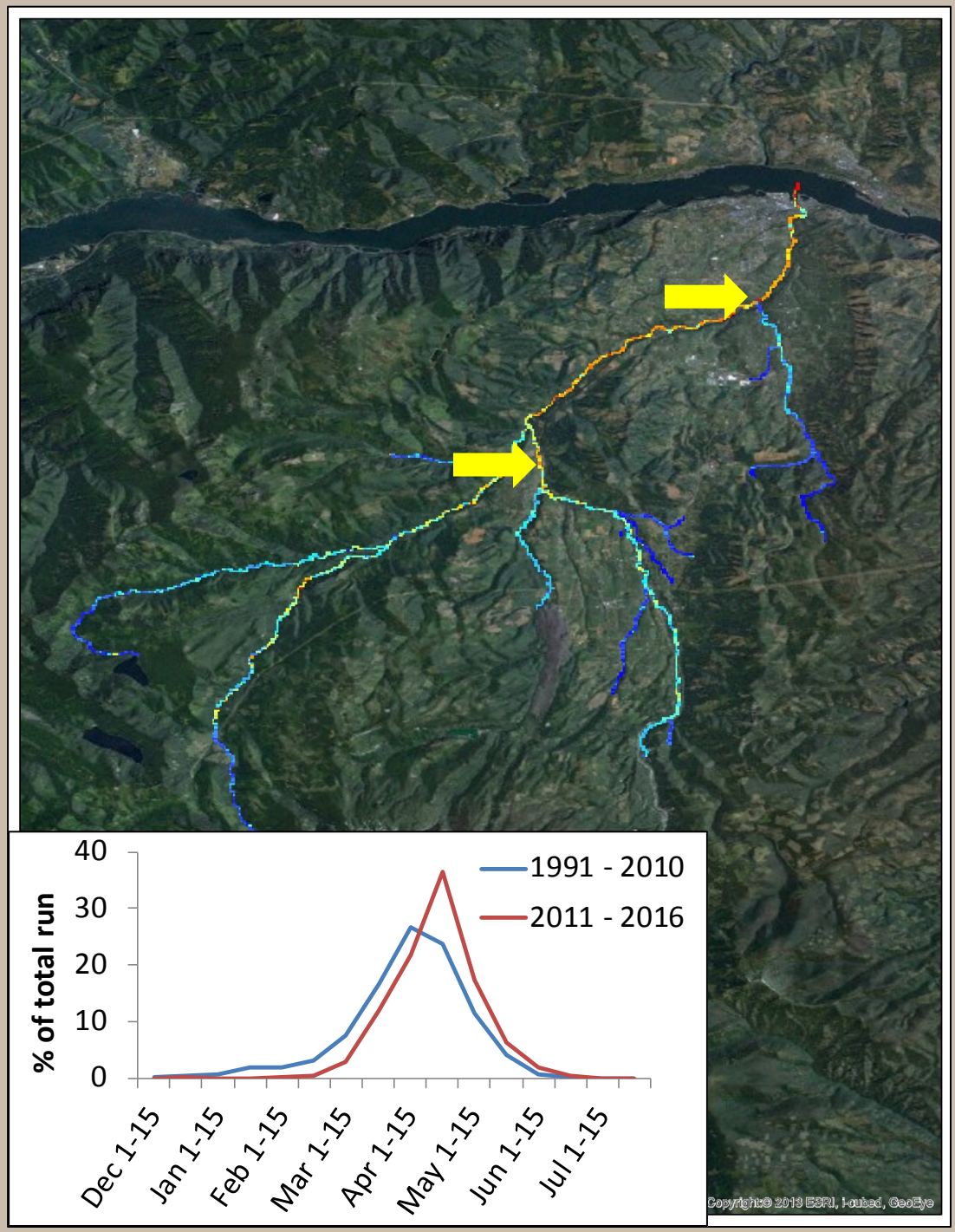


- 2000 – 2002 Brood Years
- Mean N = 1,110

	Year																		
Ecosystem Indicators	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
PDO (Sum Dec-March)	16	6	3	12	7	18	11	15	13	9	5	1	14	4	2	8	10	19	17
PDO (Sum May-Sept)	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8	17	19	18
ONI (Average Jan-June)	18	1	1	6	12	14	13	15	8	11	3	10	16	4	5	7	9	17	19
46050 SST (°C; May-Sept)	15	8	3	4	1	7	19	14	5	16	2	9	6	10	11	12	13	18	17
Upper 20 m T (°C; Nov-Mar)	18	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2	19	17
Upper 20 m T (°C; May-Sept)	15	11	13	4	1	3	19	17	7	8	2	5	12	10	6	16	18	9	14
Deep temperature (°C; May-Sept)	19	6	8	4	1	10	12	16	11	5	2	7	14	9	3	15	18	17	13
Deep salinity (May-Sept)	18	3	8	4	5	15	16	9	6	1	2	13	17	12	11	10	19	14	7
Copepod richness anom. (no. species; May-Sept)	17	2	1	7	6	13	12	16	14	10	8	9	15	4	5	3	11	18	19
N. copepod biomass anom. (mg C m^{-3}; May-Sept)	17	13	9	10	3	15	12	18	14	11	6	8	7	1	2	4	5	16	19
S. copepod biomass anom. (mg C m^{-3}; May-Sept)	19	2	5	4	3	13	14	18	12	10	1	7	15	9	8	6	11	16	17
Biological transition (day of year)	17	11	6	7	8	12	10	16	15	3	1	2	14	4	9	5	13	19	19
Ichthyoplankton biomass (log (mg C 1000 m^{-3}); Jan-Mar)	19	10	2	6	8	17	16	12	15	14	1	11	3	13	9	7	18	4	5
