BIOACCUMULATION in MUSSELS in the KETTLE RIVER, BRITISH COLUMBIA:

of HEAVY METALS & other SUBSTANCES

Al Grant [a], Posted Jan 2012

KEYWORDS: Mussels, Bioaccumulation, Heavy-Metals, Margaritifera falcata, Kettle River, B.C.

STUDY PURPOSE:

A follow-up to and an expansion of our 2009 study and report: ***Bioaccumulation of Uranium in Mussels in the Kettle River, B.C***. http://www.boundaryalliance.org/bioreptcombined.pdf

Our 2009 sampling of mussel tissue from two locations in the Kettle River showed bioaccumulation of Uranium in mussels, Margaritifera falcata,[b] of up to 158 times the average uranium concentrations in surface water of the Kettle River, concentrations that were up to nine times greater than the Federal Drinking Water Guideline, (MAC.)

After publishing our 2009 report (see above) we were contacted by the B.C. Government, Ministry of Environment, who were interested in acquiring the full 2009 Laboratory analysis of metals in our mussel samples. MOE agreed to pay lab costs of the full metals scans, (our thanks) and that additional 2009 data is included in this new report.

In 2010 we sampled mussel tissue from eight locations in the Kettle system and obtained a full metals Laboratory analysis on each of those samples as well as a full analysis of mussel shells from three of those locations.

Shells from some samples were retained and sent out for ageing analysis.

The results show significant bioaccumulation of heavy metals and other substances in mussels to a degree that we recommend: "**don't eat the mussels**".

BACKGROUND:

The Kettle watershed is in a region known as the Idaho Batholith geologic formation, an area known for the high content of metal bearing ore. A Regional Geochemical Survey in the 1970's identified numerous "hotspots" for uranium in the Kettle and Okanagan basins. Numerous claims have been staked in these areas and two companies have stated intent to mine uranium in areas that drain to the Kettle or Okanagan Rivers. The incidence of high radon readings found in the Kettle basin and the levels of

Figure 1 Mussels at work photo: al grant

uranium found in the Kettle River are indicators of high natural levels of radioactive materials throughout the basin. Some proposed and existing domestic supply wells in the Kettle and Okanagan basins have been decommissioned or refused approvals due to uranium levels exceeding Federal Drinking Water standards. As there are no known "point sources" of uranium going into the Kettle we have assumed that uranium levels in the Kettle River are from "natural sources" and our mussel sampling was initiated to establish whether uranium bioaccumulation was occurring from so-called "natural" river water and to obtain some record of existing bioaccumulation prior to the start-up of any uranium mine with associated potential for leaching into Kettle groundwater. Other ground disturbances e.g. roads, rails, mines and excavations can also disturb bedrock and expose radioactive materials to weathering and leaching into groundwater and streams.
Further details on the Kettle Basin can be found in our 2009 report;
http://www.boundaryalliance.org/bioreptcombined.pdf
Our 2009 results for bioaccumulation of uranium is mussels made it likely that significant bioaccumulation of other heavy metals and substances would also be found in mussels. The full data obtained later from our 2009 samples confirmed that expectation.

SAMPLING:

Five locations on the Kettle system provided mussel samples between Aug 5th & 6th 2010 to a team[c] led by field tech George Floyd.
Three additional locations were sampled by Al Grant between Sept 16th and Oct 17th 2010.
Full metals analysis of tissue was conducted on all eight samples and analysis of shells was obtained from three of those locations. On all of the dates, mussels were mostly close to being fully exposed as compared to sampling Oct 11th 2009 where colder and icy water conditions resulted in mussels retreating almost entirely into sandy substrate.

