Stantec

Memo

To:	Nicola Banton	From:	Bryan Leece, Rick Lee
	KGHM Ajax Kamloops BC		Stantec Consulting Ltd. Stoney Creek, ON
File:	123510762	Date:	May 16, 2016

Reference: Bioaccumulation and Biomagnification Potential of Metals in Fish Tissue

INTRODUCTION

This technical memo has been prepared in response to information requests from the Canadian Environmental Assessment Agency (CEAA) and Health Canada (IR#'s CEAA-021 and HC-021). The information request states:

> "*If juvenile fish were sampled, rather than adult fish, the metals concentration would be underestimated, which would then result in underestimation of potential health risk*".

The statement appears to be based upon the assumption that metal concentrations in adult rainbow trout are always greater than those for younger life stages (e.g., fingerlings, yearlings and sub-adults) as a result of either bioaccumulation (i.e., when an organism uptakes chemicals in the environment faster than it can excrete/metabolize the chemical) or biomagnification (i.e., increasing concentrations of chemicals in multiple species of plants and animals up the food chain). Although some metals have the potential to bioaccumulate and biomagnify, these metals do so under specific environmental conditions which may not apply to the Project area. This technical memorandum summarizes the information regarding metal concentrations in rainbow trout from the project area, and the potential for metal bioaccumulation and biomagnification.

Potential Bioaccumulation of Metals in Fish

To determine whether bioaccumulation of metals in rainbow trout in the project area currently exists, the concentration of metals in fish was plotted against fork length and body weight. Jacko Lake is annually stocked with approximately 10,000 rainbow trout fingerlings (<5 grams average body weight) and yearlings (5-12 grams average body weight)(GofishBC). Of the 10 rainbow trout analyzed for metal concentrations, three were yearlings that weighed 20 grams or less, while seven were sub-adults up to 131 grams. If bioaccumulation of metals exists in rainbow trout in the project area, metal concentrations would increase from yearlings to sub-adults, with the assumption that concentrations continue to increases in adult fish. Analysis of the results shows that overall, metal concentrations reported in fish in Jacko Lake and Peterson Creek metal concentrations do not increase in fish tissue with an increase in age.

The results of this analysis are shown in Figures 1 to 17 for chemicals of potential concern (aluminum, antimony, arsenic, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, thallium and uranium) and for metals that are often a concern for aquatic life (cadmium, methylmercury and zinc).

Overall, the metal concentrations in fish collected for the human health risk assessment (HHRA) does not support the presence of metal bioaccumulation in rainbow trout at Jacko Lake and Peterson

Creek. Concentrations of cobalt, copper, manganese, selenium and zinc tended to decrease with greater fish size. Concentrations of arsenic, cadmium, mercury, methylmercury and thallium showed no clear trend with fish size. Concentrations of chromium, lead, molybdenum, nickel and uranium were mostly below the detection limit.

This information does not support the statement that metals bioaccumulate with increasing fish size, and it also does not support the statement that health risk would be underestimated from analyzing non-adult rainbow trout.

Potential for Biomagnification of Metals in Fish

The current scientific understanding of biomagnification in freshwater aquatic food chains suggests that most inorganic forms of metals do not biomagnify in the food chain. For example, Cardwell et al. (2011) concluded that although uptake factors varied for each metal in aquatic environments, cadmium, copper, nickel, lead and zinc generally do not biomagnify in food chains consisting of primary producers, macroinvertebrates and fish. Biomagnification of metals across multiple trophic levels for the most part, do not occur for inorganic metals (McGeer et al. 2003). Despite general public perceptions, biomagnification of metals in aquatic organisms is rare with the exception of methylmercury, an organometallic chemical which is often formed in association with anoxic (i.e., low oxygen) aquatic conditions associated with deep reservoirs created from hydroelectric dams (Drexler et al. 2003). The environmental conditions at Jacko Lake do not meet the conditions described in these studies for metal bioaccumulation to occur.

Regarding Health Canada's reference to bull trout, Section 6.7.2.3 of the Application (Fish Populations and Fish Habitat – Baseline Studies), rainbow trout are currently the only fish species present in Jacko Lake and in Peterson Creek within the Ajax Project area. Bull trout was identified to inhabit the geographical region from government databases, but are not present in either Jacko Lake or Peterson Creek within the Project area.

Potential for Underestimating Health Risk from Consuming Fish

The absence of metal bioaccumulation in rainbow trout in the project area does not support the assumption that the health risk to people consuming rainbow trout from Jacko Lake was underestimated in the HHRA. The statements also do not recognize the multiple conservative assumptions applied in the HHRA that overestimate health risk including:

- The application of the 95% upper confidence limit of the mean for metal concentrations in fish to estimate baseline health risk to people consuming fish.

- The concentration of metals in rainbow trout presented in the HHRA were based on whole body analysis (i.e., including the scales, bones, organs and the liver which is a metal accumulating organ.) Using whole body analysis results in an overestimation of risk because people typically consume only the filet and not the bones and organs.

- The use of the "worst case" water quality (i.e., Peterson Creek water quality) to represent future chemical exposures to fish significantly overestimates the health risk because rainbow

trout in Peterson Creek do not support a recreational fishery. As described in Section 6.7.2.3 of the Application (Fish Populations and Fish Habitat – Baseline Studies) stocked rainbow trout from Jacko Lake may enter Peterson Creek when lake water levels exceed the dam spillway elevation during high flow events but they are stranded because there is no means of upstream fish passage back into Jacko Lake. Fish that have entered Peterson Creek are generally fingerlings or yearlings due to their tendency to inhabit shallow near-shore environments near the spillway. Fish in Peterson Creek do not contribute to the productivity of Jacko Lake due to their permanent segregation from the Jacko Lake system.

CONCLUSIONS

The information in this technical memorandum provides supporting evidence that bioaccumulation of metals in rainbow trout with increasing fish size may not exist in the Jacko Lake system for the Project area. Concentrations of aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, methylmercury, molybdenum, nickel, selenium, thallium, uranium, and zinc did not increase between rainbow trout fingerlings and sub-adults. Metal concentrations in fingerlings to sub-adults exhibited one of the three characteristics:

1. Metal concentrations decreased when fish size increased;

2. Metal concentrations showed no clear relationship with fish size; or,

3. Metal concentrations were below the detection limit for most fish tissue samples.

Based on these results, the assumption that health risks were underestimated in the Application/EIS for consumers of fish is not supported by the evidence. Studies also indicate that metals typically do not biomagnify in aquatic food chains with the exception of methylmercury under specific environmental conditions. These environmental conditions are not present at Jacko Lake, which is supported by the comparison of methylmercury concentrations with fish size which showed no clear trend.

On-going monitoring of metal concentrations in fish tissue will be included as part of the monitoring program for the Project. To address Health Canada's request for tissue samples from adult rainbow trout, the monitoring program may be updated to target only adult rainbow trout. However, the current information provided does not support the statement that health risks were underestimated for consumers of rainbow trout. The proponent maintains that the overall health risks to consumers of fish are overestimated based on the absence of bioaccumulation and the conservative assumptions applied in the HHRA. Therefore, additional collection of fish tissue samples to include metals data from adult fish in the Baseline Case and Future Case assessment of human exposure is not warranted, and the lack of this data will not alter the determination of the significance of Project residual effects on metals levels in fish tissue in Jacko Lake.

