Infilling of Cobble Substrate used by White Sturgeon on the Nechako River

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Study Outline

Nechako white sturgeon are experiencing a recruitment failure which has been attributed to the failure of eggs and larvae to survive as a result of changes in the substrate at the locations where they are known to spawn. As part of the overall recovery effort initiative, coarse substrate was placed at two locations in May 2011 (referred to as Patches in figures) and substrate assessments have been conducted every year since. The assessments have been done using an underwater camera and freeze core sampling. These observations have shown that coarse sand and fine gravels (fine bedoad) have in-filled the coarse substrate where it was placed along the inside corner of the bends, while placed substrate located on the outside of the bends has remained sand free.

The infilling of substrate on the inside corners, but not outside has led to the quandary:

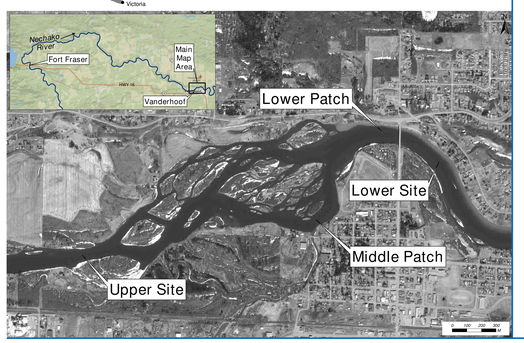
Is placed cobble substrate on the outside corner of the bends not being filled in with fine bedload because fine bedload is not moving past these sites, or are post-regulation flood flows sufficient to ensure fines remain suspended and are not deposited in the interstitial spaces?

Methods

A Hellysmith sampler was lowered from a boat and used to collect samples over a 30 second to 10 minute period (usually 5 minutes).

An underwater camera was used to observe sediment mobility and confirm the results of the Hellysmith sampler.

An ADCP with GPS was used to assess moving bottom and near bed shear stress.



Map Overview

The four maps below and to the right display:

Substrate information from underwater video images.

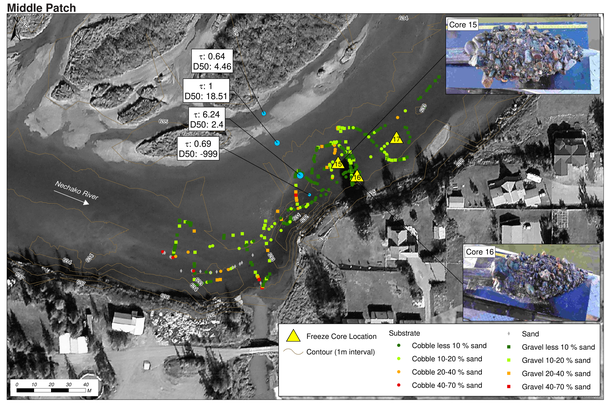
Hellysmith bedload transport data from August 15th, 2013.

Shear stress data from August 15th, 2013.

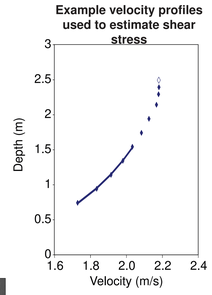
The Patch locations had cobbles placed on the bed in 2011 while the Site locations are composed of natural substrate

