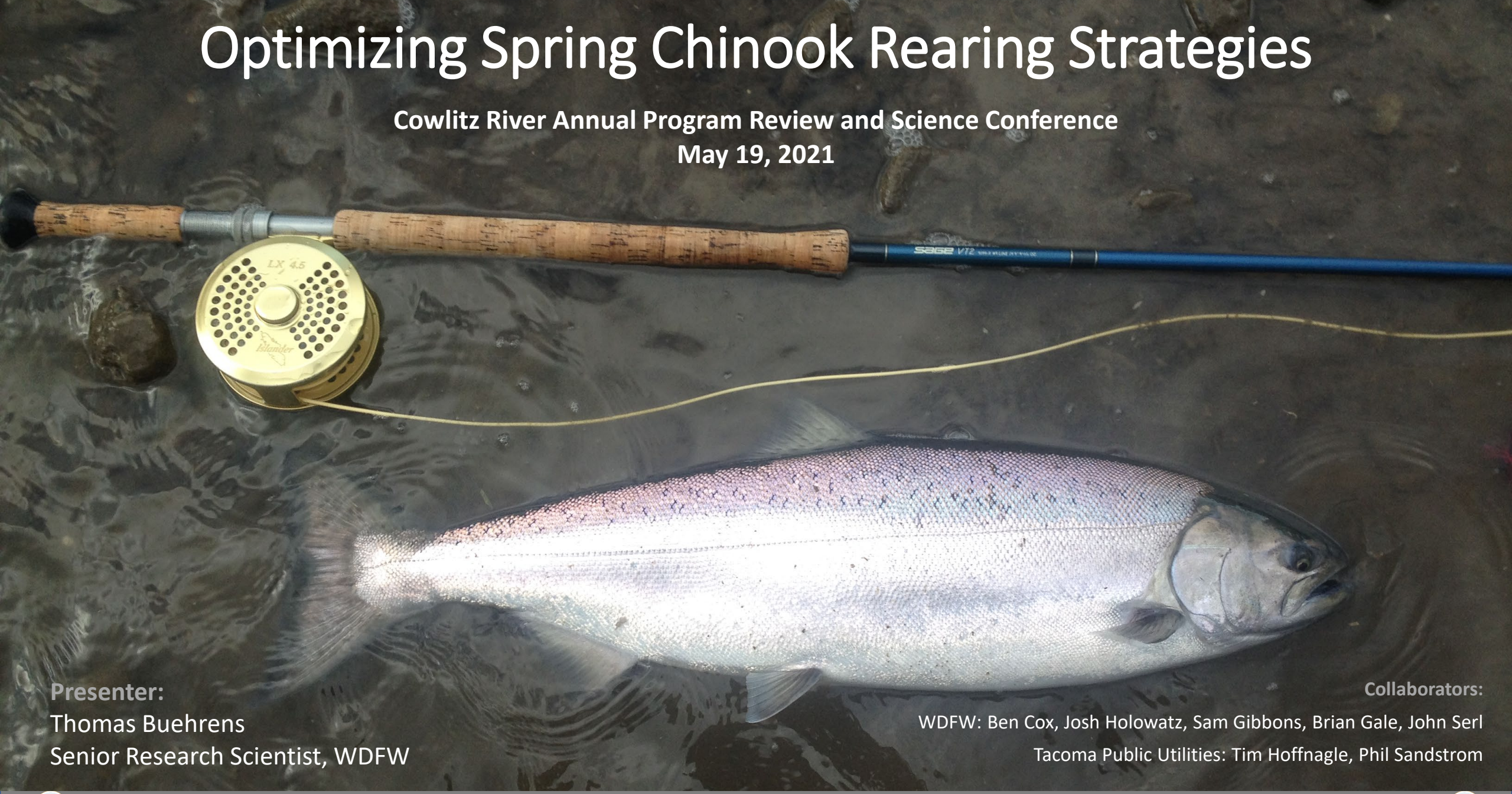
Optimizing Spring Chinook Rearing Strategies