Ichthyoplankton community index (PCO axis 1 scores; Jan-Ma	9	13	1	6	4	10	18	16	3	12	2	14	15	11	5	7	8	17	19
Chinook salmon juvenile catches (no. km^{-1}; June)	18	4	5	16	10	13	17	19	12	8	1	6	7	15	3	2	9	14	11
Coho salmon juvenile catches (no. km^{-1}; June)	18	7	12	5	6	2	15	19	16	3	4	9	10	14	17	1	11	8	13
Mean of ranks	16.4	7.0	5.7	6.9	5.8	11.9	14.6	15.5	11.0	8.7	2.7	8.1	11.8	7.9	6.3	7.4	12.0	15.3	15.3
Rank of the mean rank	19	6	2	5	3	13	15	18	11	10	1	9	12	8	4	7	14	16	16
Ecosystem Indicators not includ in the mean of ranks or sta tical analyses																			
Physical Spring Trans. UI based (day of year)	3	7	18	15	4	12	14	19	12	1	6	2	8	11	16	9	17	10	5
Physical Spring Trans. Hydrographic (day of year)	18	3	13	8	5	12	14	19	6	9	1	9	17	3	11	2	15	7	16
Upwelling Anomaly (April-May)	9	3	16	5	8	13	12	19	9	4	6	7	14	16	14	11	18	1	2
Length of Upwelling Season UI based (days)	6	2	17	11	1	12	9	19	5	3	8	3	14	16	14	13	18	10	7
SST NH-5 (°C; May-Sept)	8	6	5	4	1	3	19	15	9	17	2	18	10	7	13	12	14	11	16
Copepod Community Index (MDS axis 1 scores)	18	5	4	8	1	13	14	16	15	10	2	6	12	9	7	3	11	17	19
Coho Juv Catches (no. fish km^{-1}; Sept)	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA	NA	NA	NA

Improved Spawner Access?