AGEING of MUSSELS : some shells were retained from the 2010 sampling and sent out for what we had hoped was a process that would establish the age of various sizes of mussels sampled. Such data would help to establish size and longevity comparisons with mussels in other locations and perhaps provide indicators as to recruitment (juvenile replacement evident) sufficient to maintain populations. If/when this data is available we will update this report

CONCLUSIONS:

All samples obtained were tested using standard laboratory protocol approved by Environment Canada. Bioaccumulation of various heavy metals and other substances were then compared to the average concentrations of these heavy metals and substances in Kettle River water using Environment Canada's bi-weekly (every other week) sampling at Midway, B.C.
Tissue sampling results of note for arsenic, cadmium, chromium, selenium, uranium are shown on ***Table 1 (***below)
As Table 1 indicates, bioaccumulation in mussel tissue is high, with arsenic accumulating (multiplying) at 2,385 times average of river water, cadmium 54,000, chromium 3,266, selenium 7,017, uranium 235

times.
Mussel tissue samples have accumulated arsenic at 100 times the concentration designated as a Maximum Acceptable Concentration (MAC) for water, cadmium 108 times, chromium 21.56 times, selenium 98.2 times and uranium 11.75 times.
Other substances of potential concern e.g. aluminum and barium are also bioaccumulating in amounts significantly exceeding water MAC's, by 178 and 88 times respectively.

We reiterate our earlier caution: "**don't eat the mussels**"
(see our 2009 alert) http://www.youtube.com/user/standupforthekettle

Table 1 *figures Col's B, C, E, G, H, in parts per million (PPM)*

A	B	C	D	E	F	G	H
Substance	Average in Tissue 2009 & 2010	MAC	Tissue Average X MAC	Environment Canada river Water average	Tissue average X river water average	highest	lowest
arsenic	1.145	0.01	100	0.00048	2385	1.4	0.98
cadmium	0.54	0.005	108	0.00001	54000	0.65	0.48
chromium	1.078	0.005	21.56	0.0003	3266	1.9	0.62
selenium	0.9825	0.01	98.2	0.00014	7017	1.2	0.8
uranium	0.235	0.02	11.75	0.001	235	0.4	0.17

Column B: average of all 2010 mussel tissue samples (8) and 2009 (2).
Column C: Maximum Acceptable Concentration in water as provided by Environment Canada.
Column D: number of times by which bioaccumulation exceeds MAC.
Column E: an average obtained from Environment Canada's biweekly water samples at Midway, B.C.[d]
Column F: number of times by which bioaccumulation exceeds the average concentrations in river water.
Column G: highest sample recorded.
Column H: lowest sample recorded.

Laboratory Report, actual sample is attached.
Mussel Sampling Field Form, actual sampling is attached.

As ***Table 1*** indicates, significant bioaccumulation is occurring in mussels of substances regarded as harmful or potentially harmful to human health.
Shell analysis (along with tissue testing) at three locations varied between (matching) shell and tissue

samples to a point where no useful relationship was demonstrated from this small sample. Shell testing was undertaken in part to determine if shell testing of scavenged shells might be an alternative to sampling of live populations.
A larger sample might show some useful relationship between tissue and shell tests, however it appears from our expanded sampling and reconnaissance in 2010 that scavenged shells might not be found in sufficient quantity for laboratory requirements. While mussel predators, river otters, bears, raccoons, muskrats and crayfish are all present in the area, no middens or quantities of shells were found.

QUESTIONS RAISED, AREAS for FURTHER STUDY

Our 2010 sampling answered some of the questions raised in our 2009 Study and some outside complaint that the 2009 sampling was too small. We have now provided evidence of substantial bioaccumulation in mussels of numerous heavy-metals and substances and point out again; "don't eat the mussels." Many of the questions raised in 2009 remain.

