

# Large River Habitat Complexity and Productivity of Puget Sound Chinook salmon



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\*Work completed with NOAA NWFSC, Now  
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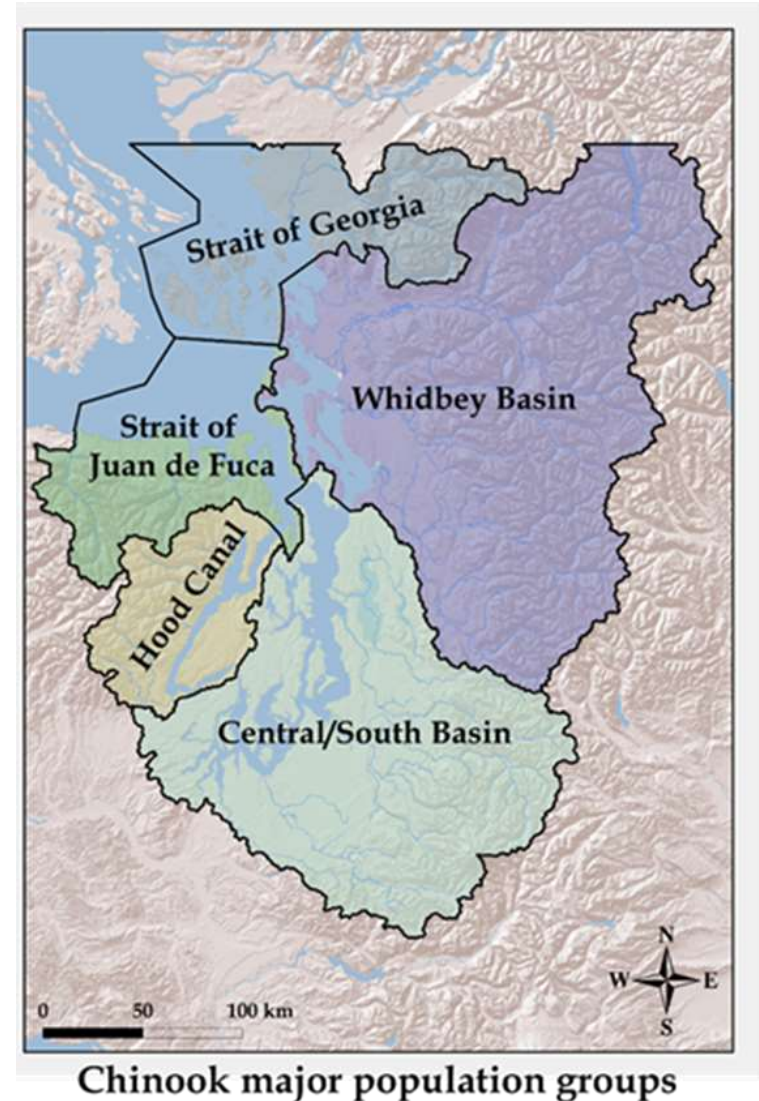


# Presentation Outline

1. **Background:** *The Salmon Habitat Status and Trends Monitoring Program (SHSTMP)*
2. **Approach:** *Mapping large river habitats and evaluating relationships with productivity*
3. **Results:** *Habitat complexity and productivity*
4. **Next Steps and Implications:** *Future directions and implications*
5. **More Information:** *Publications and where to find more information on this project*

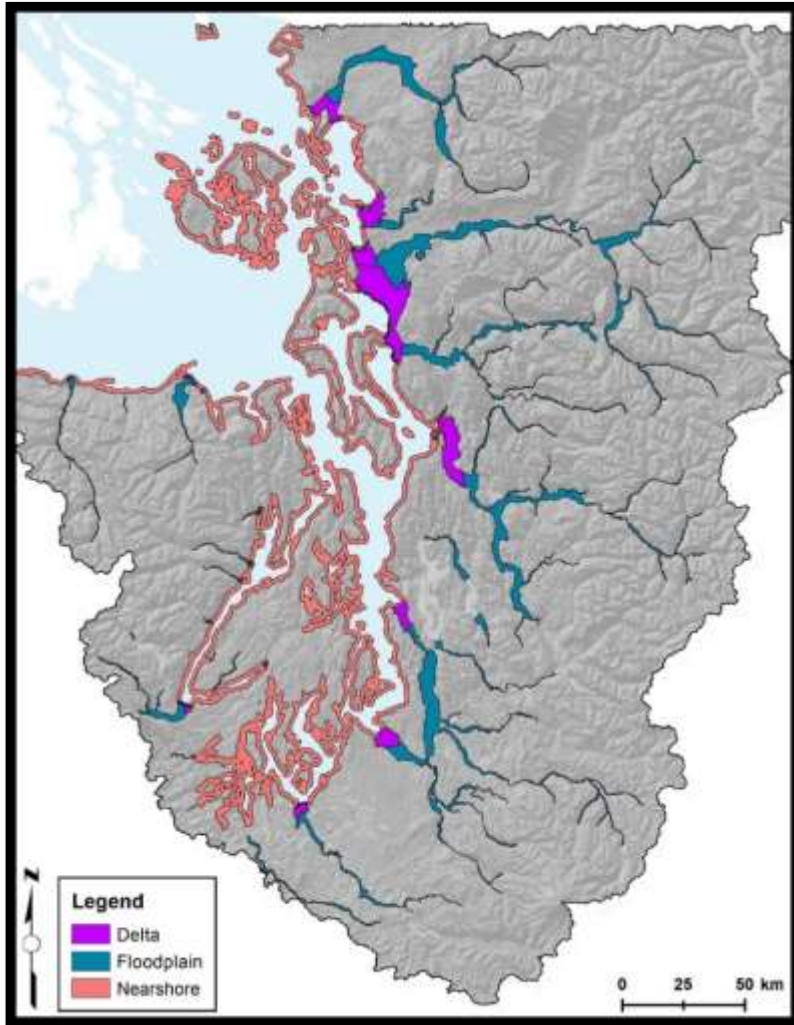
# Background: Salmon Habitat Status and Trends Monitoring Program (SHSTMP)