Cowlitz River Annual Program Review and Science Conference
May 19, 2021

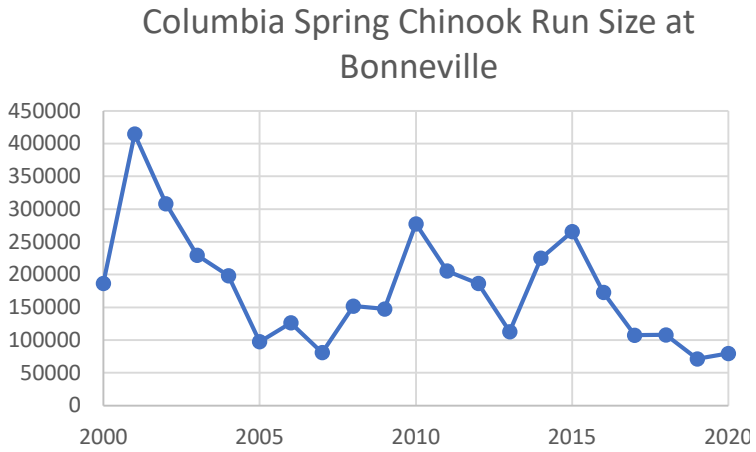


Presenter:
Thomas Buehrens
Senior Research Scientist, WDFW

Collaborators:
WDFW: Ben Cox, Josh Holowatz, Sam Gibbons, Brian Gale, John Serl
Tacoma Public Utilities: Tim Hoffnagle, Phil Sandstrom

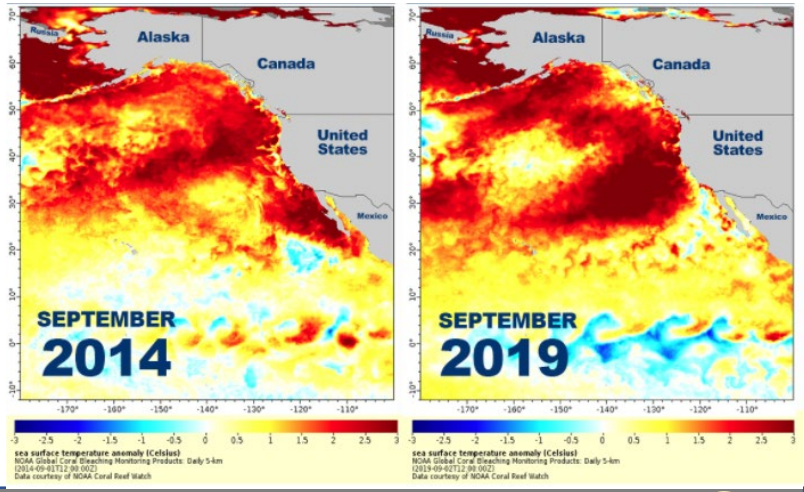
Spring Chinook Blues

Declining Runs



Fishing Closures

Blobs



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What can be done?

We may have a limited ability to influence what goes on in the ocean…

…but we should do all we can in our hatchery operations to maximize returns.

Objective: *Identify rearing strategies that maximize returns for the Cowlitz spring Chinook program*

We already know that more and larger smolts = more returning adults, but we need to consider additional factors:

- Hatchery facility constraints:
  - Space and resources limited; can't produce unlimited smolts
  - Bigger fish take more space so we can't rear as many of them
- Brood constraints:
  - Strategies need to produce at least 1 spawner per spawner back to the hatchery to operate in perpetuity
- Conservation constraints
  - Effects of programs on hatchery-wild interactions

Objective: *Identify rearing strategies that maximize returns for the Cowlitz spring Chinook program*

Theoretically, the same total poundage deployed via multiple rearing strategies could return the same number of adults

- Many small with low survival
- Few big with high survival
- Example:

  1,000,000 fall smolts at 20/lb. and 0.005 SAR = 50,000 lbs. of smolts, 5,000 adults

  250,000 spring smolts at 5/lb. and 0.02 SAR = 50,000 lbs. of smolts, 5,000 adults

Objective: *Identify rearing strategies that maximize returns for the Cowlitz spring Chinook program*

Project Goals

1. Develop a transparent and reproducible analysis of survival rates by size, age, and timing of release

2. Find mixture of release dates and sizes that, with equivalent usage of resources (space, money, etc.):
    1. Maximize average adult returns
    2. Maintain program consistency (return >1 adult per adult spawned in almost all years so program size is maintained)

