Assessing Potential Aquatic Natural Resource Damage Assessment Injury at the DOE Hanford Site to Native Mussels

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Introduction

The Hanford Reach (Reach) of the Columbia River is located in arid southwestern Washington State. The Reach has received contaminants from the Department of Energy Hanford site (a plutonium production facility) since the 1940s. Hexavalent chromium, added to the cooling waters of 7 nuclear reactors, has been released to the river through both surface water and upwelling ground water pathways (Tiller et al. 2004), and laboratory toxicity studies indicate that concentrations of hexavalent chromium similar to those measured or predicted in the river could negatively impact Chinook salmon and/or Steelhead trout (Farag et al. 2006a, 2006b). However, because of the mobile life history of fish, habitat alteration, and hydrologic changes, attributing impacts to fish due to release of contaminants from the Hanford site is complex. Thus, the Hanford Natural Resource Trustee Council, as part of a Natural Resource Damage Assessment, is considering several alternative aquatic species to use in an assessment of potential injury resulting from Hanford hazardous substances. The Reach has historically supported populations of native mussels such as species of the genera *Anodonta* and *Margaritifera*. Although reduced in numbers, *Anodonta* (floaters) still occur in the Reach, whereas the once abundant *Margaritifera falcata* (western pearlshell) may be extirpated. While habitat modifications may have contributed to these declines, historical contaminant releases may have also played a role, particularly if the western pearlshell is found to be more sensitive to contaminants than floaters. Because mussels are sessile and can be exposed to contaminants both from the water column and sediments, and one species of significant cultural importance is apparently extirpated, these native mussels have been chosen as the subject of injury studies planned for Summer 2012.

Hexavalent Chromium

Concentrations of hexavalent chromium (CrVI) in the ground water in the vicinity of the 100-D nuclear reactor area have exceeded 50,000 µg/L in one area with plumes greater than 5,000 µg/L more widespread (Petersen et al. 2009, Dresel et al. 2008). Concentrations are increasing in ground water moving towards the Columbia River (Figure 1). More recently, measurements of Cr(VI) upwelling into the river from ground water have exceeded previous estimates (>100 µg/L in the middle of the river) and determined that the extent of contamination from upwelling into the Hanford Reach is more extensive than previously thought (Hulstrom and Tiller 2010). The EPA drinking water criterion for chromium(total) is 100 µg/L and the Washington State allowable concentration of Cr(VI) for the protection of aquatic life and EPA chronic ambient wqc is 11 µg/L. A release of 140,000 pounds of sodium dichromate to the Hanford Reach in the 110-B reactor area in 1966 undoubtedly impacted biota. Samples taken downstream at the city of Richland and Pasco drinking water intakes exceeded 100 µg/L. This historical event may have disproportionately impacted *Margaritifera falcata*, thus contributing to the apparent extirpation of this species today.

Existing Toxicity & Effects Data

The 96 h LC50 for juvenile *Utterbackia imbecillis* to Cr(VI) is 39 µg/L in soft water (40-48 mg/L $CaCO_3$), and 618 µg/L in relatively hard water (80-100 mg/L $CaCO_3$, Keller and Zam 1991). When combined with mercury the chromium 48 h LC50 was lowered from 295 µg/L to 170 µg/L. In a study of the marine mussel, *Mytilus galloprovincialis*, Parlak et al. (1999) found hexavalent chromium to be of second highest concentration in the foot. Pauley (1961, 1968) found high levels of pedunculated tumors in Anodonta in the Hanford Reach (Table 1). Other studies to detect uptake of compounds in soft tissue have shown increases in uranium in molluscs in the Hanford Reach (Patton et al. 2003, Buske 2005). This uptake appears to be variable and tied to seasonal and river flow regime differences (Larson et al. 2008).

Figure 1. Hexavalent chromium GW concentration in 1999 and 2006 at one reactor location at Hanford. Even with GW treatment, Cr(VI) continues to move into the Hanford Reach.