- MaxEnt
  - Maximum entropy model based on presence data and associated environmental attributes
- Habitat variables
  - Unit Type
  - % Gravel
  - Depth
  - Slope



Negative Effects of Dam

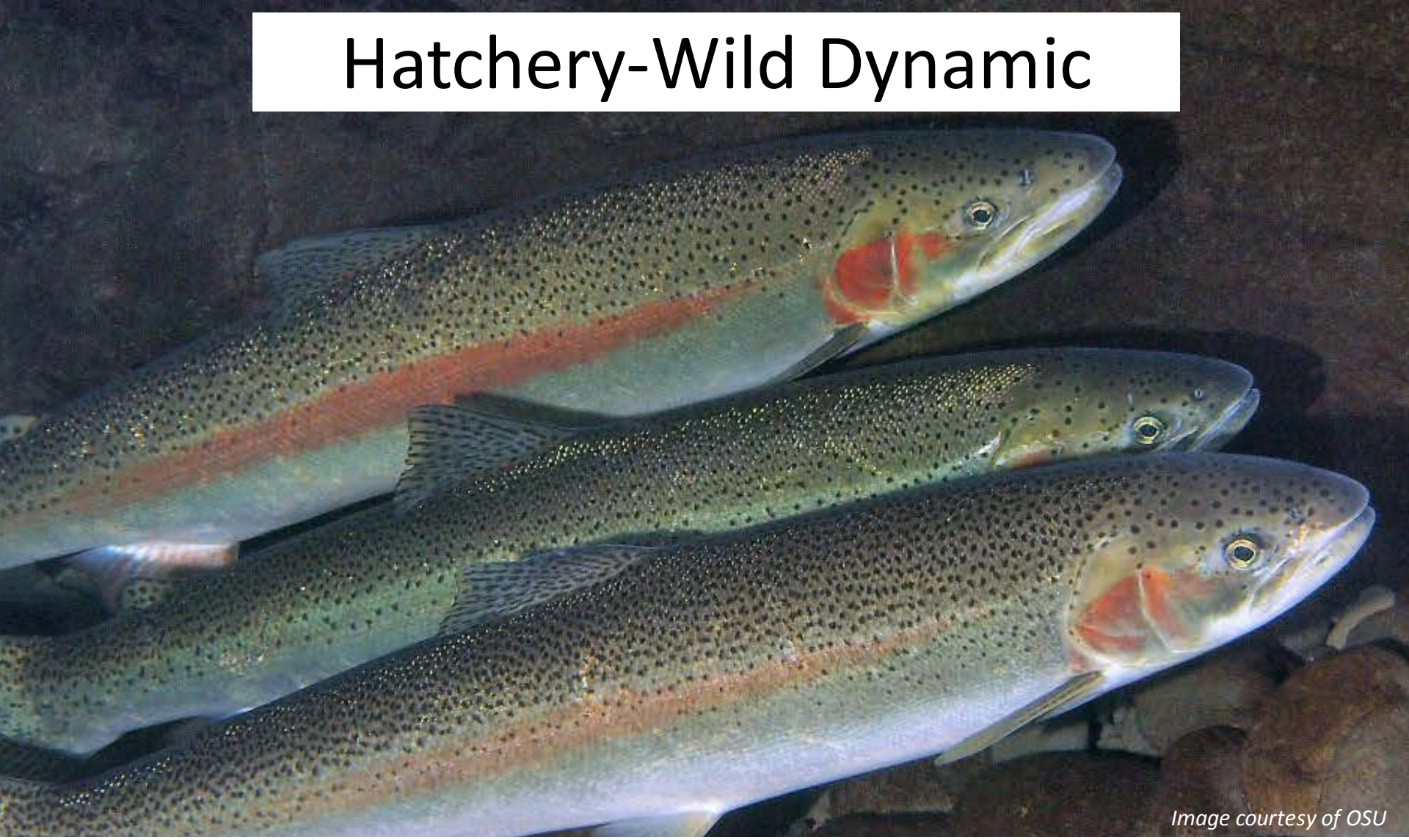
- ✓ Adult delayed migration, targeted by sport anglers
- ✓ Greater spill from west bank may have masked attraction flow to fish ladder
- ✓ Water diverted, at times, may have precluded fish passage in 3.2 miles between dam and powerhouse and altered fish habitat
- ✓ Limited passage/connectivity for juveniles
- ✓ Inadequately screened diversion channels potentially trapped downstream migrating fish

