Evaluation of Risk to Onondaga Lake Bald Eagles Posed by Mercury-Contaminated Prey

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SUMMARY

Elevated concentrations of mercury have been documented in animals that are likely to be consumed by Onondaga Lake bald eagles. To determine the potential risk to these birds from consumption of contaminated prey, the U.S. Fish and Wildlife Service (FWS) used measured concentrations of mercury in Onondaga Lake fish to estimate mercury concentrations in eagle blood. These modeled blood concentrations were compared to information in the peer-reviewed literature that reports eagle blood mercury concentrations and observed effects – or lack of effects – on endpoints such as reproductive success and survival. The range of estimated Onondaga Lake bald eagle blood concentrations suggests potential risk to some eagles. However, there is substantial uncertainty associated with these conclusions, which are more likely to overestimate risk than underestimate it.

ANALYSIS

To assess the potential risk to Onondaga Lake bald eagles from consumption of mercury-contaminated prey, the FWS: 1) estimated the likely range of Onondaga Lake bald eagle blood mercury concentrations, 2) conducted a literature review of the potential effects of mercury on eagles, and 3) identified uncertainties associated with this analysis.

MODELED ONONDAGA LAKE BALD EAGLE BLOOD MERCURY CONCENTRATIONS

This analysis estimates Onondaga Lake bald eagle blood mercury concentrations using a correlation developed from data contained in Weech (2003) between mean pikeminnow mercury concentrations and bald eagle blood mercury concentrations at British Columbia lakes (Table 1). Relationships between mean pikeminnow mercury concentrations and minimum, mean, and maximum eagle blood concentration are estimated using log regression (Table 2).

TABLE 1 PIKEMINNOW AND EAGLE BLOOD CONCENTRATIONS AT BRITISH COLUMBIA LAKES (WEECH 2003)

LAKE	PIKEMINNOW	BALD EAGLE		
	MEAN TISSUE MERCURY (MG/KG-WW)	MINIMUM BLOOD MERCURY (MG/KG-WW)	MEAN BLOOD MERCURY (MG/KG-WW)	MAXIMUM BLOOD MERCURY (MG/KG-WW)
Fraser	0.10	1.78	1.96	2.26
Pinchi	0.42	4.25	6.55	9.44
Tezzeron	0.18	3.47	4.08	4.68

LAKE	PIKEMINNOW	BALD EAGLE		
	MEAN TISSUE MERCURY (MG/KG-WW)	MINIMUM BLOOD MERCURY (MG/KG-WW)	MEAN BLOOD MERCURY (MG/KG-WW)	MAXIMUM BLOOD MERCURY (MG/KG-WW)
Stuart	0.21	1.59	2.85	4.86
Note: WW = wet weight.				

TABLE 2 SUMMARY OF PIKEMINNOW TISSUE MERCURY - EAGLE BLOOD MERCURY REGRESSION EQUATIONS

REGRESSION DESCRIPTION	REGRESSION EQUATION[1,2]
1. Pikeminnow Tissue Hg Vs. Minimum Eagle Blood Hg	$y = 1.6453\ln(x) + 5.4116$
2. Pikeminnow Tissue Hg Vs. Mean Eagle Blood Hg	$y = 3.1965\ln(x) + 8.9861$
3. Pikeminnow Tissue Hg Vs. Maximum Eagle Blood Hg	$y = 5.1295\ln(x) + 13.538$
Notes: [1] y = Estimated eagle blood concentration. [2] x = Whole body pikeminnow tissue concentration. Data underlying regressions from Weech (2003).	

Because pikeminnow are not present in Onondaga Lake, we applied the mean mercury concentration of smallmouth bass – a species that feeds at a similar trophic level and for which mercury concentrations in Onondaga Lake are available. To estimate a range of likely Onondaga Lake bald eagle blood mercury concentrations, the mean Onondaga Lake tissue mercury concentration in smallmouth bass 38.2 cm or smaller was substituted for pikeminnow mercury concentrations, represented in the Table 2 regressions by "x."[1] The mean smallmouth bass concentration used in this calculation, and subsequent estimated minimum, mean, and maximum eagle blood mercury concentrations are presented in Table 3.

