

# Spatio-temporal patterns of SAR and survival probability of coho smolt and parr hatchery populations released in Yakima river basin (2004-2016)

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Yakama Nation Fisheries



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# Introduction

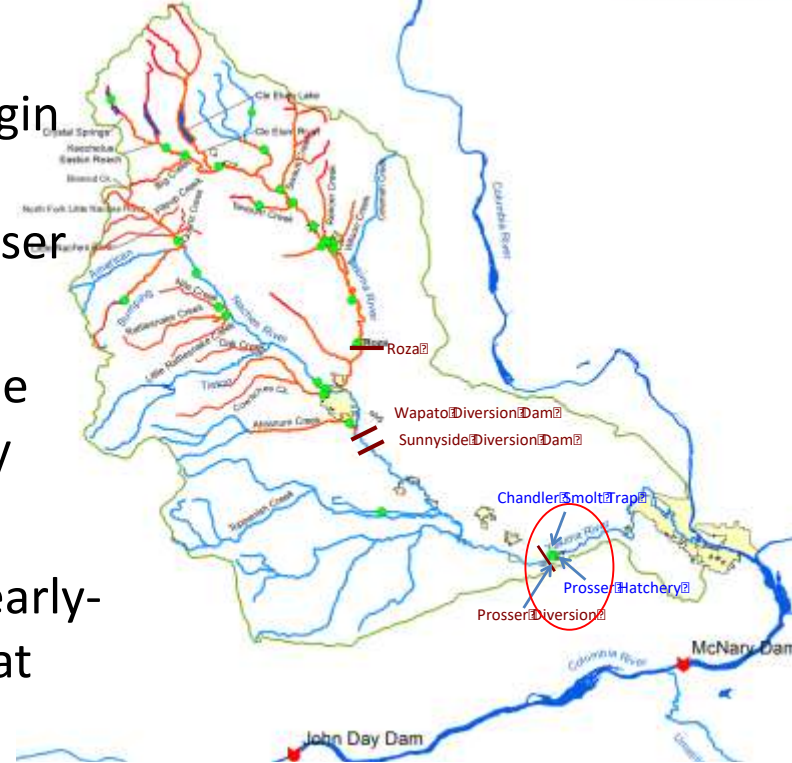
- Coho species historically present in most upper tributaries of the Yakima river and annual return was 45,000 to 100,000
- Extirpated by 1985 and since then, Yakama Nation has implemented a reintroduction program that has successfully achieved some level of natural production and local adaptation.



## Collection of Adults



- Local natural-origin brood stock are collected at Prosser
- Adults are maintained at the Prosser Hatchery until spawning
- Incubation and early-reared occurred at Prosser Hatchery



## Incubation and Early-rearing

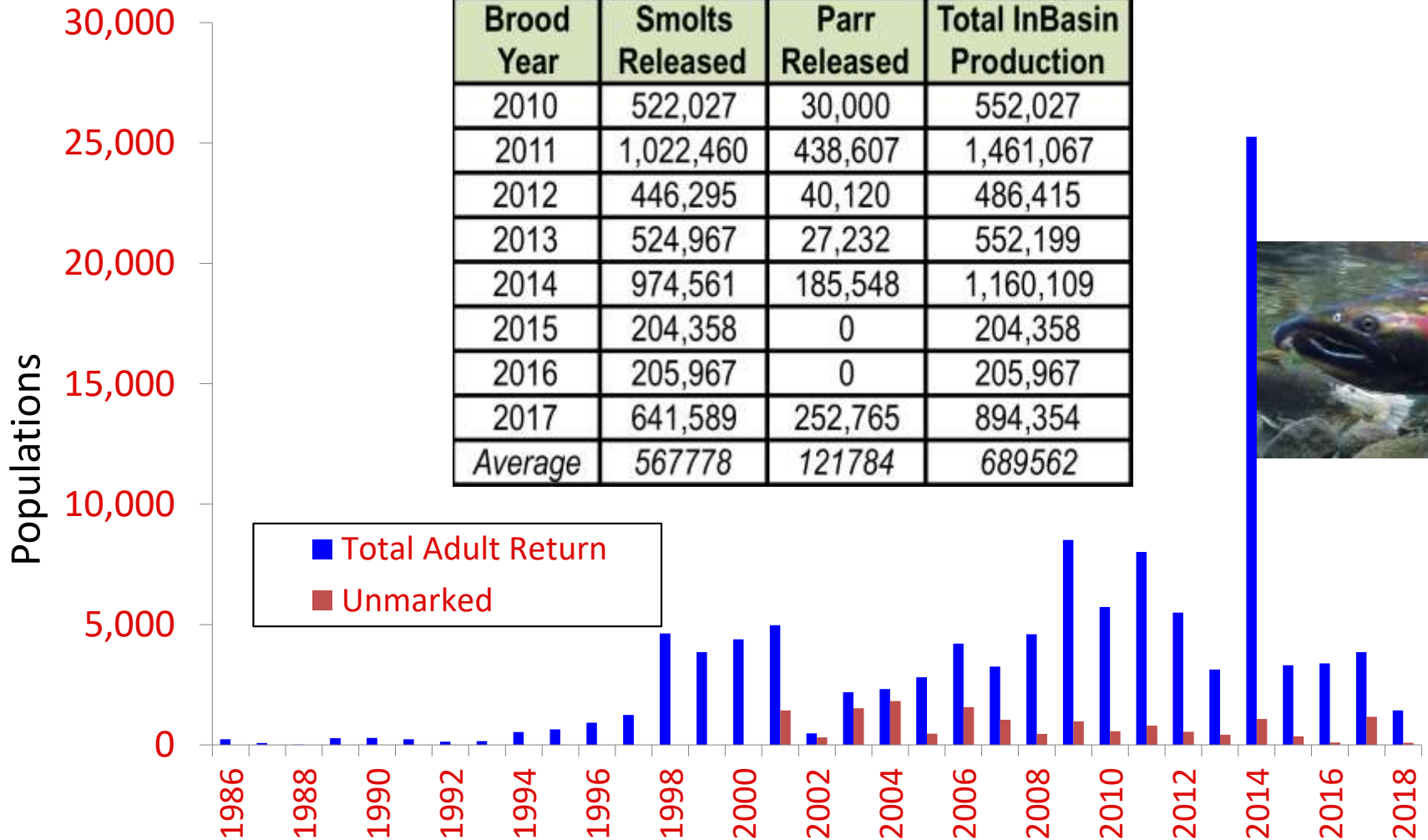


## Smolt Acclimation



# Yakima Coho Returns

| Brood Year     | Smolts Released | Parr Released | Total InBasin Production |
|----------------|-----------------|---------------|--------------------------|
| 2010           | 522,027         | 30,000        | 552,027                  |
| 2011           | 1,022,460       | 438,607       | 1,461,067                |
| 2012           | 446,295         | 40,120        | 486,415                  |
| 2013           | 524,967         | 27,232        | 552,199                  |
| 2014           | 974,561         | 185,548       | 1,160,109                |
| 2015           | 204,358         | 0             | 204,358                  |
| 2016           | 205,967         | 0             | 205,967                  |
| 2017           | 641,589         | 252,765       | 894,354                  |
| <i>Average</i> | <i>567778</i>   | <i>121784</i> | <i>689562</i>            |





# Yakima basin Redd Counts (1998-2018)

## **Achievements:**

- Established a Naturally Spawning Population of Coho Salmon (Currently not self sustaining but it is stable).
- Established an In basin Hatchery Brood stock.
- Increased average annual adult returns from 0 in 1985 to: 6780
- During Phase I the Naches River seemed to provide the most opportunity for rearing and spawning, however it has been discovered that the Upper Yakima River's potential may be far greater than the Naches River.



# Coho program

Phase II

**Tributaries**

**Summer Parr  
Releases into  
Tributaries**

Identify quality  
habitat for  
Reintroduction, & ID  
Poor habitat for possible  
restoration

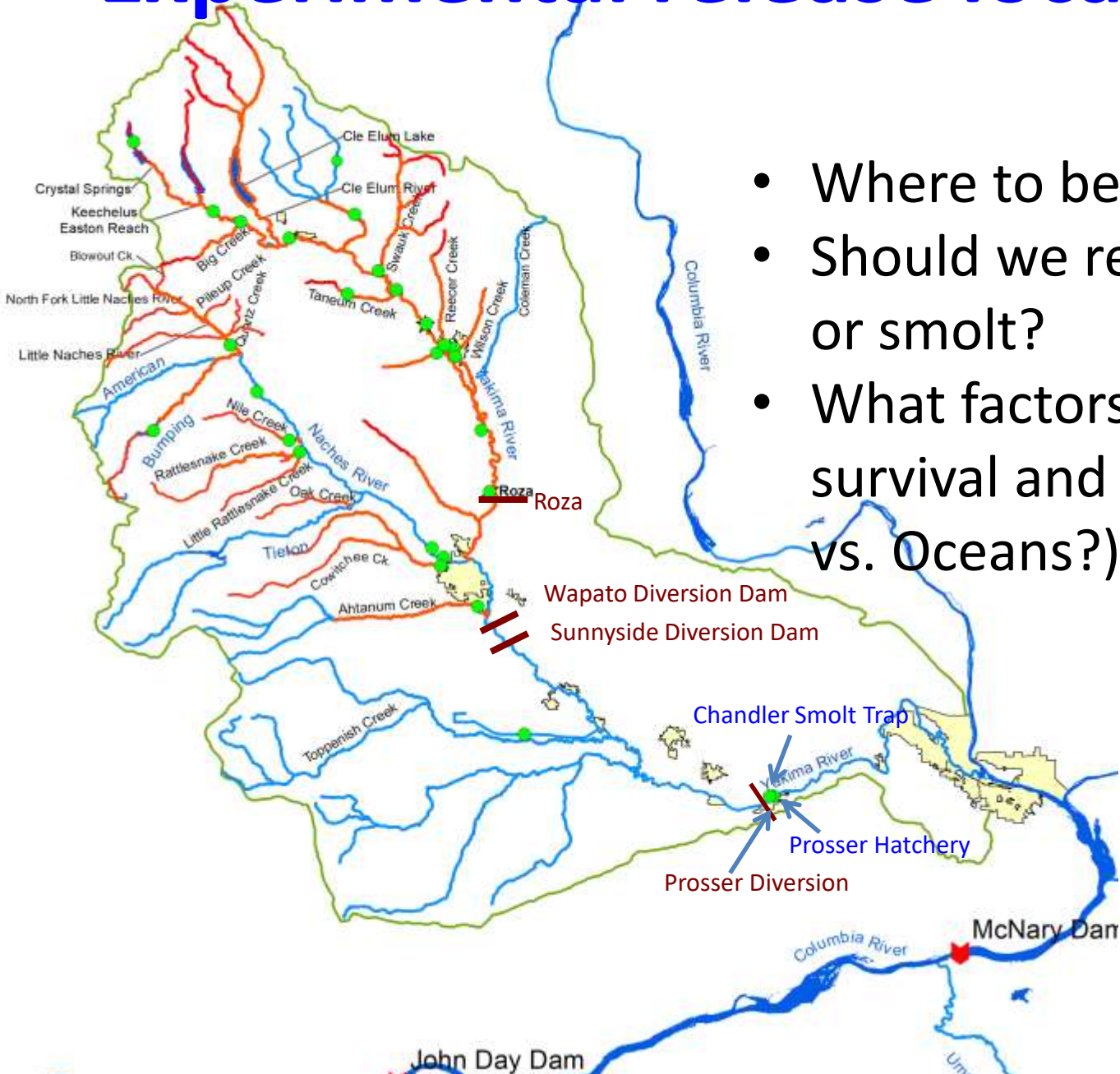
**Adult Coho  
out plants**

Monitor effects of  
reintroduction  
of adult coho into stream on  
Resident Fish Spp.

