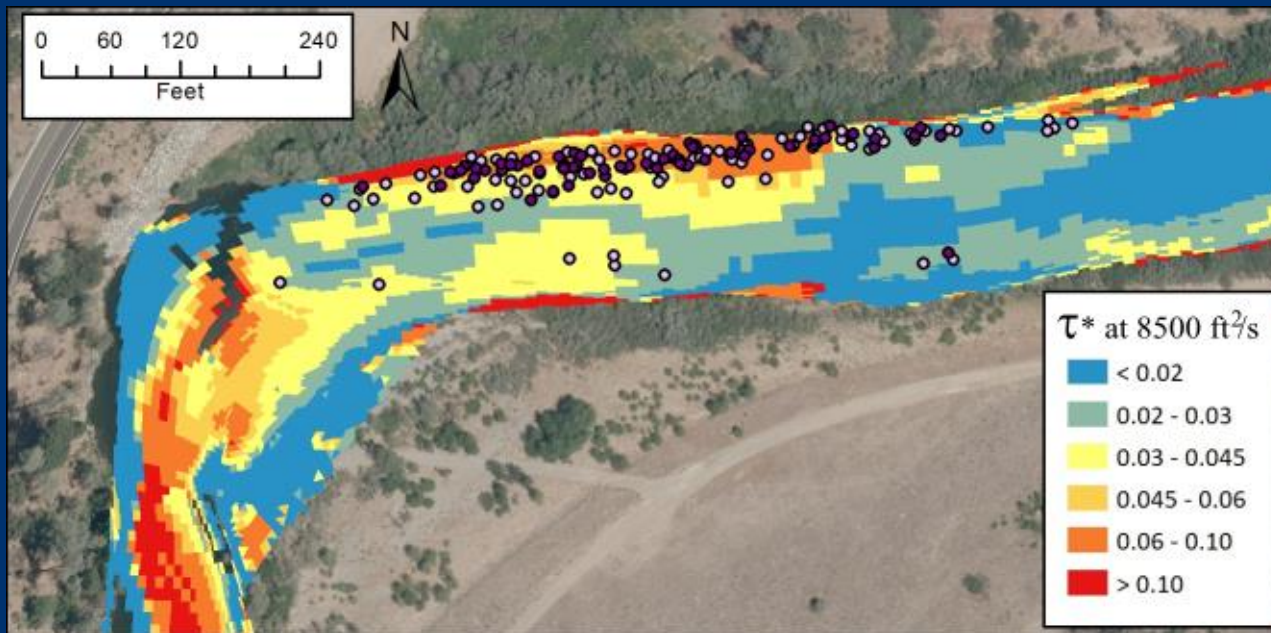


Modeling stream bed disturbance and risk of redds scour in the Trinity River, California

David Gaeuman¹, Kyle De Juilio¹, Todd Buxton²



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Fisheries Department, Trinity Division
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Trinity River Restoration Program
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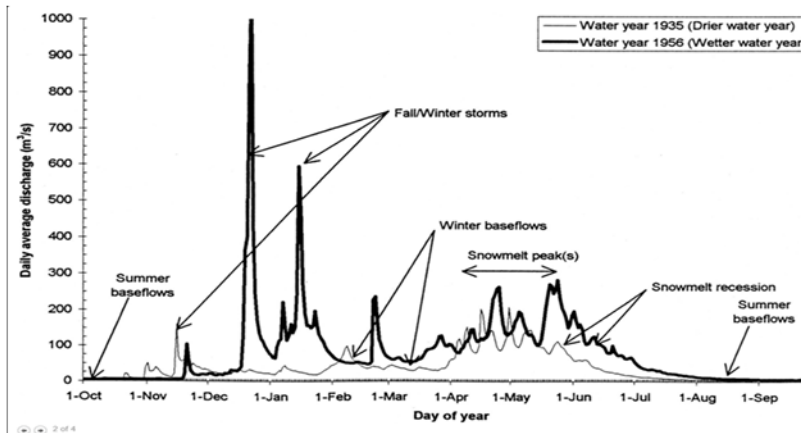
Stream bed disturbance food web response

Ecosystem ecology meets adaptive management: food web response to a controlled flood on the Colorado River, Glen Canyon

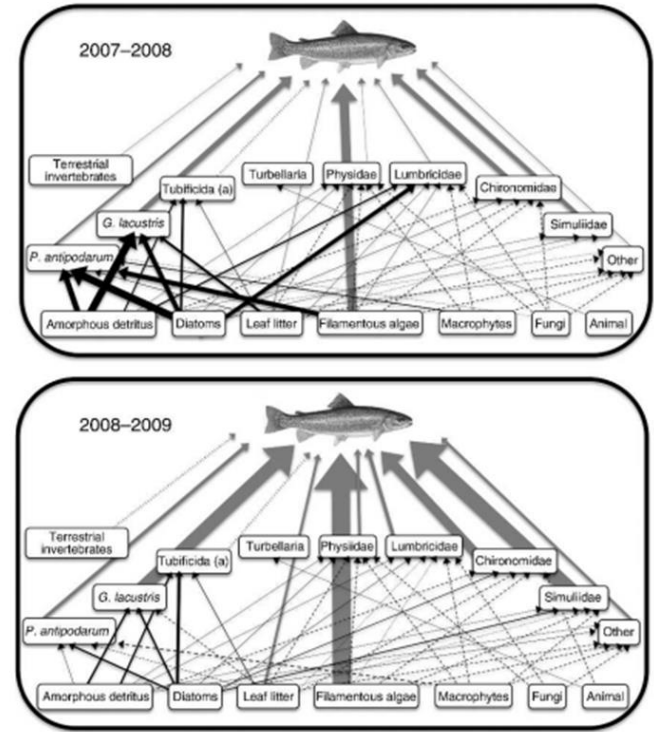
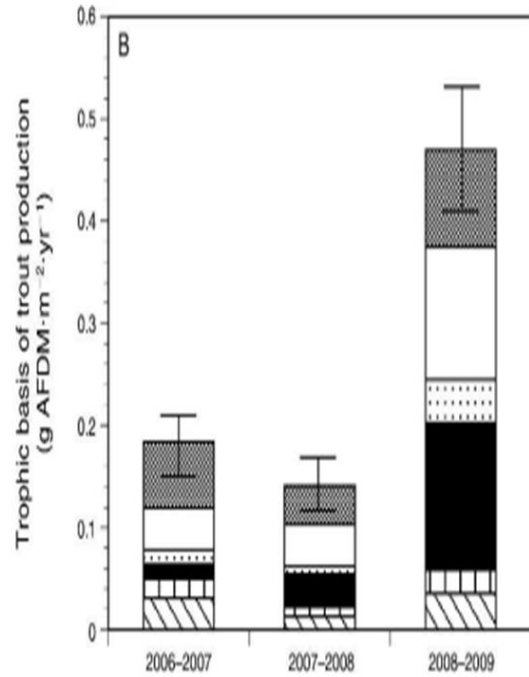
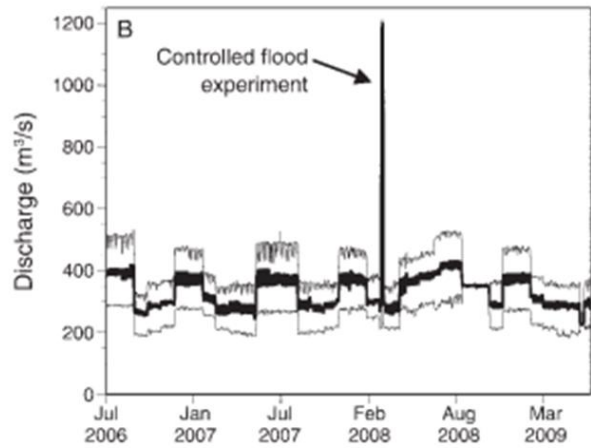
WYATT F. CROSS, COLDEN V. BAXTER, KEVIN C. DONNER, EMMA J. ROSI-MARSHALL, THEODORE A. KENNEDY,
ROBERT O. HALL, JR., HOLLY A. WELLARD KELLY, AND R. SCOTT ROGERS