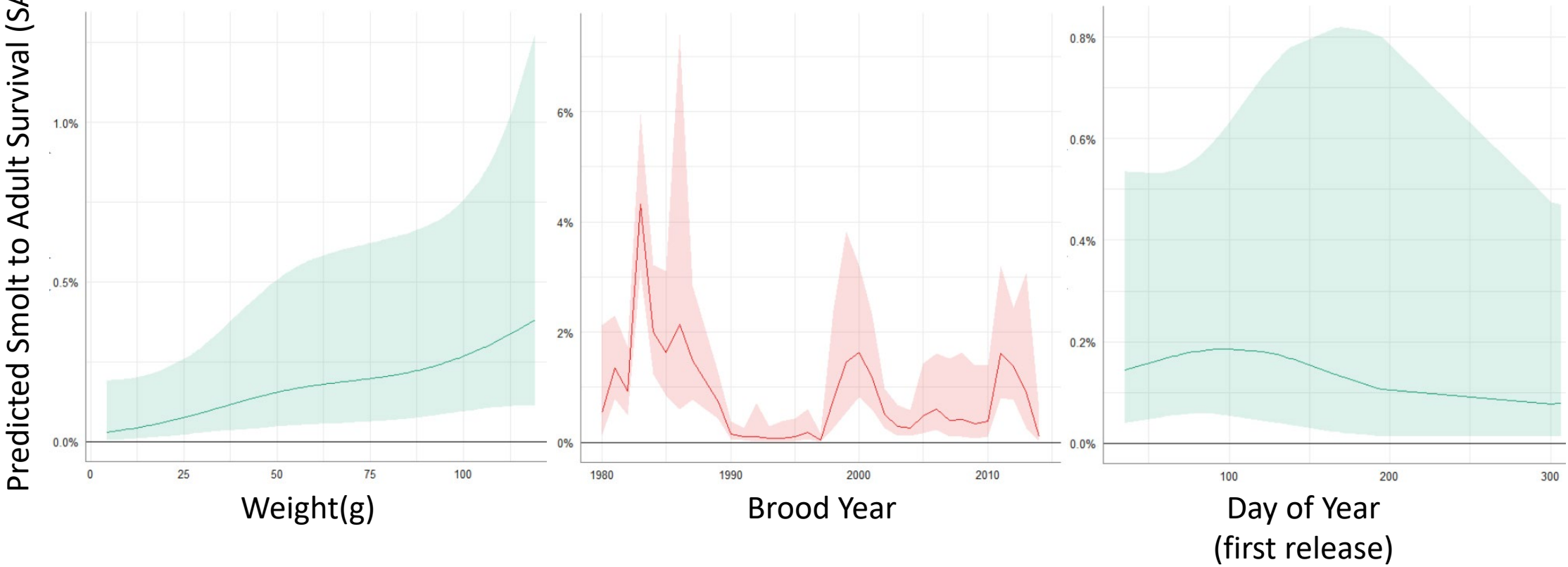
Process

Step	Status	Result
Identify dataset for use	DONE	Regional Mark Information System (RMIS) Coded Wire Tag (CWT) data excluding jacks/minijacks
Agree to common definitions, data filters, (what should be included in Smolt to Adult Return rates (SAR)?)	DONE	Expand escapement recoveries for terminal tributary harvest
Agree to common analytical framework to estimate SAR	DONE	Generalized Additive Model (GAM) model with main effects of timing, size, year.
Compare alternative release strategies to identify “best” strategy	In Process	

