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Wildlife health indicators and mercury exposure: A case study of river otters (*Lontra canadensis*) in central British Columbia, Canada

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ABSTRACT

Indicators of wildlife health are important elements of a comprehensive approach for assessing and monitoring trends of methyl mercury (MeHg) contamination in the environment. River otters (*Lontra canadensis*) have been used as a model species for toxicological studies on the effects of MeHg bioaccumulation due to their position as an apex predator in aquatic systems and sensitivity to environmental disturbance. Although laboratory studies suggest that sublethal MeHg exposure may have detrimental effects on wildlife, they are limited in their ability to reflect real world exposure and forecast population level effects. Few studies have identified the threshold at which MeHg exposure results in a population-level effect for wild populations of river otters in marine or freshwater systems. We used a series of data sets collected over a 7-year period for river otter populations in central British Columbia, Canada, to assess mercury concentrations (river otter fur) and measurements of population status and health relative to a lake with an inactive and reclaimed mercury mine along its shoreline (Pinchi Lake). We used a combination of remote cameras, marked individuals, hair snares, and scat counts/inventories to collect measurements of population status and health including: activity levels, population estimates, sex ratios, group sizes, litter sizes, behaviour, stress hormones, diet, and habitat quality. We found that mercury concentrations in river otter inhabiting Pinchi Lake were significantly higher than all other lakes in the study, and were also high relative to other areas in Canada and the United States. We did not, however, detect significant differences between the two lakes in many of the population parameters measured. We discuss the knowledge gaps and challenges of identifying the effects of MeHg for wild populations of mammals, determining sensitive and appropriate methods for measuring these effects, and the implications of our results for monitoring the impacts of natural resources activities. Detailed studies on population effects across a range of exposure and background conditions are required to address these data deficiencies. Typically, river otters are not included as monitoring species in environmental assessments even though their value as an indicator of anthropogenic contaminants has clearly been documented. We encourage inclusion of river otters in environmental assessments pre-, during -, and post-industrial activities as a measure of pollutant exposure and bioavailability as well as a critical first step in addressing knowledge gaps associated with contaminants and its effects on populations.

1. Introduction

Indicators of wildlife health are important elements of a comprehensive approach for assessing and monitoring trends of mercury contamination in the environment (Wolfe et al. 2007). Methylmercury (MeHg), a toxic derivative of elemental mercury, readily accumulates to high concentrations in organisms atop aquatic food webs. Biological effects in fish, birds, and mammals may include behavioural, neurochemical, hormonal, and reproductive changes (See Review; Scheuhammer et al., 2007). River otters (*Lontra canadensis; Schreber, 1777*) have been used as a model species for toxicological studies on the effects of mercury bioaccumulation due to their position as an apex predator in aquatic systems (Ben-David et al., 2001; Chan et al., 2003; Wolfe et al. 2007). River otters are also considered an “indicator” or “sentinel” species, or one that is sensitive to environmental disturbance and useful for measuring or indexing levels of ecosystem health (Basu, 2012; Ben-David et al., 2001; Bowyer et al., 2003). The otter’s position as a top-level predator, combined with its sensitivity to environmental disturbances, makes it an ideal species for measuring environmental change. However, few studies have identified the threshold at which

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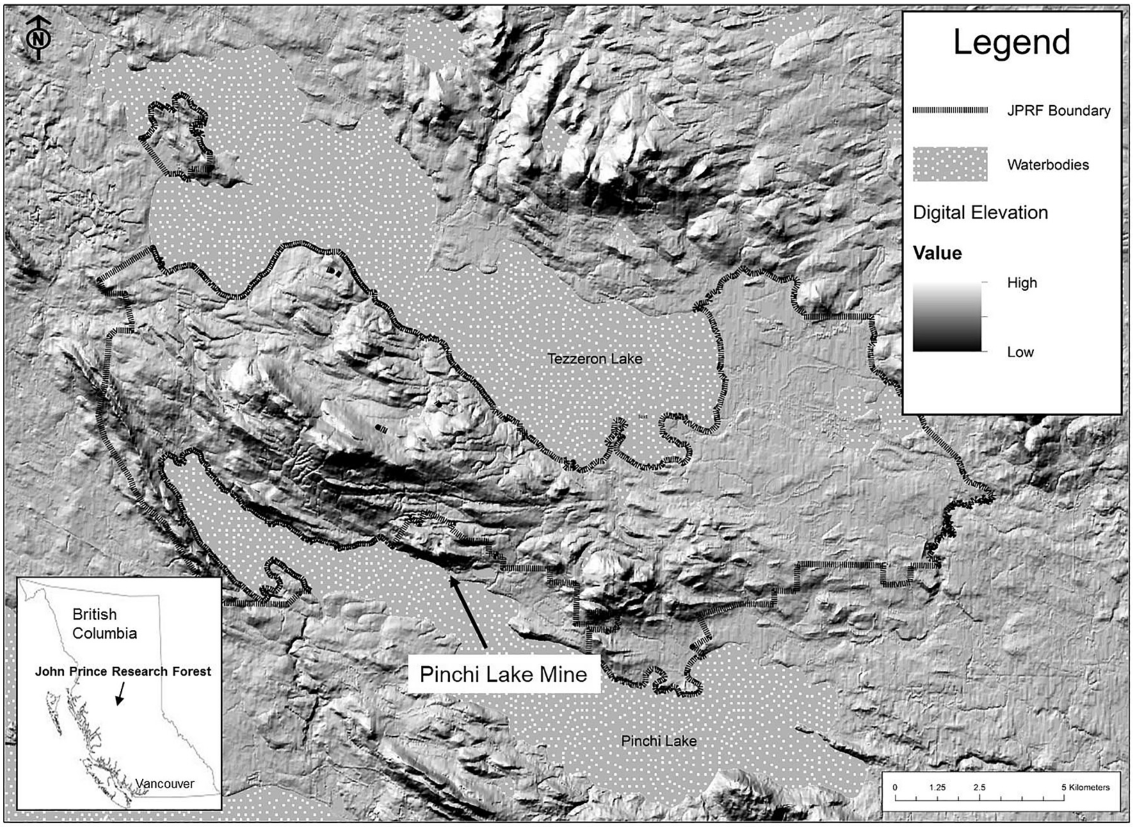