**Stream Seeding**

Test mobile  
Acclimation Facilities

# Experimental release locations



- Where to be released?
- Should we release more parr or smolt?
- What factors are important in survival and SAR (freshwater vs. Oceans?)



# Introduction

- The majority of studies have found that, for several populations of anadromous fish species, fish released as yearlings have higher rate of survival than subyearling releases
- Survival rates have been shown to increase with larger smolt size at release but there are differences between geographical regions
- Low survival probability and poor returns are thought to be associated with the small size of subyearlings and declining environmental conditions.
  - Coho are unusual among salmon species as they have an affinity for low-velocity habitat throughout their freshwater existence.
  - Coho are known to move in order to avoid temperatures greater than 23.4 °C or low flows
  - Limited information is available for Coho hatchery populations

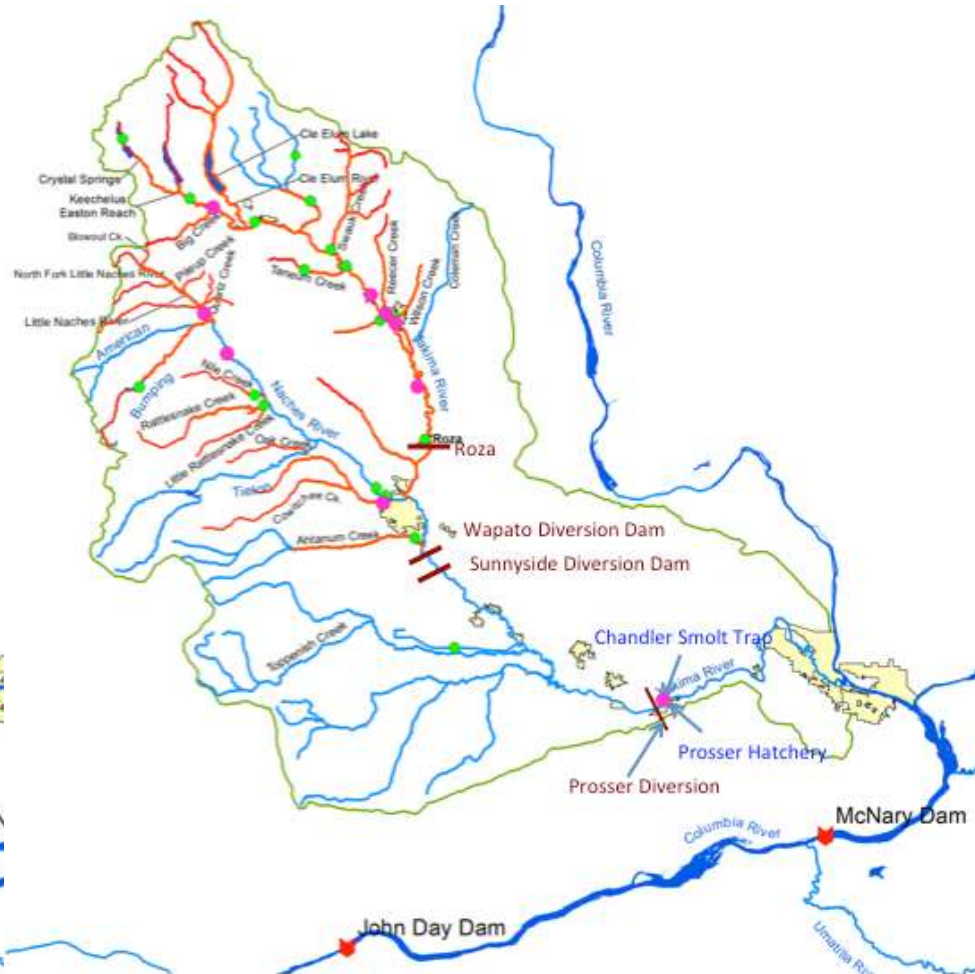
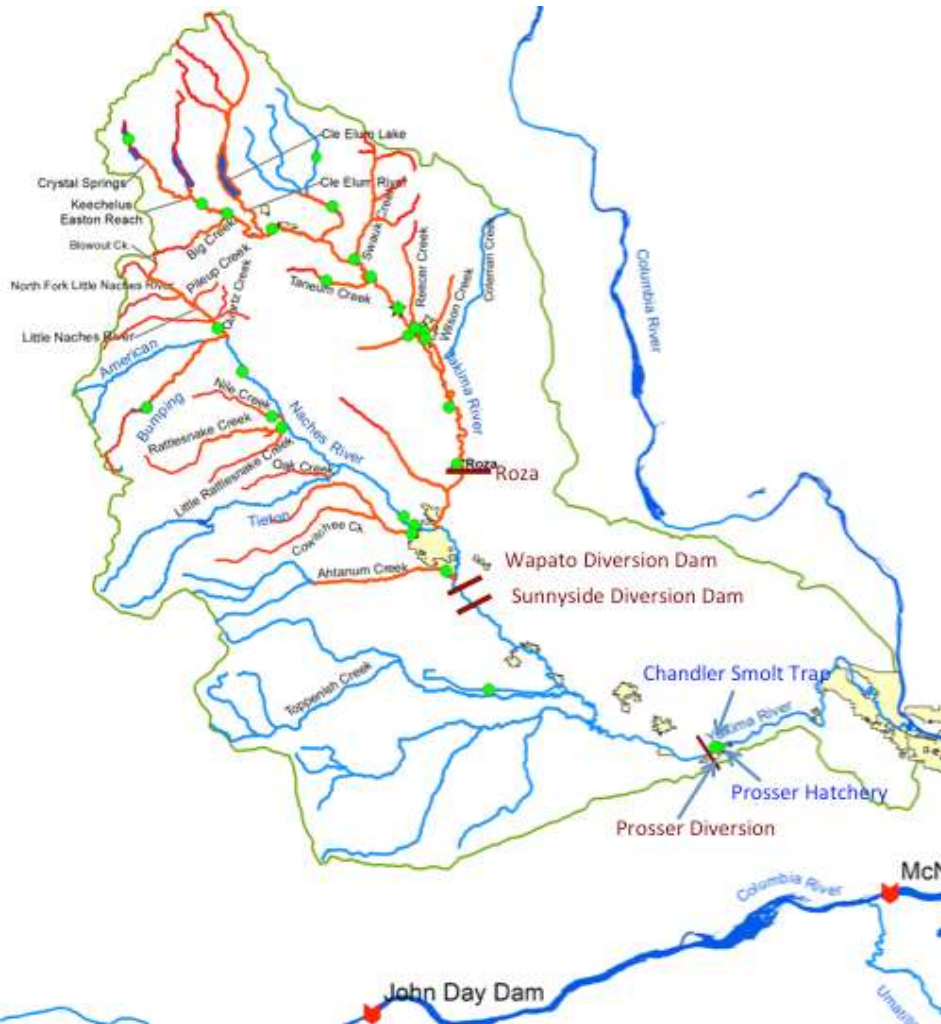




# Research Questions

- Do the Smolt-adult return (SAR) and outmigration survival rates differ between parr and smolt and how do they differ among the sites at which they were released?
- If a larger size of smolt had higher survival rate for Chinook, can we expect similar patterns for Coho?
- Which environmental variables are important for Coho survival rate and return rate (SAR)?
  - What are the relative effects of freshwater versus marine conditions?
  - Are the SAR and survival rates higher for coho which were released in the lower Yakima river (at or below Prosser dam)?

# Study Locations (Experimental)



Smolt 14 locations  
 Parr 22 locations

From 2004 to 2016

8 locations were selected for the analysis



# Coho smolt release populations & locations (Experimental)

| RLSLOC        | 2004        | 2005        | 2006        | 2007        | 2008        | 2009        | 2010        | 2011        | 2012        | 2013        | 2014        | 2015        | 2016        | total        |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|
| Ahtanm        | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 1           | 8           | 869         | 878          |
| Boone         | 2488        | 5052        | 2501        | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 10041        |
| Bucksk        | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 1572        | 1247        | 2501        | 5320         |
| Chandl        | 2           | 2026        | 913         | 2343        | 198         | 372         | 520         | 351         | 1281        | 1249        | 0           | 0           | 0           | 9255         |
| CleElm        | 0           | 3331        | 11999       | 11998       | 11917       | 11933       | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 51178        |
| Cowich        | 0           | 0           | 0           | 0           | 0           | 817         | 1248        | 1272        | 1277        | 2495        | 1249        | 1250        | 0           | 9608         |
| <b>Easton</b> | <b>2501</b> | <b>0</b>    | <b>0</b>    | <b>0</b>    | <b>2500</b> | <b>0</b>    | <b>0</b>    | <b>1272</b> | <b>2547</b> | <b>0</b>    | <b>0</b>    | <b>0</b>    | <b>0</b>    | <b>8820</b>  |
| <b>Holmes</b> | <b>2522</b> | <b>0</b>    | <b>2512</b> | <b>2460</b> | <b>2493</b> | <b>2512</b> | <b>2516</b> | <b>2520</b> | <b>2508</b> | <b>0</b>    | <b>0</b>    | <b>0</b>    | <b>0</b>    | <b>20043</b> |
| <b>LostCr</b> | <b>2444</b> | <b>5232</b> | <b>2491</b> | <b>2501</b> | <b>2499</b> | <b>2508</b> | <b>2505</b> | <b>2502</b> | <b>0</b>    | <b>2531</b> | <b>0</b>    | <b>2506</b> | <b>2502</b> | <b>30221</b> |
| Marion        | 0           | 0           | 0           | 0           | 3013        | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 0           | 3013         |
| <b>Prossr</b> | <b>0</b>    | <b>0</b>    | <b>0</b>    | <b>2499</b> | <b>0</b>    | <b>2506</b> | <b>1371</b> | <b>5036</b> | <b>3811</b> | <b>2520</b> | <b>3004</b> | <b>1265</b> | <b>2501</b> | <b>24513</b> |
| RattSn        | 0           | 0           | 0           | 0           | 0           | 0           | 1144        | 0           | 1274        | 1263        | 0           | 1249        | 0           | 4930         |
| Roza          | 1           | 6667        | 0           | 0           | 19          | 73          | 7           | 22          | 35          | 1229        | 1500        | 3           | 2793        | 12349        |
| <b>Stiles</b> | <b>2457</b> | <b>0</b>    | <b>2490</b> | <b>2449</b> | <b>2492</b> | <b>2515</b> | <b>2501</b> | <b>0</b>    | <b>0</b>    | <b>2504</b> | <b>2505</b> | <b>2520</b> | <b>2503</b> | <b>24936</b> |