- **Puget Sound Chinook:**
  - *Complex life histories*
  - *Rely on many habitats*
  - *Focus of regional recovery efforts*
  - *Need for consistent monitoring*
- **SHSTMP Objectives:**
  - *Consistent regional metrics*
  - *Remotely-sensed census approach*
  - *Habitat status and trends metrics*
  - *Metrics related to VSP parameters*
  - *Support regional recovery evaluations*

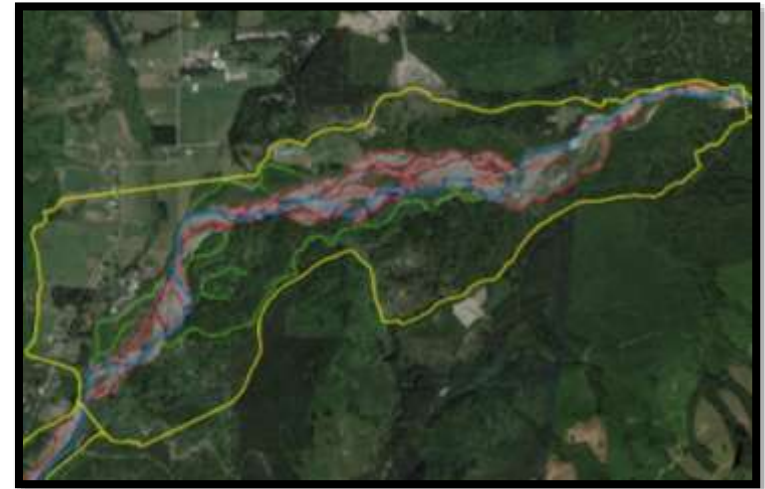


# Approach: SHSTMP Sampling Strata

## *SHSTMP Sampling Strata*



***Large River & Floodplain***  
(2015 mapping completed  
for Puget Sound)



*Nearshore*

*Large River Deltas*



# Approach: Large River and Floodplain Mapping

- **Map large river features:**

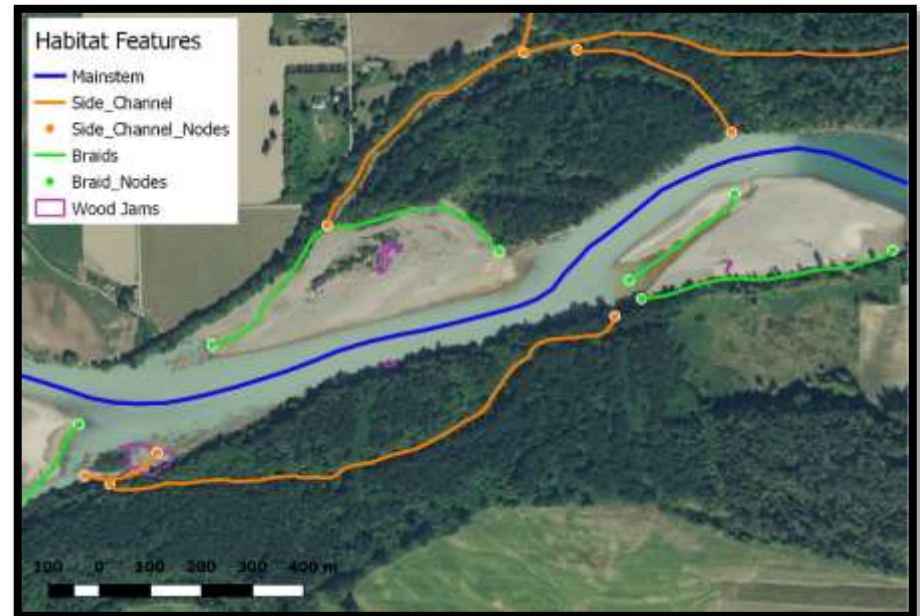
- *Main channel*
- *Side channel*
- *Braid channel*
- *Large wood jams*

- **Habitat Complexity:**

- *Side & braid : mainstem*
- *Side & braid node densities*
- *Wood jam density*

- **Metrics related to VSP parameters?**

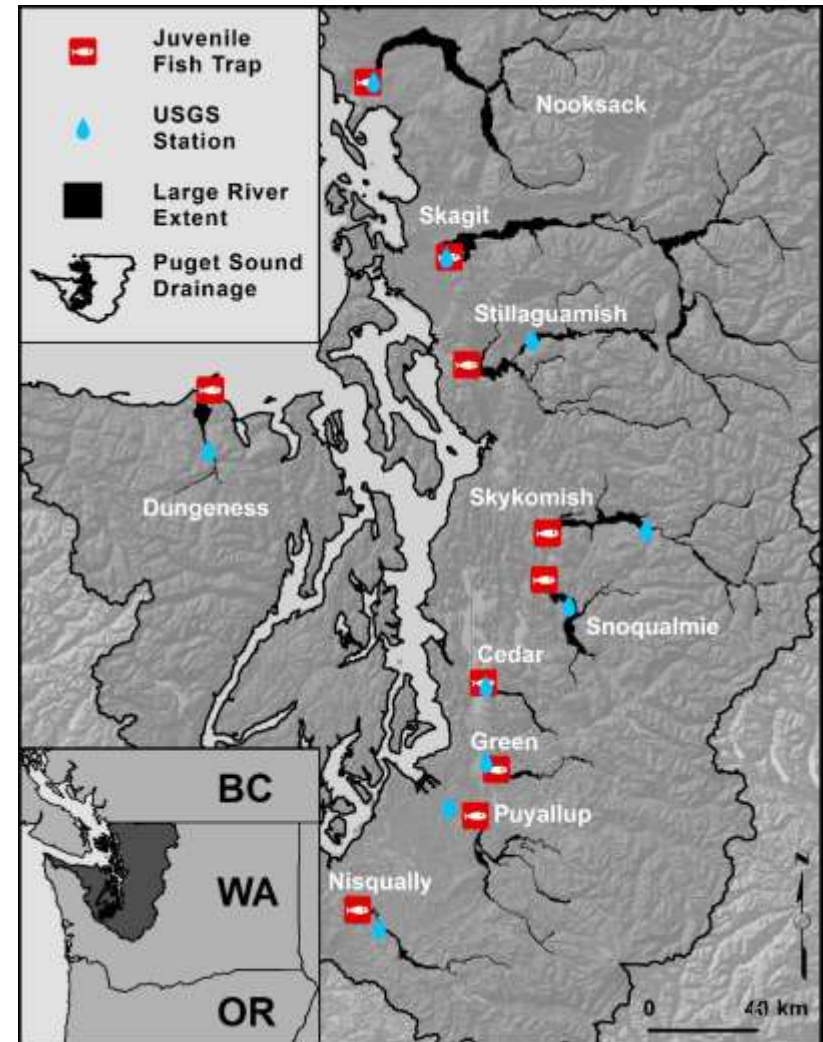
*Example of digitized habitat features in the mainstem and floodplain of a large river*