- What levels of bioaccumulation or bioconcentration are occurring in organisms (including humans) other than mussels?
- What are human health implications of heavy metals concentrations in mussels and some groundwater sources in the Kettle basin and what are the health implications of the combinations of heavy metals?
- What are effects of frequent low water levels, with resultant higher water temperatures and reduced dissolved oxygen, on mussels and the fish populations they depend on?
- Mussel populations? The 2010 sampling found many additional populated areas however estimates made at the various locations were very much rough estimates. No comparative data from previous years is available to enable useful comparisons. Any actual repeated count in populated areas might be useful but likely only over a very long term. Many of the sites with higher populations had predominantly similar sizes of mussels. These were in the 'medium size' classification but were close to or at the largest sizes we found and are therefore presumed to be the most mature populations. Many of these sites had no evidence of smaller (juvenile) mussels. Without ageing data on mussels no determination can be made as to whether Kettle mussels live as long as their counterparts elsewhere. Kettle mussels do not reach the size or perhaps the age of counterparts elsewhere, however nutrition availability, colder water temperatures (with longer aestivation periods) could all factor into the smaller size as could the effects of the known bioaccumulation.
- What oversight or policy requirements should local and other governments be undertaking to determine potential heavy-metal contamination in streams, rivers and wells and groundwater or in activities likely to encourage leaching of heavy-metals and substances into water sources?

FUNDING:

August sampling: **Committee for a Clean Kettle Valley**

Sep & Oct sampling: tissue plus shells, **Boundary Environmental Alliance.**

- **THANKS :**
  to Robert Plotnikoff, Senior Aquatic Ecologist, Tetra Tech Surface Water Group, Seattle Washington, Charter Member of the Pacific Northwest Native Freshwater Mussel Workgroup. Robert provided much of the information on the ecology of freshwater mussels which led to our curiosity about bioaccumulation in mussels. We thank him for his input, advice and guidance and for introducing us to the fascinating life of mussels in the Kettle and elsewhere.
- To those who provided access, information or other resources to assist this study.

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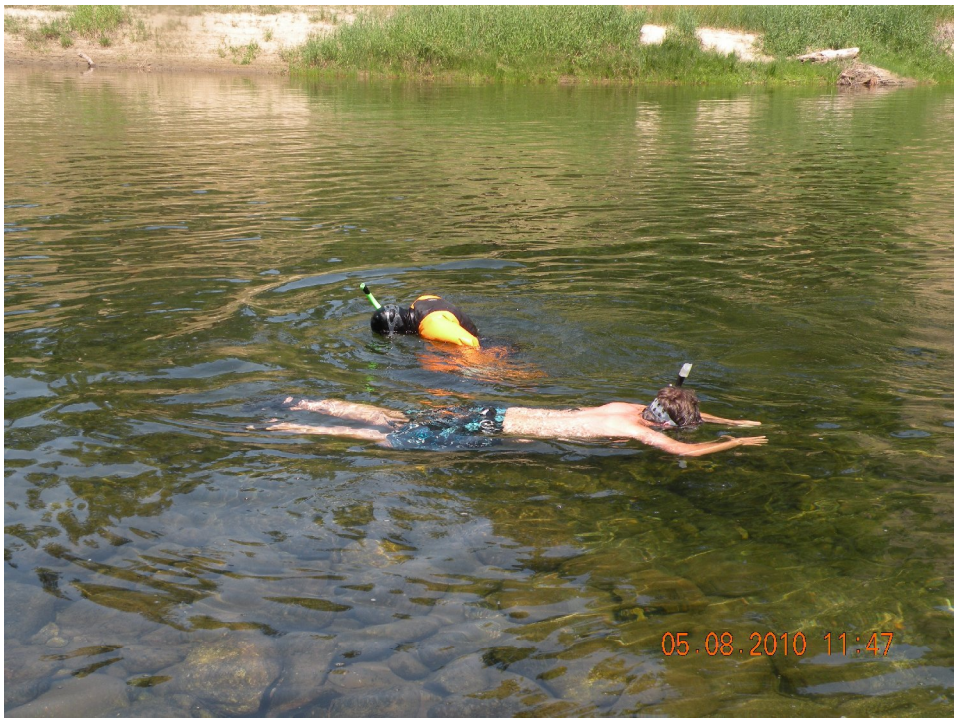
[a] Al Grant, researcher/writer, who proposed and initiated this project on behalf of Boundary Environmental Alliance www.boundaryalliance.org

[b] A comprehensive report on Margaritifera falcata can be found at: http://www.xerces.org/wp-content/uploads/2010/12/xerces-status-review-margaritifera-falcata.pdf