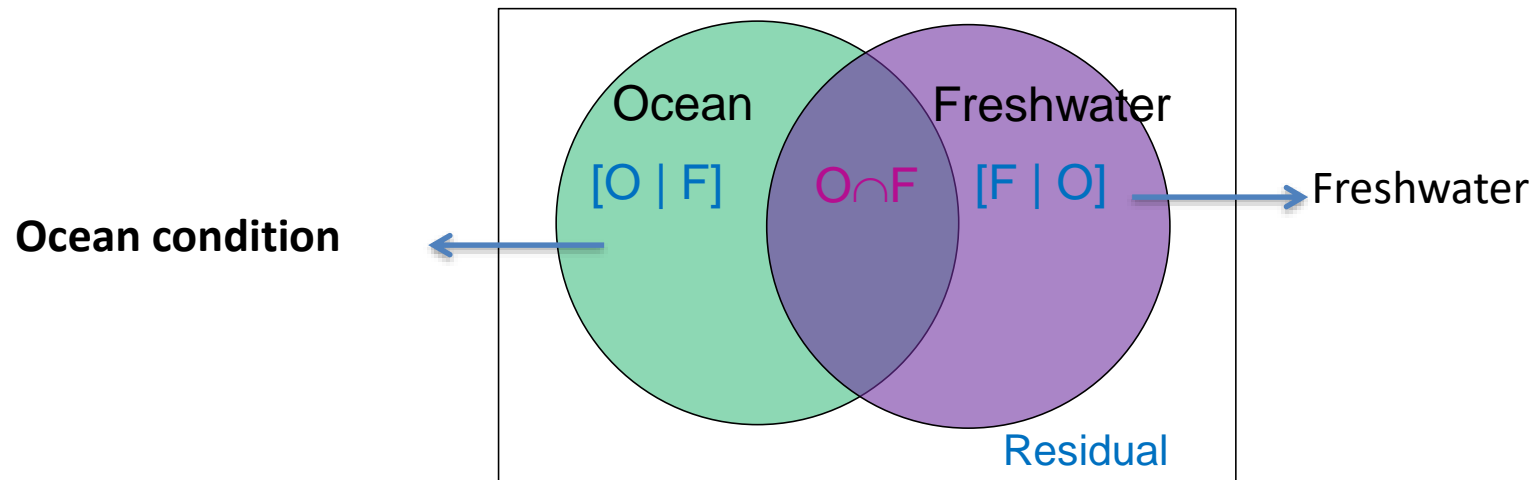
# Methodology

- SAR was calculated based on McNary dam smolt to McNary dam adult
- Survival probability was estimated using Capture-recapture models
- Model was developed under GLM with stepwise selection procedures



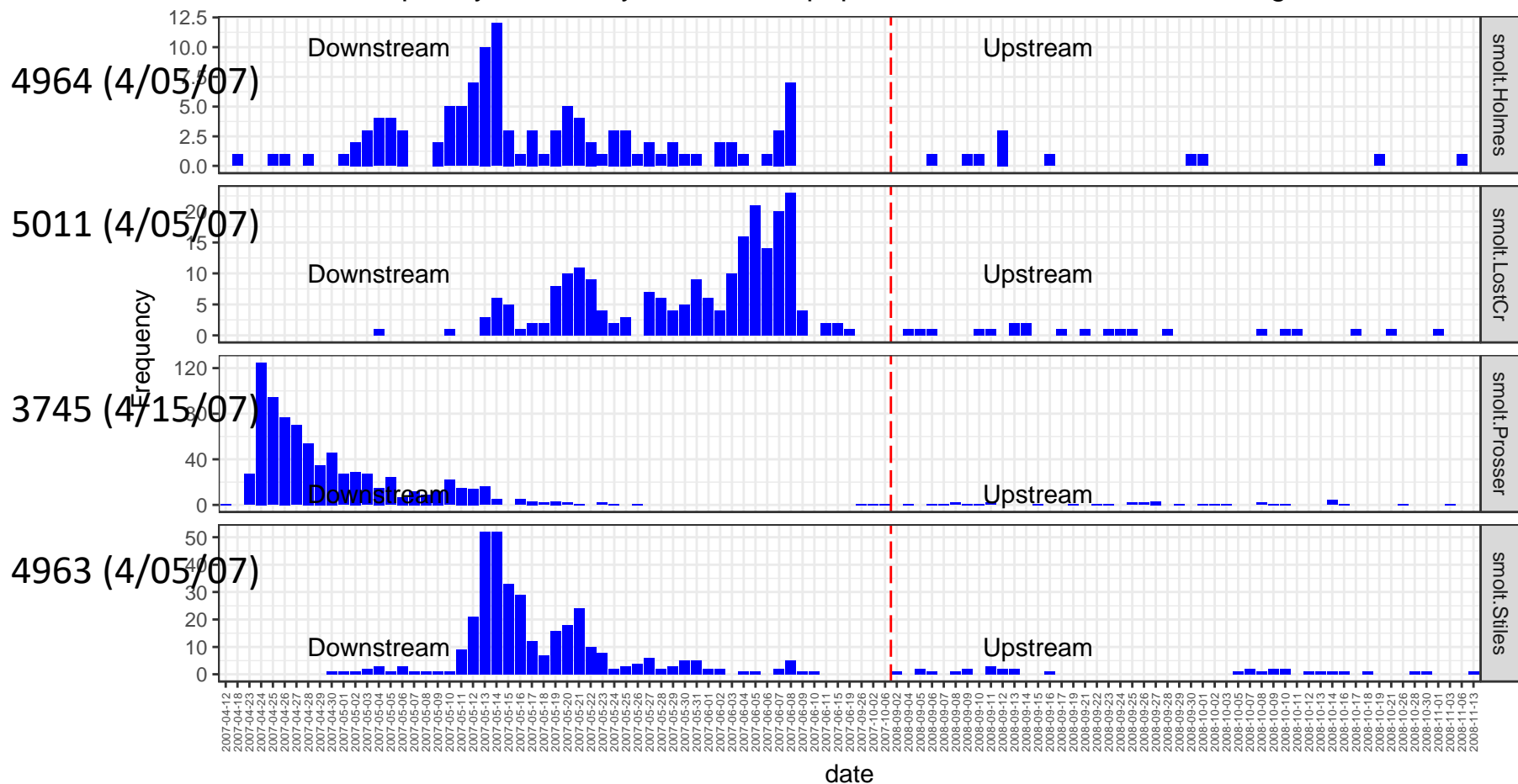
# Methodology

Variation partitioning: Multivariate Redundancy Analysis (RDA) was used to tease apart the effects of freshwater vs. Ocean effects on SAR





### Detection frequency at McNary dam for the population that was released during 2007



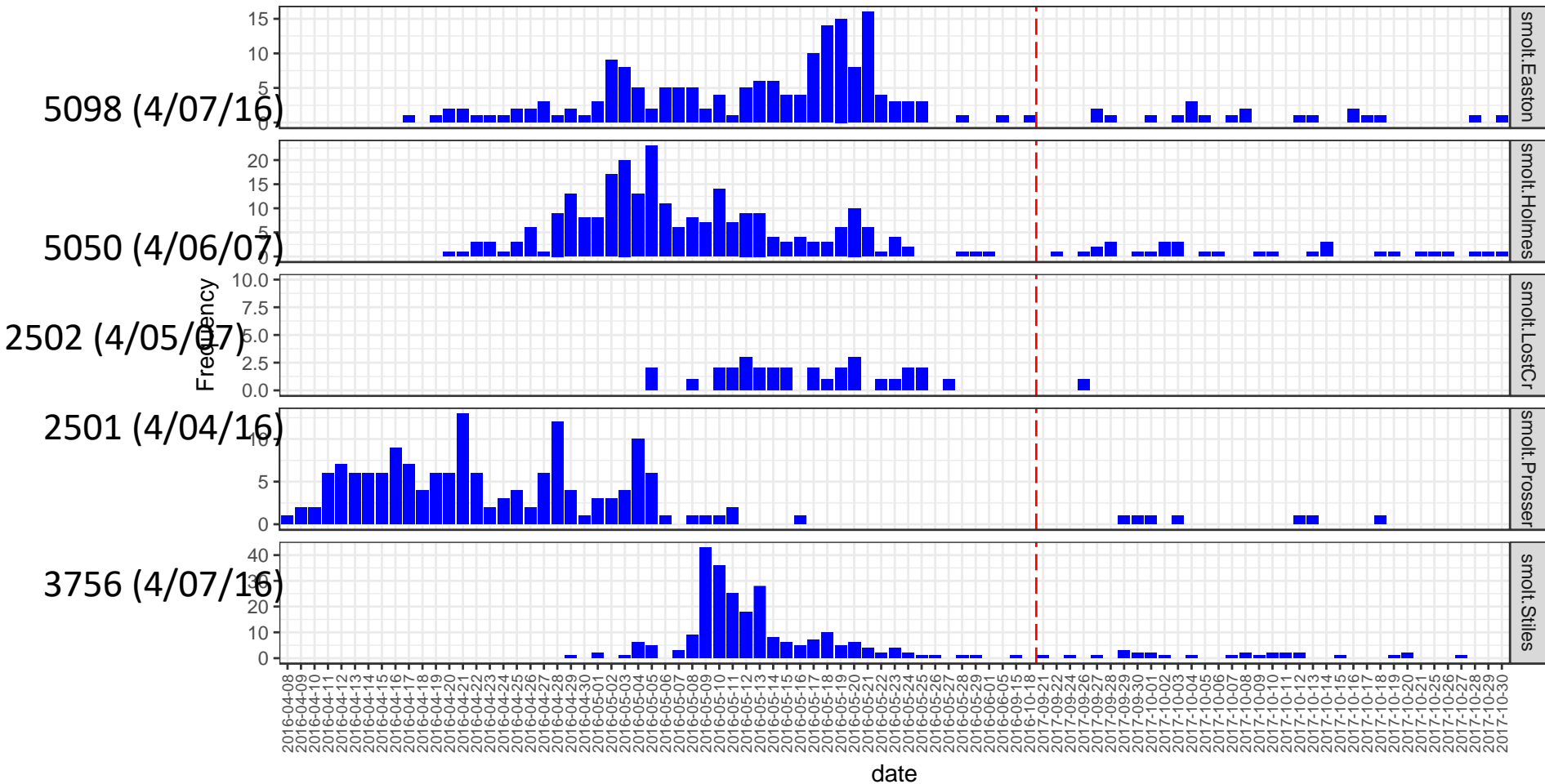
First detection at MCN = April 12, 2007 (7 days after releasing)

Last detection at MCN = Oct 06, 2007 (184 days after releasing) [~6 months]

First detection at MCN as an adult= Sept 12, 2008 (332 days after last detection) [~11 months]