Model Results: Effects of Covariates on SAR

Model: Survival = Brood Year + Weight + Day of Year of Release

Adjusted R^2 = 0.92, Percent of Deviance Explained = 95.2%



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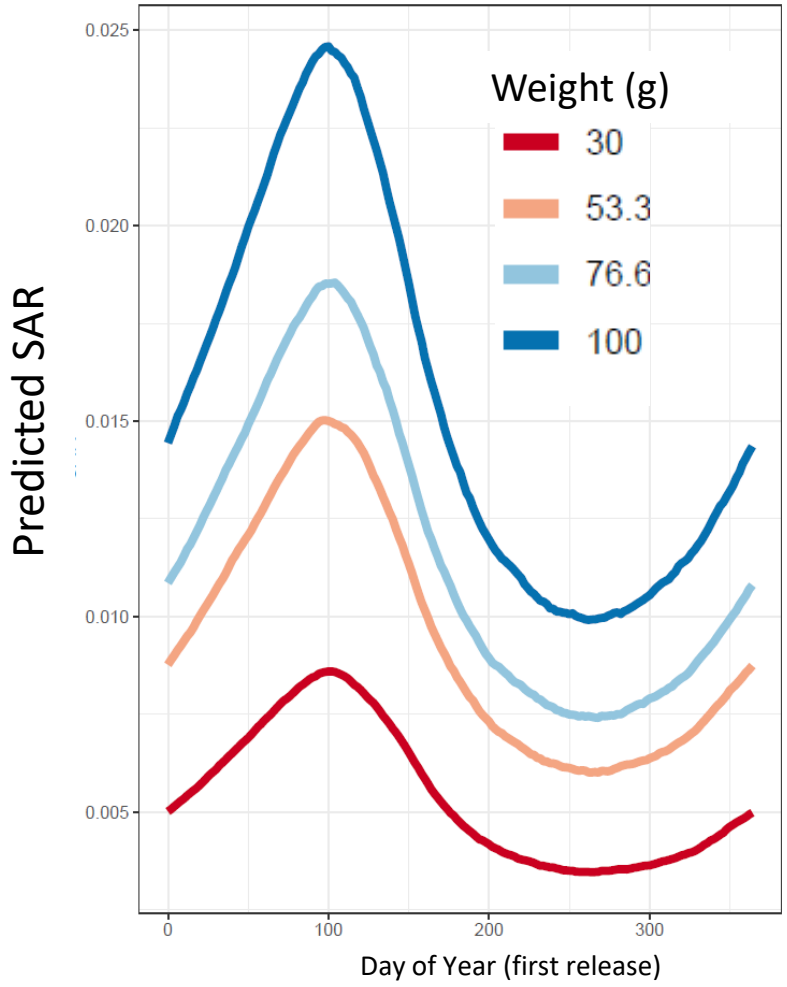
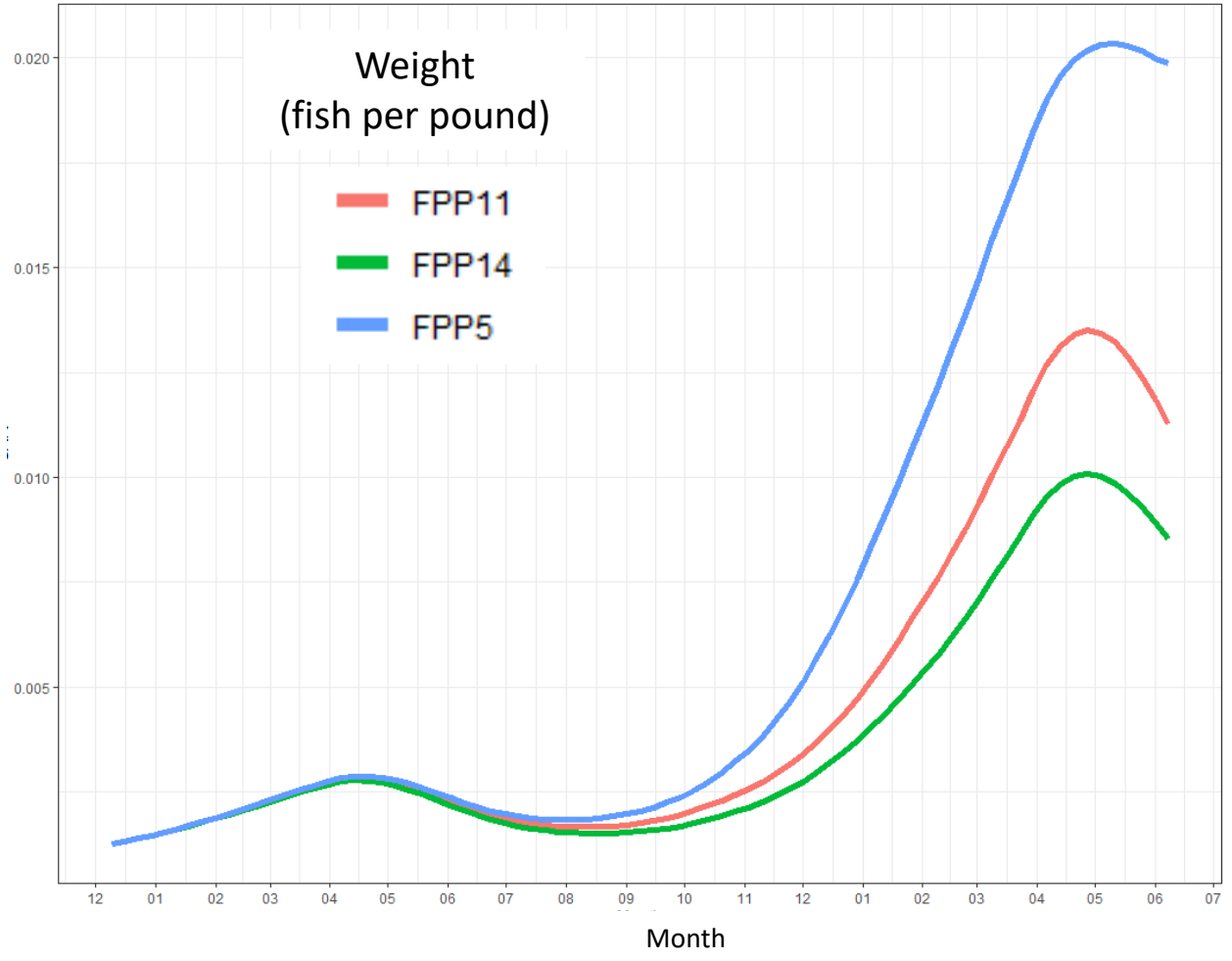
Effects of date, size, growth trajectory