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References

Cardwell, R.D.; DeForest, D.K.; Brix, K.V.; and Adams, W.J. (2011). Do Cd, Cu, Ni, Pb, and Zn Biomagnify in Aquatic Ecosystems? Reviews of Environmental Contamination and Toxicology. 226:101-122.

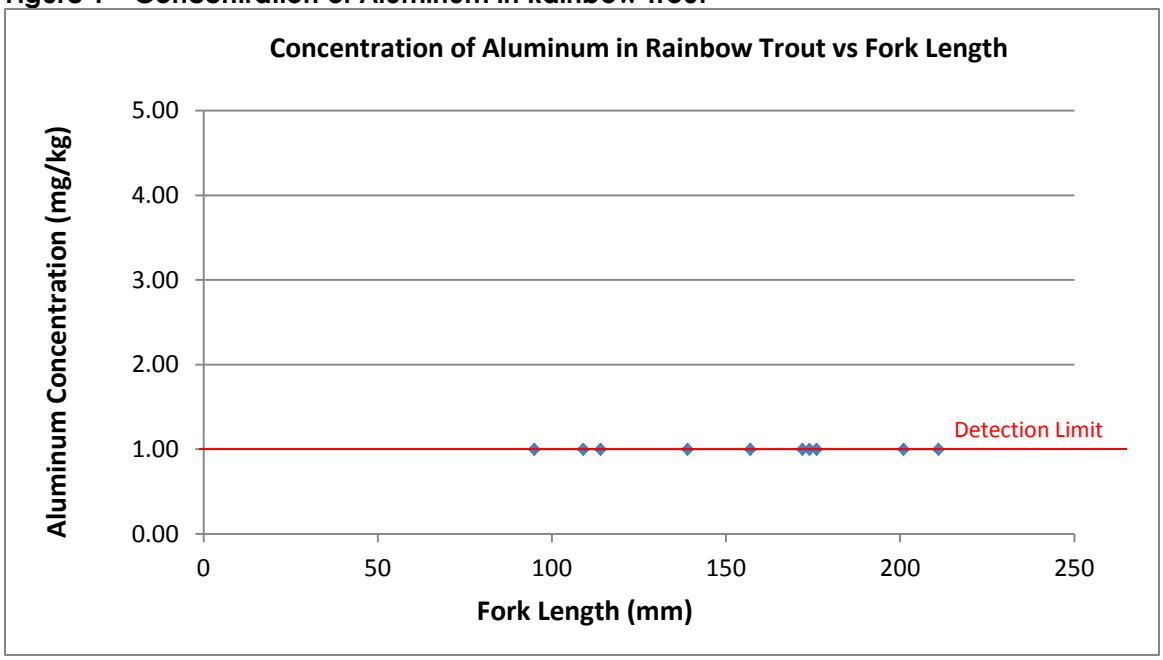
Drexler, D.; Fisher, N.; Henningsen, G.; Lanno, R.; McGeer, J.; and Sappington, K. (2003). Issue paper on the bioavailability and bioaccumulation of metals. US Environmental Protection Agency. Risk Assessment Forum.

GoFishBC (Online resource). Fish Stocking Reports – Nicola-Thompson Region – Jacko Lake. Available at: http://www.gofishbc.com

McGeer, J.C.; Brix, K.V.; Skeaff, J.M.; DeForest, D.K.; Brigham, S.I.; Adams, W.J.; and Green, A. (2003). Inverse relationship between bioconcentration factor and exposure concentration for metals: implications and hazard assessment of metals in the aquatic environment. Environmental Toxicology and Chemistry. 22(5): 1017-1037.

Reference: Bioaccumulation and Biomagnification Potential of Metals in Fish Tissue