From the Final Biological Opinion on the Decommissioning of the Powerdale Hydroelectric Project:

"Finally, after removal of Powerdale Dam and the associated facilities, NMFS expects that the condition of many habitat indicators in the action area would improve. Removal of Powerdale Dam under the proposed action would restore the natural hydrologic regime, passage conditions, and habitat quality in the lower Hood River, and improved essential features of critical habitat associated with substrate, water quality, safe passage, space, cover and shelter, and riparian vegetation. Removal of Powerdale Dam would ultimately restore unimpeded passage of LCR Chinook salmon, LCR coho salmon, and LCR steelhead to 180 miles of freshwater habitat in the Hood River Basin."

September 19, 2005

Hatchery-Wild Dynamic



- Desired Historical Reference Point for dam removal
- Dam removal often championed as opening numerous miles of habitat
- Potentially deleterious interactions with hatchery fish
  - http://people.oregonstate.edu/~blouinm/Publications.html

Elwha River

Five Years Later, The Elwha Reborn —
“Fish are coming back. More than 4,000 chinook spawners were counted above the former Elwha Dam the first season after it came down. Overall, fish populations are the highest in 30 years. And that’s before the first progeny of salmon and steelhead going to sea since dam removal come back this year.”

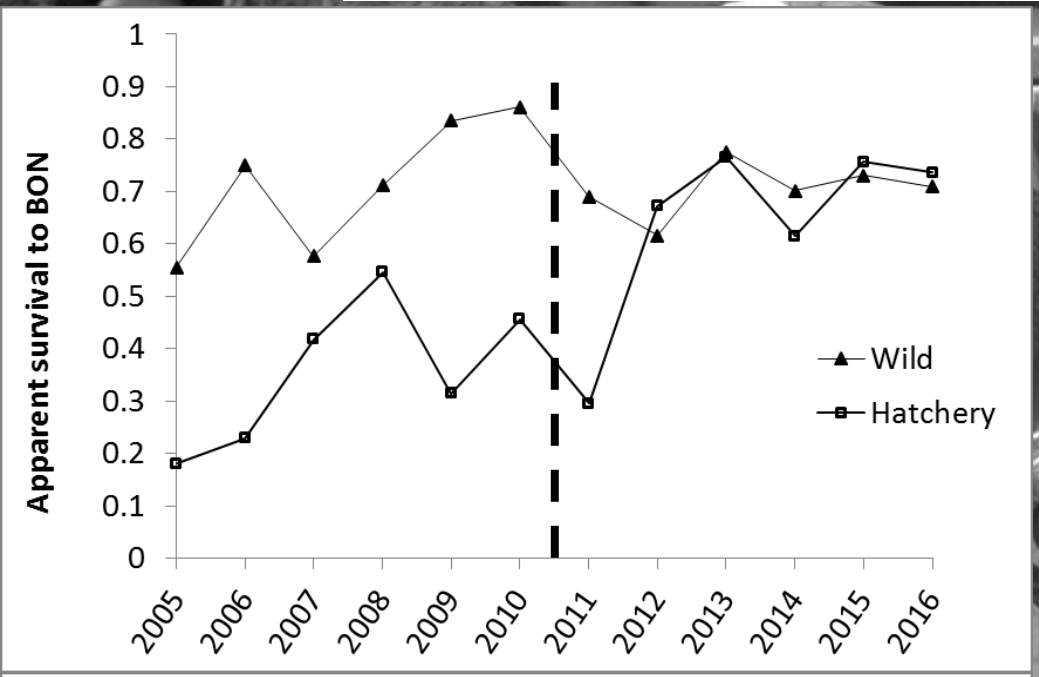
– American Rivers, September 9, 2016

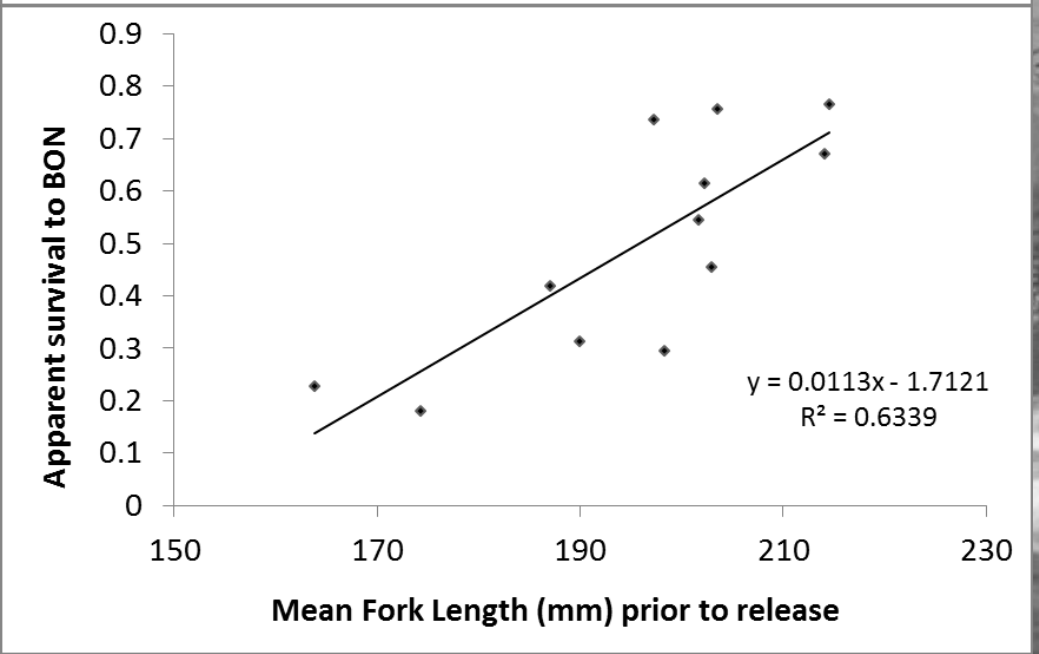
After Largest Dam Removal in U.S. History, This River Is Thriving –
“Conservationists can now point to the largest dam removal project in the U.S. as a success story. The ecosystem of Washington's Elwha River has been thriving since the removal of its hydroelectric dam system. Recent surveys show dramatic recovery, especially in the area at the river's mouth, where the flow of sediment has created favorable habitat for the salmon population. A new generation of salmon species, some of which are endangered, are now present in the river. Some hope that the restoration of the Elwha River will become a shining example for the removal of dams across the U.S.”