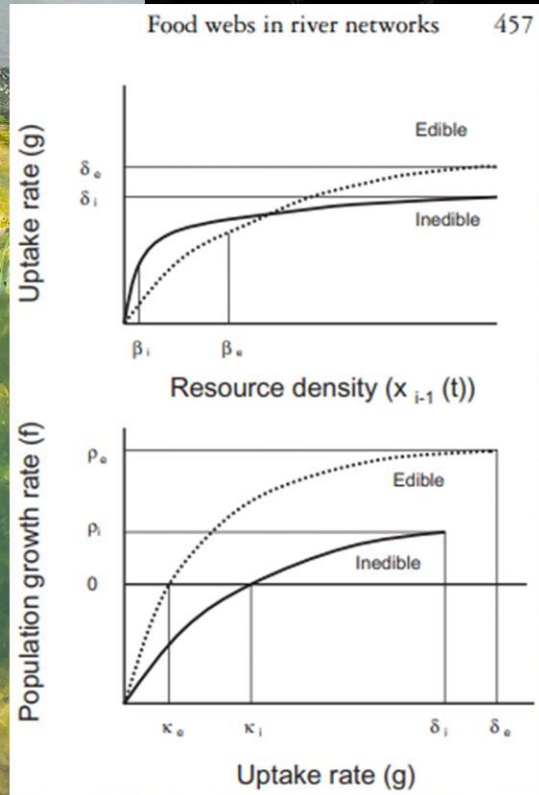
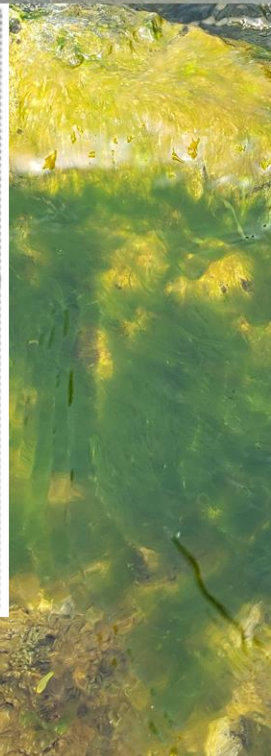
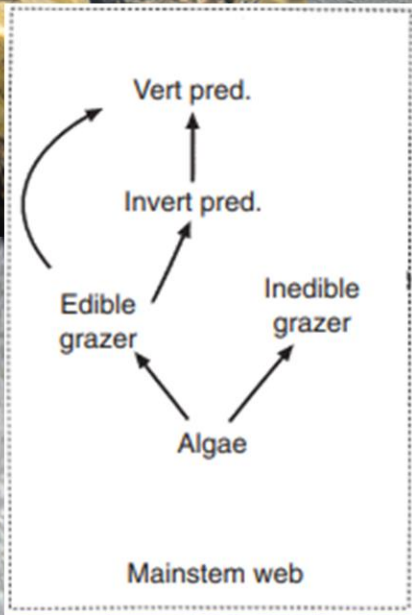
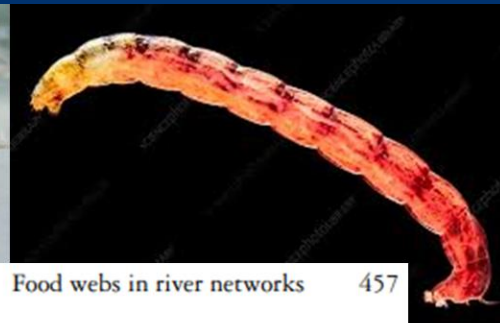
SEASONAL REASSEMBLY OF A RIVER FOOD WEB: FLOODS, DROUGHTS, AND IMPACTS OF FISH

