Quantifying the role of sediment supply on channel evolution, habitat availability and food web dynamics

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1.Introduction

Objective

o Quantify physical-ecological interactions that evolve from a recently restored meandering gravel-bed river.

Research Questions

1) How do spatial patterns in bed mobility influence the number of invertebrates and the species composition in the restored reach relative to a reference reach?

2) How do the simple initial conditions evolve towards complexity and dynamism characteristic of alluvial rivers?

3) What is the role of sediment supply in promoting morphologic change?

4) To what extent do evolving physical processes influence habitat availability?

Approach

- Utilize recently restored reach of the Merced River, CA as a field-scale laboratory:
  - Experimental manipulation of physical variables (e.g. substrate).
  - High-resolution measurements and computations from known initial condition.
  - Quantify rates of morphologic evolution and habitat availability.
  - Test models that can be used to generalize findings to other rivers.

2. Field Setting

Figure 1. Study reaches on the Merced River, CA. Studies were conducted in an upstream reference reach (bottom left) and the 2.5 km restored Robinson reach (bottom right).

3. Food-Web Dynamics

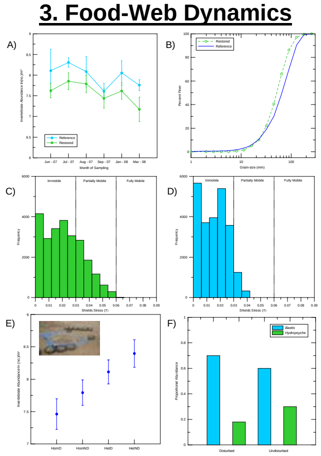

Figure 2. Bed mobility-invertebrate relations between restored and reference reaches: A) Invertebrate abundance; B) Grain-size distribution; C) Shields stress (restored); D) Shields stress (reference); E) Experimental disturbance results and F) Proportional abundance.

4. Morphologic Evolution

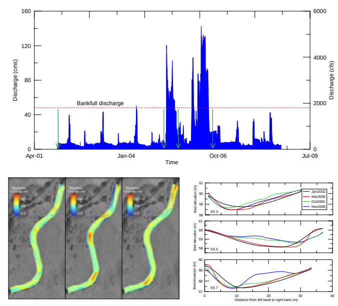

Figure 3. Morphologic response to variable discharge. The upper panel shows the flood hydrograph of the Merced River, CA (2002-2008). The lower panels illustrate the change in bed elevation between successive surveys (left) and cross-sectional changes in erosion and deposition over time (right).

5. Sediment Budget

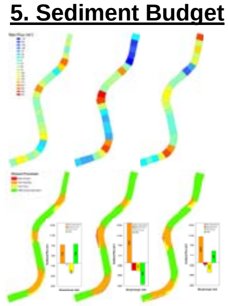

Figure 4. In-channel gravel budget of the Robinson Reach illustrating A) the net sediment flux calculated within 30mx30m budget cells and B) the magnitude of sediment flux terms calculated per morphologic unit.

6. Channel Migration

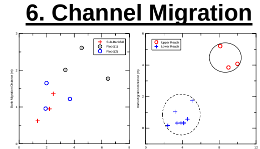

Figure 5. Bar storage versus migration distance of the outer bank for the upper restored reach (left) between successive floods. On the right, the relation between bar storage and bank migration distance is compared between the upper and lower restored reaches (2002-2008)

7. Modeled Flow Field

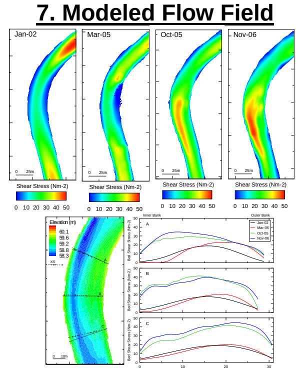

Figure 6. Modeled bed shear stress changes over time at Q = 42.5 cms (90% of bankfull discharge).

8. Modeled Bed Evolution

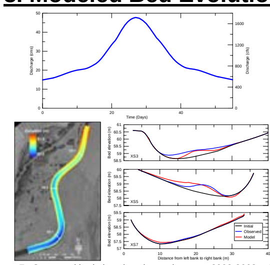

Figure 7. Computed bed elevation change between 2002-2003 using the Wilcock and Kenworthy (2002) two-fraction transport function. The upper panel shows the input hydrograph. Comparison between observed and computed bed evolution is shown in the lower right.

9. Habitat Availability

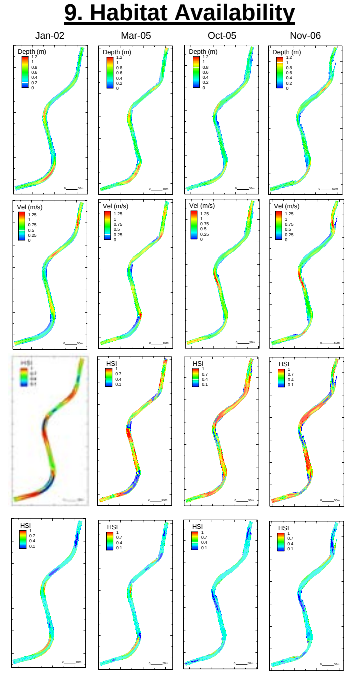

Figure 8. Modeled changes in depth, velocity and Chinook salmon spawning and rearing habitat (discharge = 6.4cms). HSI values were calculated based on suitability curves developed by Gard (2006).

10. Conclusions

- Shifts in the food web structure are influenced by bed mobility.
- Channel evolution is driven by sediment supply and large flows.
- Changes in sediment storage lead to hydraulic adjustments and shifts in the available habitat → self-maintained condition.
- Results indicate the sediment supply, storage and mobility have ecological relevance across multiple spatial scales and life-stages of Chinook salmon.

❖ Findings highlight the necessity of evaluating the sediment supply and in-channel gravel budget when establishing process-based reference conditions and their relation to biota.

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We wish to acknowledge Rich McDonald, Daniele Tonina and Jon Nelson for help with the MD-SWMS modeling. Funding was provided by the CALFED Bay Delta Program