By size class and date



By growth trajectory



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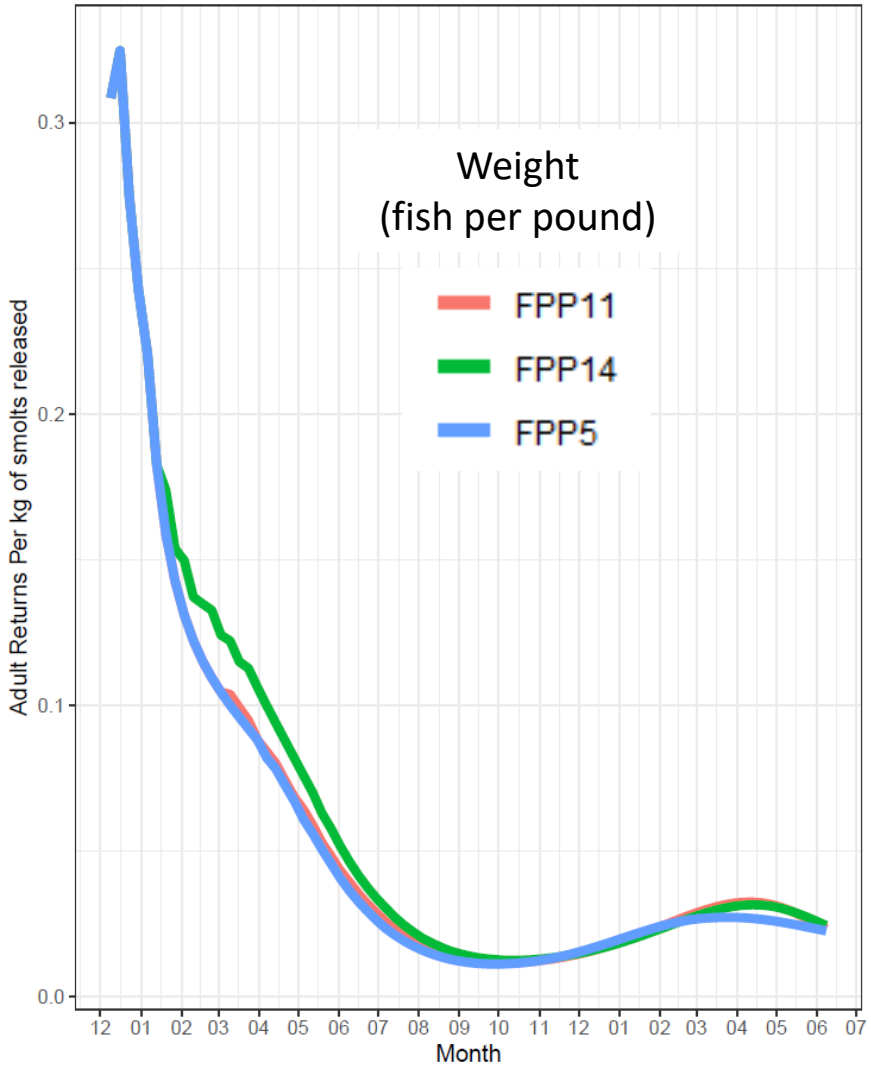
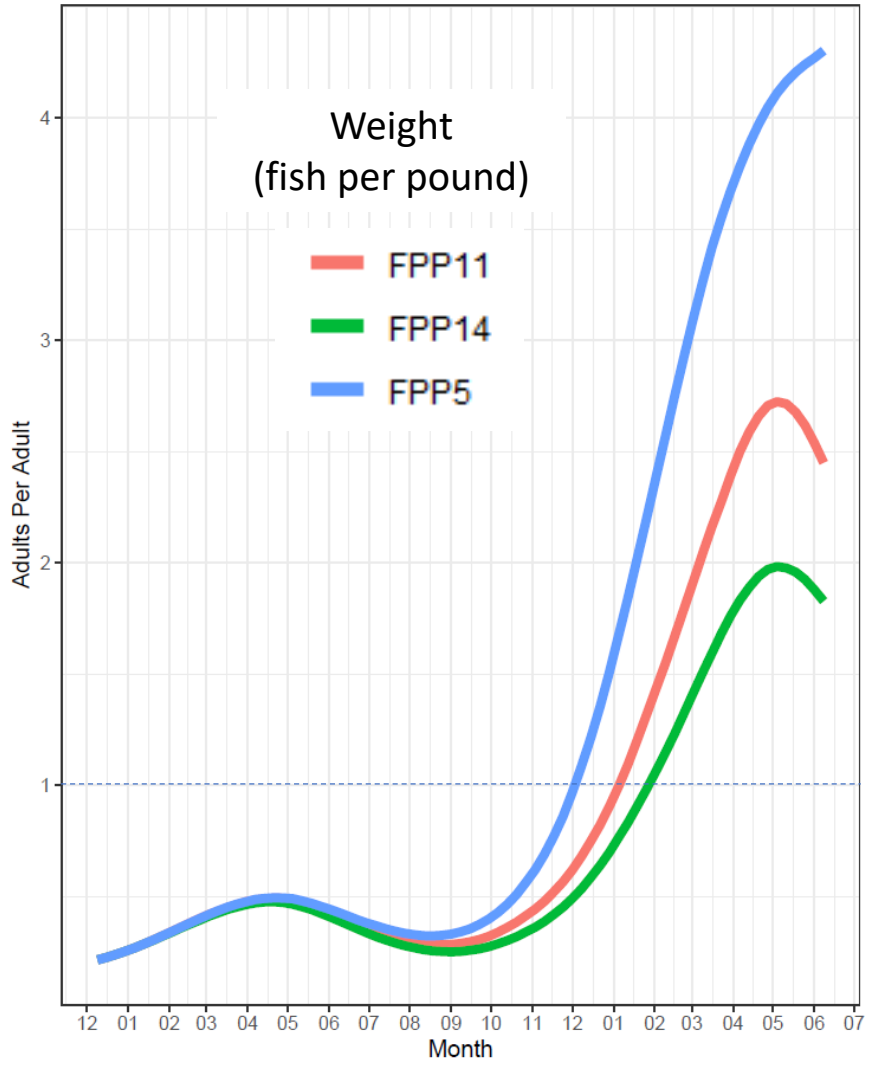
Tradeoff between adult returns per lbs. of smolts and ability to make brood