MARY E. POWER, MICHAEL S. PARKER, AND WILLIAM E. DIETRICH

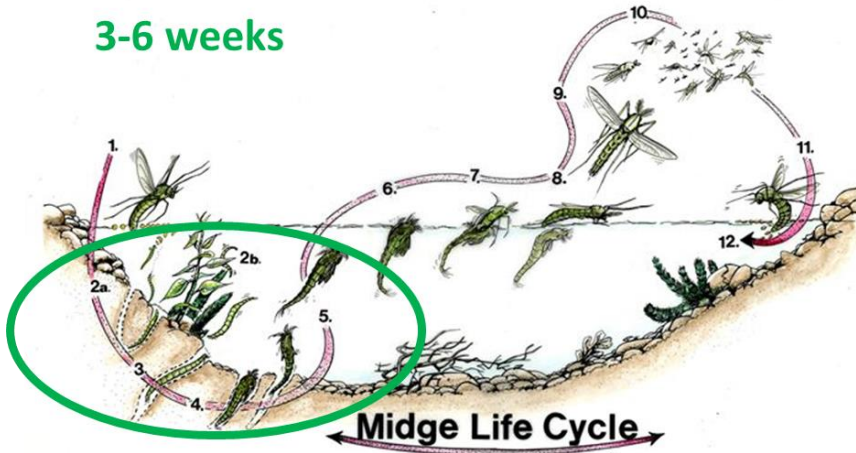


Cross et al. 2011





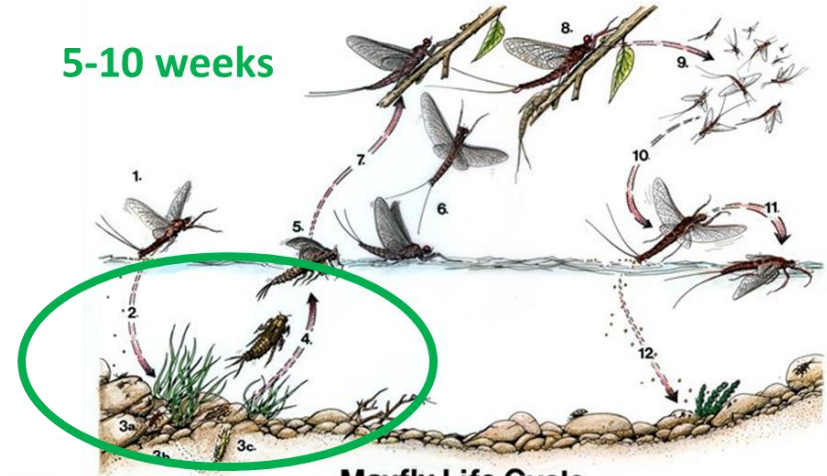
3-6 weeks



Midge Life Cycle

Image from Dave Whitlock's Guide to Aquatic Trout Food

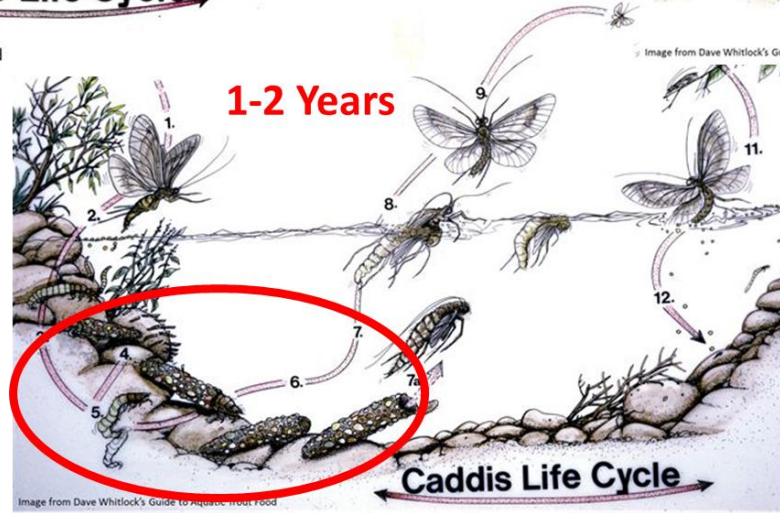
5-10 weeks



Mayfly Life Cycle

Image from Dave Whitlock's Guide to Aquatic Trout Foods

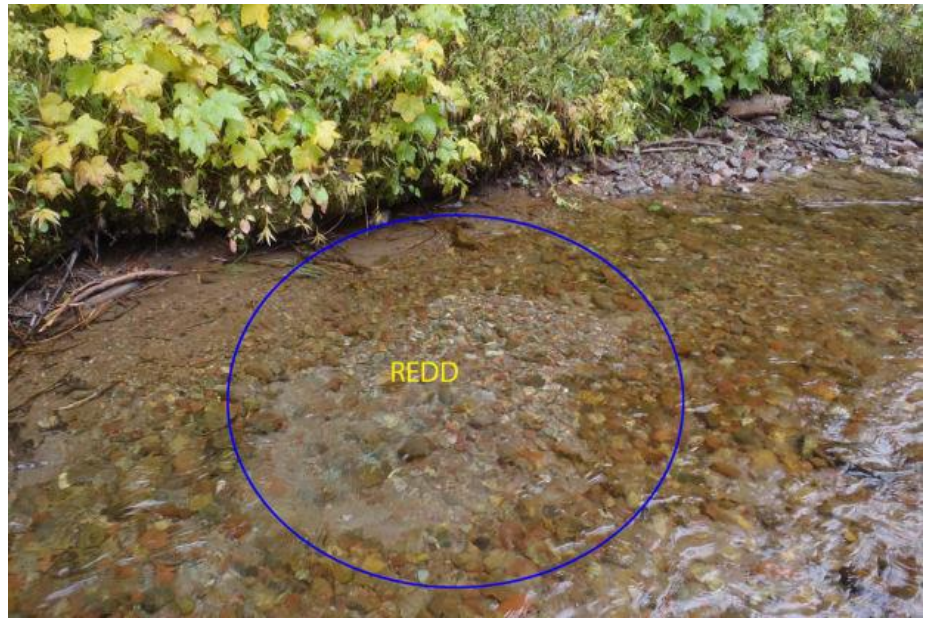
1-2 Years



Caddis Life Cycle

Image from Dave Whitlock's Guide to Aquatic Trout Food

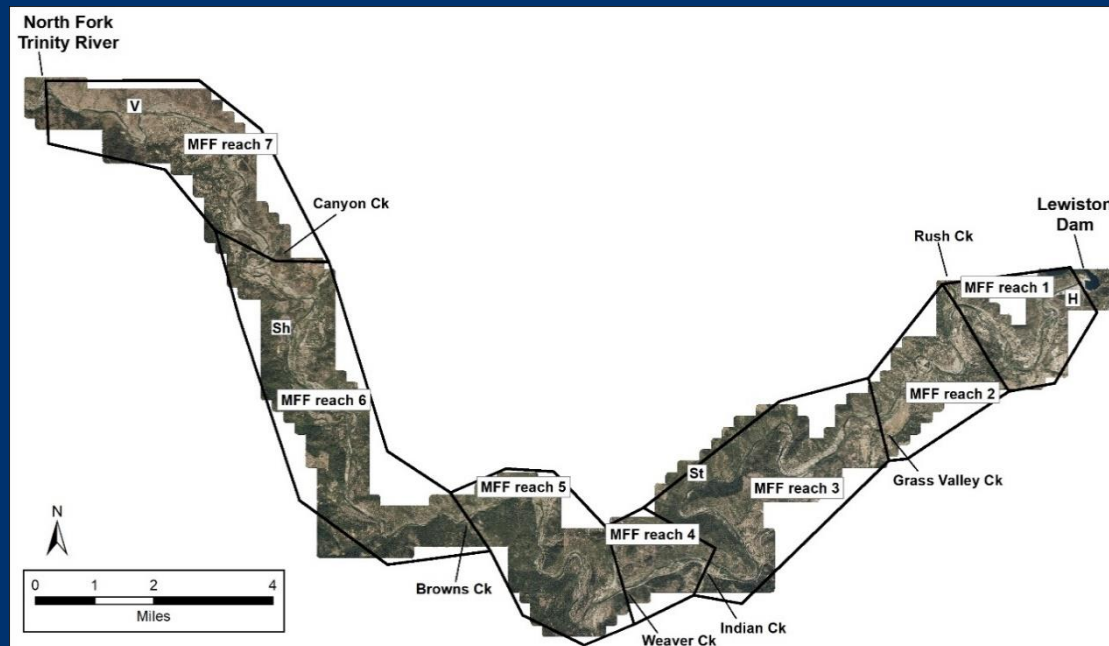
Impacts to Salmon redds from stream bed disturbance?



Study Area: MFF River Segments

MFF river segments defined within the TRRP rehabilitation domain. *Event magnitude estimated by fitting gage record to Log-Pearson type III probability distribution. ^FEvent magnitude according to FEMA (2016). Gages identified by USGS gage numbers.

Segment	MFF (ft ³ /s)	10-yr event (ft ³ /s)	Gage and Records Used*	Segment Boundaries
1	11000	10910*, 11000 ^F	11525500, 2000-2020	Lewiston Dam to Rush Creek
2	12096	11090 ^F	Not available	Rush Creek to Grass Valley Creek
3	13692	11813*, 12940 ^F	11525655, 2003-2020	Grass Valley Creek to Indian Creek
4	15771	15360 ^F	Not available	Indian Creek to Weaver Creek
5	17544	12698*, 20180 ^F	11525854, 2003-2020	Weaver Creek to Browns Creek
6	21336	18278*, 25070 ^F	11526250, 1995-2020	Browns Creek to Canyon Creek
7	23207	19910*, 31150 ^F	11526400, 2005-2020	Canyon Creek to North Fork Trinity



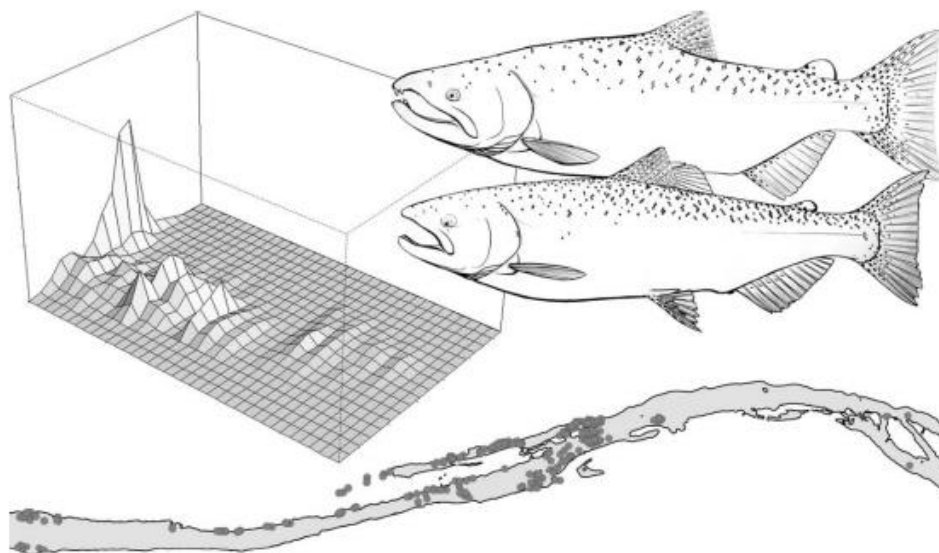
Data and Methods 1:

Identify locations with Salmon redds

- Annual redds surveys conducted by TRRP partners
- Selected redds mapped in 2012 and 2014 for this analysis

Mainstem Trinity River Chinook Salmon Spawning Distribution 2012–2014

Derek L. Rupert¹, Charles D. Chamberlain¹, Stephen A. Gough¹, Nicholas A. Som¹,
Nick J. Davids², Billy C. Matilton³, Andrew M. Hill⁴, and Eric R. Wiseman⁵



U.S. Fish and Wildlife Service¹
Arcata Fish and Wildlife Office
1655 Heindon Road, Arcata, California 95521
(707) 882-7201

Data and Methods 2

Estimates of shear stress (τ) as function of discharge

- **40-mile SRH-2D model (Bradley 2016)**
- **All modeled flows 4000 ft³/s through 23207 ft³/s**

Discharges modeled with SRH-2D used to assess shear stresses in this study.

