Impact of Copper Mine Tailings on Survival and Early Development of Lake Sturgeon and Lake Trout near Gay, Michigan

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Background
• Copper mining in the Keweenaw Peninsula took place between 1887–1969.
• Mined ore was sent to stamp mills to crush the ore down to sand size to more easily extract copper (Kerfoot et al. 1994).
• Leftover “stamp sand” was deposited into the nearest waterway.
• Stamp sand has elevated concentrations of copper, arsenic, lead, cadmium, and chromium.
• Stamp mills, run by the Mohawk and Wolverine Mining Companies, deposited approximately 25 billion kilograms of stamp sand at Gay, Michigan (Rasmussen et al. 2002).
• Deposits are constantly being reworked by wind and wave action, and the finer particles are being washed into deeper waters (Kerfoot et al. 1994), including Buffalo Reef, a critical lake trout spawning site.

Research Questions
1. Do organisms show a preference when given a choice between stamp sand and the natural Lake Superior substrate?
2. Does lake sturgeon and lake trout egg survival and early development vary when eggs are incubated over each substrate type? Does incubation time matter?

Methods
• To test substrate preference, 6 earthworms were placed in aquaria divided into 3 compartments, with varying substrate/sand mixtures (Figure 1). Compartments were divided with Plexiglas so that earthworms were able to pass between them. After 72 hours, final locations were noted.
• To test short-term fish egg incubation, lake sturgeon eggs were collected and incubated at 12°C over both stamp sand and natural beach sand (Figure 2) until hatching (37-42 days).
• To test long-term fish egg incubation, lake trout eggs were collected and incubated at ~6°C over both stamp sand and natural beach sand (Figure 4) until hatching (91-121 days). Eggs were kept in “Living Streams” with recirculating water for the duration of incubation.

Results
Figure 6. Tasks were divided into 3 substrate categories with 50% potting soil and then either 50% beach sand, 50% stamp sand, or 25% each beach/stamp sand. After 3 trials, 18 earthworms per trial, the mean number of earthworms (± 1 SD) choosing 50% beach sand was significantly higher (p=0.002 using single-factor ANOVA) than either mixture containing stamp sand.

Figure 7. Lake sturgeon were incubated over 3 substrate types (n=150 sturgeon eggs per type). The mean total length (± 1 SD) was calculated. There was no significant difference among each type (p=0.63 using single-factor ANOVA).

Figure 8. Lake trout eggs incubated over 4 substrate types, and started hatching after 86 days. Stamp sand fish hatched faster and had greater success (81.7%) than eggs incubated over beach sand (67%).

Figure 9. Surface water copper concentrations were analyzed from each of the substrate types. The mean concentrations are shown (± 1 SD). A single-factor ANOVA and Tukey Test show that each of the substrates are significantly different (p<0.004) from one another (62 µg/L in water above rinsed stamp sand, 180 µg/L in water above un-rinsed stamp sand, and 10 µg/L in water above the natural beach sand).

Conclusions
• Earthworms show a clear preference for natural beach sand substrate over any type of substrate that includes stamp sand, and this is the first study to test the effect of stamp sand on fish egg survival.
• Lake trout eggs hatched earlier and had higher hatch success when incubated over stamp sand compared with natural sand and lake sturgeon also showed increased survival on stamp sand; the copper in stamp sand possibly deters the growth of bacteria which infected lake sturgeon eggs on natural sand.
• Initial analysis of surface water copper concentrations shows that water over stamp sand from the Gay, MI beach has 10x the copper concentration as water over the natural beach sand.
• Additionally, surface water copper concentrations from the un-rinsed stamp sand found on the Gay, MI beach are significantly higher than the copper concentrations found above the rinsed stamp sand from Lake Superior off of the Gay, MI coast. This supports the belief that the finest particles containing the highest heavy metal concentrations are being moved away from the dump site toward spawning habitat found offshore.

Future Research
• Incubating frog embryos over each substrate type to examine the effect of stamp sand on organisms that use the ephemeral ponds on the Gay, MI beach.
• Additionally, lake sturgeon incubation will be repeated and lake trout eggs will continue to develop over each substrate type for observation of skeletal development.
• Finally, the physical structure of each substrate will be examined to help determine if organisms show a preference based on physical properties.

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Literature Cited