# Approach: Habitat Complexity and Productivity

*Analysis extent, smolt traps,  
and USGS stations*

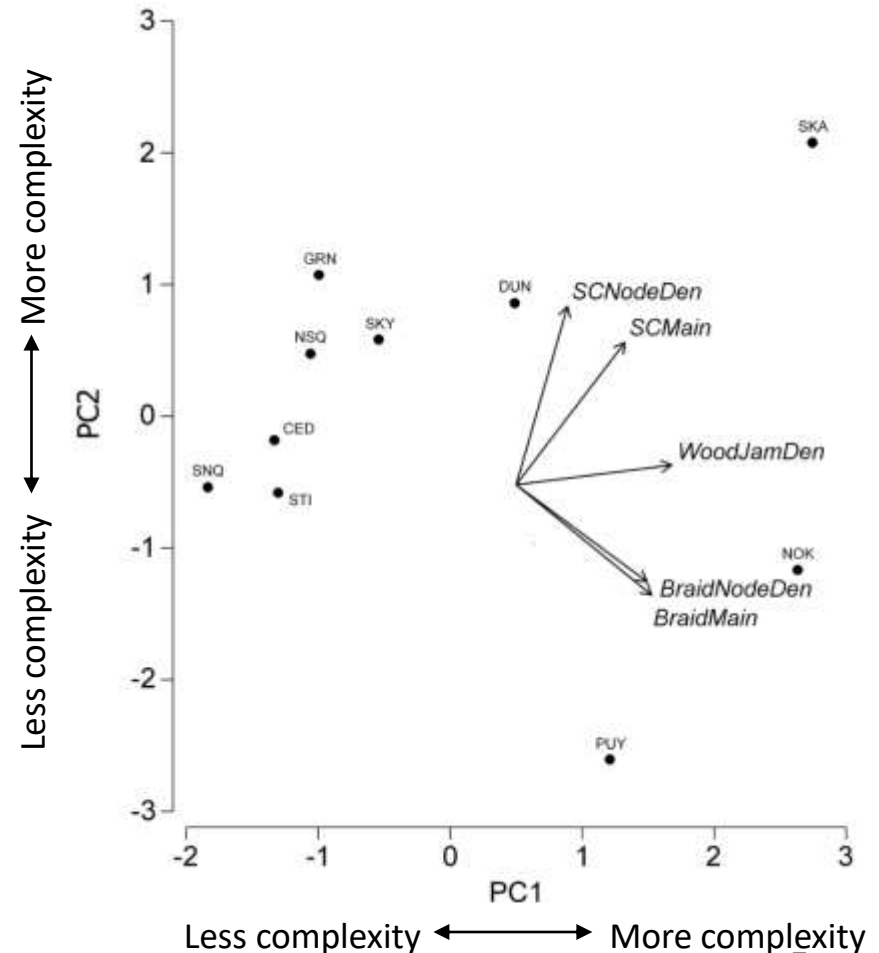
- **Compiled productivity rates: for subyearling Chinook**
  - *Regional smolt traps (WDFW & Tribal)*
  - *Subyearling Chinook*
  - *Fry per Spawner (FpS)*
  - *Parr per Spawner (PpS)*
  - *Subyearling per Spawner (SpS)*
- **Subset habitat complexity:**
  - *Area upstream of traps*
  - *Influences productivity?*



# Approach: Habitat Complexity PCA

- **PCA approach:**
  - Metrics highly correlated
  - Strong spatial gradients
  - Quantity  $\neq$  complexity
- **Principle components:**
  - PC1 (56%): wood & braids
  - PC2 (35%): side channels
- **Exploratory Approach**
  - Full subsets LMER with AICc
  - PC1, PC2, peak flow recurrence interval (RI), spawner density (SD), and broodyear

PCA biplot of habitat complexity metrics



# Results: Model Selection and Predictors

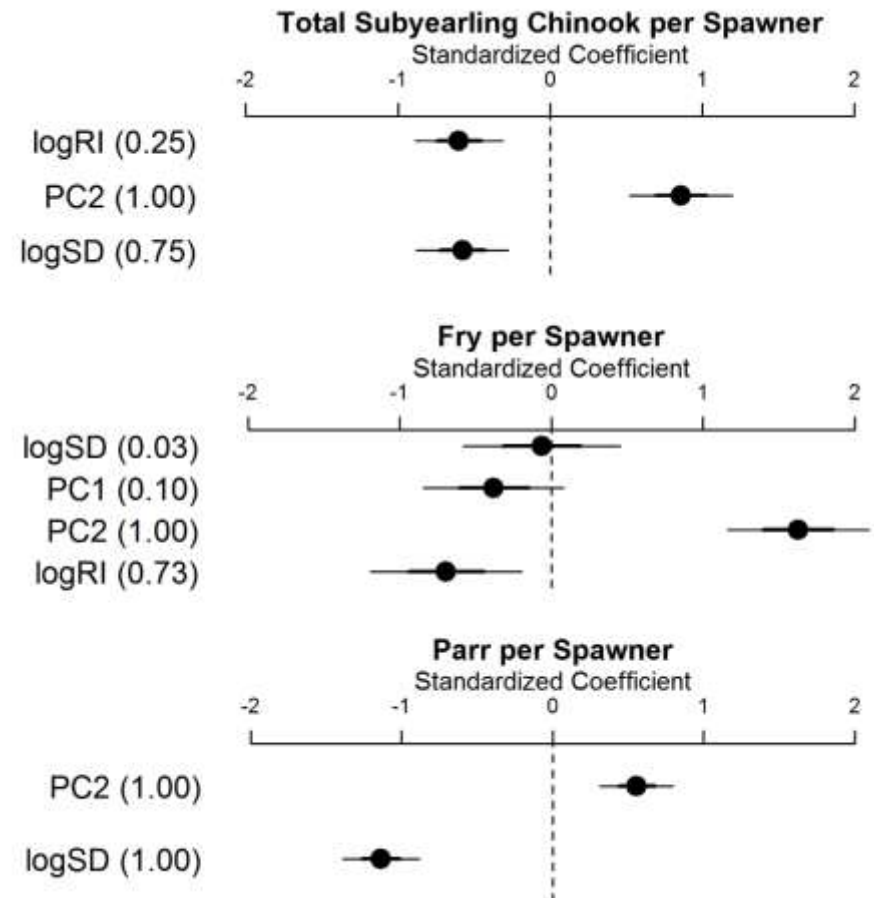
- **Habitat complexity was a strong predictor:**