Figure 1 – Concentration of Aluminum in Rainbow Trout



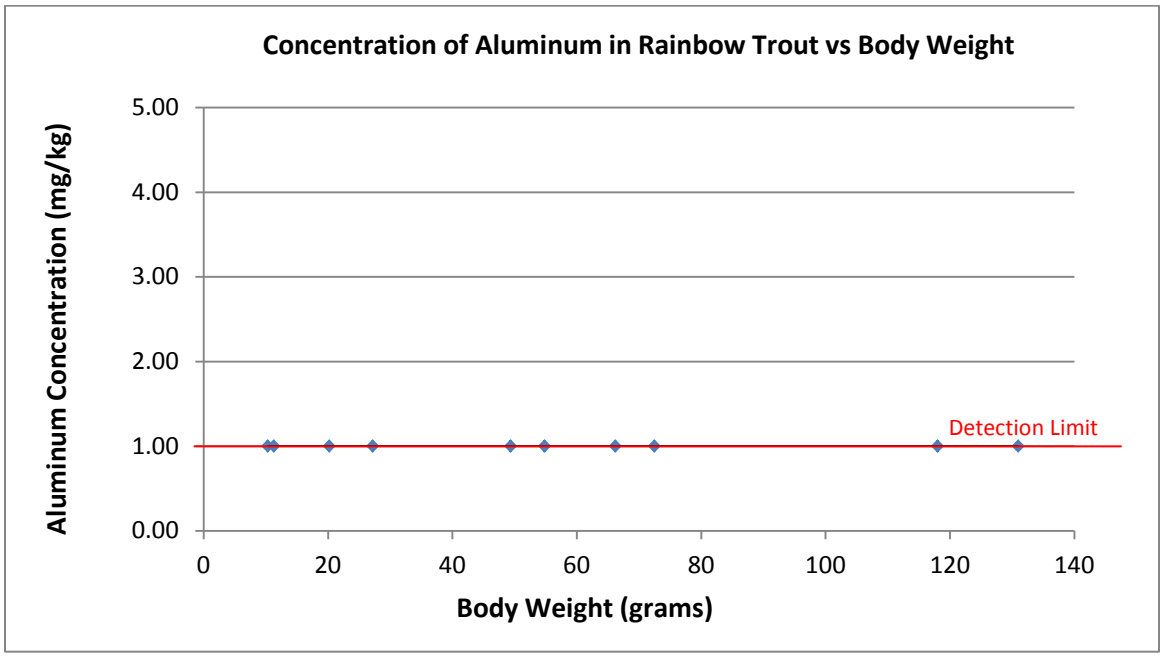


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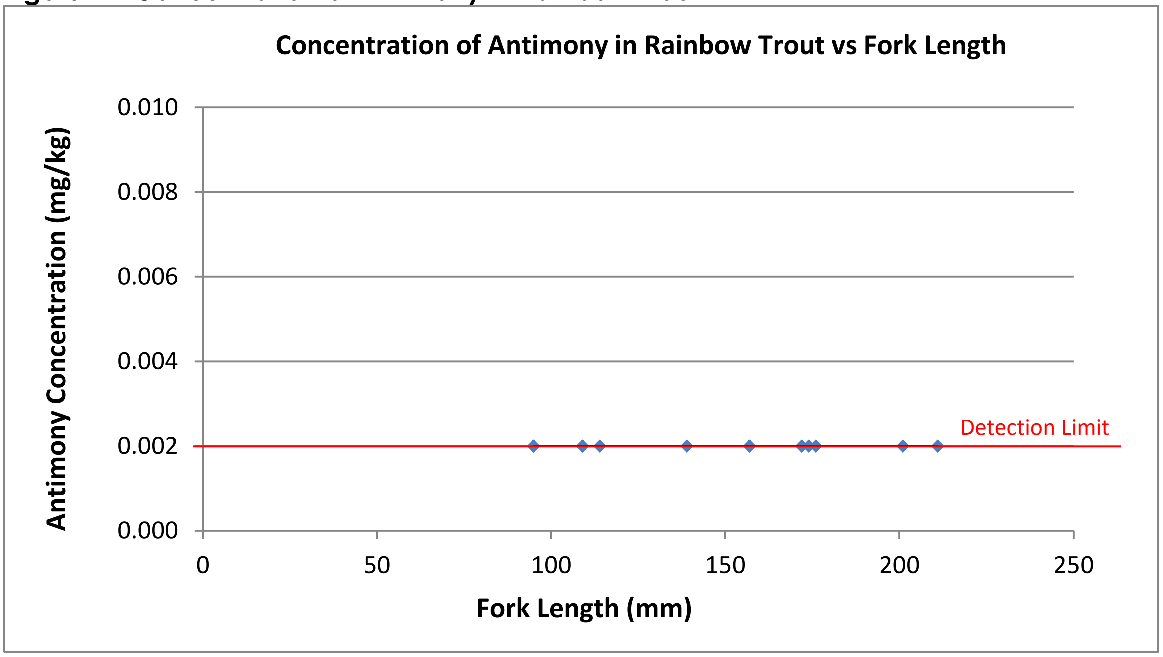
Figure 2 – Concentration of Antimony in Rainbow Trout



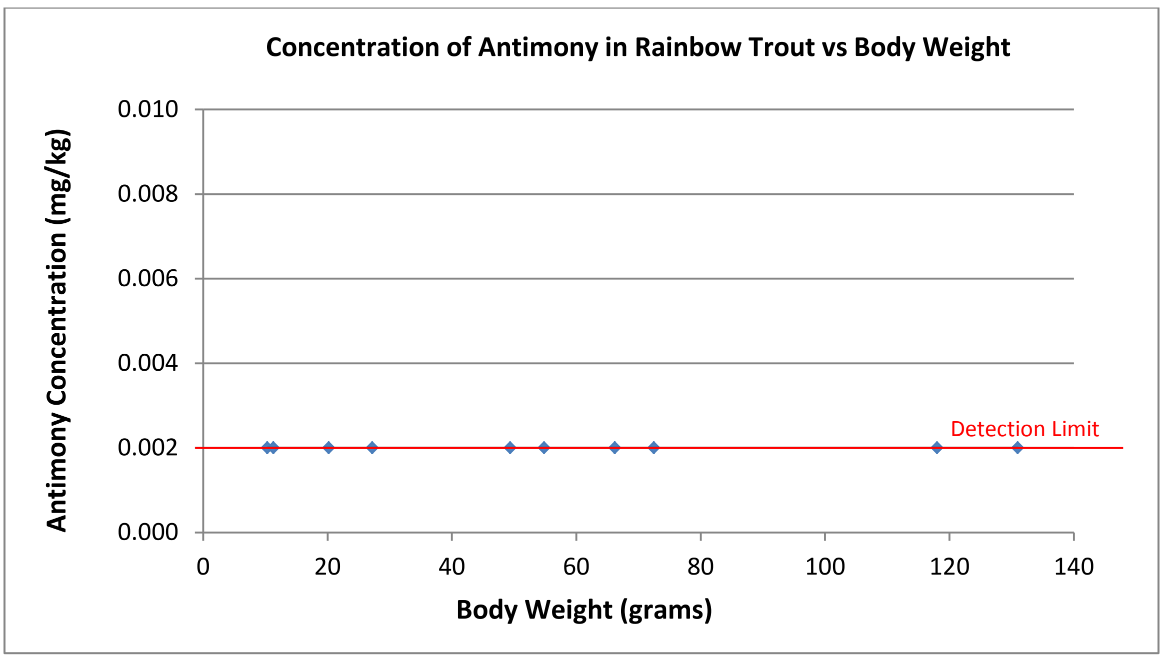


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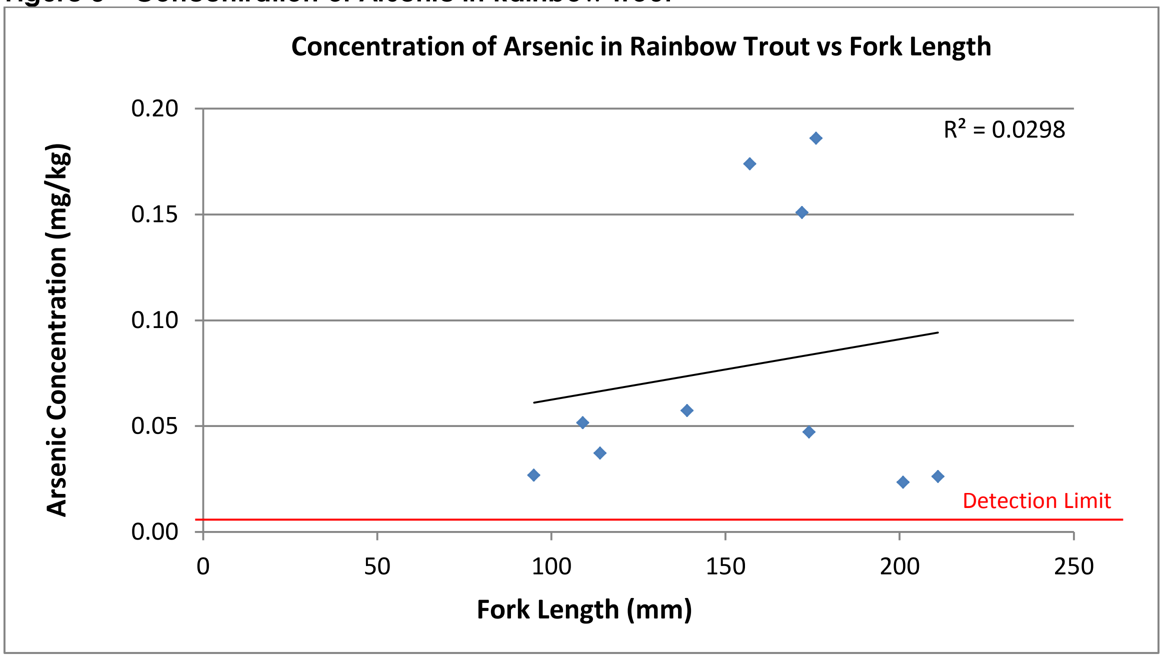
Figure 3 – Concentration of Arsenic in Rainbow Trout