– National Geographic, June 2, 2016

Gary Stewart, AP

Hatchery Considerations



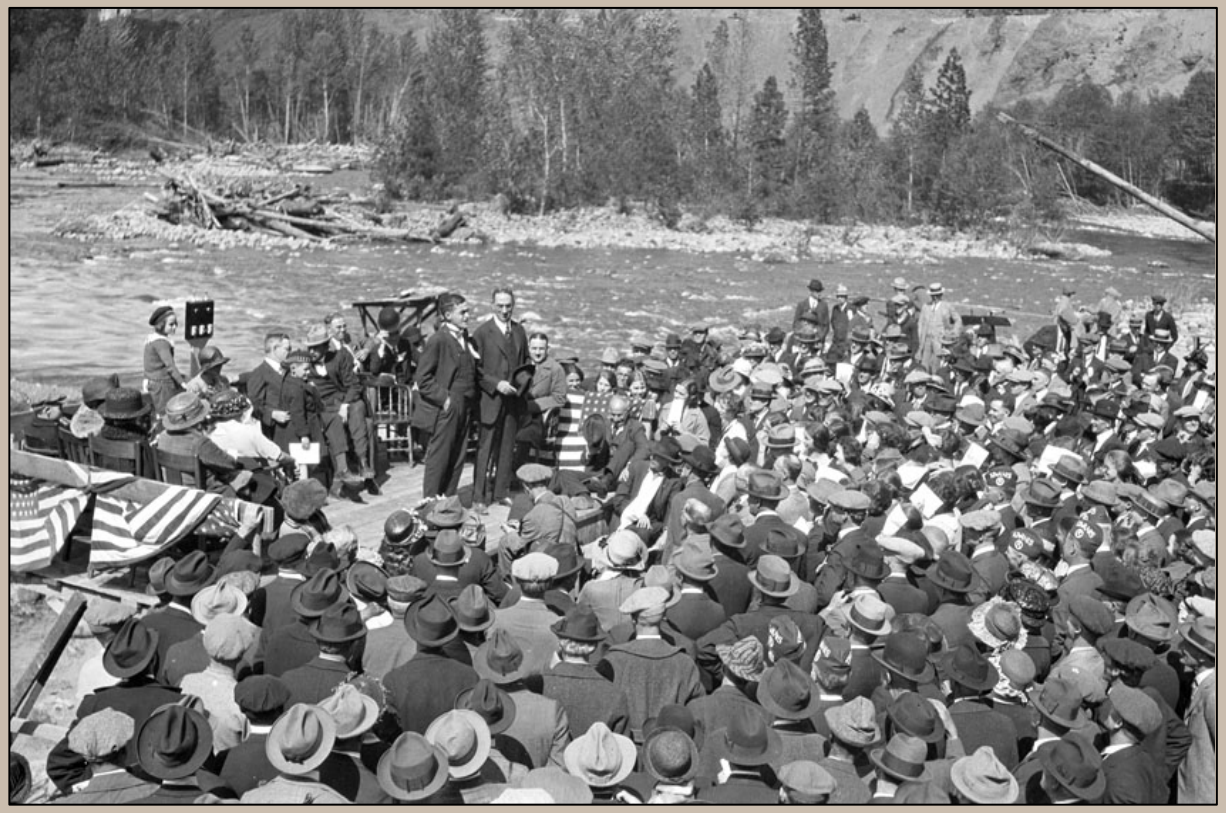


- Apparent survival of hatchery smolts increased since dam removal
- Average wild HR survival to BON = 70.9%
- Mean fork length
  - 1994 – 2010: 187.6mm
  - 2011 – 2016: 206.5mm
- Larger mean size improved survival, reduced probability of residuals
- Simplified release strategy
  - Timing, location, acclimation

Smolt to Adult Return Rate

Conclusions

- Can Hood River steelhead continue on recovery trajectory?
- Develop a cooperative ecosystem-based management plan
  - Stakeholder endorsement is critical
  - Each watershed is unique
    - Species composition
    - Resource utilization
    - Geology, Geography
    - Anthropogenic impacts
    - Variety of stakeholders
  - Species recovery is generally a common goal



Powerdale Dam Dedication Ceremony, 1923. Historichoodriver.com

Acknowledgements

- Bonneville Power Administration
- Confederated Tribes of Warm Springs Oregon
- ODFW Mid-Columbia District and Hood River Program staff
- USGS
  - Ian Jezorek, Scott Evans
- ODFW R&E Program

THE END!

Summer/Winter Smolt Summary

Year	Winter proportion	Summer proportion	Estimated Winter Smolts (N)	Estimated Summer Smolts (N)	95% C.I.
2005	0.333	0.667	7,161	14,323	±0.095
2006	0.477	0.523	4,005	4,390	±0.095
2007	0.262	0.738	1,131	3,185	±0.086
2008	0.551	0.449	8,860	7,220	±0.082
2009	0.665	0.335	6,192	3,125	±0.074
2010	0.645	0.355	10,845	5,965	±0.070
2011	0.633	0.367	11,585	6,713	±0.074
2012	0.574	0.426	14,920	11,052	±0.083
2013	0.632	0.368	27,426	15,999	±0.110
2014	0.515	0.485	18,847	17,781	±0.098

- Successfully able to generate estimate within expectations
- Generally p(W)>p(S), but averages are similar