Q (ft³/s)	Significance
4000	Approximate initiation of coarse bedload transport
5000	Approximate threshold for significant bedload transport
6000	Nominal normal year spring flow release from Lewiston Dam
8500	Nominal wet year spring flow release from Lewiston Dam
11000	Maximum authorized spring flow release from Lewiston Dam
12096	MFF in river segment 2 (Rush Ck to Grass Valley Ck)
13692	MFF in river segment 3 (Grass Valley Ck to Indian Ck)
15771	MFF in river segment 4 (Indian Ck to Weaver Ck)
16000	Approximately the 8- and 6-yr events in segments 6 and 7, respectively
17544	MFF in river segment 5 (Weaver Ck to Browns Ck)
21336	MFF in river segment 6 (Browns Ck to Canyon Ck)
22000	10- to 15-yr event in river segment 7
23207	MFF in river segment 7 (Canyon Ck to North Fork Trinity River)

Data and Methods 2, step 2:

Convert τ to τ^*

$$\tau^* = \tau / \rho g R D_{50}$$

ρ is density of water;

R is submerged specific gravity of sediment

D_{50} is median particle size on bed surface

How to estimate D_{50} ?

Data and Methods 3:

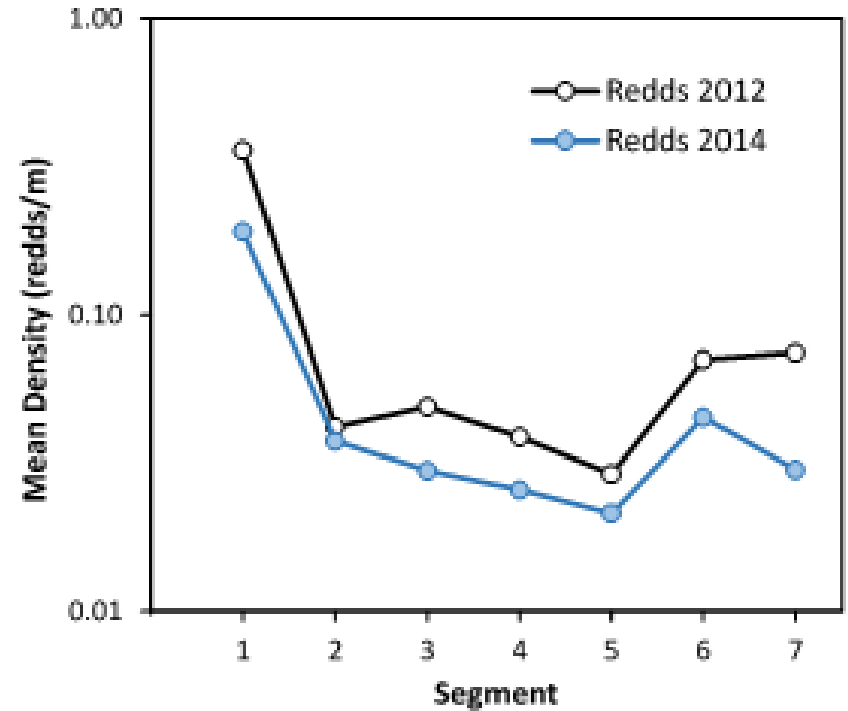
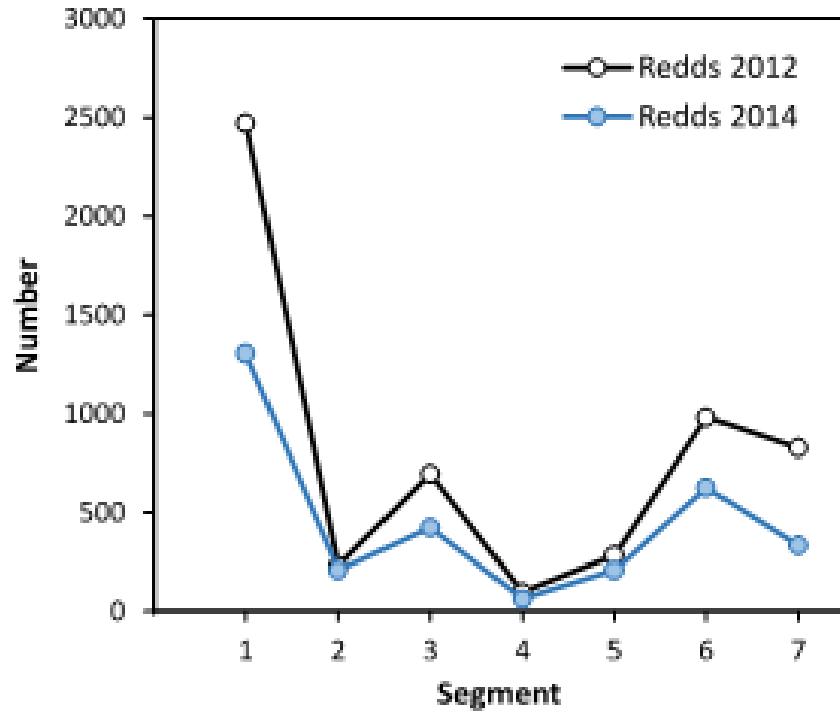
Adapt the D_{84} map of Alvarez et al. (2015)

- Covers full 40-mile study area
- Approximate 2000 ft³/s inundation zone

But, there are issues...

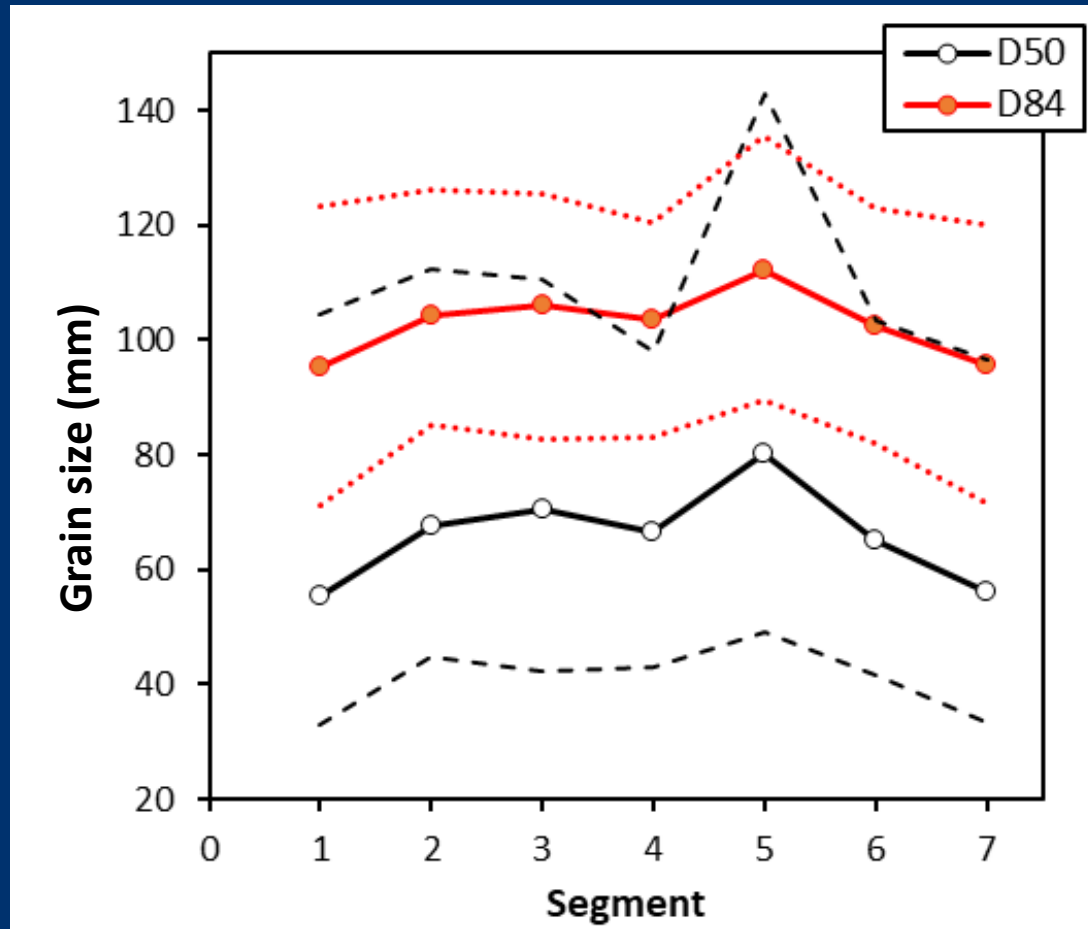
- Mobility thresholds are referenced to D_{50} , not D_{84}
- No standard transform from D_{84} to D_{50} exists
- Ratio mapped D_{84}/D_{50} varies with particle size