TABLE 3 MODELED RANGE OF ONONDAGA LAKE BALD EAGLE BLOOD MERCURY CONCENTRATIONS

SCENARIO	≤ 36.2CM SMALLMOUTH BASS TISSUE CONCENTRATION (MG/KG - WB WW) [1]	ESTIMATED EAGLE BLOOD CONCENTRATION (MG/KG) [2]
1. Minimum	0.71	4.9
2. Mean	0.71	7.9

[1] Sampled pikeminnow from British Columbia lakes were all 38.2cm or smaller, though they are known to grow larger. Because mercury in fish typically increases with length, the mean Onondaga Lake smallmouth bass mercury concentration in fish of the same size class is applied.

SCENARIO	≤ 36.2CM SMALLMOUTH BASS TISSUE CONCENTRATION (MG/KG - WB WW) [1]	ESTIMATED EAGLE BLOOD CONCENTRATION (MG/KG) [2]
3. Maximum	0.71	11.8
Notes: [1] Data Source: NYSDEC/TAMS Onondaga Lake Project Database. [2] Results of regression equations provided in Table 2. WB WW = whole body wet weight.		

LITERATURE STUDIES OF THE EFFECTS OF MERCURY ON BALD EAGLES

To assess the potential for eagles to experience adverse effects from Onondaga Lake dietary mercury exposure, we conducted a review of the peer-reviewed literature. With one exception, available studies have not identified a relationship between mercury concentrations and adverse effects on bald eagle reproductive success, overall productivity, or survival. Modeled Onondaga Lake eagle blood mercury concentrations are somewhat higher than those reported in the literature, so mercury-related adverse effects are possible. However, there are uncertainties associated with this analysis that affect the potential risk (see Uncertainties section).

Summaries of relevant literature reviewed to date are presented below:

Weech et al. (2006)

This study found no adverse effects on reproductive success or overall productivity in resident eagles at Pinchi Lake in British Columbia. Adult blood mercury concentrations ranged from a minimum concentration of 4.7 ppm to a maximum of 9.4 ppm, with a mean of 6.7 ppm. The study also notes that the "birds appeared to be in good body condition, did not differ significantly in terms of weight from eagles nesting on reference lakes, and exhibited no evidence of obvious abnormal behavior or lack of coordination."

Weimeyer et al. (1989)

This study reported blood mercury concentrations in adult eagles in the western United States:

- Mean blood mercury in adult bald eagles from Oregon: 2.3 ppm (maximum 4.8 ppm).
- Mean blood mercury in adult bald eagles from Oregon and Northern California: 2.3 ppm (maximum 5.4 ppm).
- Mean blood mercury in bald eagles from Montana: 2.0 ppm (maximum 4.5 ppm). Note that a maximum blood mercury concentration of 9.5 ppm in sub-adults was also reported.

The paper does not discuss the effects of mercury on eagles, but states that per Frenzel (1985) no effects were noted on reproductive success in Oregon and Northern California bald eagles.

DeSorbo et al. (2009)

This study collected blood samples from 304 eaglets at 150 nesting territories in interior Maine with a mean concentration of 0.53 ppm (range of 0.08-1.62 ppm). It found a weak but statistically significant correlation between 3, 5, and 10 year productivity and eaglet blood mercury concentrations. The study did not collect blood samples from adult eagles, and it did not address the potential impacts of other contaminants.

Rutkiewicz et al. (2011)

The authors found a relationship between mercury exposure and neurochemical effects, but blood was not one of the tissues sampled. The study concluded that 14 - 27% of bald eagles in the Great Lakes region are exposed to levels of mercury that may be capable of causing subclinical neurological damage.

Grim and Kallemyn (1995), Chan et al. (2003), Pittman (2010), and Pittman et al. (2011).

These papers include brief summaries characterizing the authors' interpretations of available literature regarding the toxicity of mercury to bald eagles. They conclude that there is no documented relationship between bald eagle mercury exposure and reductions in endpoints such as reproductive success or survival at mercury levels studied in the literature.