Last detection at MCN as an adult=Nov. 13, 2008 (404 days after last detection) [~14 months]

### Detection frequency at McNary dam for the population that was released during 2016



First detection at MCN = April 8, 2016 (4 days after releasing)

Last detection at MCN = Oct 18, 2016 (197 days after releasing) [~7 months]

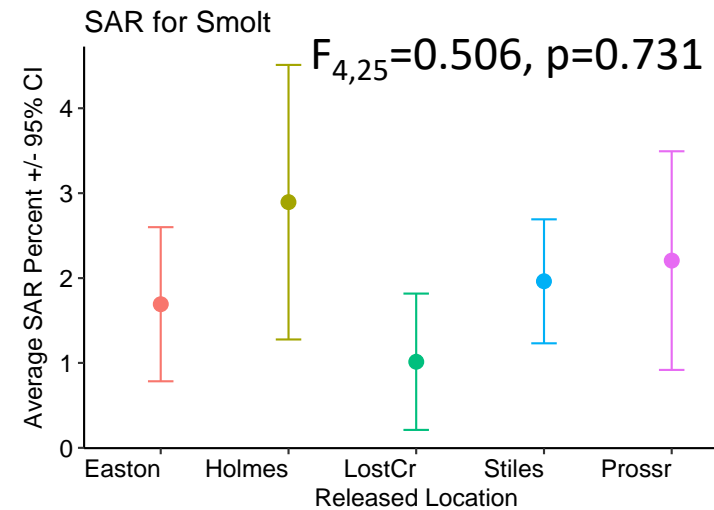
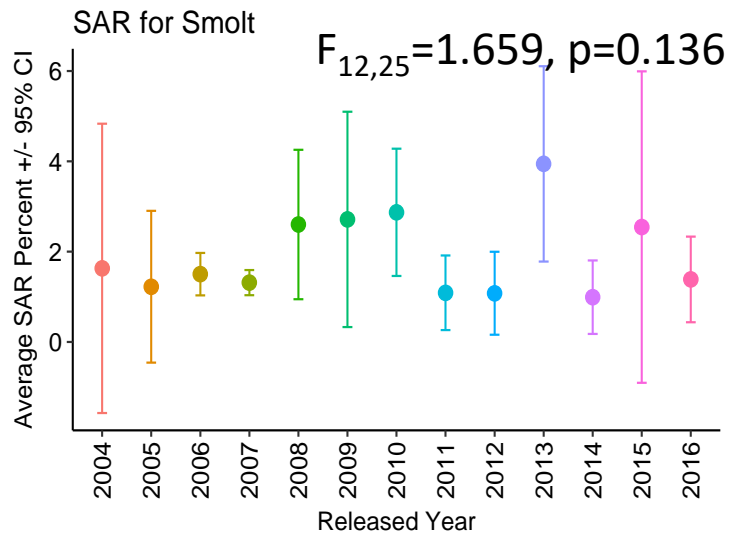
First detection at MCN as an adult= Sept 21, 2016 (338 days after last detection) [~11 months]

Last detection at MCN as an adult=Oct. 30, 2008 (377 days after last detection) [~13 months]



# Results

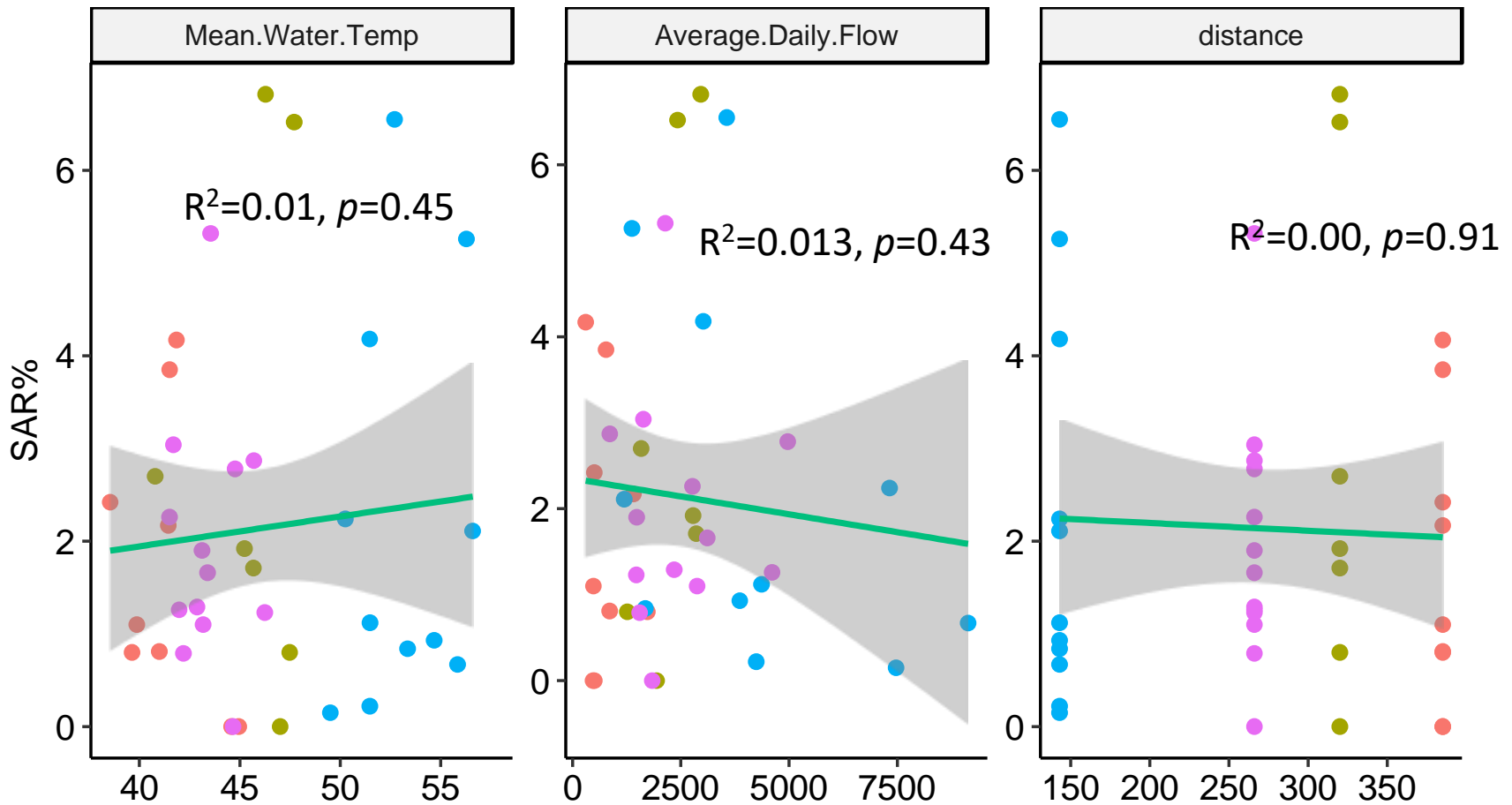
Are the Smolt-to-Adult Returns (SAR) of the populations that were released at different locations significantly different?



# Results



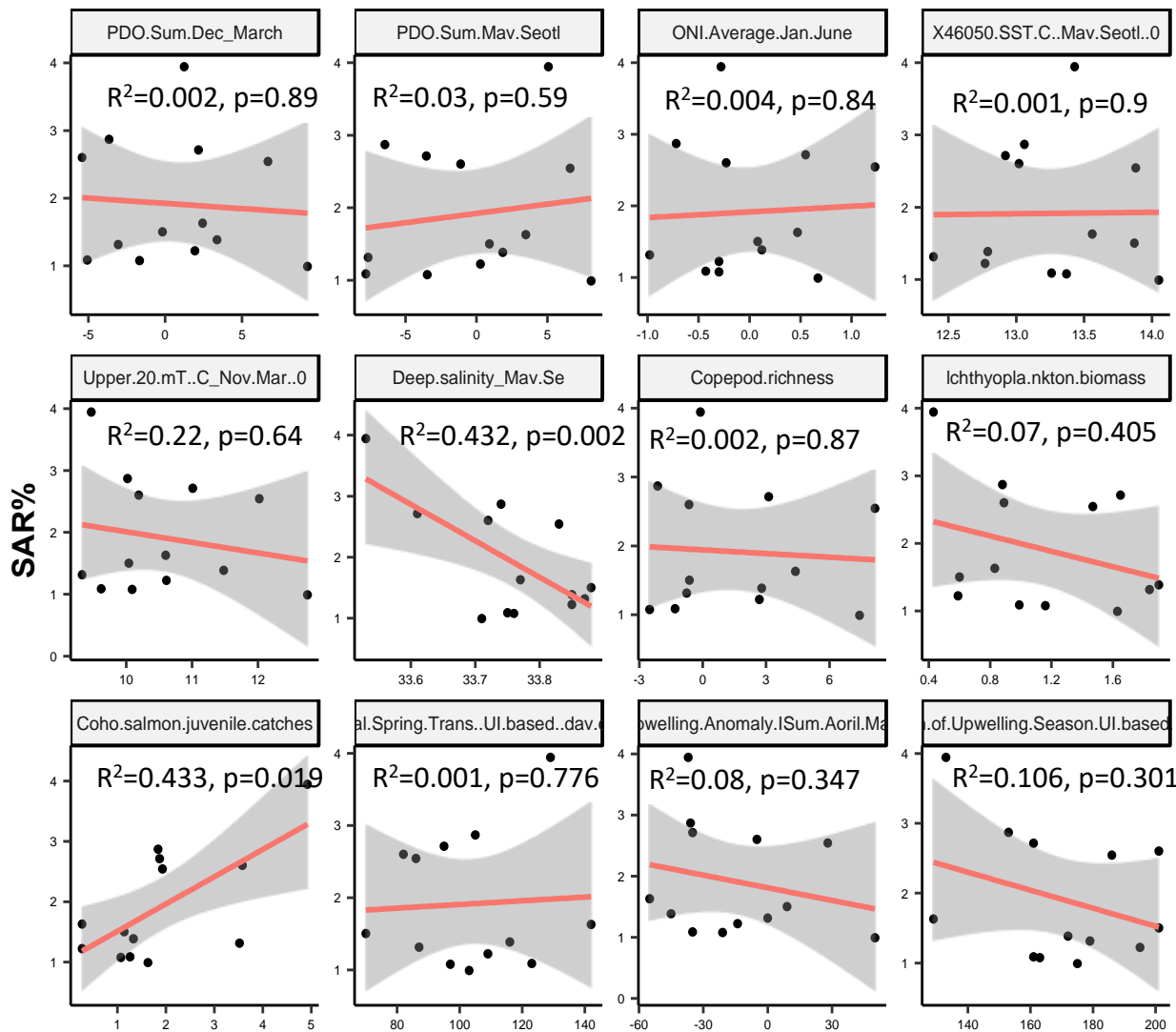
Does the environmental condition of the release locations affect the SAR?