Results 1: Spatial distribution of redds



Results 2: change axis

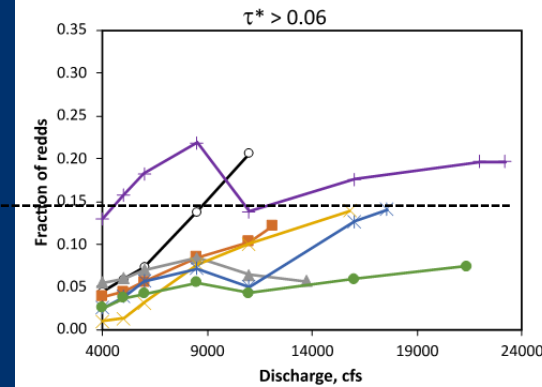
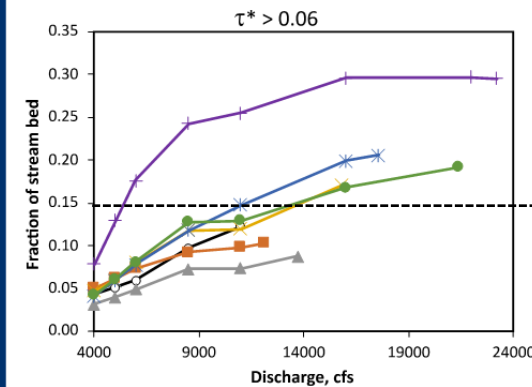
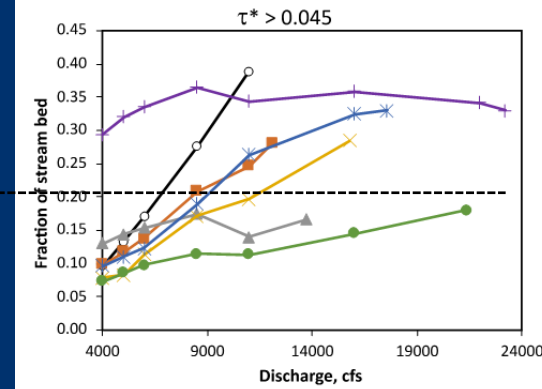
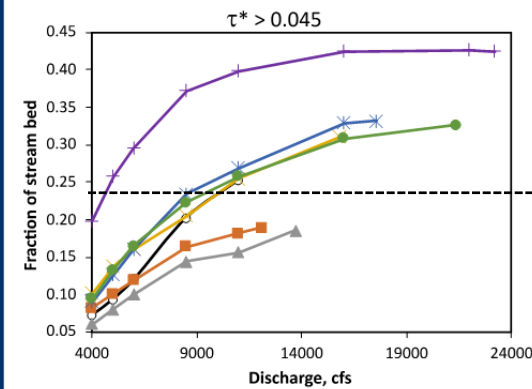
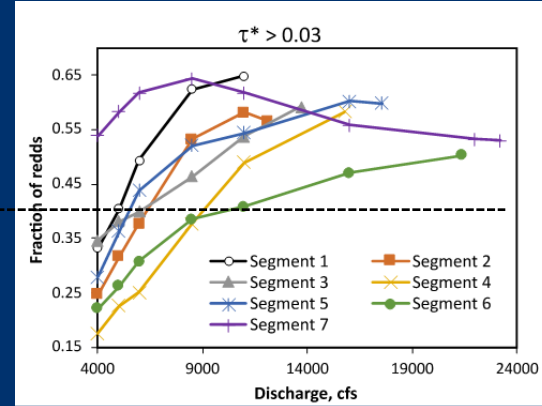
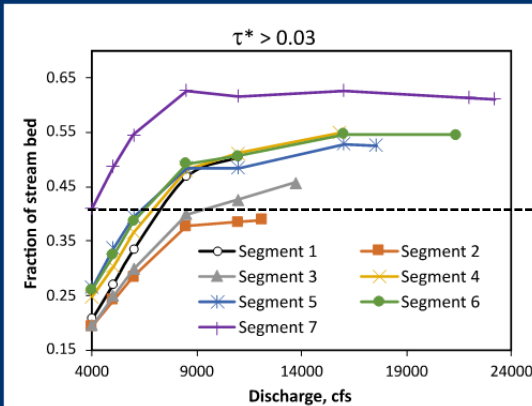
Spatial trends in grain size



Results 3: Fraction stream bed with $\tau^* >$ thresholds

Stream bed
(600 ft³/s inundation)

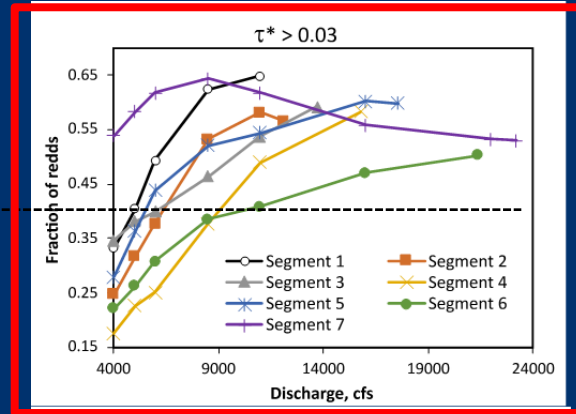
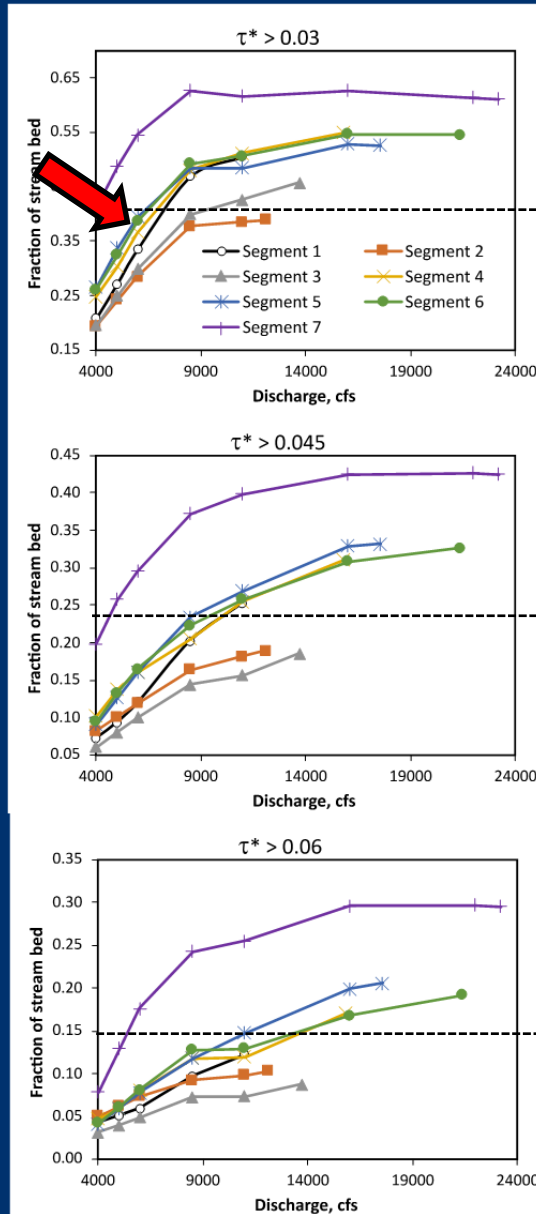
Redd locations