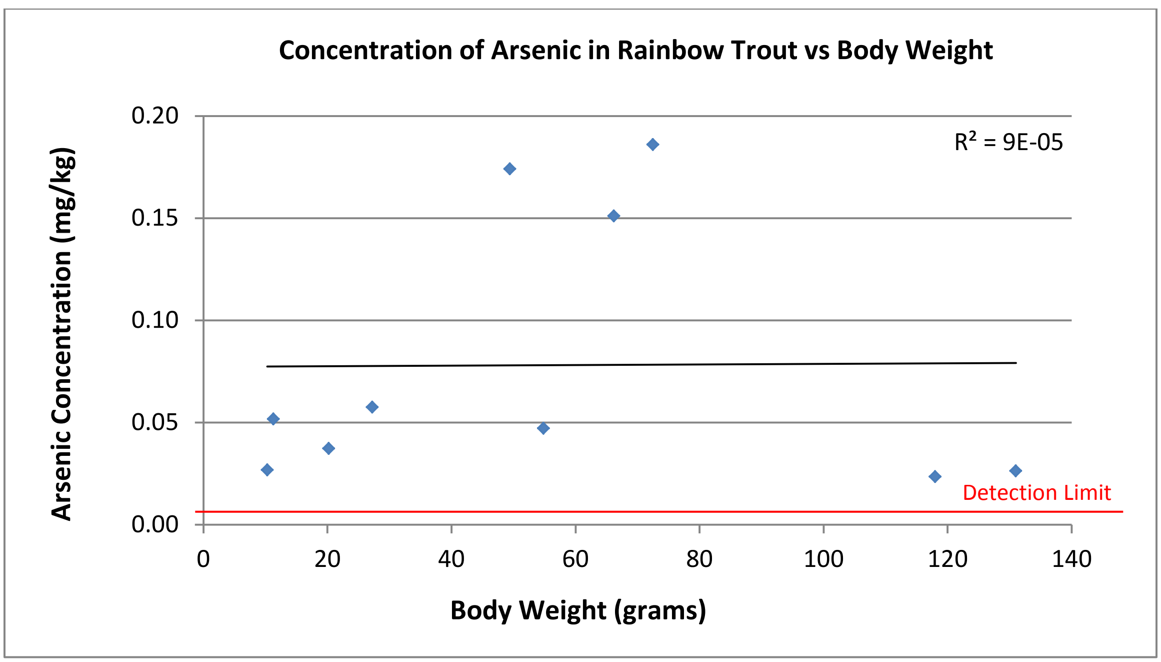


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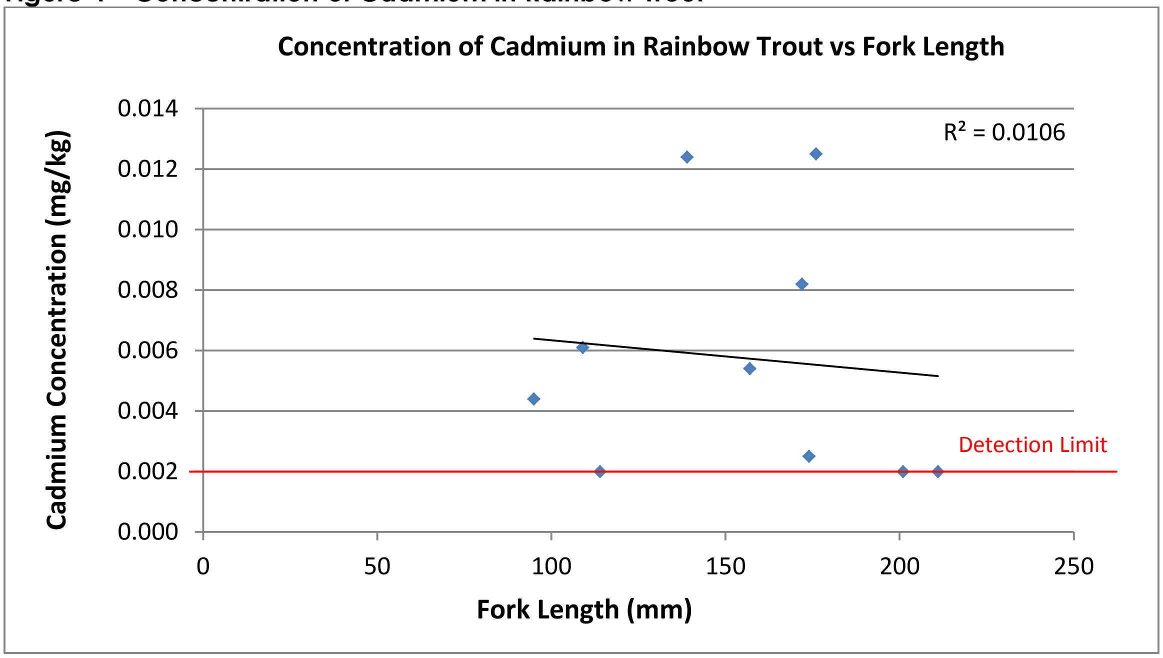
Figure 4 – Concentration of Cadmium in Rainbow Trout