Upper Site

Middle Patch

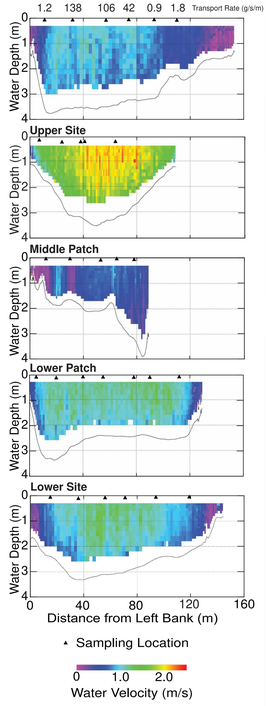


Example velocity profiles used to estimate shear stress

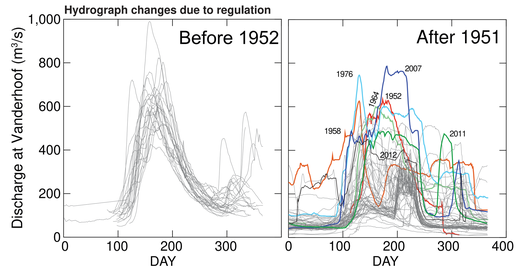


Fort Fraser

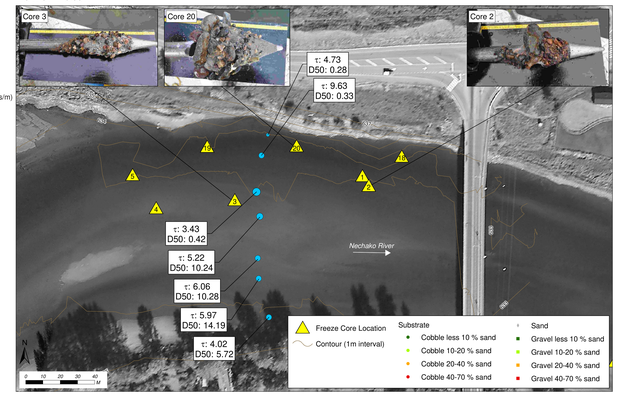
STN1	STN2	STN3	STN4	STN5	STN6	
3.1	3.1	5.0	3.0	2.0	4.7	Shear Stress (Pa)
8.2	0.6	0.5	0.4	0.2	0.3	D_{50} (mm)
1.2	138	106	42	0.9	1.8	Transport Rate (g/s/m)



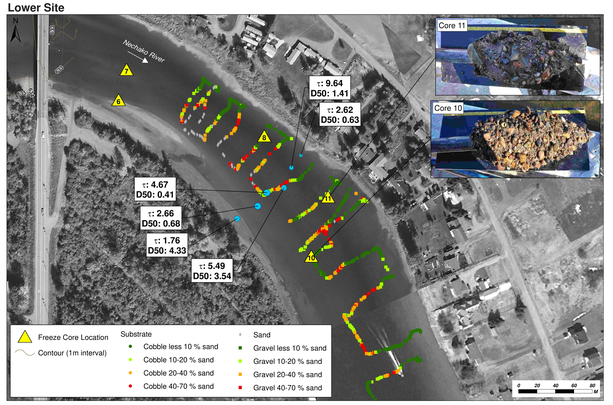
Hydrograph changes due to regulation



Lower Patch



Lower Site



Site Summary Data

		Fort Fraser	Upper Site	Middle Patch	Lower Patch	Lower Site
Aug-13	Q_s (g/s)	6235	186	245	5793	2308
	Q (m^3/s)	270	331	92	321	316
	Average Shear Stress (Pa)	3.5	27.1	2.4	5.6	4.5
Oct-13	Q_s (g/s)	Not Applicable	1	97	4	319
	Q (m^3/s)	Not Applicable	48	30	48	45
	Average Shear Stress (Pa)	Not Applicable	4.3	5.9	5.5	4.8

Results

- Bedload was moving at all sites at a flow of 325 m^3/s and some bedload was moving at 46 m^3/s at the lower site.
- Transport rates do not correspond with shear stress observations.
- Transport rates do correspond with bed infilling observations from previous years. More sediment is transported over areas that are in filled with fine gravel and coarse sand. No sediment was observed to be transported at sites with clean placed material.
- Suspended sediment transport rates are very low.
- Highest transport rates occurred where bed was coarse sand.

Analysis

Discharge during measurements was not particularly high (325 m^3/s: exceeded 8.8 % of the time).

As a first order approximation the transport rate is zero at flows less than 325 m^3/s and transport rate equals the observed rate at flows greater than 325 m^3/s.

	Fort Fraser	Upper Site	Middle Patch	Lower Patch	Lower Site
Average 1957-2013	10901	326	428	10129	4035
2011	43028	1285	1691	39980	15927
2012	39979	1194	1571	37147	14798
2013	5421	162	213	5037	2007

Data suggest that at the Lower Patch, if all the sediment was coming from the island complex the bed would degrade 1 cm per year on average. In 2011 and 2012 though the degradation would have been 4.0 and 3.8 cm. These rates of degradation are not consistent with observations, suggesting bedload must be coming from elsewhere and moving through the upper site at other flows.

Ongoing Research Questions and Challenges

- Given the poor correspondence between shear stress and transport, can sediment transport be modelled with any success?
- It seems there is too much sand and gravel to be from local area; in which case, when does it move through the upper site?
- Secondary currents clearly drive the transport of fine gravel and coarse sand past placed patches. Can this transport pattern be predicted using a 2D or 3 D numerical model? Or will numerical models predict that the material follows the high velocity/high shear stress vectors?

Acknowledgements

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Data Sources

Microsoft Corporation and its data suppliers. 2013. BingMap Apr-2012 imagery from Esri. Data set accessed 06-Dec-2013.

Esri, National Geographic, and Natural Resources Canada. 2013. Esri National Geographic World Map. Data set accessed 06-Dec-2013.

Contours are from survey conducted in 2006 prior to the placement of the spawning substrate. Only available for some areas.

September 2009 orthophoto supplied by Ministry of Forests, Lands and Natural Resource Operations.