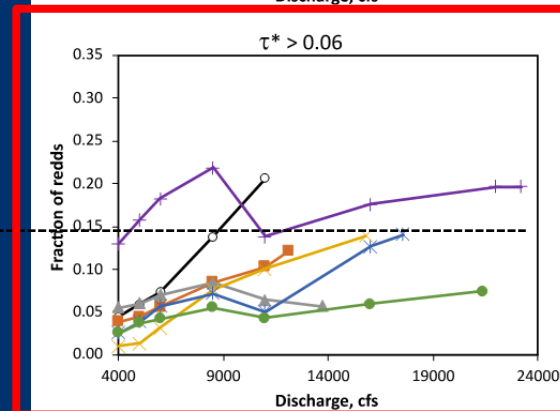
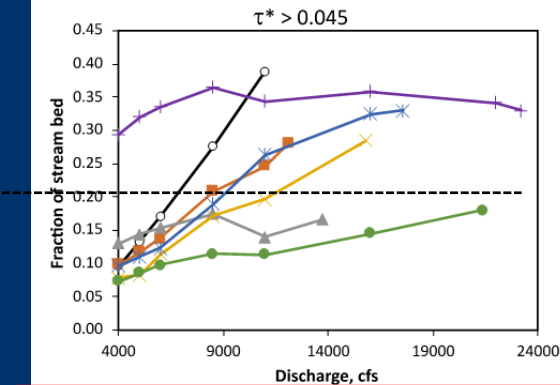
Results 3:

Fraction stream bed with $\tau^* > \text{thresholds}$

Stream bed
(600 ft³/s inundation)



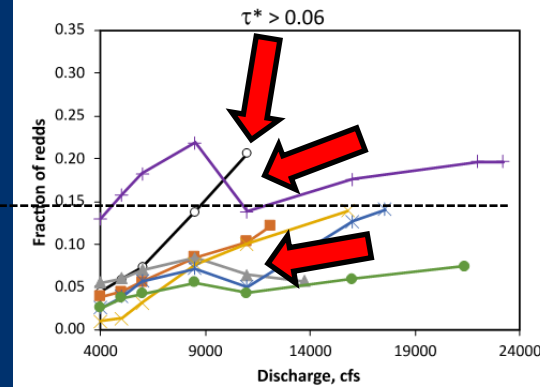
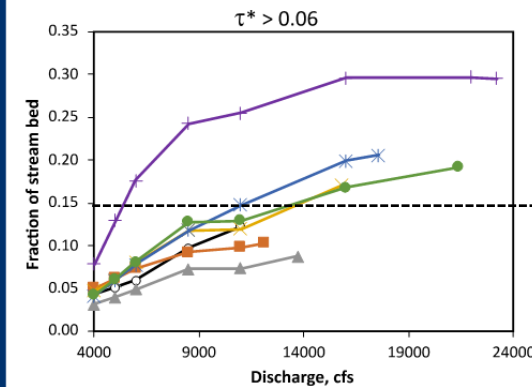
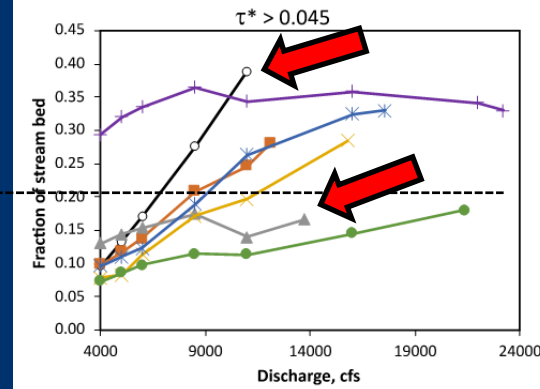
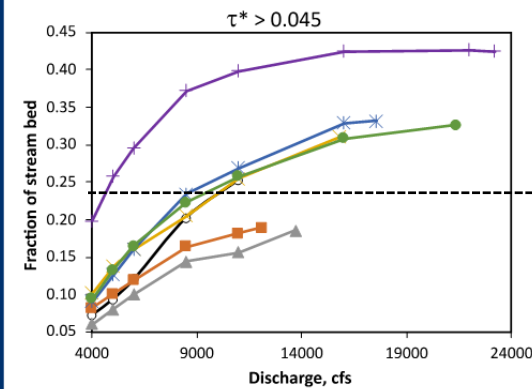
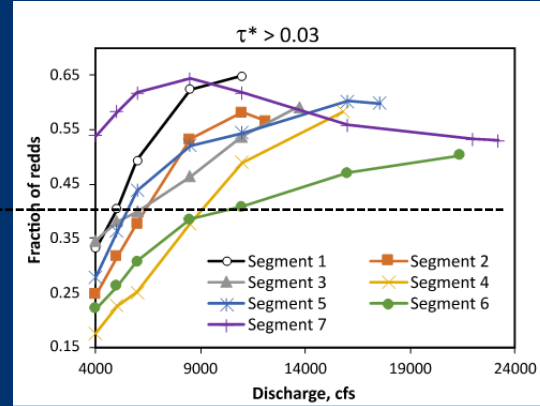
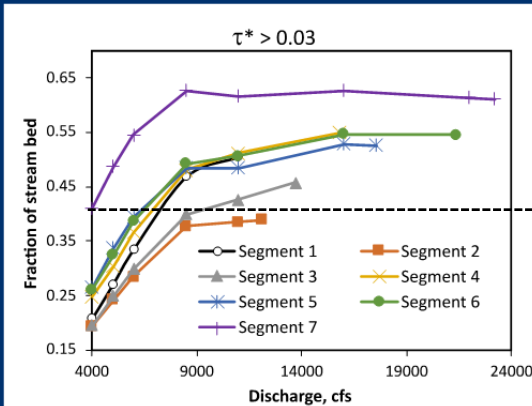
Redd locations



Results 3: Fraction stream bed with $\tau^* >$ thresholds

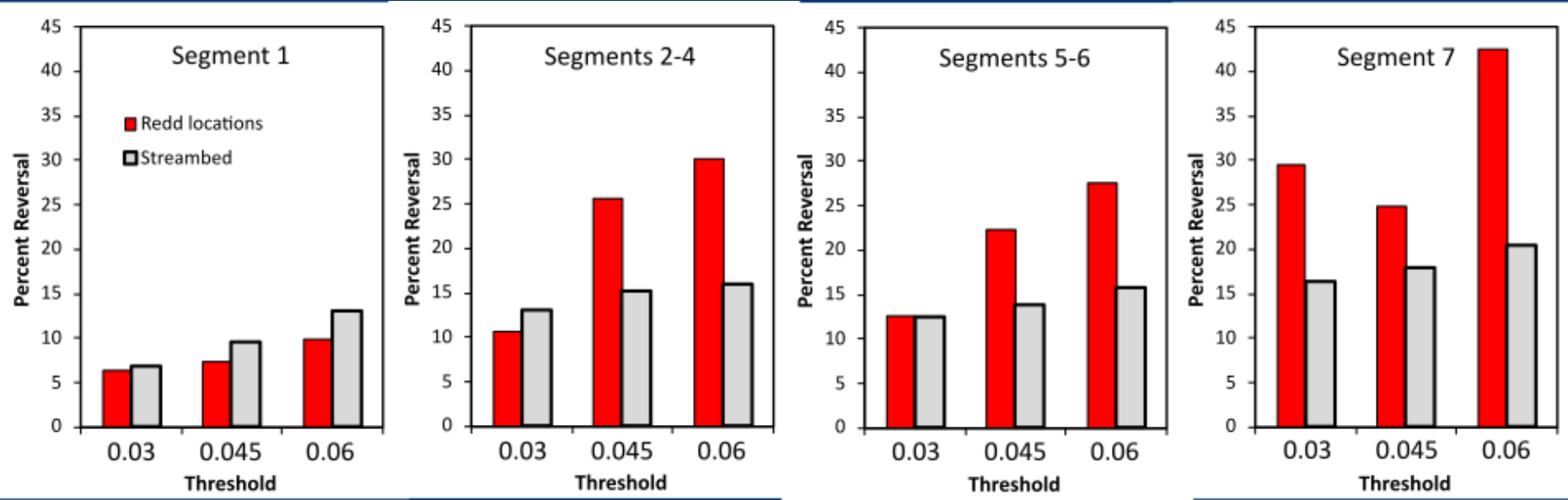
Stream bed
(600 ft³/s inundation)

Redd
locations



Discussion

What's special about redd locations?

