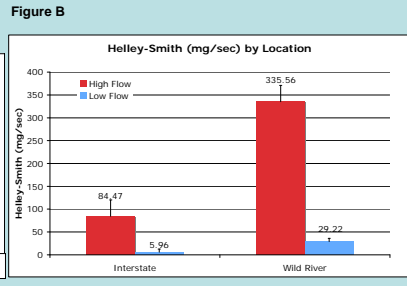
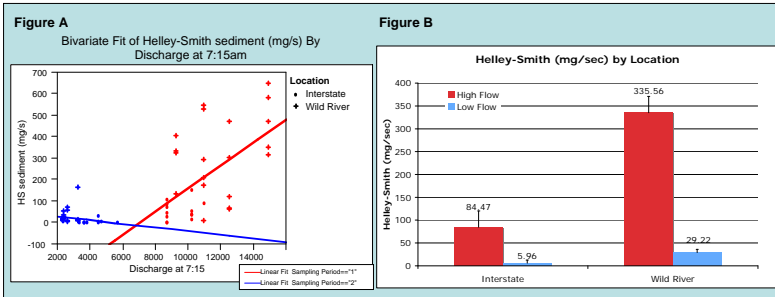


Near-bed sediment transport as indicator of substrate stability and suitable mussel habitats in the St. Croix River

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October 2008

Introduction:

- The St. Croix River located between Minnesota and Wisconsin provides pristine habitat for several freshwater mussel species including federally endangered and threatened species.
- Suitable mussel habitats are characterized by environments with low shear stress and stable and supportive substrate, while at the same time providing food and other essential materials like oxygen and calcium (Strayer 2008).
- Objectives of this study include 1) assessing sediment transport in near bed environments using a Helley-Smith (HS) sampler at both Wild River (above St. Croix Falls dam) and Interstate Park (below the dam), and 2) determining how sediment transport relates to mussel densities at each location.

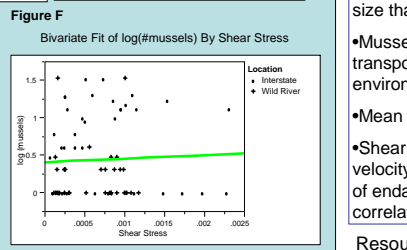
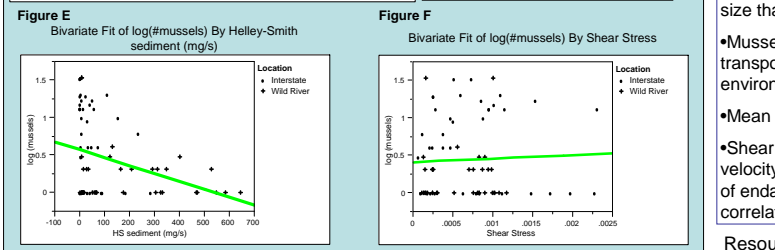
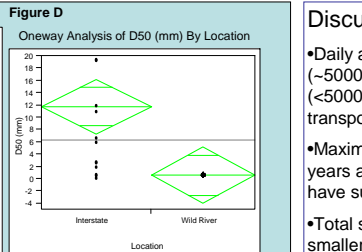
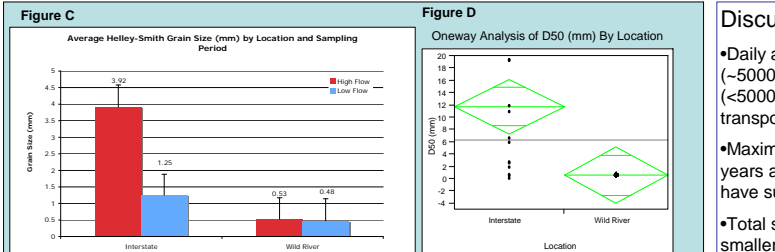
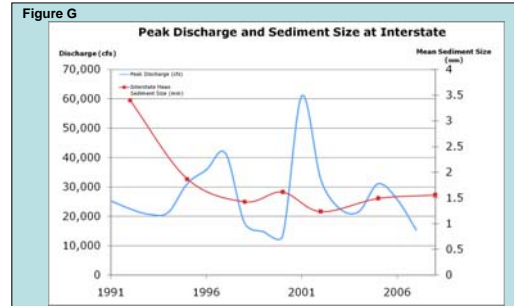


