

EXECUTIVE SUMMARY

PROJECT TITLE – “Mercury Tissue Dose-Response in Fish: A Literature Analysis Using ‘Injury’ to Combine Diverse Biological Test Endpoints”

For this project, we reviewed the residue-effect literature to construct a dose-response curve for mercury in fish. Fish exhibit a variety of adverse biological effects associated with a wide range of mercury body burdens. The diversity of test endpoints reported in the literature represents a substantial challenge to constructing a unified residue-based dose-response curve. Therefore, we adapted the concept of “injury” as a common metric allowing us to combine lethal and various sublethal biological effects endpoints measured in laboratory tests. “Injury” is defined as a “measurable adverse change, either long or short term, in the chemical or physical quality or viability of a natural resource resulting either directly or indirectly from exposure to the released substance” (U.S. DOI 1995). This regulatory definition is sufficiently broad to include the many biological test endpoints reported in the literature.

Published papers reporting mercury residues in fish and associated biological responses from sources described in Beckvar et al. (2005) were included. We also used the same screening guidelines developed by Beckvar et al. (2005) for reviewing and accepting papers published since 2005. However, the current approach differed in two important aspects. One, we considered all reported residue-effects information, not just residues in the vicinity of threshold-effect concentration. To accomplish our goal, we were especially interested in endpoints that appeared dose-responsive and ecologically important (e.g., survival, growth, reproduction, development, behavior). The current study also differed because we included papers reporting muscle mercury residues and used Peterson et al. (2005) to convert to whole body tissue concentrations.

Table 1 (accompanying Excel[®] file) is a hypothetical example of how residue-effects information from individual investigations was compiled and injury estimates calculated. Tables following this general template were constructed for each paper reviewed. Each biological response was control-normalized. For example, if survival in the highest mercury treatment was 45% and control survival was 97% (Table 1), the control-normalized survival would be 48% (i.e., $45\% + [100\% - 97\%]$). For mortality endpoints we assigned injury equivalent to the control-normalized response, so for this example injury would be 48%. Some sublethal endpoints (i.e., failure to spawn, failure to hatch, lethal developmental deformities) were considered to be biologically equivalent to death or Lethality-Equivalent (L-E). For these sublethal endpoints, we assigned injury equivalent to death; i.e., a 30% reduction in control-normalized spawning success would be equal to 30% injury. Other sublethal responses were judged to be less injurious than death and assigned a corresponding weighting factor; e.g., 0.5 for growth (Table 1).

These are referred to as Lethality-Weighted (L-W) responses. Total injury was calculated as the sum of L-E injury plus the highest proportion L-E injury.

Narrative descriptions of the investigations reviewed are shown in Table 2 (accompanying Excel[®] file). Seventeen investigations reported residue-effects in juvenile/adult fish while four evaluated ELS. Investigators used a variety of fish species as test organisms with freshwater forms predominating. Fish were exposed to either inorganic or methylmercury delivered via diet or aqueous solution. In one study (Birge et al. 1979), investigators exposed ELS fish to mercury via contaminated sediments and overlying water. In almost all instances, mercury residues were measured as total mercury (tHg) in whole body using cold vapor spectrophotometry. Residues represent mixed gender samples unless stated otherwise. In three studies, specific tissues (gonads and/or viscera) were removed prior to whole body residue analysis. In five experiments, investigators report tHg in muscle tissue. For these reports, whole body residues were estimated using the quantitative relationship between muscle and whole body concentrations as reported by Peterson et al. (2005). This U.S. EPA-funded research found a “highly significant relationship ($R^2 = 0.96$)” between 210 muscle and whole body samples representing 13 piscivorous and non-piscivorous fish species from 65 sites in 12 states. Finally, Table 2 reports some of the major biological effects evaluated by individual investigators. The list is not exhaustive but does include those endpoints that appear most adversely affected by mercury exposure. Commonly measured endpoints include reduced survival, failure to spawn, altered behavior and altered growth.

Beckvar et al. (2005) found a major source of uncertainty in the mercury residue-effect literature was that adverse effects appeared to be occurring at lower residues in ELS fish compared to juvenile and adults. Consequently, separate residue-based dose-response curves for ELS and juvenile/adult fish were constructed based on information mined from the papers listed in Table 2. These curves will be reported and discussed in a peer-reviewed journal article which is currently in preparation.

Beckvar N, Dillon TM, Read LB. 2005 Approaches For Linking Whole-Body Fish Tissue Residues Of Mercury Or DDT To Biological Effects Thresholds. *Environ Toxicol Chem* 24:2094–2105.

Peterson, S.A., Van Sickle, J., Hughes, R.M., Schacher, J.A., Echols, S.F. 2005 A Biopsy Procedure for Determining Filet and Predicting Whole-Fish Mercury Concentration. *Arch. Environ. Contam. Toxicol.* 48:99–107.

U.S. Department of the Interior (DOI) 1995. 43 CFR Subtitle A, Part 11. Natural Resource Damage Assessments.