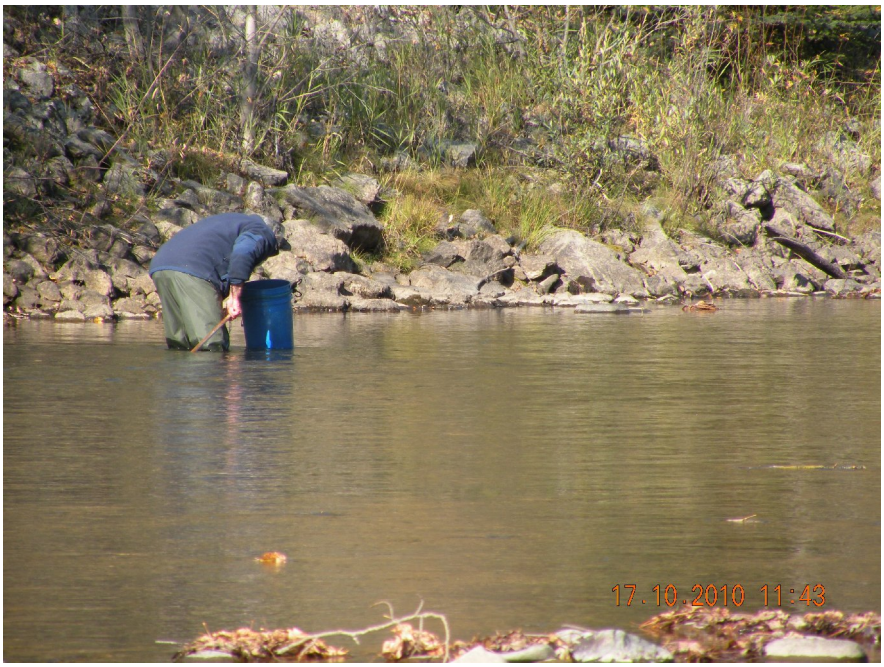
[c] August 2010 sampling Team: Willy Floyd, George Floyd, Al Grant, Tristan Blaine

[d] This data is available at Environment Canada: http://waterquality.ec.gc.ca/waterqualityweb/stationOverview.aspx?stationId=BC08NN0011 however the data now on view is less current than was previously available at that site.



George Floyd and Tristan Blaine searching. Photo: al grant

Mussel sample photo: al grant



Al Grant with glass bottomed viewing bucket photo: sue grant

Mussels at work photo: al grant

ACTUAL EXAMPLE

MUSSEL SAMPLING

SAMPLE ID: Name. KR21 RECORDED BY Al Grant

DATE: Aug 5th 2010 TIME: 10 30 am

LOCATION: Bartelings UTM's 361494 E 5434483 N

SAMPLE OBTAINED BY: Tristan & George

COLLECTED SIZES: (Length). Average 6.55 cm. TOTAL EST WEIGHT: 217.1 g gross

WEATHER CONDITIONS: (Today and previous weeks) Sunny, slight precipitation in past two weeks.....

RIVER CONDITIONS: (depth, visibility, flow rate, temperature, ph, conductivity, TDS, dissolved oxygen

24" depth, flow gentle, clear (temp etc, device failure)

MUSSEL BED Estimated Size In 100 yard stretch, 1000 guestimate

POPULATION DENSITY: many groups of 8-9.

CLASSIFICATION of above: small (under 6cm)—medium 6 to 10cm—large, 10cm & over (as per BCC field form)

All medium .....

EMPTY SHELLS OBSERVED: nil.....

DEPTH of MUSSELS: 8 " to 24" .....

SUBSTRATE TYPE: (As per BC Conservation Field Survey Form) cobble small to medium, not much sandy area...

PHOTOS : yes.....