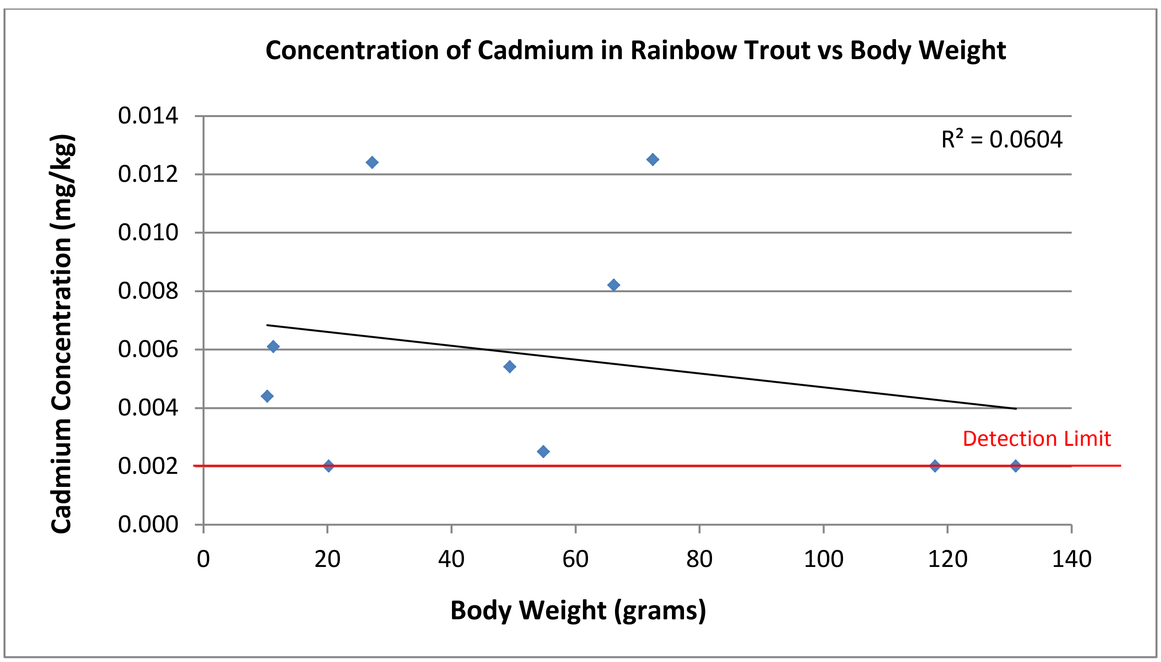


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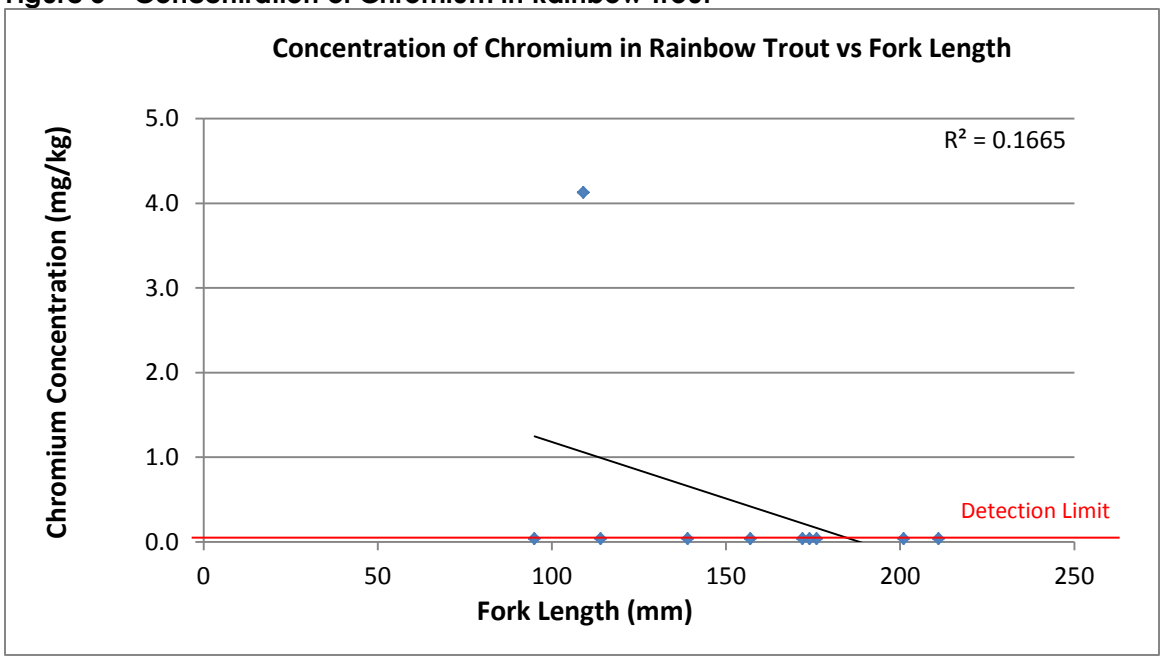
Figure 5 – Concentration of Chromium in Rainbow Trout



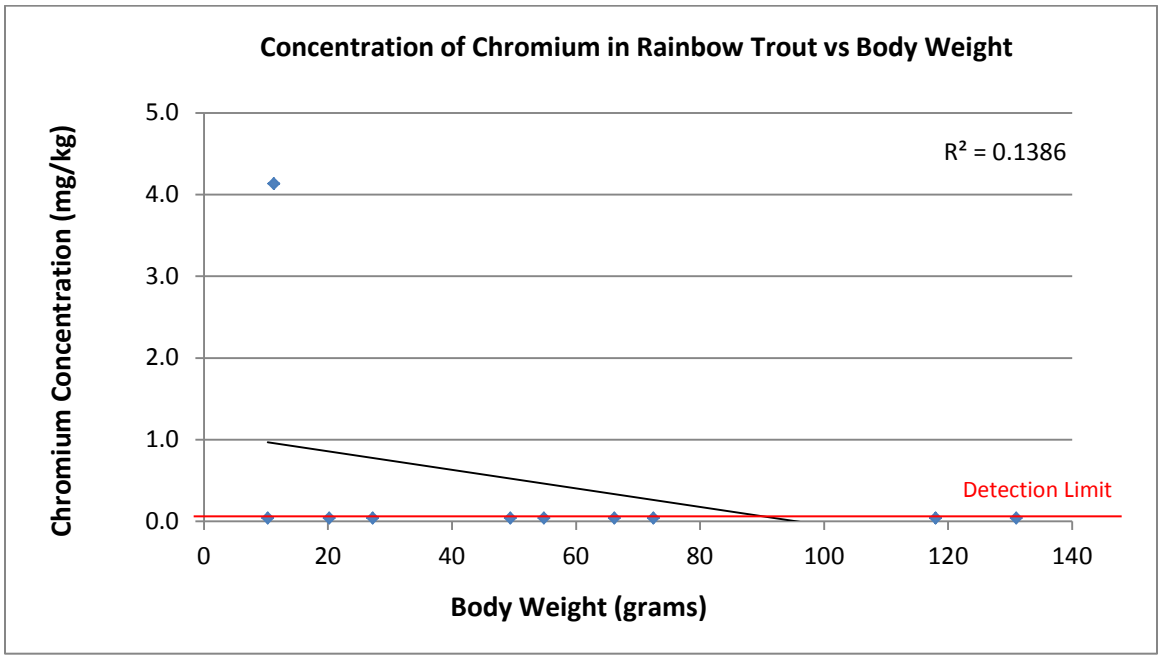


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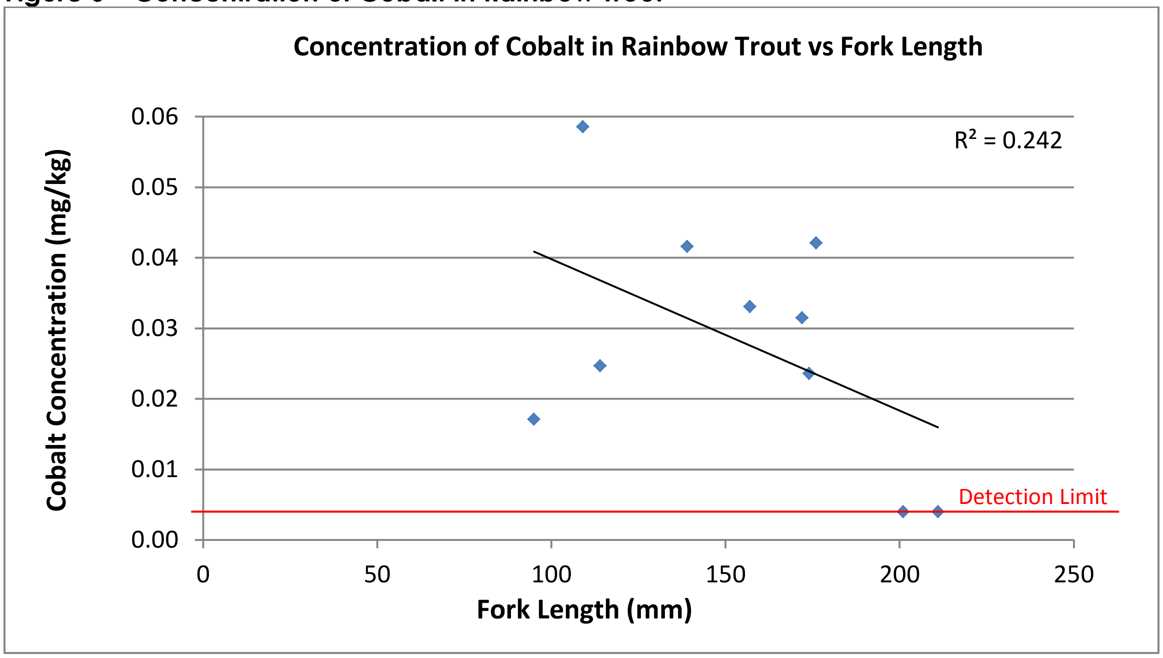
Figure 6 – Concentration of Cobalt in Rainbow Trout