| Ecosystem Indicators        | Year |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|-----------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|                             | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| PDO<br>(Sum Dec-March)      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| PDO<br>(Sum May-Sept)       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| ONI<br>(Average Jan-June)   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 46050 SST<br>(°C; May-Sept) |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

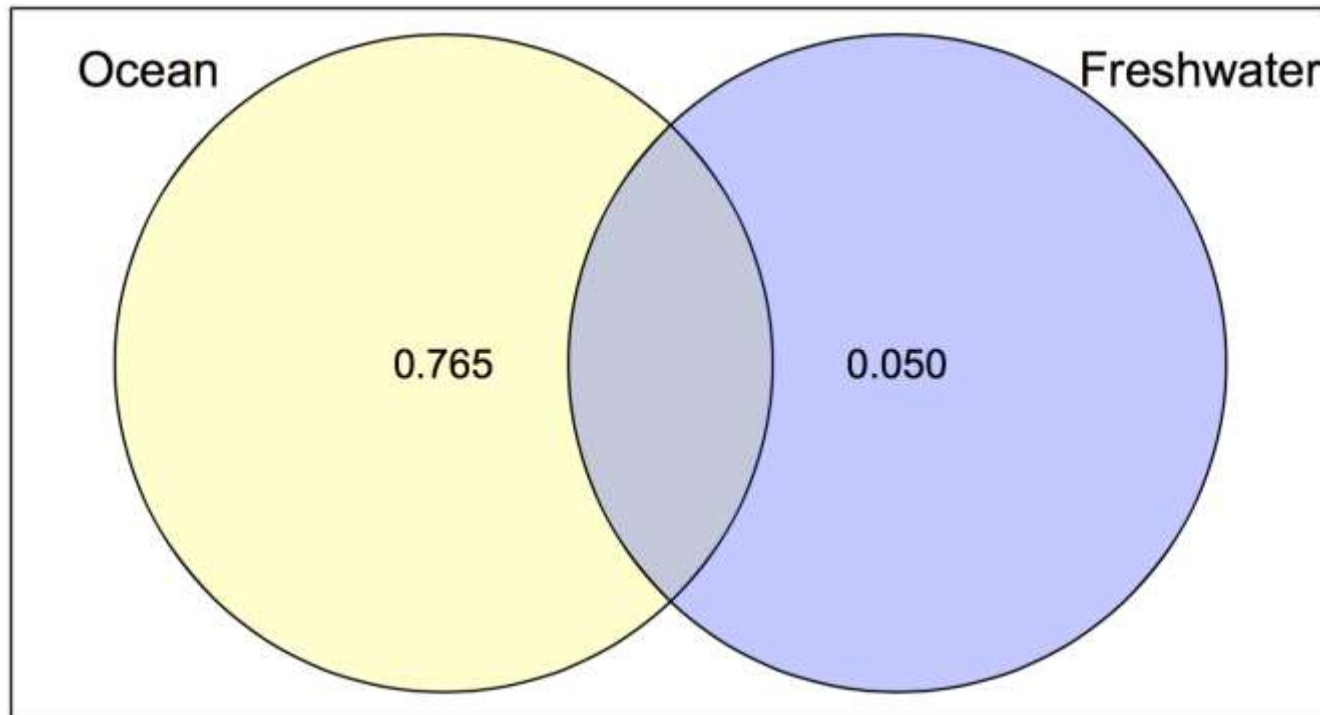
# SAR (smolt)-Ocean condition



"PDO.Sum.Dec\_March"  
 "PDO.Sum.Mav.Seotl"  
 "ONI.Average.Jan.June"  
 "X46050.SST.C..Mav.Seotl..0"  
 "Upper.20.mT..C\_Nov.Mar..0"  
 "Upper.20.mT..C\_Mar\_sept..0"  
 "Deeptemp\_OC\_.Ma\_Seotl"  
 "Deep.salinity\_Mav.Se"  
 "Copepod.richness"  
 "Ichthyopla.nkton.biomass"  
 "Coho.salmon.juvenile.catches"  
 "Physical.Spring.Trans..UI.based..dav.of.vearl"  
 "Physical.Spring.Trans..Hvdrogra.chic..dav.of.vea"  
 ""  
 "Upwelling.Anomaly.ISum.Aoril.MavI"  
 "Length.of.Upwelling.Season.UI.based.Idavsl"

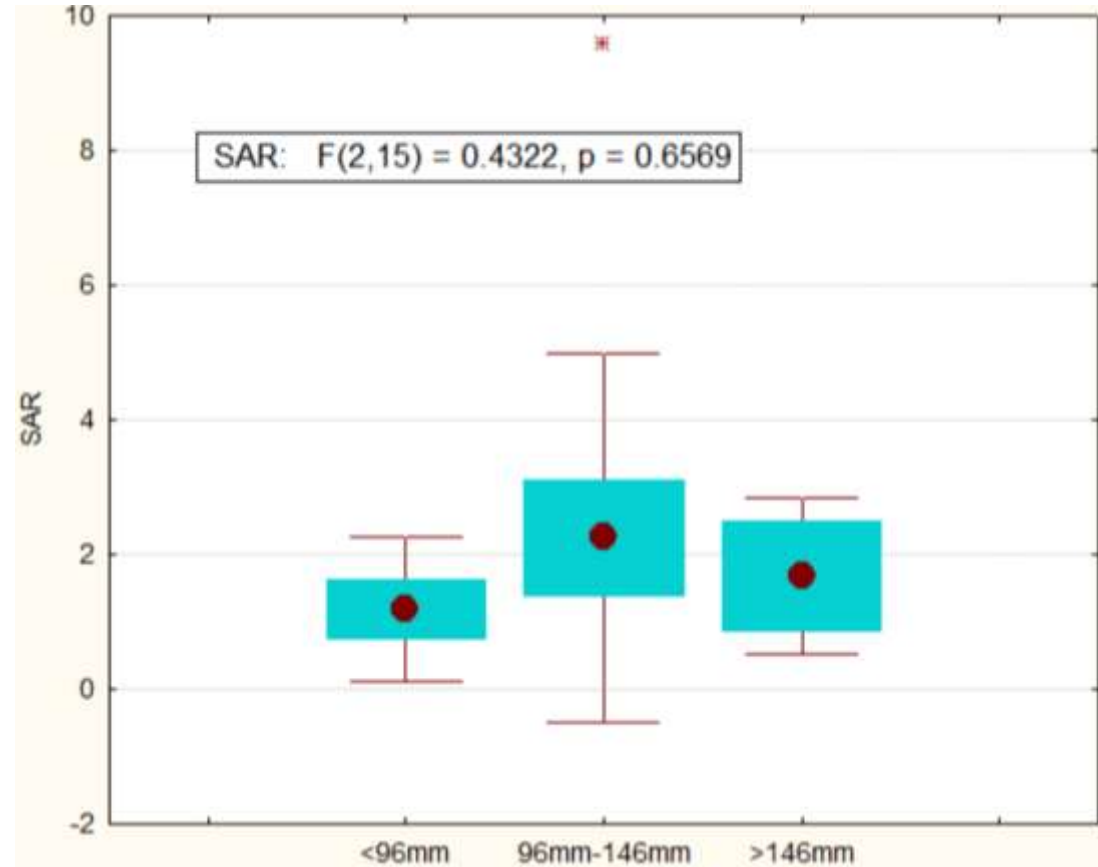
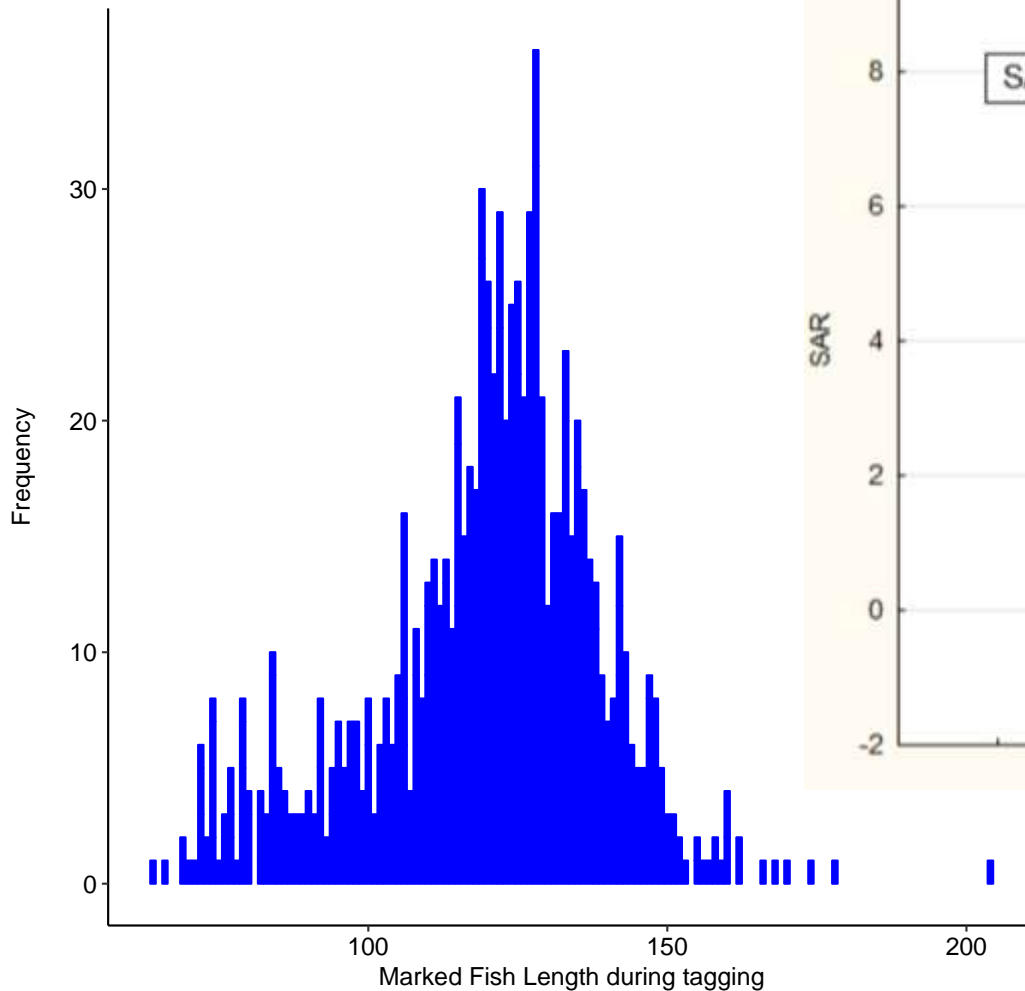
|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
|    |    |    |    |    |    |    |    |
| 11 | 18 | 9  | 19 | 10 | 5  | 16 | 11 |
| 3  | 11 | 2  | 16 | 7  | 17 | 19 | 14 |
| 17 | 15 | 12 | 19 | 1  | 2  | 20 | 5  |
| 18 | 16 | 15 | 20 | 11 | 8  | 13 | 7  |
| 7  | 14 | 13 | 15 | 12 | 17 | 8  | 20 |
| 9  | 7  | 5  | 11 | 19 | 21 | 17 | 14 |
| 5  | 10 | NA | NA | NA | NA | NA | NA |