- *All selected models included PC2 (+)*
- *Best models PC2 with SD (-) or RI (-)*

- **PC2 strongest predictor for FpS**

- **logSD strongest predictor for PpS**

*Standardized coefficient plots from selected model sets*

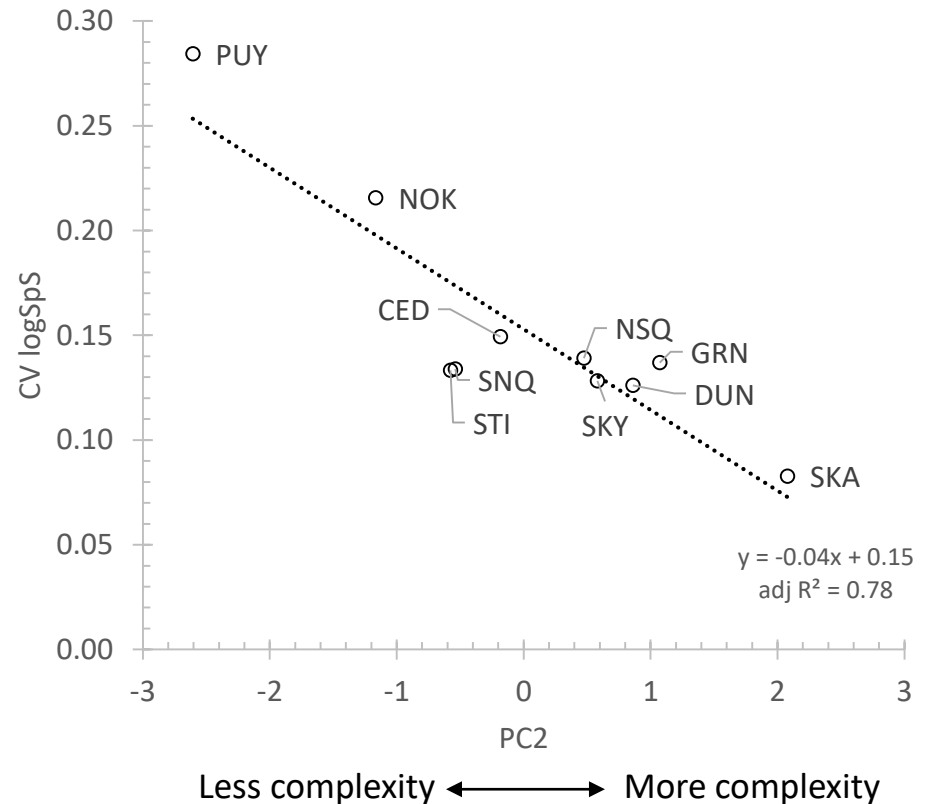




# Results: Habitat Complexity and Population Resilience

- Does habitat complexity buffer productivity?
- CV decreases with increasing complexity
- Supports hypotheses:
  - Complexity buffers populations from disturbance
  - Increasing complexity (restoration) could increase population resilience

*Coefficient of variation in SpS among watersheds vs complexity*



# Results: Habitat Complexity and Restoration

Does SHSTMP approach detect change from restoration?



**Pre-restoration**

**Example from  
Cedar River:**

*Floodplain restoration  
creates new features*



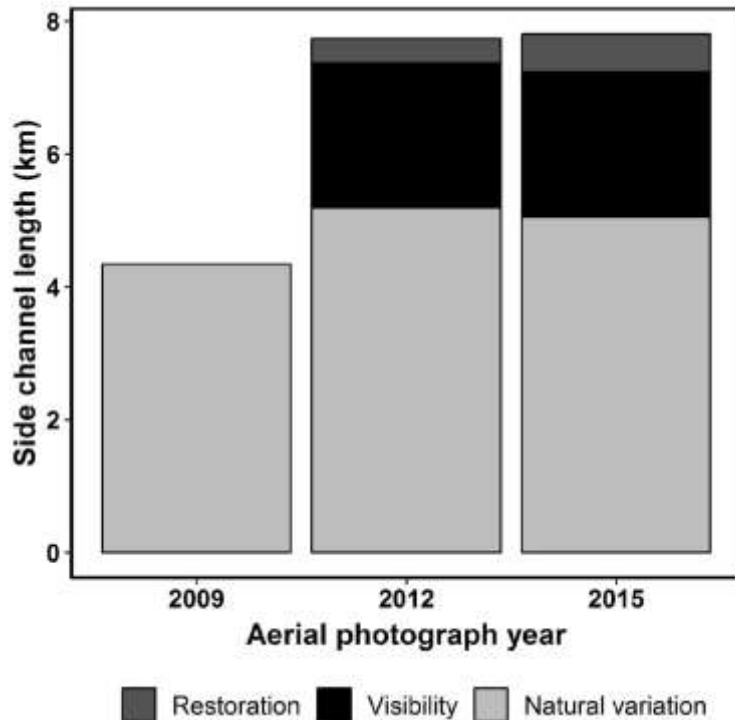
*Map features from  
archived and future  
imagery to  
evaluate change*