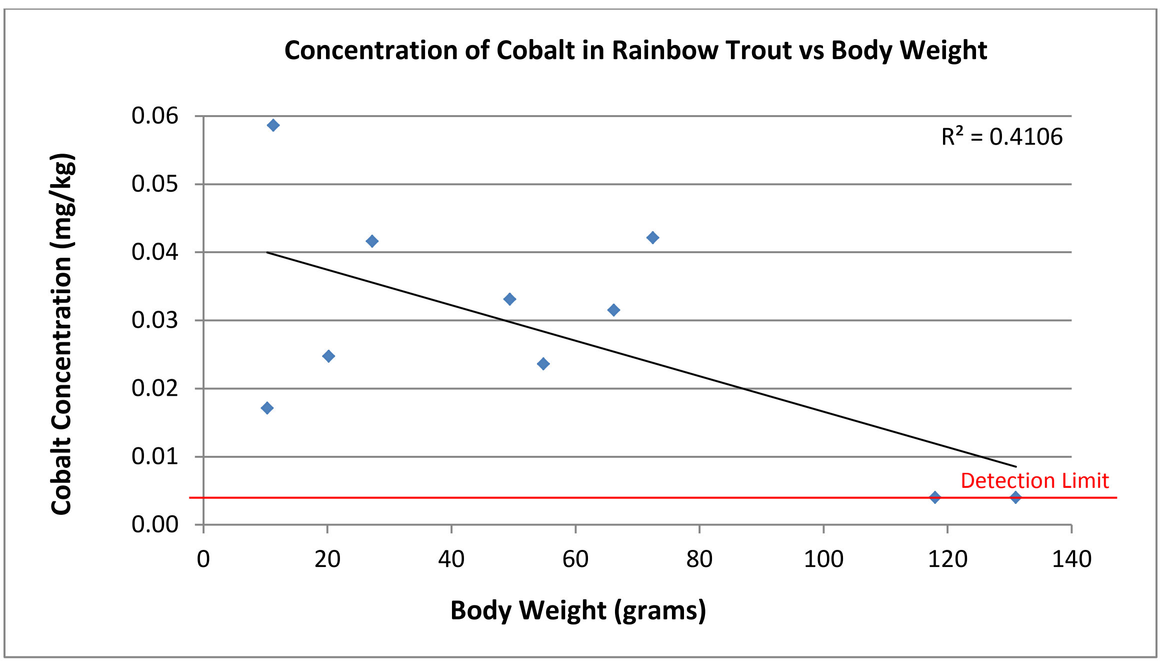


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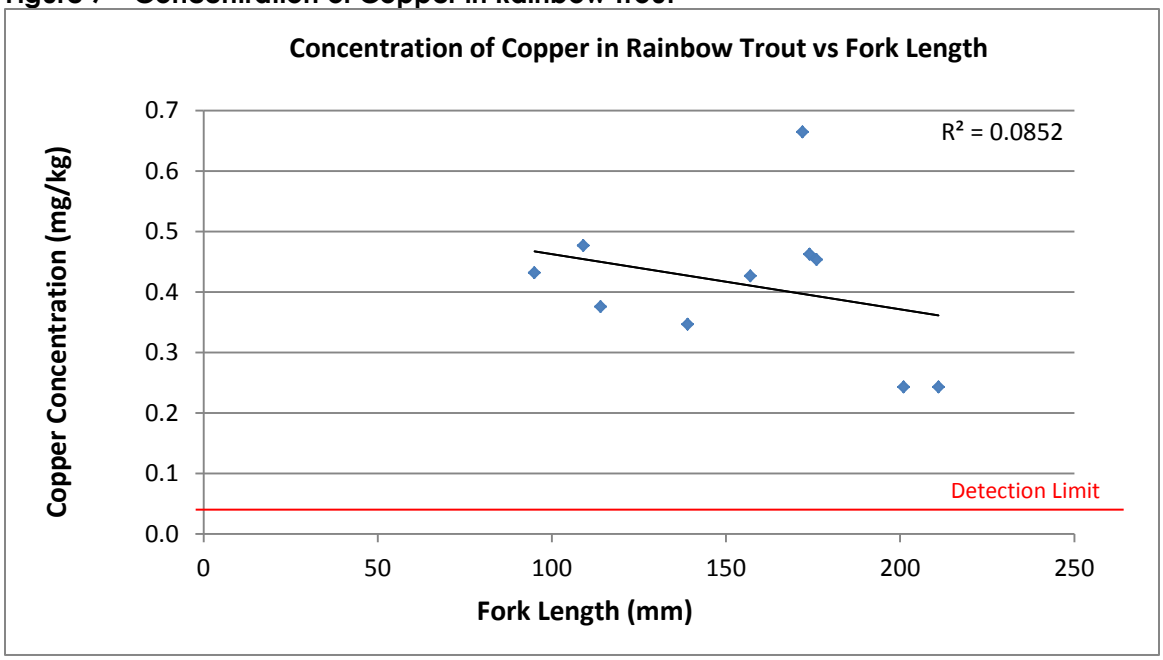
Figure 7 – Concentration of Copper in Rainbow Trout