# SAR (smolt): Variation partitioning

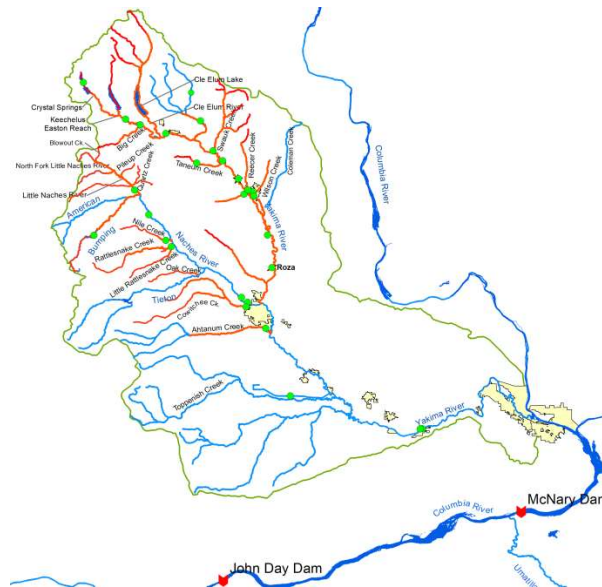


# Effect of fish size at tagging on SAR

Upstream detection frequency by fish size



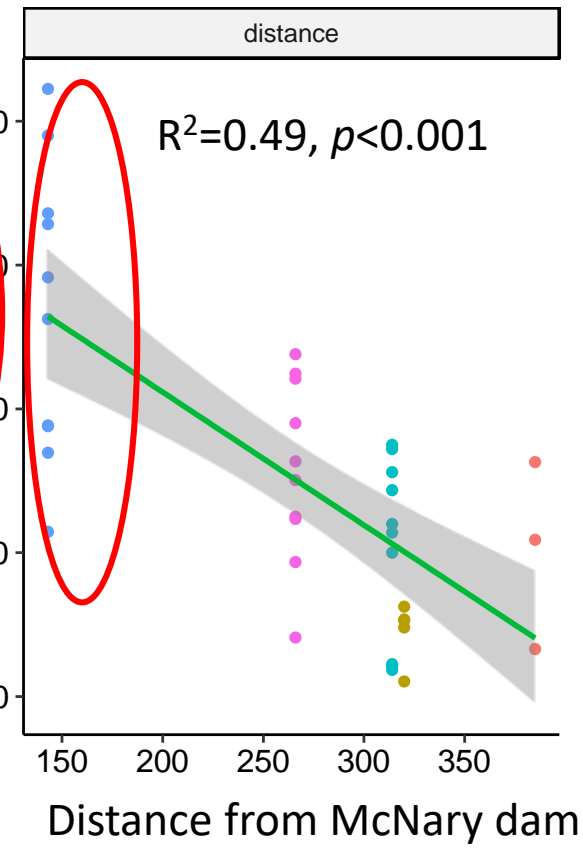
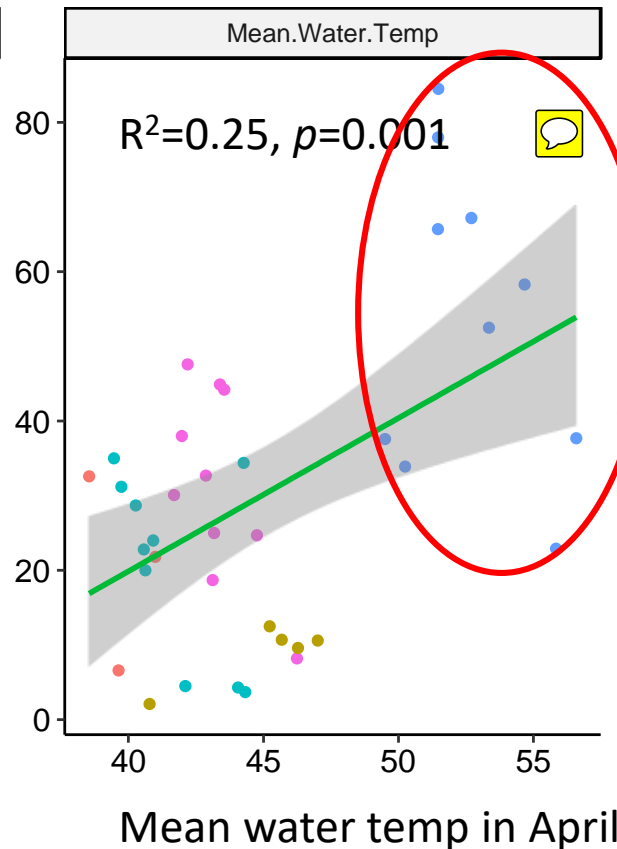
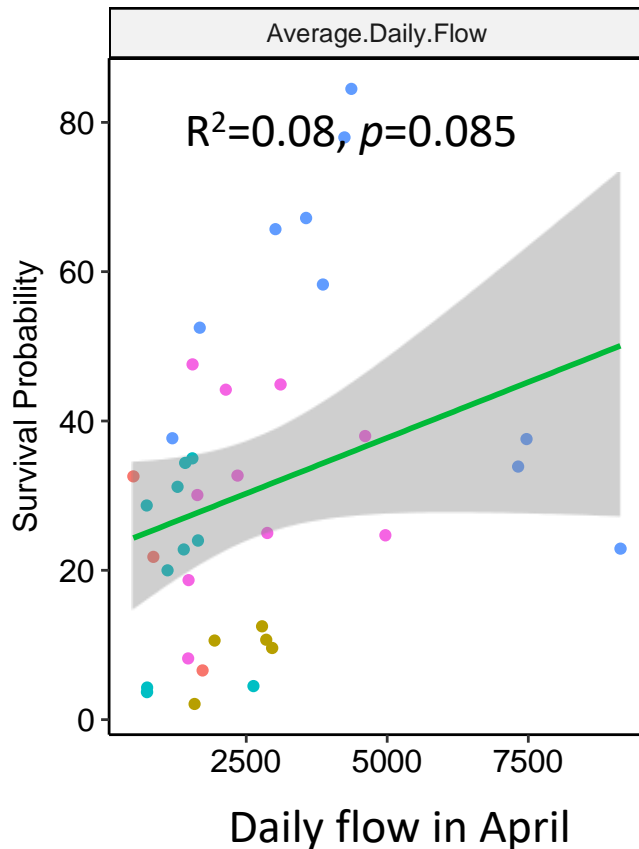
# Smolt outmigration survival rate (from released locations to McNary dam)



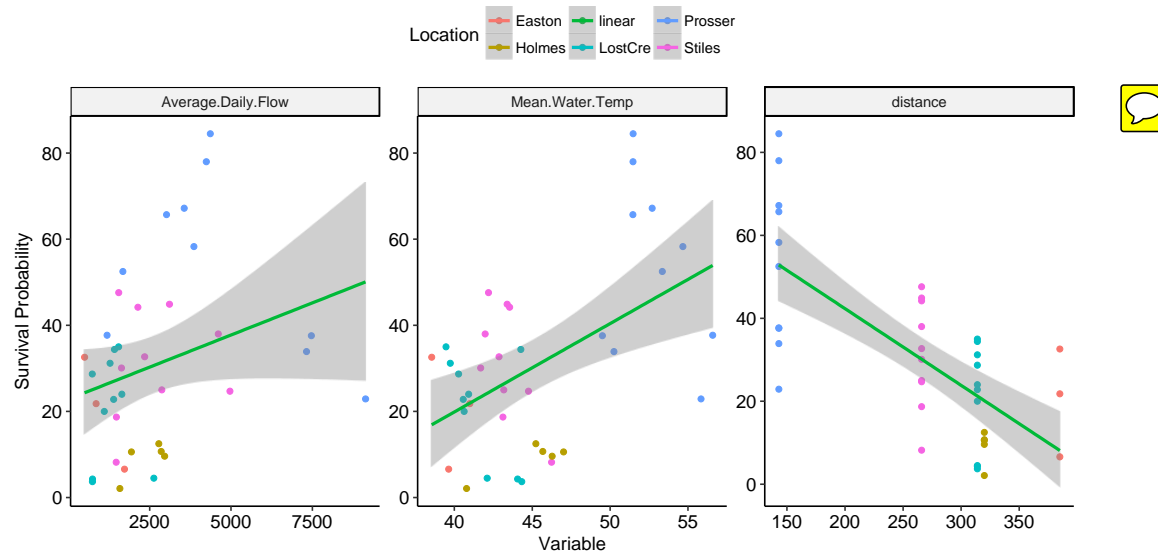
# Is the survival probability affected by the environmental conditions?