**Post-restoration**

# Results: Habitat Complexity and Restoration

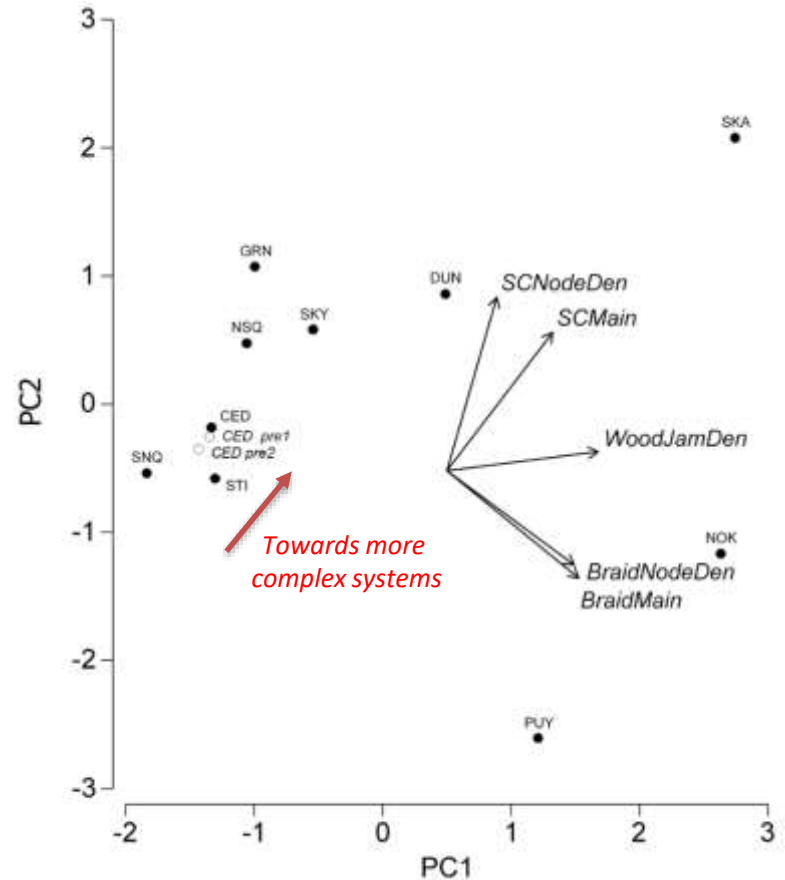
Map change in habitat over time  
(Cedar River example)



From: Stefanki et al. (2019). Proof of concept for the SHSTMP status and trends monitoring.

Less complexity ← → More complexity

Measurable change in PC scores  
attributed to restoration



Less complexity ← → More complexity

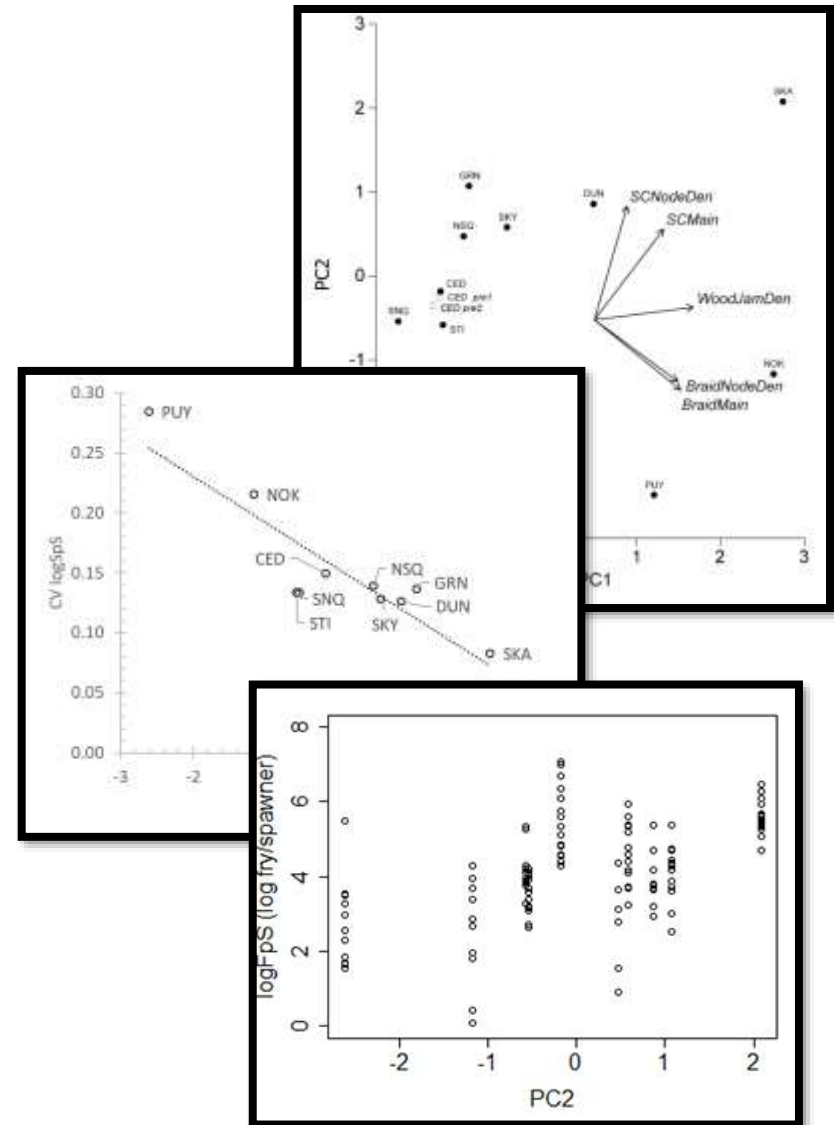
# Next Steps and Implications:

## Implications:

- *Proof of concept for SHSTMP approach*
- *Products being integrated into regional recovery (e.g., NOAA, PSP)*
- *Evidence for key concepts at regional scales*

## Next Steps:

- *Complete mapping other strata*
- *Link to other VSP parameters*
- *Complete trends analysis*





