Gravel Augmentation for Salmon Habitat below Dams in Northern California


Conclusions

- Gravel added in N. CA: 380,000 m³ (1968-p)
  - 114 projects on 21 rivers, >$8 million total

- Need better documentation and a central repository (where will your data be in 20 years?)

- Spawning gravel may not be a limiting factor
  - adding gravel is visible and popular, but useful?

- Where it is needed, gravel is not added in sufficient amounts (but we’re starting to get there)
Introduction

- >$1 billion per year spent on river restoration in US (Bernhardt et al. 2005)

- ~10% percent of restoration projects are evaluated after construction (Bernhardt et al. 2005)

- To learn, we need to evaluate our successes and failures

- Example: Gravel augmentation

Gravel Augmentation

What is gravel augmentation?
- process of adding gravel to a stream

Why add gravel?
- stop incision
- restore spawning habitat (often below dams, but can be in gravel-limited reaches)
- restore coarse sediment dynamics
Stop Incision

River Rhine

~100,000 m³ / yr depends on yearly hydrograph

(photograph by G.M. Kondolf)

Restore Spawning Gravel

Sacramento R.  ~3,000m³

(photograph by G.M. Kondolf)
Context

(reservoir sedimentation)

bedload

water

(dam)

(reservoir sedimentation)

bedload deficit)

bedload

water

incision

coarsening

Scale & Geography

are critical
History of this study

Trinity River Restoration Project (2003-04)

- Evidence and stories of old gravel addition projects, but no one knew where they had been installed, in what amount, etc.
- Could we learn lessons from these old projects?
- Did they last?
Methods

• 1999-2000 contacted 50+ agency personnel & retirees
• 2003-2004 contacted 80+ agency personnel & retirees
• Numerous visits to regional offices and agency libraries
Results

Number of Gravel Projects Completed

Amount of Gravel Added (m$^3$)

Upper Sacramento
< 3 projects for the 14 other rivers
<200 m$^3$ gravel added to other 9 rivers
Summary of Results

- 114 projects on 21 rivers (1968 – 2004)
- 380,000 m³ of gravel added
- Cost: >$8 million dollars (non-adjusted)
  - currently $25-40 / m³
- Difficult to find information on past projects
  - limits learning

Types of Gravel Augmentation

Injection Methods
- High-flow stockpile
- In-channel bed stockpile
- High-flow direct introduction
- Helicopter placement and alternative approaches for remote sites

Artificial Riffle Construction Methods
- Artificial riffle construction and maintenance
- Riffle supplementation and contouring to mimic alluvial forms
- Side channels and artificial spawning channels

Other Methods
- Gravel ripping (scarification) and cleaning
Injection

No immediate benefit
Requires flow to mobilize the sediment

Clear Creek

(photo by Matt Brown, USFWS)
Artificial Riffle Construction

Available for immediate use
Does not depend on flow releases

Mokelumne R, Oct 2005
Choosing the gravel augmentation technique for you
- clear, quantifiable project goals (target species, life history stage, habitat, sediment mobility?)
- what are the limiting factors? (spawning gravel?)
- river’s ability to move sediment (need flows?)
- sediment budget (gravel in storage?)
- need: immediate, long-term or both

Answers: how, what size & how much?

Grain Sizes
Depends on the project goal:

“Spawning Gravel”
½” – 3” (12mm – 76mm)

“Coarse Sediment”
¼” – 5” (6mm – 128mm)

Should be sized in reference to the transport ability of the post-dam system

Fines: Cleanliness (3X cost)
Where to add the gravel?

Mesick, 2000

“Mini-me” channel
Change in cross section & change in meas. sed. trans rate
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Unresolved Issues

1. Gravel augmentation for other life history stages?
2. Accurate sediment routing over large spatial / temporal scales
3. Measuring storage over large spatial / short temporal scales
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Where to add the gravel?
Trinity River – artificial weir downstream of constructed riffle (riffle built in 1984, photo in 2003)
Outstanding Issues
(or questions we should be asking ourselves)

• Do we really need gravel augmentation?
FaS Method
what dams do

flows altered & coarse sediment decreased

restoration activities

Watershed Inputs & Channel & Network Connectivity

Fluvial Geomorphic Processes

Physical Attributes

Habitat Structure, Complexity & Connections

Biotic Response

restoration activities

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Biotic Response

Hierarchy of processes influencing watershed biological baseline conditions.

Bed coarsening &/or incision

What dams do

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Reconnect floodplain

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