OTHER COMMENTS: Sizes: 7.01 – 6.4 – 6.9 – 6.5 – 5.8 – 6.4 – 6.2 – 6.7 – 6.5 – 7.0 – cm

Average length: 6.55 cm

Total weight: 217.1 grams

Average gross weight of 10 mussels: 21.7 g

ACTUAL SAMPLE

SAMPLE DATA

CARO ANALYTICAL SERVICES

CLIENT	Committee for a Clean Kettle Valley	**WORK ORDER #**	K0H0354
PROJECT	Metals	**REPORTED**	Aug-23-10

Analyte	Result	Canadian DW Guidelines (May 08)	RDL	Units	Analyzed	Method	Lab	Notes
Strong Acid Leachable Metals by ICPMS, Continued								
CCKV GF1 (K0H0354-01) Matrix: Solid Sampled: Aug-05-10 14:00, Continued								
Thorium	<0.5		0.5	mg/kg	Aug-20-10	EPA 6020A	RMD	
Tin	<0.2		0.2	mg/kg	Aug-20-10	EPA 6020A	RMD	
Titanium	<4.0		4.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Uranium	**0.2**		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Vanadium	<1.0		1.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Zinc	**22**		2.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Zirconium	<2	16 OVER	2	mg/kg	Aug-20-10	EPA 6020A	RMD	
CCKV KR 18 (K0H0354-02) Matrix: Solid Sampled: Aug-05-10 11:00								
Aluminum	**25**		20	mg/kg	Aug-20-10	EPA 6020A	RMD	
Antimony	<0.1		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Arsenic	**1.3**		0.4	mg/kg	Aug-20-10	EPA 6020A	RMD	
Barium	**110**		1.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Beryllium	<0.1		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Bismuth	<0.1		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Boron	<2.0		2.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Cadmium	**0.56**		0.05	mg/kg	Aug-20-10	EPA 6020A	RMD	
Calcium	**9300**		200	mg/kg	Aug-20-10	EPA 6020A	RMD	
Chromium	<2.0		2.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Cobalt	<0.2		0.2	mg/kg	Aug-20-10	EPA 6020A	RMD	
Copper	**0.7**		0.5	mg/kg	Aug-20-10	EPA 6020A	RMD	
Iron	**330**		100	mg/kg	Aug-20-10	EPA 6020A	RMD	
Lead	<0.1		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Lithium	<0.1		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Magnesium	**260**		10	mg/kg	Aug-20-10	EPA 6020A	RMD	
Manganese	**770**		0.3	mg/kg	Aug-20-10	EPA 6020A	RMD	
Mercury	**0.09**		0.05	mg/kg	Aug-20-10	EPA 6020A	RMD	
Molybdenum	<0.1		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Nickel	<0.5		0.5	mg/kg	Aug-20-10	EPA 6020A	RMD	
Phosphorus	**5260**		0.5	mg/kg	Aug-20-10	EPA 6020A	RMD	
Potassium	**170**		10	mg/kg	Aug-20-10	EPA 6020A	RMD	
Selenium	<1.0		1.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Silicon	**970**		500	mg/kg	Aug-20-10	EPA 6020A	RMD	
Silver	**0.7**		0.2	mg/kg	Aug-20-10	EPA 6020A	RMD	
Sodium	**250**		100	mg/kg	Aug-20-10	EPA 6020A	RMD	
Strontium	**92**		0.2	mg/kg	Aug-20-10	EPA 6020A	RMD	
Sulfur	<1000		1000	mg/kg	Aug-20-10	EPA 6020A	RMD	
Tellurium	<0.1		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Thallium	<0.1		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Thorium	<0.5		0.5	mg/kg	Aug-20-10	EPA 6020A	RMD	
Tin	<0.2		0.2	mg/kg	Aug-20-10	EPA 6020A	RMD	
Titanium	<4.0		4.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Uranium	**0.2**		0.1	mg/kg	Aug-20-10	EPA 6020A	RMD	
Vanadium	<1.0		1.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Zinc	**23**		2.0	mg/kg	Aug-20-10	EPA 6020A	RMD	
Zirconium	<2	18 OVER	2	mg/kg	Aug-20-10	EPA 6020A	RMD	