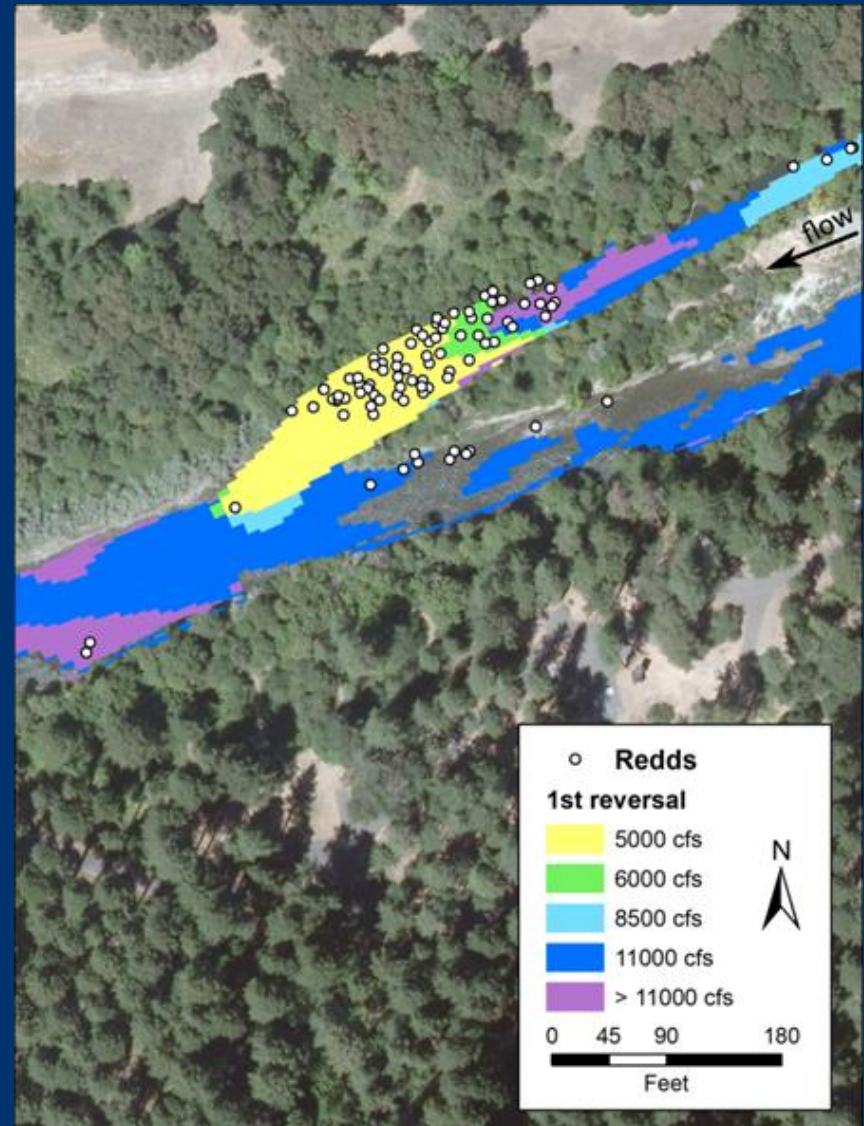


**Shear stresses don't always increase with discharge!
Local decreases occur as hydraulic controls change.**

**Redd locations are often twice as likely to reverse when τ^* is large than general stream bed locations.
(except in segment 1)**

