An Epigenetic Assessment of Stamp Sand Toxicity to Salmonid Eggs from Buffalo Reef, Lake Superior

Project ID – 2020_PAT_791010

by:

Gordon Paterson[1], Kristin Brzeski[2], Michael Lowe[3]

[1]Michigan Technological University, Biological Sciences Dept.,
Houghton, MI 49931
[2]Michigan Technological University
College of Forest Resources & Environmental Science
Houghton, MI 49855
[3]United States Geological Survey
Hammond Bay Biological Station
Millersburg, MI 49759

April 2025

ABSTRACT:

Lake Superior lake trout (Salvelinus namaycush) and whitefish (Coregonus clupeaformis) represent a conservation success story in that these populations are self-sustaining in the general absence of significant stocking programs and following decades of stressors including sea lamprey predation and commercial fishery overharvest that depleted stocks. However, regional stressors within the lake continue to represent a hazard to lake trout and whitefish natural reproduction and recruitment. Legacy copper mining activities around Lake Superior's Keweenaw Peninsula resulted in the disposal of millions of metric tonnes of metals contaminated tailings ('stamp sands') around this region's shoreline of this region where erosion of these deposits threaten sensitive natural spawning habitats. To investigate this concern, we conducted epigenetic analysis of lake trout and lake whitefish eggs from females collected from Buffalo Reef located in Lake Superior's Keweenaw Bay to assess for stressors related changes in the DNA. We also used a population genetics approach to estimate the contributions of Buffalo Reef fish to overall genetic diversity among Lake Superior lake trout and whitefish and evaluate population connectivity. Epigenetic evaluation of Buffalo Reef eggs demonstrated a reduced degree of DNA methylation for both lake trout and whitefish relative to Lake Michigan and Lake Huron outgroups. Differentially methylated regions of lake trout and whitefish DNA suggested dysregulation of pathways related to DNA damage, immune responses, stress and metabolism. Importantly, a number of the differentially methylated regions of the DNA were conserved between lake trout and whitefish suggesting a conserved toxicity effect. Given the heritable nature of epigenetic modifications to the DNA, these results are indicative of potential chronic toxicity and stamp sand exposure effects for Buffalo Reef lake trout and whitefish. Population genetics analysis did not demonstrate uniqueness for Buffalo Reef fish and suggest that individual stocks and productive spawning sites such as Buffalo Reef provide an equal but not a particular source of genetic diversity due to high connectivity and gene flow. Lake whitefish demonstrated a greater degree of genetic divergence by distance relative to lake trout over an east-west gradient across Lake Superior. The results of this study underscore adverse effects associated with stamp sand exposure at Buffalo Reef and highlight genetic diversity among lake trout and whitefish that can help inform current efforts to rehabilitate and conserve the Buffalo Reef resource and its contributions to the Lake Superior fishery.