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Conclusions

- Survival varies by:
  - Size: Bigger is better, but there is a threshold of ~50 grams with more modest benefits above that
  - Brood year:
    - Big and variable effect on survival
    - Therefore, it is necessary to account for year effects when comparing size and timing of release
  - Day of year:
    - Clearly a peak that occurs on average from mid-April through mid-May, with lower survival earlier in the spring and later in the summer
    - There is considerable uncertainty in the effect of release date other than the spring because we haven't used a crossed experimental design to assess factors affecting survival→ particularly high uncertainty for summer and mid-winter release dates.
  - We don't currently have enough data to estimate interactions — would need "crossed study design"
  - Models are explaining most of the variability in survival (~90%)

Conclusions

- Optimal Release Strategies
  - Tradeoff between adults per pound of smolts and adults per adult
    - Strategies that release small fish return more adults per pound of smolts, but have lower productivity
    - Survival too low for replacement until winter-spring as juveniles become yearlings
    - This suggests the current program is close to optimal because it prioritizes large yearlings
    - Can fine tune exact size/date of yearling release to optimize size vs. number of yearlings
  - Other tradeoffs and final recommendations beyond our scope
    - Tradeoffs in space usage between spring Chinook and other species
    - Total poundage limit
    - If sub-yearlings residualize, determining an acceptable level of residualism

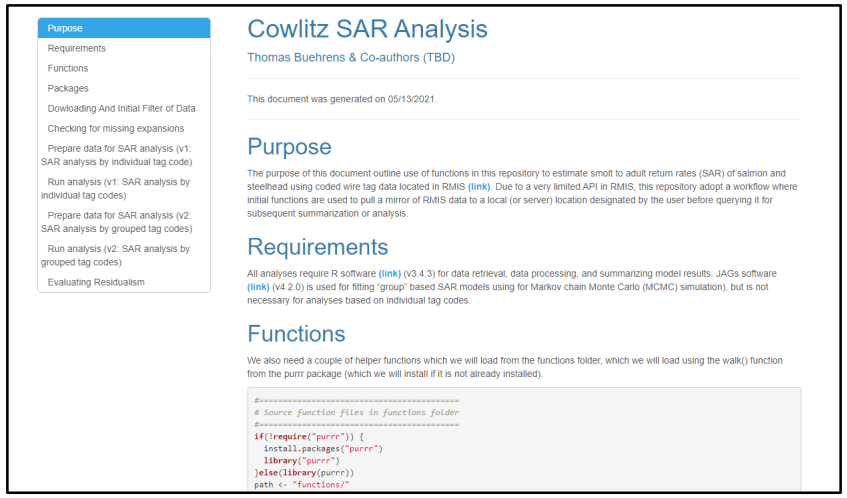
Future Work

- Finish release strategy comparison with scenarios from hatchery staff
- Compare SARs with other programs in region (beyond effects of size/date, is their survival lower than expected?)
  - Lewis
  - Clackamas
  - Kalama
  - Sandy
- Residualism of sub-yearling releases?
  - Potential coupled, scale, otolith work on CWT+ fish to flesh out if sub-yearling smolts are residualizing
- Effect of rearing strategy on adult age composition, fecundity.
  - Implications for spawner-to-spawner replacement.

Questions?

Want to see the data and results for yourself?

1. https://github.com/tbuehrens/CWT_SAR_Analysis
2. See the projects/results/cowlitz folder
   - Raw Cowlitz CWT Data
   - Summarized data for SAR analysis
   - Model outputs
   - Plots
   - Webpage documenting modeling process and results



Extra Slides

Analysis Methods

- Statistical model attributes/needs
  - Account for effects of covariates of interest
    - Day of year or season
    - Size/age
    - Interactions
  - Account for effects of “nuisance variables” that affect survival but are not under our control
    - Year effects
    - Interactions between year effects and covariates of interest.
  - Deal with effectively with data structure
    - “Partially Observed” data (tag groups of all sizes and dates not released all years)
    - Effects of tag and survivor sample sizes (binomial error)
    - Effects of unknown variance involved in expanding raw recoveries to survivors
- Solution
  - Generalized Additive Models
  - Logit link function
  - Quasi-binomial likelihood (to account for overdispersion of released and recovered CWT due to uncertainty in expanded tags; both from RMIS expansion factor AND due to expansion of escapement recoveries to account for in-Cowlitz R harvest)
  - Weights = reported expansion rates (raw tags/expanded tags); larger expansion=lower weight.