Fig. 1. Map of the John Prince Research Forest (JPRF) displaying the location of the reclaimed Pinchi Lake Mine in central British Columbia, Canada.

elevated mercury concentrations result in population-level effects for wild river otters in marine or fresh-water systems.

Substantial evidence indicates that prolonged and excessive intake of MeHg-contaminated fish can result in adverse health outcomes in river otter (Chan et al. 2003; Scheuhammer et al., 2007; Wolfe et al., 1998). Most of the acute effects related to mercury exposure in aquatic mammal species such as river otter or American mink (*Neovison vison*), however, have been documented using laboratory studies (Aulerich et al., 1974; O'Connor and Nielsen, 1981; Wren et al., 1987a,b) or the rare discovery of individuals with mercury poisoning in the wild (Wren, 1985; Sleeman et al., 2010; Wobeser and Swift, 1976). Although laboratory studies suggest that sublethal mercury exposure may have subtle detrimental effects on wild populations (Halbrook et al., 1994), they are limited in their ability to reflect real-world exposure to mercury and forecast population-level effects (Basu, 2012). Sublethal effects of less extreme mercury contamination on free-living individuals and populations are also far more difficult to measure and assess. The majority of studies investigating sublethal effects in wildlife have focused on fish or bird species. Reproductive impairment of fish species has been documented in both laboratory and wild populations (See review; Crump and Trudeau, 2009). There is a growing body of evidence showing adverse effects of environmental MeHg on the behaviour (Counard, 2000; Nocera and Taylor, 1998) and reproductive success (Evers et al., 2008) of free-living common loons (*Gavia immer*). Evers et al. (2008) state that there are many inherent difficulties in understanding MeHg exposure and its impacts on reproductive success of common loons related to the compounding effects of intrinsic factors (e.g., density dependence, species longevity), extrinsic factors (e.g., weather, habitat quality), and anthropogenic stressors (e.g., recreational disturbances, and other contaminants). These same difficulties hold true for river otter; however, there are additional challenges in obtaining measurements of population health. For example, it is often difficult to measure indices such as the reproductive success of individuals in rarely observed, cryptic, and frequently-moving species such as river otter.

Most studies in which measures of the population health of river otter have been reported, have focused on carcasses obtained from trappers (Klenavic et al., 2008; Mierle et al., 2000; Spencer et al., 2011). These studies provide some evidence, albeit primarily circumstantial, that river otter survival may be reduced in areas with higher mercury burdens (Mierle et al., 2000; Spencer et al., 2011). In another semi-aquatic mustelid, Klenavic et al. (2008) found that American mink infected with the parasite, *Dioctophyma renale*, had significantly higher Hg levels than uninfected mink, and Kruuk et al. (1997) found mercury to be higher in Eurasian otters (*Lutra lutra*) with lower body condition. Although based on limited information, several population declines of river otters in North America and Europe have been partially attributed to the potential adverse effects of mercury and other contaminants (Osowski et al., 1995; Kruuk et al., 1997; Halbrook et al., 1994; Hyvarinen et al., 2003). We currently lack an understanding of how toxicological effects of mercury exposure in laboratory settings relate to wild populations. Although measurements of population health are difficult in many species, it is important to initiate studies that relate sublethal effects of MeHg exposure to the status and trends of affected populations.

The objectives of our study were to: 1) assess mercury levels of river otter in three sampling areas of north central British Columbia (BC), Canada, including one lake with an inactive and reclaimed mercury mine along its shoreline (Pinchi Lake); and, 2) compare several measures of population status and health of river otters inhabiting a lake with a history of mercury mining (Pinchi Lake), and an adjacent lake with no history of mining. We used a combination of remote cameras, marked individuals, hair snares, and scat counts/inventories to collect measurements of population status and health including: activity levels, population estimates, sex ratios, group sizes, litter sizes, behaviour, cortisol levels, and diet. Additionally, to investigate other potential