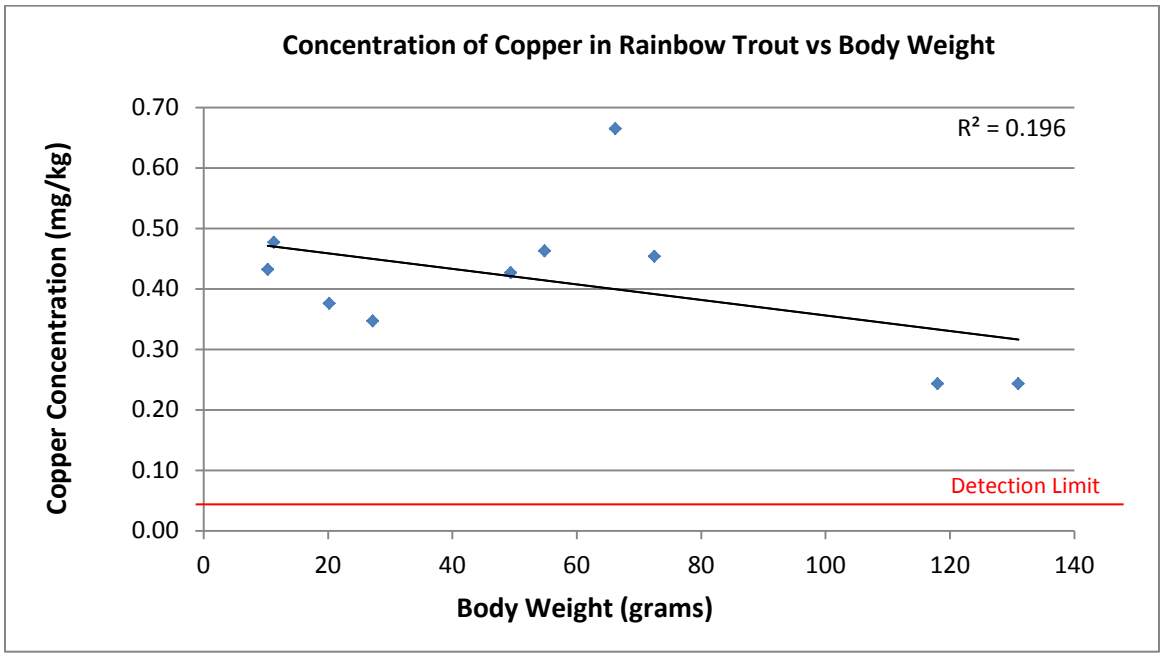


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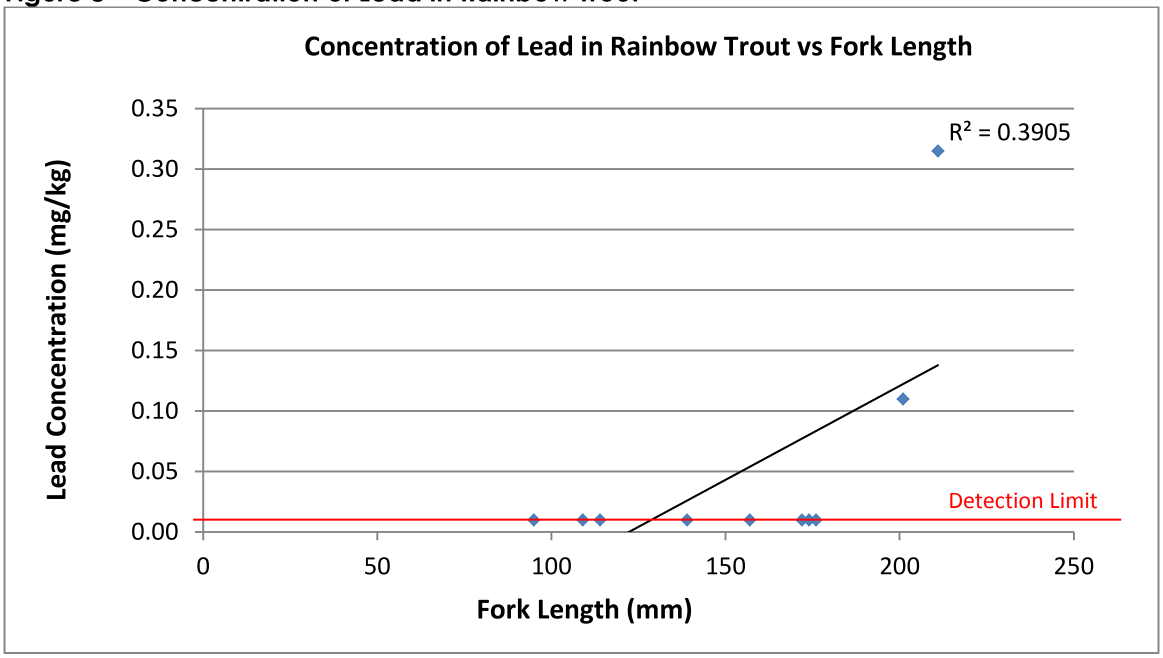
Figure 8 – Concentration of Lead in Rainbow Trout