UNCERTAINTIES

There is uncertainty associated with both this analysis' estimate of Onondaga Lake eagle blood mercury concentrations and the conclusions that can be drawn from comparison of these concentrations to the literature.

The analysis assumes that Onondaga Lake bald eagle blood mercury is correlated with smallmouth bass tissue mercury in the same way that British Colombia eagle blood mercury is correlated with pikeminnow tissue mercury. However, Onondaga Lake bald eagle blood mercury concentrations may be more strongly correlated with mercury tissue concentrations in a fish species with lower mercury concentrations, such as the gizzard shad, as Onondaga bald eagles are known to feed heavily on this species. If this is the case, the analysis would over-estimate bald eagle blood concentrations. Conversely, in the unlikely case that Onondaga eagles are eating more highly contaminated prey than modeled, eagle blood concentrations may be higher.

The relative lack of information available from the literature concerning the effects of mercury on bald eagles also introduces uncertainty. No study on adult bald eagle mercury exposure indicated reductions in endpoints such as reproductive success or survival, though these levels are below the upper range of estimated Onondaga Lake blood mercury concentrations. However, there are studies that report lethality-equivalent effects on other bird species (i.e., not eagles) with prey and/or blood concentrations below those at Onondaga Lake. Moreover, Rutkiewicz et al. (2011) indicate some risk of subclinical neurological effects in Great Lakes bald eagles, though the study was not based on blood mercury concentration so comparisons to Onondaga Lake are not feasible. Therefore, while adverse effects are possible at modeled Onondaga Lake blood mercury concentrations, their magnitude is highly uncertain.

REFERENCES

Chan, H.M., A.M. Scheuhammer, A. Ferran, C. Loupelle, J. Holloway, and S. Weech. 2003. Impacts of mercury on freshwater fish-eating wildlife and humans. Human and Ecological Risk Assessment 9(4).

DeSorbo, C.R., C.S. Todd, S.E. Mierzykowski, D.C. Evers, and W. Hanson. 2009. Assessment of mercury in Maine's interior bald eagle population. USFWS. Spec. Proj. Rep. FY07-MEFO-3-EC. Maine Field Office. Old Town, ME. 42pp.

Frenzel, R.W. 1985. Environmental contaminants and ecology of bald eagles in south central Oregon. Ph.D Thesis, Oregon State University, Corvallis, Oregon. 143 pages.

Grim, L.H. and L.W. Kallemeyn. 1995. Reproduction and Distribution of Bald Eagles In Voyageurs National Park, Minnesota, 1973 – 1993. Biological Science Report 1. April 1995. U.S. Department of the Interior. National Biological Service, Washington, D.C..

NYSDEC/TAMS. 2013. Onondaga Lake Project Database.

Pittman, H.T. 2010. Using Nestling Bald Eagles to Assess Temporal and Spatial Trends of Environmental Contaminants, Voyageurs National Park, Minnesota, MS Thesis, Clemson University, Clemson, South Carolina, USA.

Pittman, H.T., W.W. Bowerman, L.H. Grim, T.G. Grub and W.C. Bridges. 2011. Using nestling to assess spatial and temporal concentrations of mercury in bald eagles at Voyageurs National Park, Minnesota,USA. Ecotoxicology 20: 1626-1635.

Rutkiewicz, J., D.H. Nam, T. Cooley, K. Neumann, I.B. Padilla, W. Route, S. Strom, and N. Basu. 2011. Mercury exposure and neurochemical impacts in bald eagles across several Great Lakes states. Ecotoxicology 20:1699-1676.

Weech, S.A. 2003. Mercury in fish and fish-eating birds, with special reference to the Pinchi Lake region of British Columbia, Canada. Phd dissertation, University of British Columbia.

Weech S.A., A.M. Scheuhammer and J.E. Elliott. 2006. Mercury exposure and reproduction in fish-eating birds breeding in the Pinchi Lake region, British Environ. Toxicol. Chem. 25:1433-1440 Columbia, Canada.

Wiemeyer S.N., W. Frenzel, R.G. Anthony, B.R. McClelland and R.L. Knight. 1989. Environmental contaminants in blood of western bald eagles. J. Raptor Res. 23:140-146.