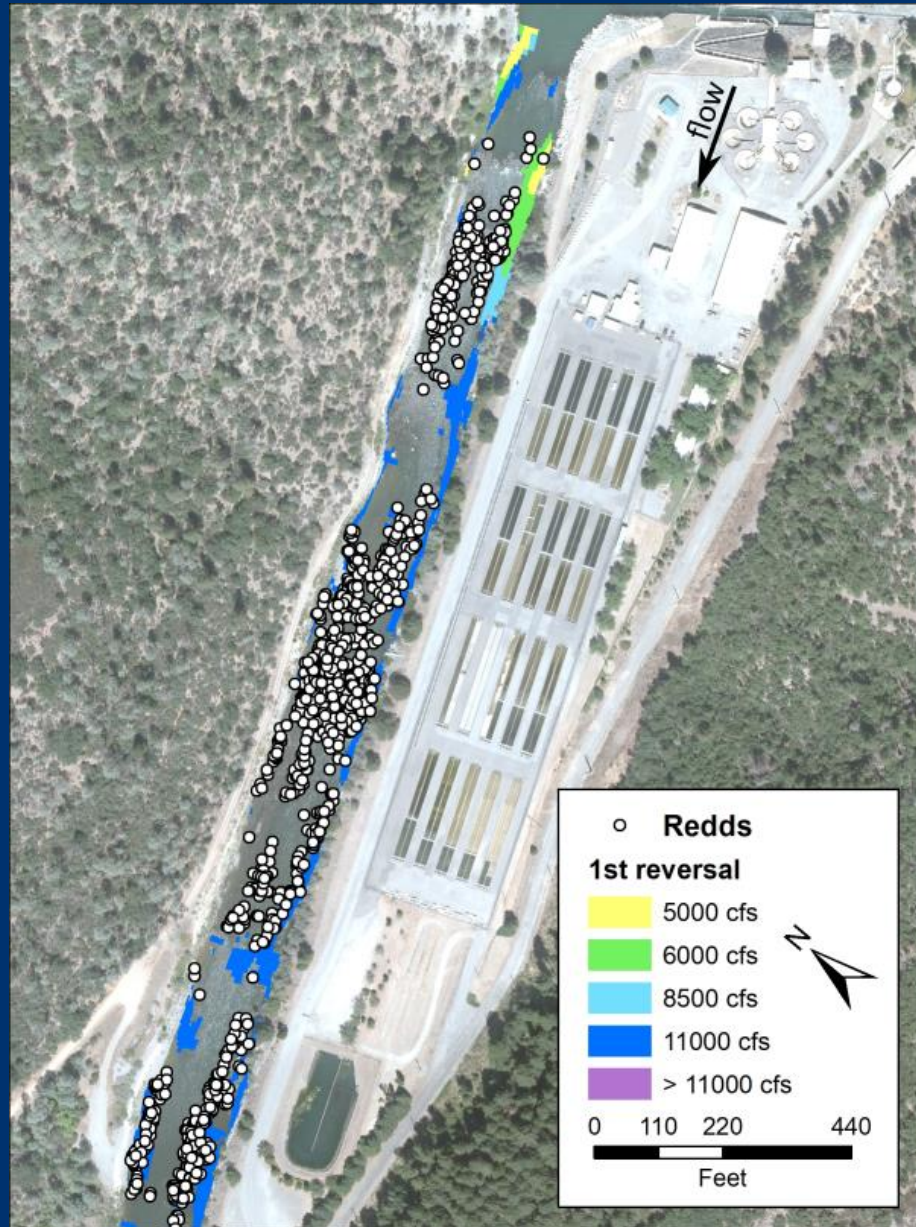
Discussion

Example of shear stress reversal



Discussion

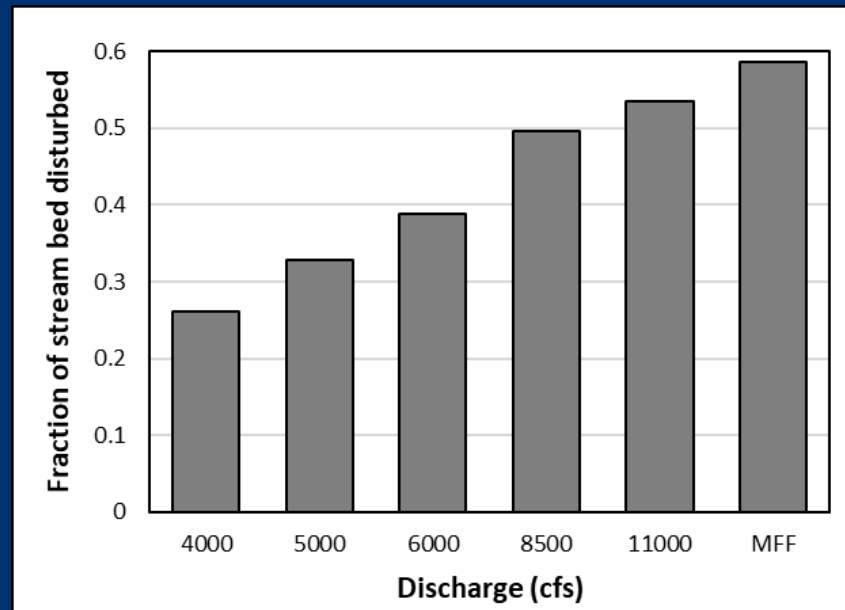
What about segment 1?



Discussion

Cumulative fractions with $\tau^* > 0.03$

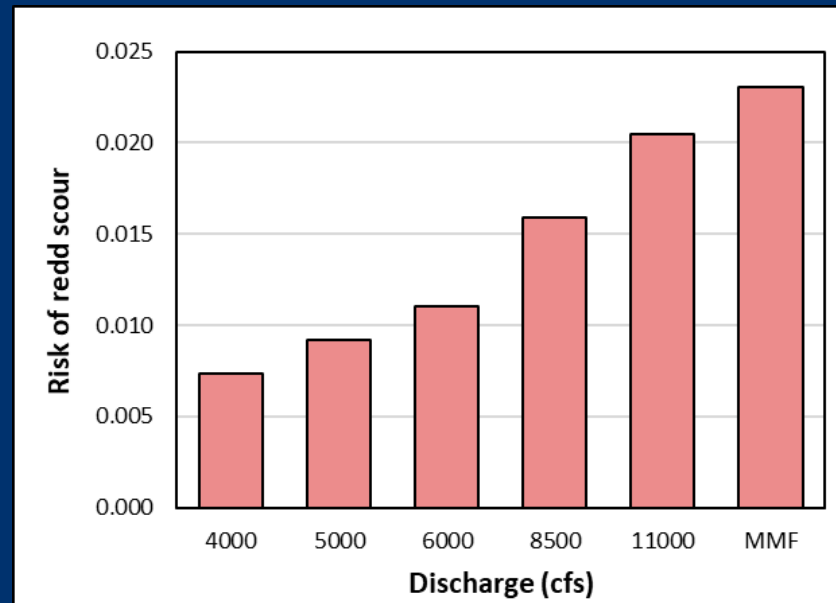
- Cumulative fractions of bed > 0.03 exceed maximum fractions at any single discharge by between about 0.05 to 0.125.
- Proportion disturbed ranges from 26% at 4000 ft³/s to 59% when discharge is at the MFF throughout the study area.



Discussion

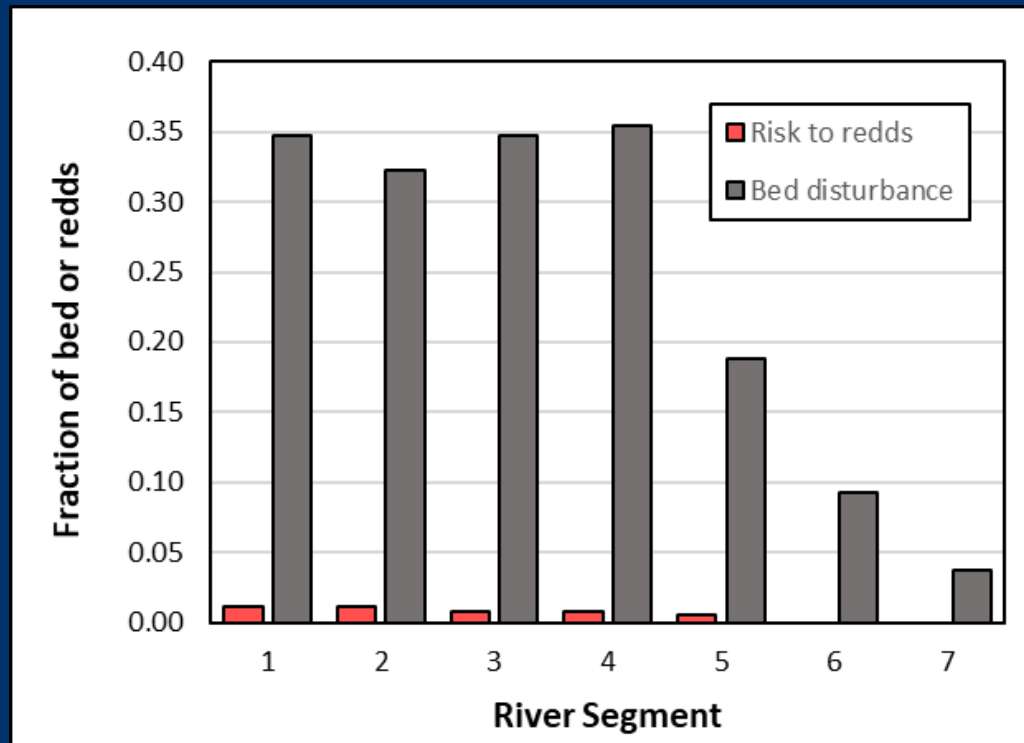
Cumulative fractions with $\tau^* > 0.06$

- **May et al. (2009) found an 8% risk of scour deep enough to disturb redds in the Trinity River when τ^* exceeds 0.06.**
- **They found the risk to be about 3% for $0.04 < \tau^* < 0.06$.**
- **Overall risk ranges from 0.7% at 4000 ft³/s to 2.3% when discharge is at the MFF throughout the study area.**



Management Implications

- Proposed dam release of 6500 ft³/s when tributary accretions at the confluence of the NF is forecast to be 4500-12000 ft³/s.
- Increases the risk of redd scour by a maximum of 1.1% in river segment 1 to near zero increase in river segments 6 and 7.
- Increases the bed area disturbed more than 30% in segments 1 through 4 and by 4 to 19% in segments 5 through 7.



Conclusions

- τ^* increases rapidly throughout the stream channel as discharge increases from 4000 ft³/s to about 8500 ft³/s.
- Redds occupy locations where τ^* is more likely to remain > 0.03 and < 0.06 . These narrower ranges are associated with shear stress reversals at moderate flood discharges.
- Shear reversals are mostly absent in the Hatchery reach. Redds in that area may therefore be at high risk in the event of a SOD release or other large winter flow release.
- A flow of 8500 ft³/s will disturb about 50% of the bed area throughout the study area. Gains in disturbed area beyond that discharge are relatively small.
- The proposed winter flow releases present negligible increases in the risk of redd scour.

Recommendations

- **Flow releases intended to generate beneficial bed disturbance should target peaks of 8500 ft³/s in river segments downstream from segment 1.**
- **Develop a comprehensive restoration plan to establish complex channel morphology and promote shear stress reversal in the Hatchery reach.**
- **Winter releases from Lewiston Dam should not exceed 6500 ft³/s before the recommended restoration of the Hatchery reach has been completed.**
- **Future substrates mapping efforts should include estimation of D_{50} .**