Dataset

Field	Filters	Comments
Recovery areas	All included except: 1) Terminal (Cowlitz R) sport fishery 2) Juvenile recoveries] 3) High Seas sampling	• Can't use sport fishery recoveries because most years there wasn't sufficient sampling for expansions • Update: used age specific Cowlitz R. harvest rates to expand escapement recoveries to account for in-river harvest
CWT status	Clipped and CWT+	
Ocean Age (recovery year – release year) & Total Age (recovery year- brood year)	OA = 2 to 5, TA=3-6	Excludes minijacks and jacks
Brood years	1980 to 2014	Complete recoveries for age 5 adults reported to RMIS through at least 2013

Model Results: Effects of Covariates

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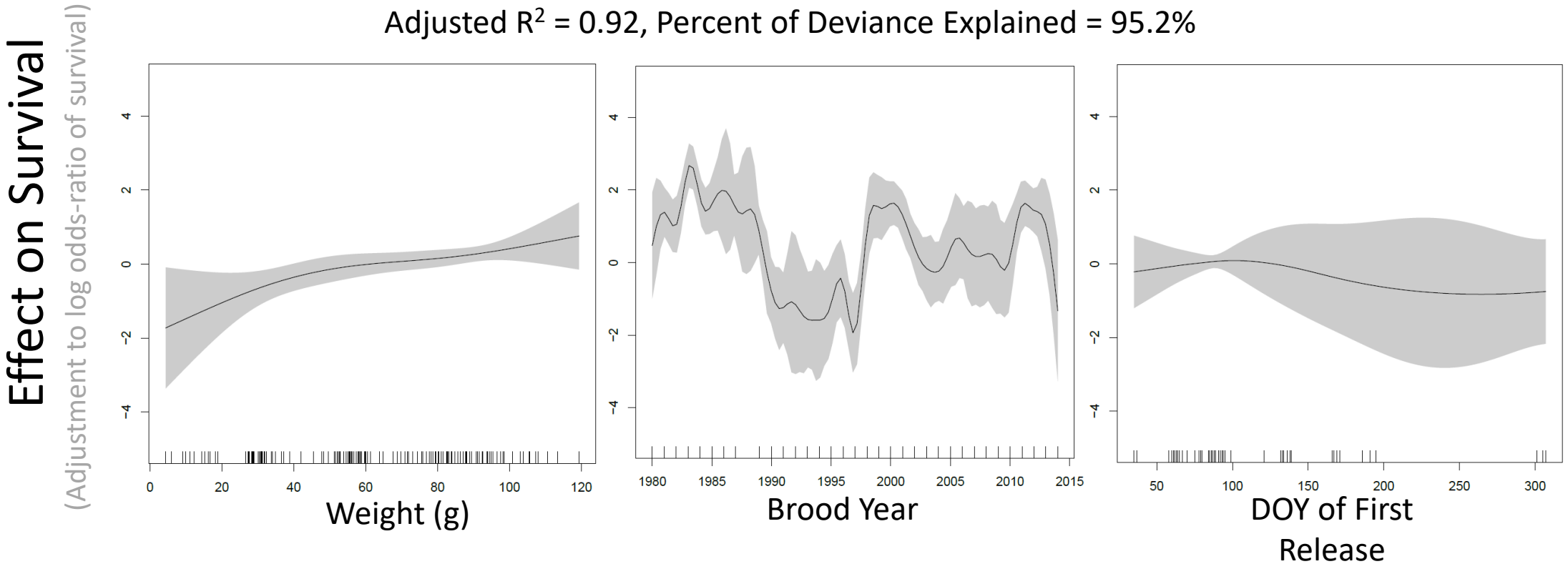

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Release Group Characteristics