Methods:

- Helley-Smith (see photos above) measured sediment transport at the river bed across 0.031m² from 20 sites at Interstate and 20 sites at Wild River.
- HS sampler and velocity probe were set on the river bottom. A sample was taken in high flow (>5000 cfs) for 5 minutes, while recording average velocity with ADP sampler. At low flow (<5000 cfs) HS was taken for 10 minutes while collecting average velocity with the Marsh-McBirney attached to a wading rod.
- Samples were dried, and total mass was recorded. Sediment was sieved in a series of 8 pans with openings from 32mm to 63um (coarse gravel to very fine sand). Weight of the sediment in each sieve was recorded, and average sediment size at each site was calculated based on weight.
- Mussels were identified and mussel density was calculated within 1 m² quadrats at each site.
- Shear stress was calculated using water depth, velocities, and discharge at each location.

Results:

- A significant relationship was found between bedload sediment flux (mg/sec) and water discharge (cfs) during high flow. High flow (discharge >5000 cfs) had more overall sediment transport at Interstate, below the dam, and at Wild River, above the dam. Low flow (discharge <5000 cfs) had little to no sediment transport at either site (Figure A)
- The most sediment transport (mg/sec) occurred at Wild River, above the dam, during high flow. Total sediment transport throughout the study period (high and low flow) was higher at Wild River than at Interstate (Figure B)
- Average grain size collected in HS samples was bigger at Interstate than Wild River. Grain size decreased at Interstate during low flow. Grain size at Wild River was similar during high and low flow (Figure C)
- The average sediment size at Wild River was smaller (~0.05 mm = sand) than at Interstate (~12.0 mm = fine gravel) (Figure D)
- Log(#mussels) is significantly related to bedload flux. Higher HS on this graph means fewer mussels (Figure E)
- Shear stress at low and intermediate flows was not significantly related to mussel density in this study (Figure F)



Discussion:

- Daily average water discharge significantly impacts bedload transport. Discharge must be above a threshold (~5000 cfs) before significant sediment transport can be observed. Very little HS was recorded during low flow (<5000 cfs) even though a 10 minute sample was collected; this is because there was little energy available for transport (Fig. A and Fig. B)
- Maximum daily discharge on the St. Croix River can be >20,000 cfs, but peak annual flows over the past 100 years average ~11,000 cfs (Source: USGS annual monthly data). The average daily summer discharge does not have sufficient energy to transport large sediment (e.g., gravel) that is found at Interstate (Fig. C and Fig. D)
- Total sediment flux, as measured with the HS, was greater at Wild River. Average sediment at Wild River was smaller (fewer coarse clasts) and is more easily entrained and transported. Interstate has a larger average grain size that is not readily transported by low velocity water (Fig. C and Fig. D)
- Mussel density is related to bedload flux of sediment (Fig. E). More mussels were found at Interstate where transport was lower. Less sediment transport could indicate more stable substrate (Strayer 2008) and an environment better suited for mussels.
- Mean particle size at Interstate has been decreasing over time but is larger this year than previously (Fig G).
- Shear stress is a frictional force along the water-river bed boundary (Gordon et al 1992). Changes in water velocity and depth drive changes in shear stress (Strayer 2008). There is a significant relationship with presence of endangered winged mapleleaf and these variables in the St. Croix (Hornbach et al.1996). This data shows no correlation at low/intermediate flows; we anticipate measuring shear stress at higher flows (20,000 cfs or greater).

Resources

Gordon, ND, TA McMahon and BL Finlayson. 1992. Stream hydrology: an introduction for ecologists. John Wiley and Sons, New York, New York. 525 pp.
Hornbach, D, DJ March, T Deneka, NH Troelstrup, and JA Perry. 1996. Factors influencing the distribution and abundance of the endangered winged mapleleaf mussel *Quadrula fragosa* in the St Croix River, Minnesota and Wisconsin. American Midland Naturalist 136(2): 278-286.
Strayer, DL. 2008. Freshwater mussel ecology: a multifactor approach to distribution and abundance. University of California Press, Berkeley, CA. 204 pp.