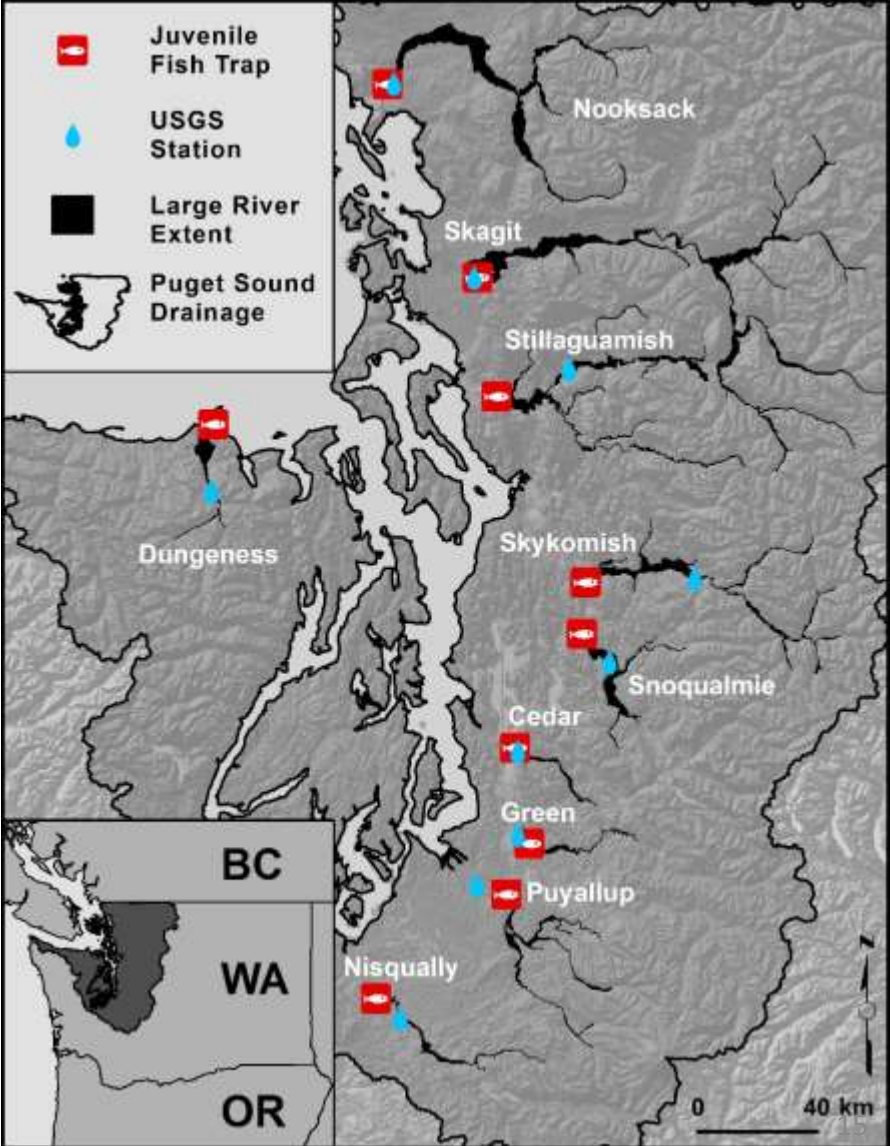
# Supporting Slides

# Habitat complexity and salmon productivity?

Smolt traps (J. Anderson)



Smolt traps and analysis extent



# PSHSTMP and Regional Salmon Recovery

Large River & Floodplain



Large River Deltas



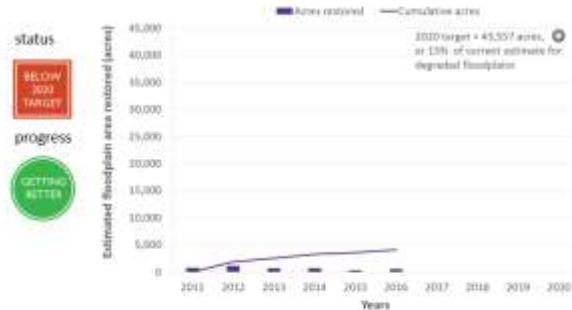
Nearshore



HABITAT WATER SPECIES HUMANS

## Floodplains

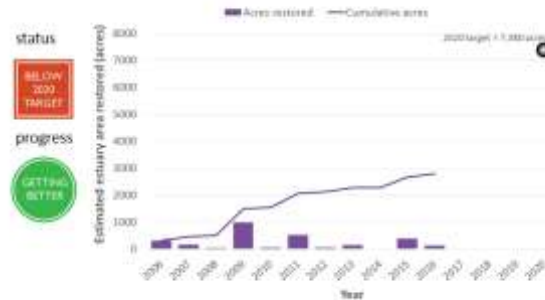
Floodplain restoration



HABITAT WATER SPECIES HUMANS

## Estuaries

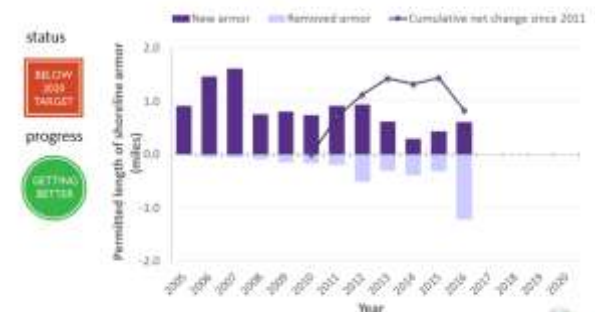
Area of estuarine wetlands restored to tidal flooding



HABITAT WATER SPECIES HUMANS

## Shoreline Armor

Miles of new and removed armor





# Subyearling Chinook Production Rates

Smolt traps (J. Anderson)



