Myth busting: Effects of sediment pulses on water quality and bed relief in bar-pool channels

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myths of dam removal

• Smothered downstream habitats
• Stinking mudflats
• Runaway knickpoints
• Muddy waters
myth busters and policy makers
Myth busters: what the science says

Study objectives
1. Articulate common management concerns (CMCs) and their potential negative consequences
   What is a CMC?
   Dam removal outcomes that may require intervention but are broadly assumed, sometimes incorrectly, to occur at most sites
2. Identify where, and how commonly, CMCs occurred
3. Evaluate what conditions control their occurrence

Tullos et al. 2017. JAWRA
Co-authors: Mathias Collins, Ryan Bellmore, Jennifer Bountry, Patrick Connolly, Patrick Shafroth, and Andrew Wilcox
the CMCs

1. Upstream incision into infrastructure
2. Non-native vegetation in former reservoir
3. Reservoir drawdown impacts to local water infrastructure
4. Downstream turbidity
5. Upstream invasion by non-native fish
6. Downstream aggradation
7. Extent and rate of reservoir erosion
the CMCs

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assessing the risk of CMCs

Evaluate CMC risks by:

- **Likelihood**: Assessing likelihood of relevant biophysical controls
- **Consequence**: Investigating intersections of the controls with ecological or human use impacts important to stakeholders

### CMC Case Studies Biophysical process controls Site conditions suggesting management implications

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| Degree and rate of reservoir incision  | N/A          | • high % of stored fine sediments  
• average sediment deposit width/channel width > ~2.5  
• phased removal                                                                             | stakeholder values; fish passage needs or sensitive habitats                                                        |
| Excessive channel incision upstream of reservoir | 38           | • reach-scale incision d/s  
• high % of stored fine sediments  
• phased removal  
• coarse delta  
• ephemeral flow                                                             | infrastructure within reservoir deposit or along margins at risk for bank erosion; fish passage needs or sensitive habitats |
| Downstream aggradation                  | 6            | • high V*  
• proximal to dam  
• antecedent channel has low slope/unconfined                                    | low-lying properties; transportation infrastructure; pump intakes; fish passage needs or sensitive habitats |
Muddy waters?
Muddy waters?
Results: Elevated suspended sediment

• For the majority of sites
  – turbidity generally within range of natural variability and/or below state standards
  – Impoundments store little sediment relative to average annual load (low $V^*$)
• Exceptional situations:
  – High $V^*$ (e.g., Elwha River)
  – Site specific circumstances (e.g., large sediment volumes of fines behind instantaneously removed dams)

Intersection with ecological and human resource?
Smothered downstream habitats?

objective: evaluate whether initial relief of a river can be used to predict the response of a bar-pool channel to the release of a pulse of sediment

methods: BACI, field-based design

Propose new variables

\[ z^* = \text{change in sediment thickness due to pulse} \]
\[ r^* = \text{cross-channel relief} \]

Use field data to evaluate hypothesis

the change in relief due to sediment pulse depends on the initial value of \( r^* \)
results: Brownsville Dam

- 14,000 m$^3$ sediment stored
- 29% eroded in year 1

Initially high relief $\rightarrow$ pulse reduced relief
Initially low relief $\rightarrow$ pulse increased relief
results: Marmot Dam

- 730,000 m³
- 50% eroded in year 1
- Reach 1 (0-250m)
  - High initial $r^*$
  - Large $z^*$
  - Initially decreased relief
  - Subsequent relief increase
results: Marmot Dam

- 730,000 m³
- 50% eroded in year 1
- Reach 2 (250-360m)
  - Higher initial r*
  - Large z*
  - Initially decreased relief
key findings

• Habitat “smothering” may be predictable
  – pool filling or bar building appears to depend on the
    • initial relief, and
    • the amount of sediment delivered to individual features

• increase relief at locations with initially low relief

• decrease relief at locations where it was initially high, often following by erosion-based recovery
Further work needed: Addressing remaining CMCs

- Post-pulse pool dynamics
- Impacts to mussels
  - determine if mussels are present
  - Obtaining permits
  - Relocating mussels
thanks!

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The other five CMCs

1. The “stinking mudflat”: The percent of reservoir sediment eroded (10%-70% after one year) depends on dam removal style and sediment management.

2. Runaway knickpoint migration: Generally follows conceptual models – rapid erosion then leaking.

3. Drawdown impacts to water infrastructure and ecosystem: Depends on connectivity of aquifer to reservoir.

4. Non-native plant colonization of reservoir: At the 25 study sites for which data were available, non-natives represented 13-68% of plants, and mostly commonly it was Reed Canary Grass.

and then there’s contaminants

• Contaminants
  – most likely in reservoirs with fine sediment and catchment land use histories that lead to contaminant releases