Location

- Easton
- Holmes
- linear
- LostCre
- Prosser
- Stiles



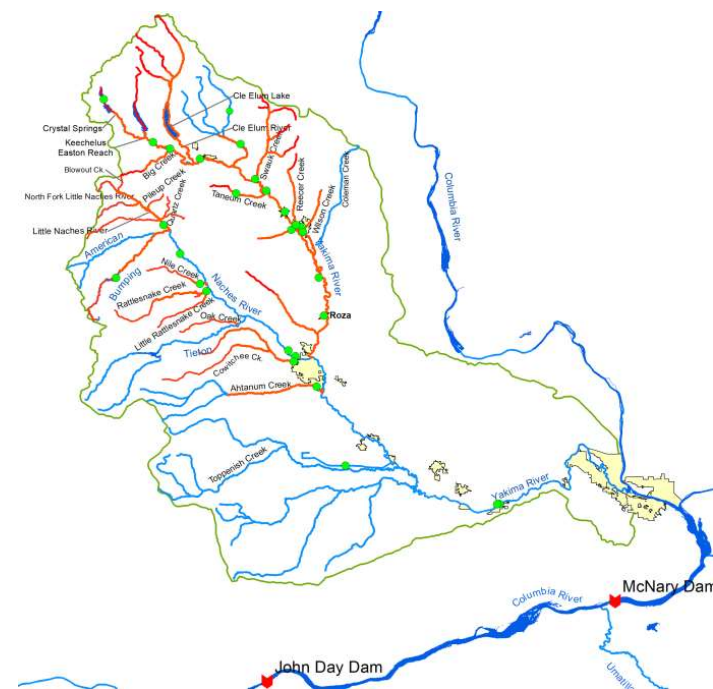
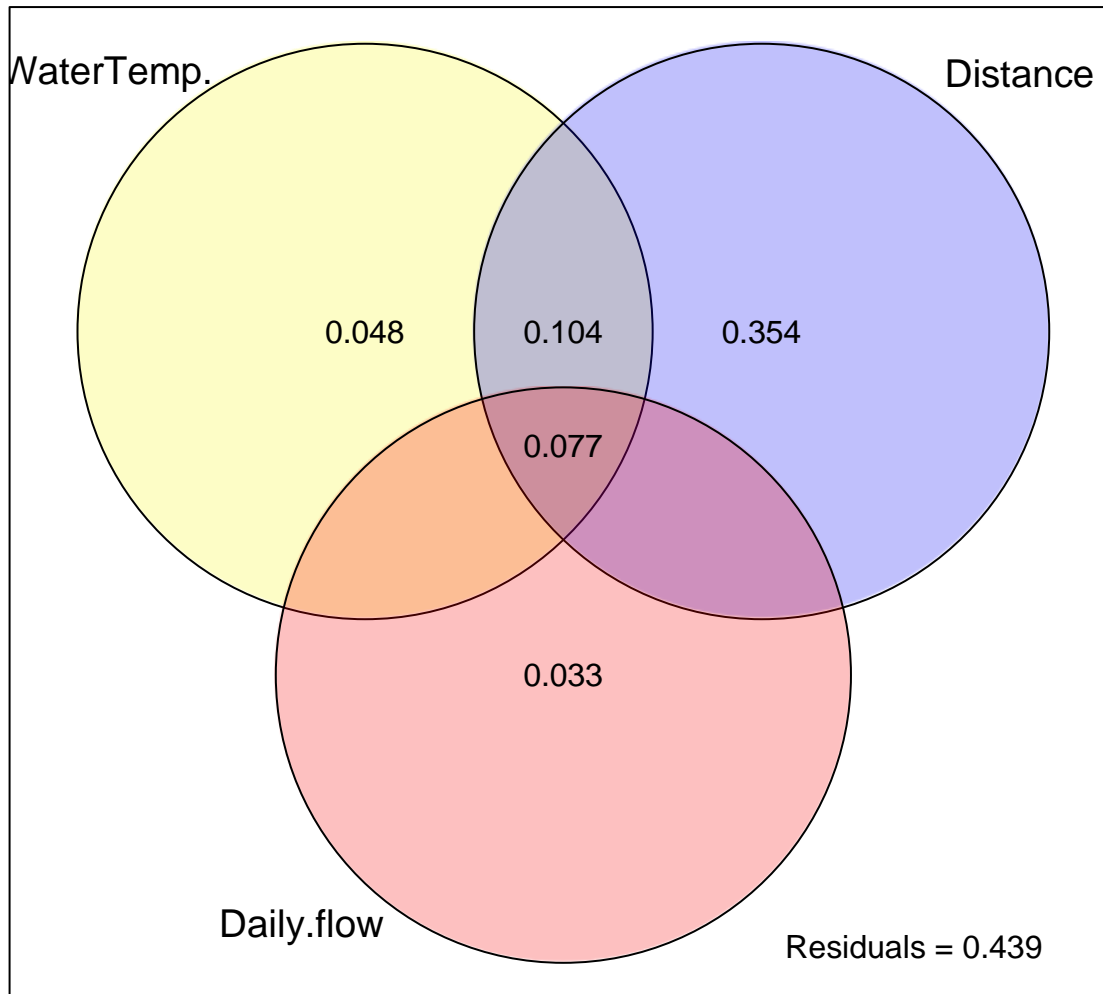
# Smolt Survival probability (freshwater)



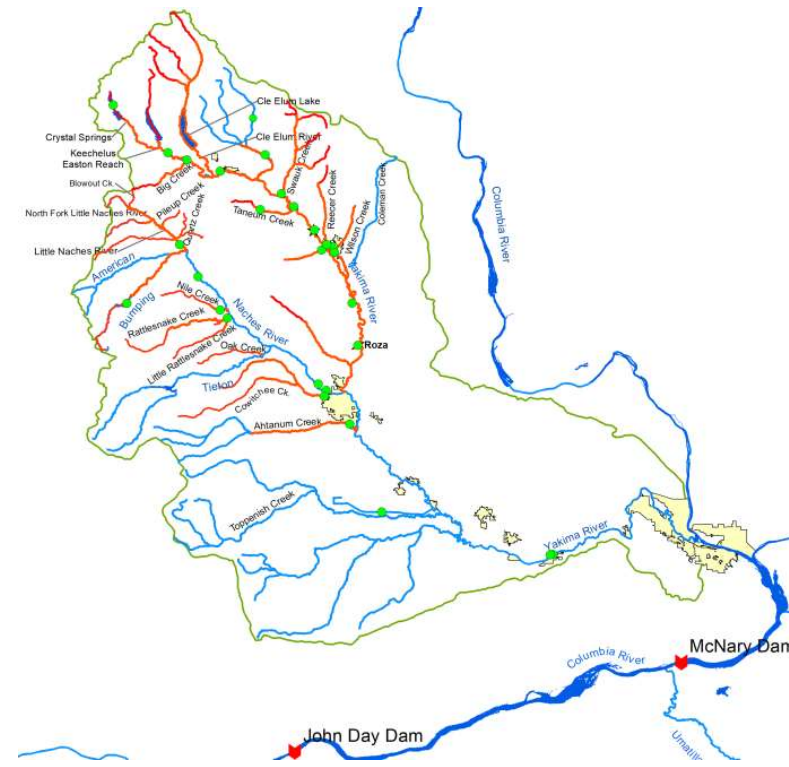
| Parameters                 | Estimate | SE     | value |
|----------------------------|----------|--------|-------|
| Intercept                  | 221.769  | 57.237 | 0.000 |
| Average.Daily.Flow         | +0.003   | 0.001  | 0.066 |
| Mean.Water.Temp            | -2.054   | 0.932  | 0.034 |
| Distance from McNary       | -0.345   | 0.064  | 0.001 |
| Total Variance Explained % | 59.62%   |        |       |
| Pvalue                     | <0.001   |        |       |



# Effects of environment and distance on Coho smolt survival rate

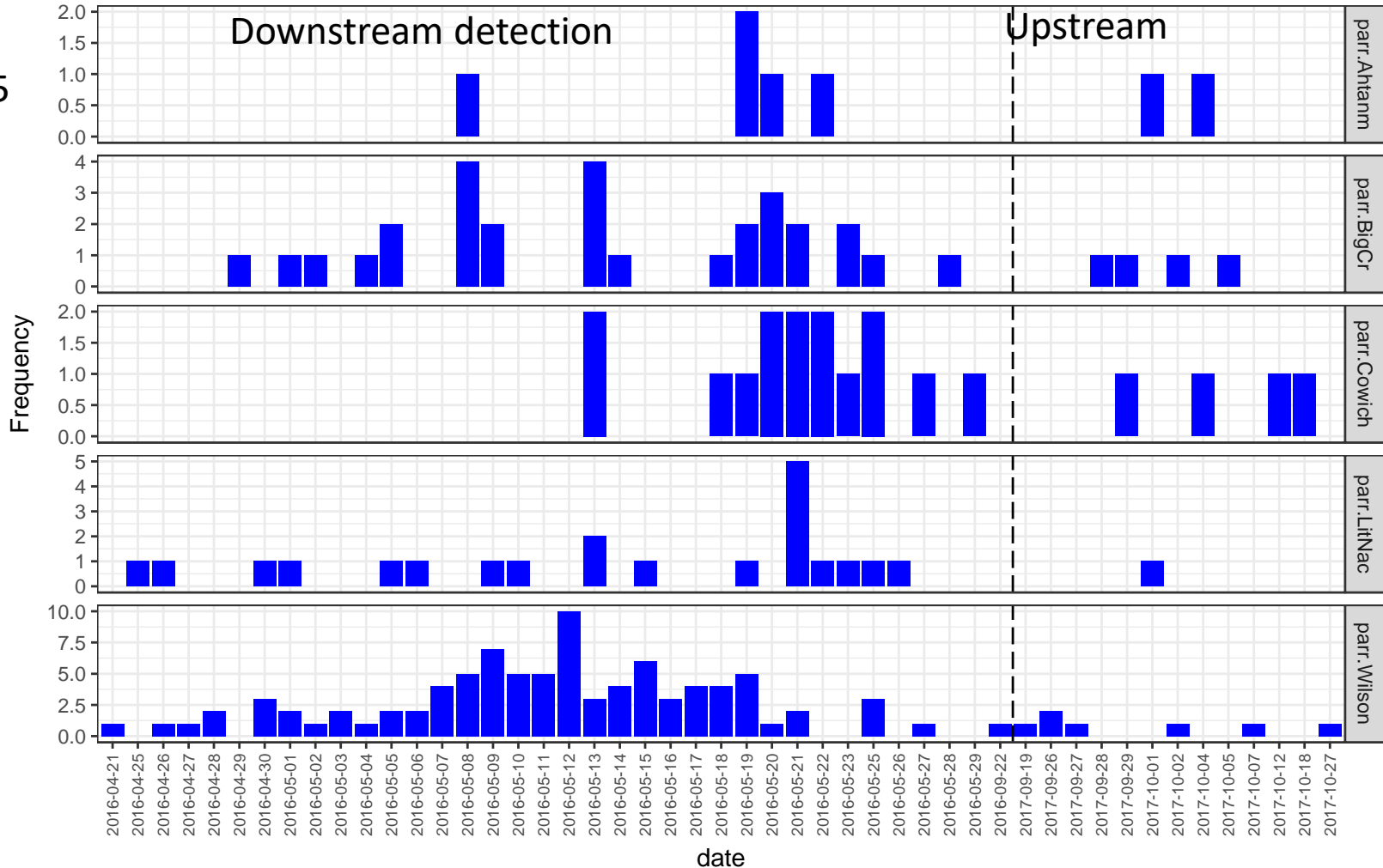


# Experimental Released Coho Parr population





Detection frequency at MCN for the parr population that was released during 2015



First detection at MCN = April 21, 2016 (268 days after releasing)