## Annual Productivity Rates:

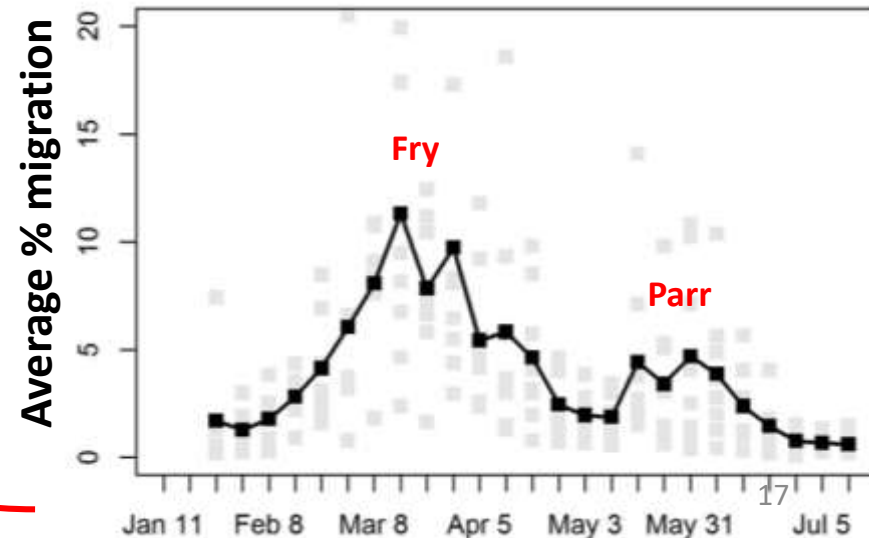
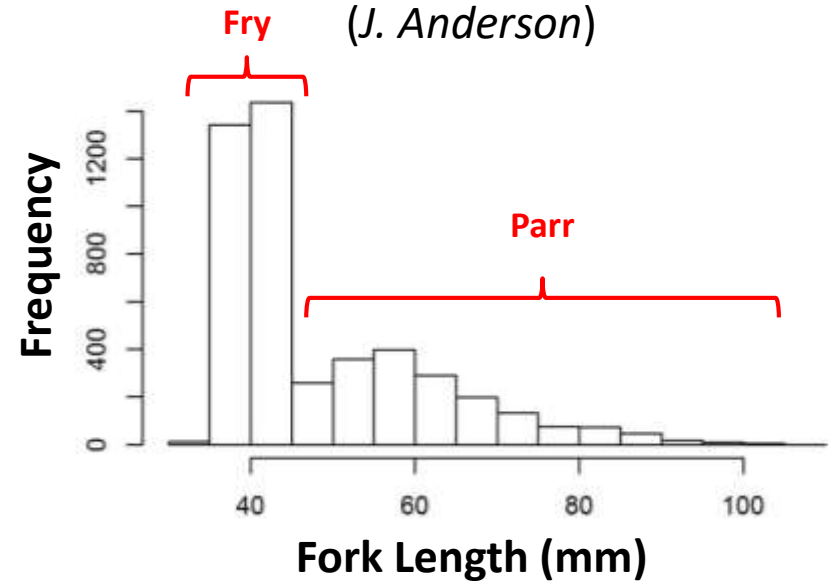
Fry per Spawner (FpS)

Parr per Spawner (PpS)

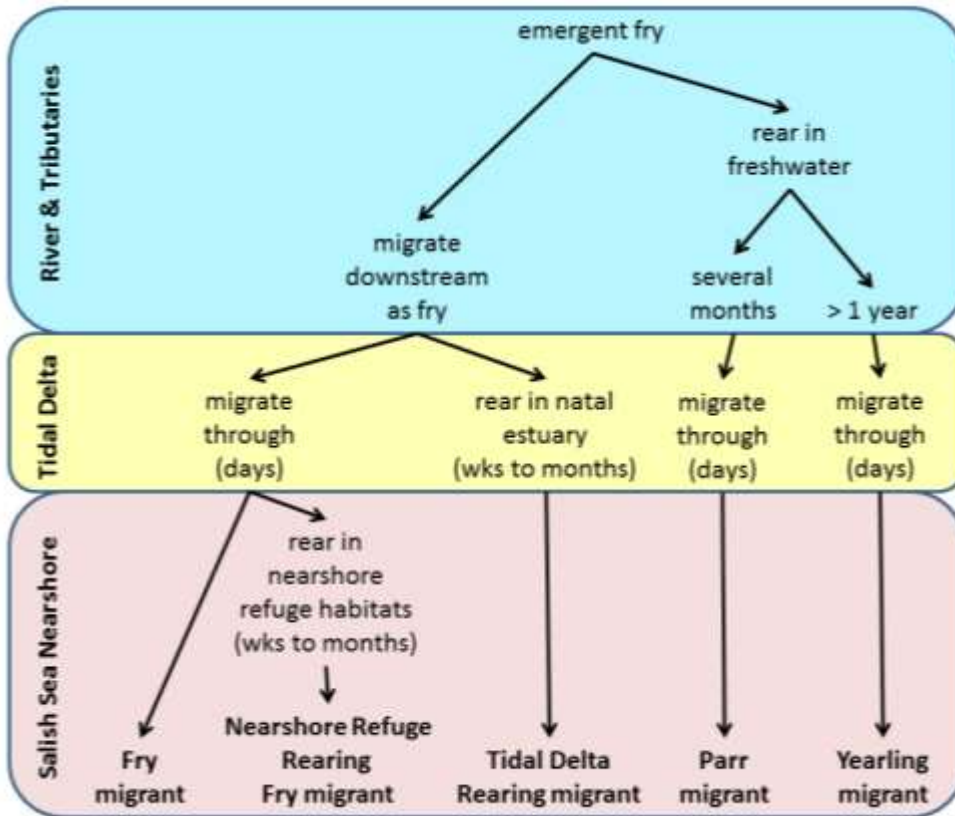
Total subyearling per Spawner (SpS)

## Skagit River Example

(J. Anderson)



# Background: Chinook Salmon Habitats and Life Histories



## Habitat Functions

Spawning capacity (all)  
 Flood refuge (all)  
 Growth opportunity (parr & 1+)

Predator refuge (fry)  
 Growth opportunity (fry)  
 Osmotic transition (all)

Predator refuge (fry)  
 Growth opportunity (all)

**Consistent monitoring needed across habitats and life stages!**

# Habitat Complexity Metrics

- Metrics highly correlated
- Habitat Quantity  $\neq$  Complexity
- Use PCA approach
  - Non-correlated PCs
  - Describes most variation
  - Captures complexity patterns

Correlation matrix for habitat complexity metrics (Pearson's  $r$ )

SC : Main				
0.21	BR : Main			
0.70	-0.21	SC Node Density		
0.13	0.91	-0.02	BR Node Density	
0.75	0.76	0.30	0.65	Wood Jam Density