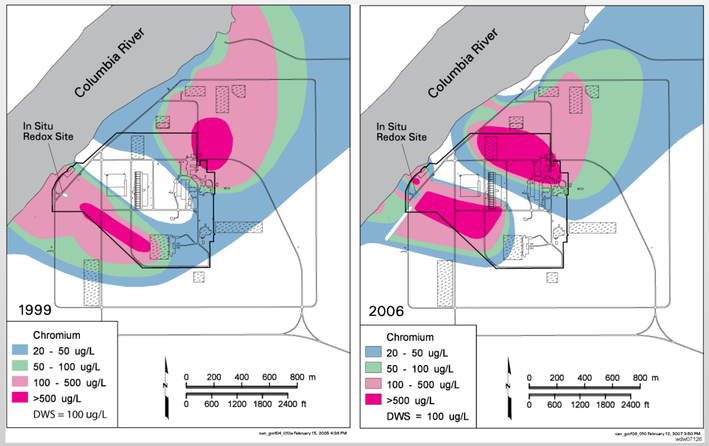

TABLE 1. Incidence of Pedunculated Tumors in Several Freshwater Mussel Populations

Collection Site	Species	Number of Molluscs Examined	Number of Tumors Observed	Number of Animals with Tumors	Percent of Animals with Tumors
Ozette River, Washington	*Margaritifera falcata*	123	8	8	6.5
Chehalis River, Washington	*Margaritifera falcata*	71	4	4	5.6
Devil's Lake, Oregon	*Anodonta oregonensis*	388	17	17	4.2
Columbia River, Washington	*Anodonta californiensis*	299	78	47	15.7

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Planned Studies:
Mussel Toxicity Testing and Habitat Occupancy

The Hanford Natural Resource Trustees are initiating a laboratory toxicity study with mussels in 2012 and evaluating a habitat characteristics and occupancy proposal to help determine if native mussels in the Hanford Reach have been, or continue to be, injured due to exposure to Cr(VI) alone or in combination with another stressor (temperature, uranium, or nitrate).

Laboratory Toxicity Studies with Mussels

Toxicity studies will conducted by the USGS in Columbia MO and by Missouri State University using standard testing methods (i.e. ASTM Method E2455). The objectives of the toxicity testing are to:

1) Determine the relative sensitivity of different native mussel species exposed to Hanford contaminants, initially focusing on chromium. Species to be evaluated include the western pearlshell (*Margaritifera falcata*) and the fatmucket (*Lampsilis siliquoidea*), a commonly tested surrogate mussel species. Studies will reflect site-specific water chemistry (pH, hardness, etc.)
2) Determine the concentration(s) of contaminants at which these mussels could potentially be "injured" as defined by the DOI NRDA Regulations (43 CFR 11).

In order to maximize the information obtained at a reasonable cost, a tiered approach will be used. The first phase will be to determine the acute and chronic toxicity of hexavalent chromium alone to both species of mussel. Once environmentally relevant Cr(VI) effect concentrations have been determined, acute toxicity tests will be conducted with at least one of the species of mussel and each of the secondary stressors (i.e. temperature, uranium, or nitrate). Should acute toxicity tests demonstrate one or more of the secondary stressors in combination with Cr(VI) to be synergistic or additive to Cr(VI) toxicity, chronic tests evaluating both Cr(VI) and those individual stressors will be performed.

Habitat Studies

The second study currently being evaluated is a survey of suitable habitat for the presence of native mussels in the Hanford Reach and evaluation of those habitats. The objectives of the habitat survey are to:

1) Determine the amount and location of habitat suitable for occupancy by native freshwater mussels, in particular the western pearlshell.
2) Provide a more comprehensive characterization of the freshwater mussel species composition, density, and distribution in the Hanford Reach, in particular the locations of extant and extirpated western pearlshell populations
3) Determine the age structure of mussel populations in the Hanford Reach to evaluate if any age classes are missing or impaired, and if recruitment is occurring.

Summary

Historical and ongoing releases of hexavalent chromium from the Hanford site, alone or with other stressors, may have negative impacts on populations of native mussels, particularly the western pearlshell. Studies are proposed to link contaminant sensitivity and presence/absence of native mussels with historical contaminant releases and groundwater contaminant information. These studies will inform potential injury determinations and help develop subsequent *in situ* studies to further refine relationships between the Hanford Reach native mussel population status and hazardous substances released from Hanford operations to the Hanford Reach of the Columbia River.