If You Build It, Will They Come?

High variance within salmonid spawning gravel at restoration sites create more suitable habitat within the hyporheic zone

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Background

- Salmon Spawning Habitat
  - Critical Indicators
  - Significant Decline
Background

- Lower American River

[Map of Lower American River with restoration sites marked]
Background

- Lower American River
  - Folsom and Nimbus Dam
    - Incised
    - Sediment Starved
Background

- **Restoration Work-3 Phases**
  - Phase 1: Pre Evaluation
  - Phase 2: Remediation Project
  - **Phase 3: Post Treatment Monitoring and Evaluation**
    - BACI Study Design
Background

- Restoration Work
  - 4 Augmented Sites
  - Natural High Use Spit
Background

- Spawning Habitat Requirements
  - Salmon Life Cycle

US Fish and Game

US Fish and Game

Bunte and Apt, 2001
Background

- Spawning Habitat Requirements
  - Hyporheic Zone
Methods

- Grain Size and it’s mobility
- Hyporheic water quality
- Surface and Subsurface Water Movement
Methods

- Grain Size and Grain Mobility
  - Wolman Pebble Count
  - Bulk Sample
  - Scour Chains
  - Tracer Rocks
Methods

- Water Quality in the hyporheic zone
  - Dissolved Oxygen
  - pH
  - Electrical Conductivity
  - Turbidity
  - Temperature
Methods

- Water Movement
  - Surface
    - Velocity, Depth, Direction
  - Subsurface gravel
    - Upwelling/ Down welling
Results

- **Salmon Spawning Requirements**
  - Appropriate sized gravel for all life stages
  - Cold shallow water
  - Fast moving water
  - Oxygenated hyporheic water
  - Flow through the gravel
Results

- **Grain Size**

**Pre Restoration**

- $D_{50} = 3 \text{ in}$
- Poorly Sorted (Well Graded)

**Post Restoration**

- $D_{50} = 1.25 \text{ in}$
- Well Sorted (Poorly Graded)

Suitable Habitat Range

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**Graph 1:** Cumulative Percent Pebble Distribution for American River Sailor Bar, Before Gravel Addition August 18, 2009

**Graph 2:** Total Cumulative Percent Pebble Distribution for American River Sailor Bar, After Gravel Addition May 20, 2010
Results

- **Dissolved Oxygen**

  **Pre Restoration**
  Mean DO = 3-5.5 mg/L

  **Post Restoration**
  Mean DO = 9-10.5 mg/L
Results

- Water Flow

Surface Flow
Depth, Velocity and Direction
Results

- Water Flow
  - Subsurface Flow
  - Upwelling and Down welling
Results

- Water Flow

Surface Flow
Depth, Velocity and Direction

Subsurface Flow
Upwelling and Downwelling
Discussion

- Physical and hydrological measurements over time have indicated positive effects in the hyporheic zone.

- **GOOD HABITAT** is created by these Rehabilitation Projects.

- Not all Sites are being used equally.
Discussion

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Discussion

- Compare Sites
Discussion

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Discussion

- Compare Sites Statistically
  - Density Histogram of Direction of Flow
    - Highly Used Sites show High Variance = Heteroegenetic

Highly Used Natural Site | Highly Used Restored Site | Low Use Restored Site
Conclusion

- Over time sites become Dynamic and Natural
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- Manufacturing small scale pool and riffles as the gravel is added may **create sub habitats**
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- Salmonids tend to use the sites with higher levels of variance
- Variance through gravel contours may be effective creating a heterogenetic habitat
- Manufacturing small scale pool and riffles as the gravel is added may create sub habitats
- Managers can allow resilience of restoration projects
Thank You

Question
Comments
Witty Anecdotes