# Model Selection Results

- **Full subsets LMER**

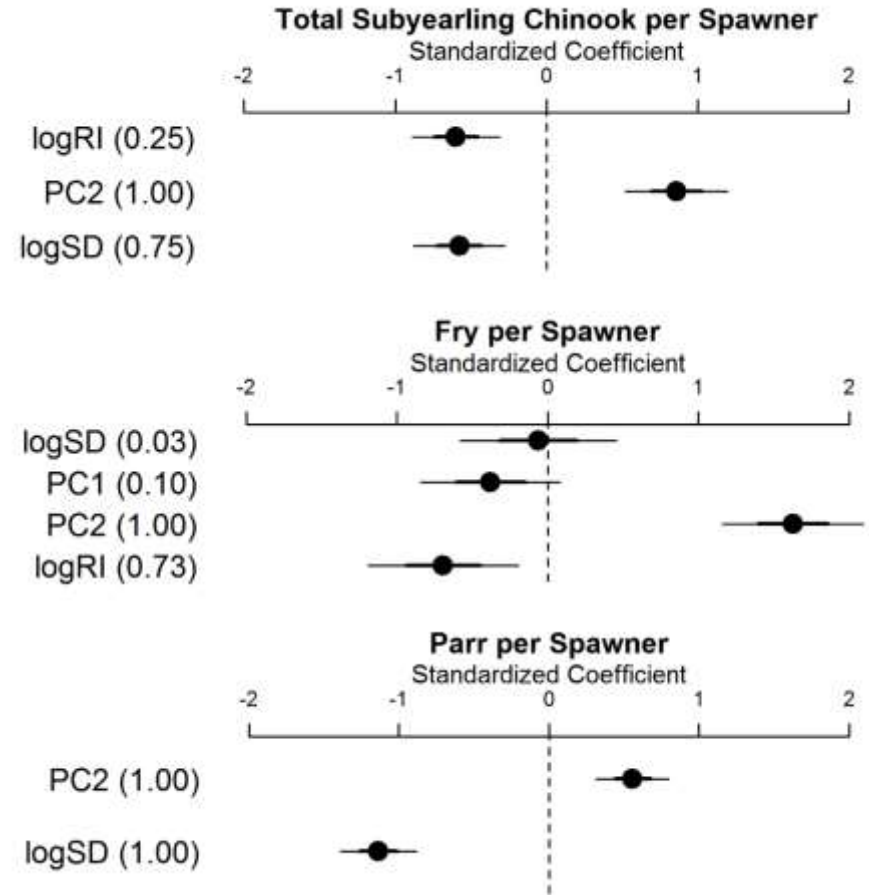
- $\Delta AICc < 7$
- SpS, FpS, and PpS Models
- Maximum of two-factors

- **All selected models included PC2**

- Strong positive predictor
- SD & RI strong negative predictors

- **Best models**

- PC2 with SD (-) or RI (-)

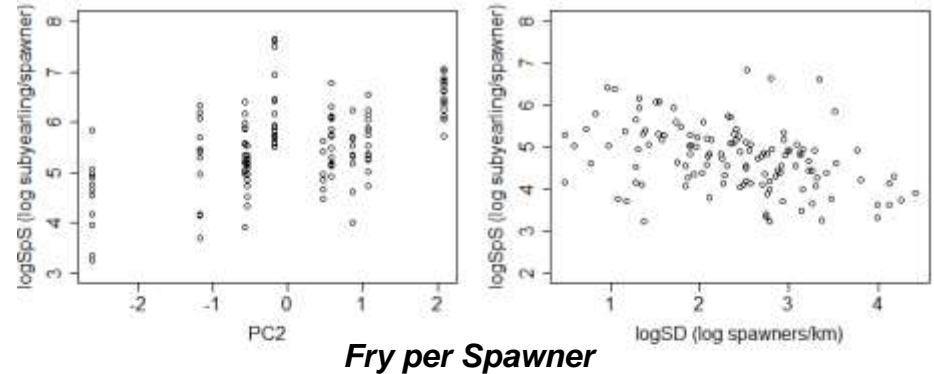


Standardized coefficient plots from selected model sets

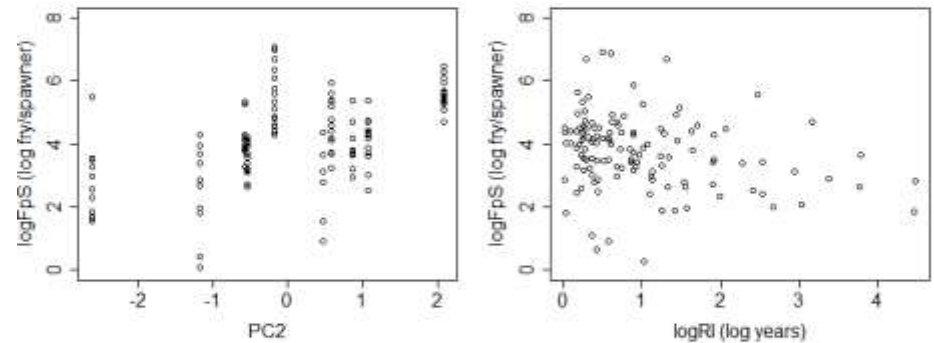
# Partial Regression Plots from Top Models

- **Controlling for other factors...**
  - See strong relationships
  - Differences in variance
- **PC2 effect strongest with FpS**
- **SD strong negative predictor for PpS**

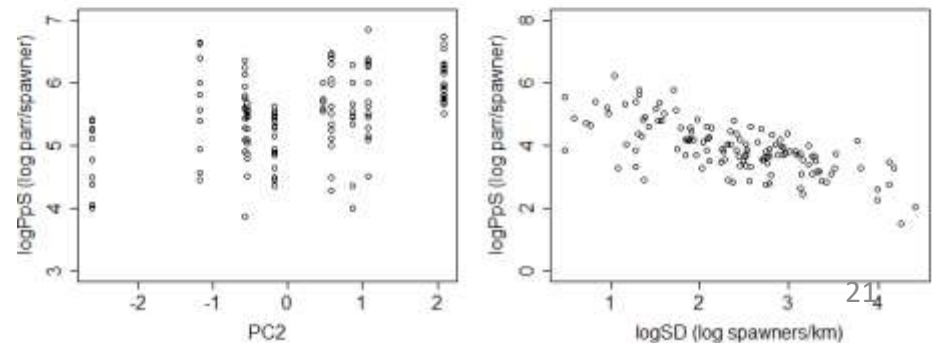
*Total subyearling Chinook per Spawner*



*Fry per Spawner*



*Parr per Spawner*



# Habitat Complexity and Restoration: Cedar River Example

- Predicted impact on productivity?

- ↑0.4 - 1.8% FpS
- ↑1.7 - 17.9% PpS

- Predicted buffering impacts?

- ↓RI 13.5 – 10-year event
- ↓4.4% SD