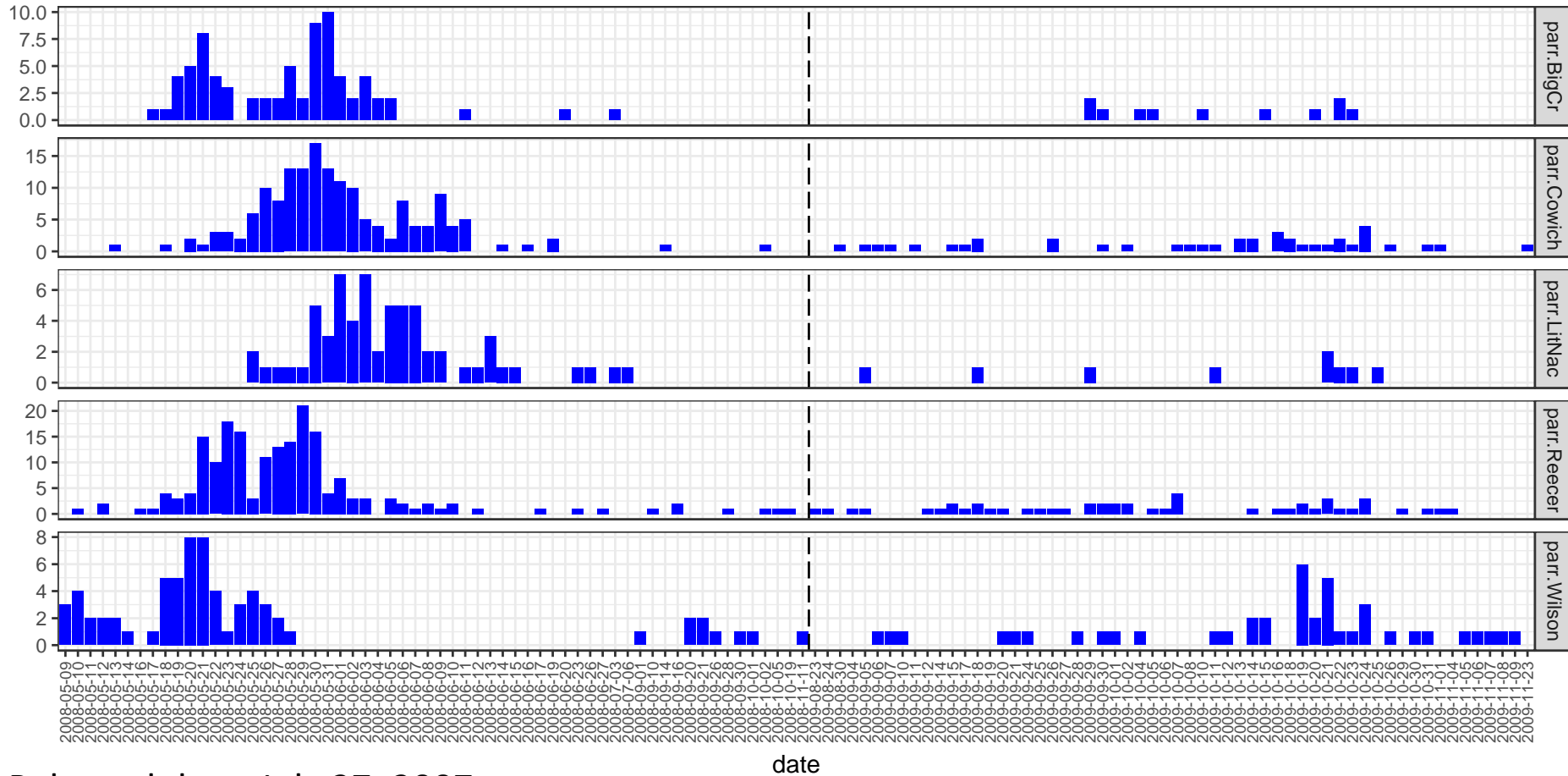
Last detection at MCN = Sept 22, 2016 (412 days after releasing)

First detection at MCN as an adult= Sept 19, 2017 (372 days after last detection)

Last detection at MCN as an adult=October 27, 2017 (410 days after last detection)



## Detection frequency at MCN for the parr population that was released during 2007



Released date: July 27, 2007

First detection at MCN = May 9, 2008 (287 days after releasing) [10 months]

Last detection at MCN = Nov 11, 2008 (473 days after releasing) [16 months]

First detection at MCN as an adult= Aug 23, 2008 (285 days after last detection) [9 months]

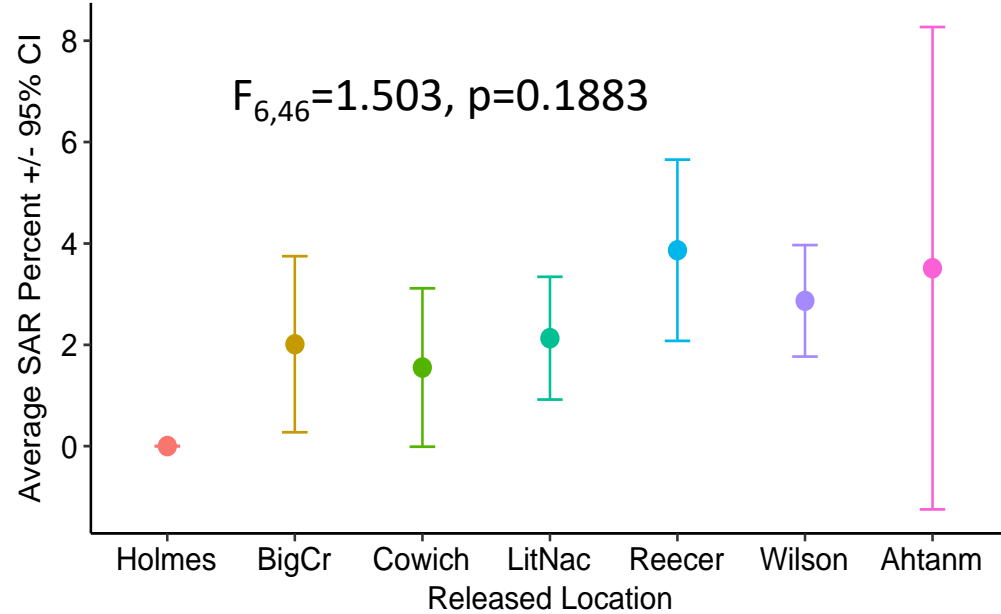
Last detection at MCN as an adult=Nov. 23, 2008 (377 days after last detection) [13 months]



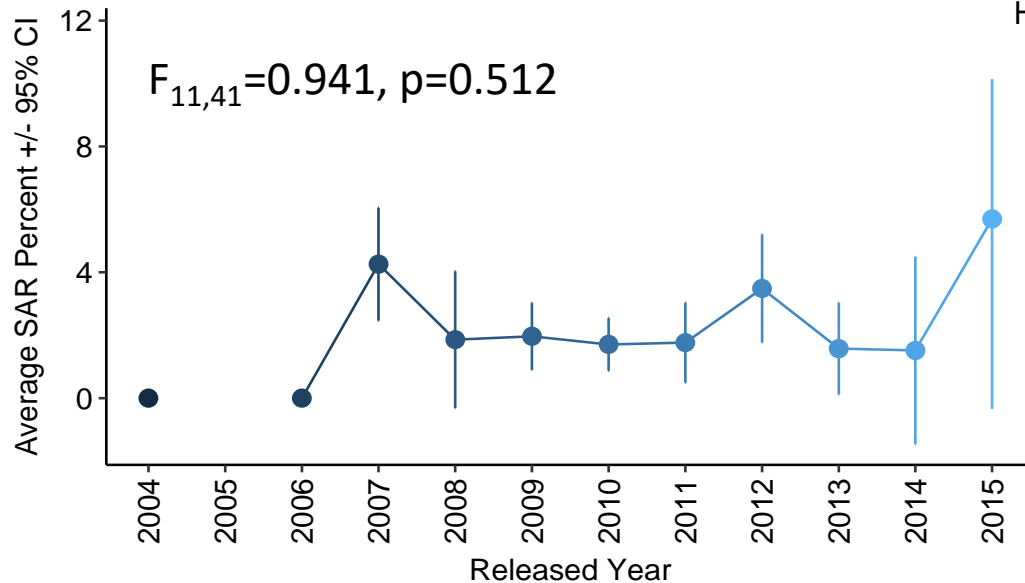
# Results

Are the Smolt-to-Adult Survivals (SAR) of the populations that were released as parr at different locations significantly different?

SAR for parr



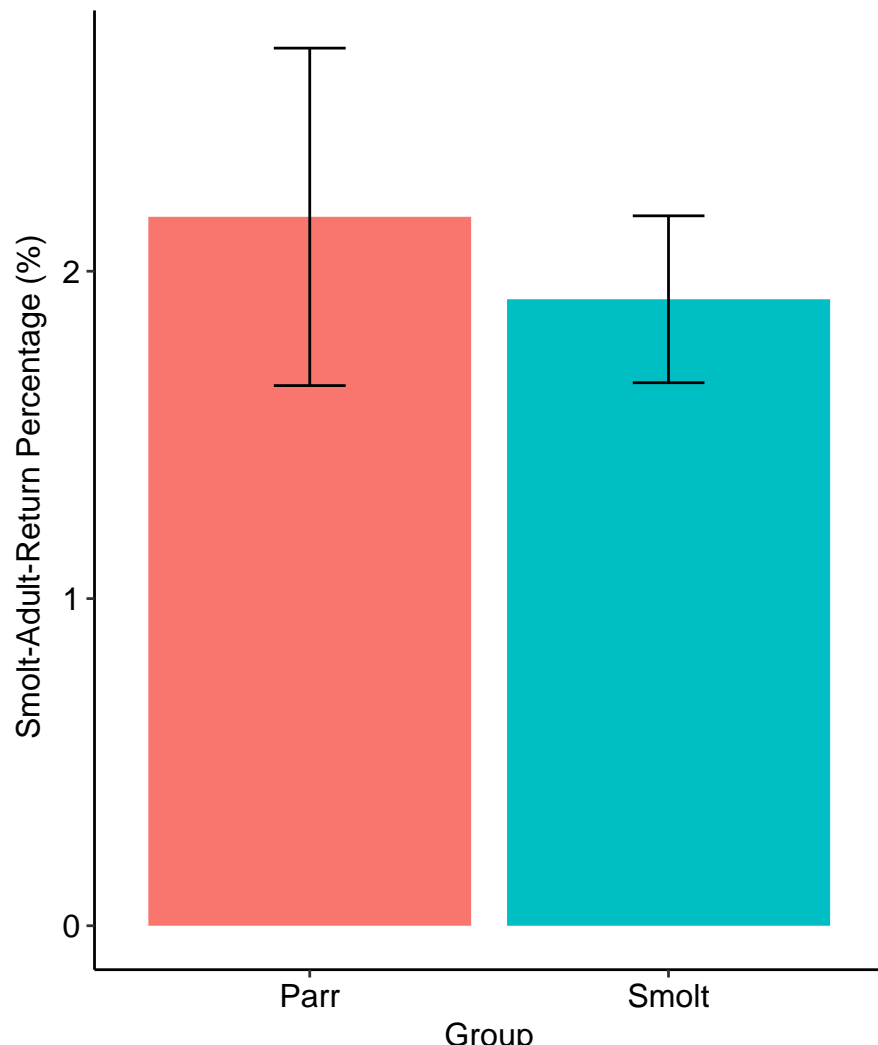
SAR for Parr



# SAR between parr and smolt *release strategies*



Were the SARs of coho released as “parr” and “smolt” different?



$F_{1, 23}=1.1491, p=0.294$



# Summary

- Survival rate decreased as water temperature in the river increased.
- Hatchery coho released as “parr” generally had higher adult return rate (SAR) than those released as “smolt”; however, statistically not significant.
- The return rate (SAR) was more affected by marine conditions than freshwater conditions.
- Survival rate was higher for coho released in the lower Yakima River (at or below Prosser) compared to fish released in the upper Yakima Basin, indicating that mortality in the Yakima River above Prosser is relatively high.
- Since there were no significant differences in SAR among the release groups, it is recommended to continue current release strategies as the presence of multiple life history types can ensure population resiliency in the face of environmental change.



# Ongoing

- Estimating SAR from McNary/Bonneville dam for both release groups (parr and smolt)
- Estimating Survival probability using barker capture-recapture models for both groups
- Analyzing the data to understand the effects of harvesting in SAR and survival probability of both life stage.





Questions?

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