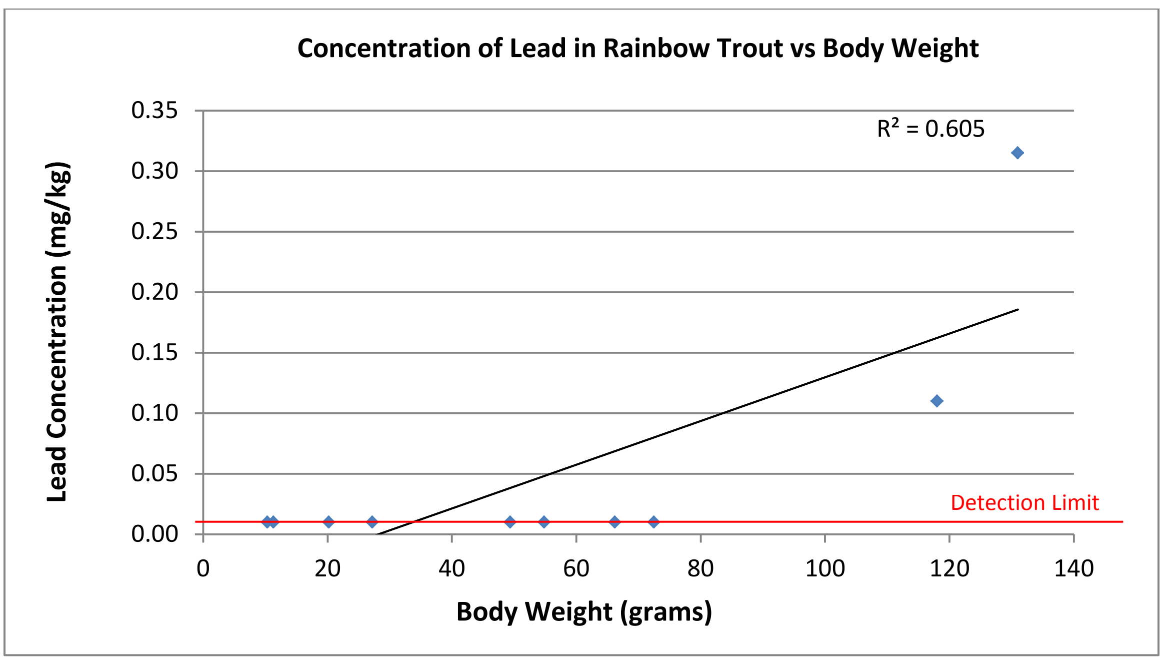


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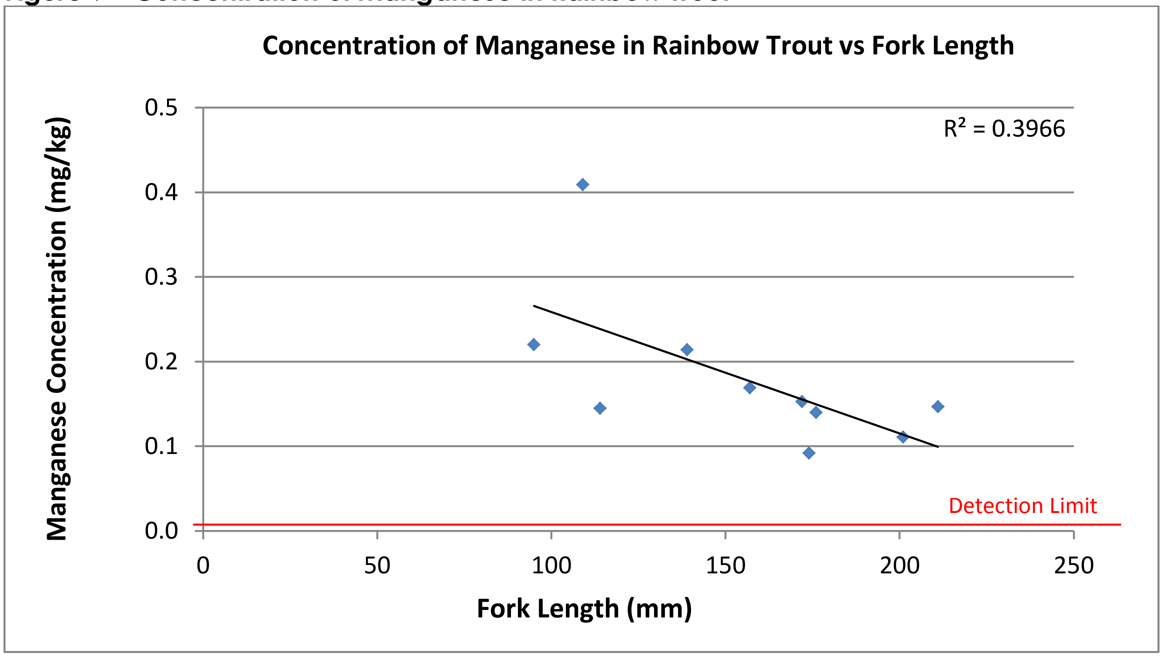
Figure 9 – Concentration of Manganese in Rainbow Trout



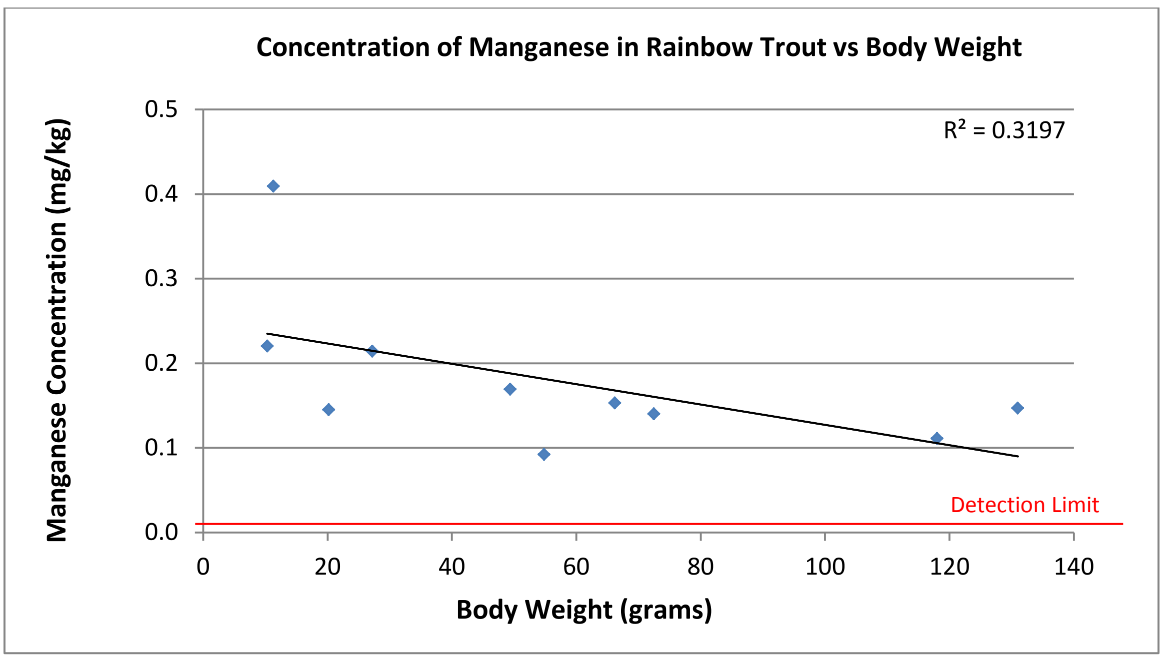


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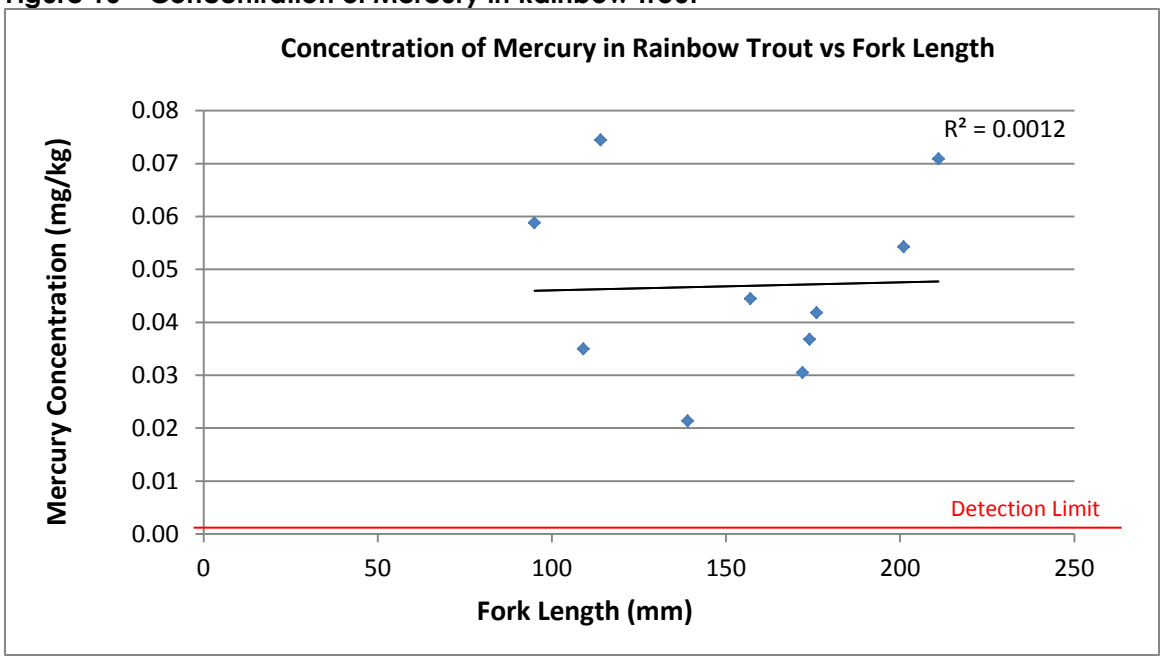
Figure 10 – Concentration of Mercury in Rainbow Trout



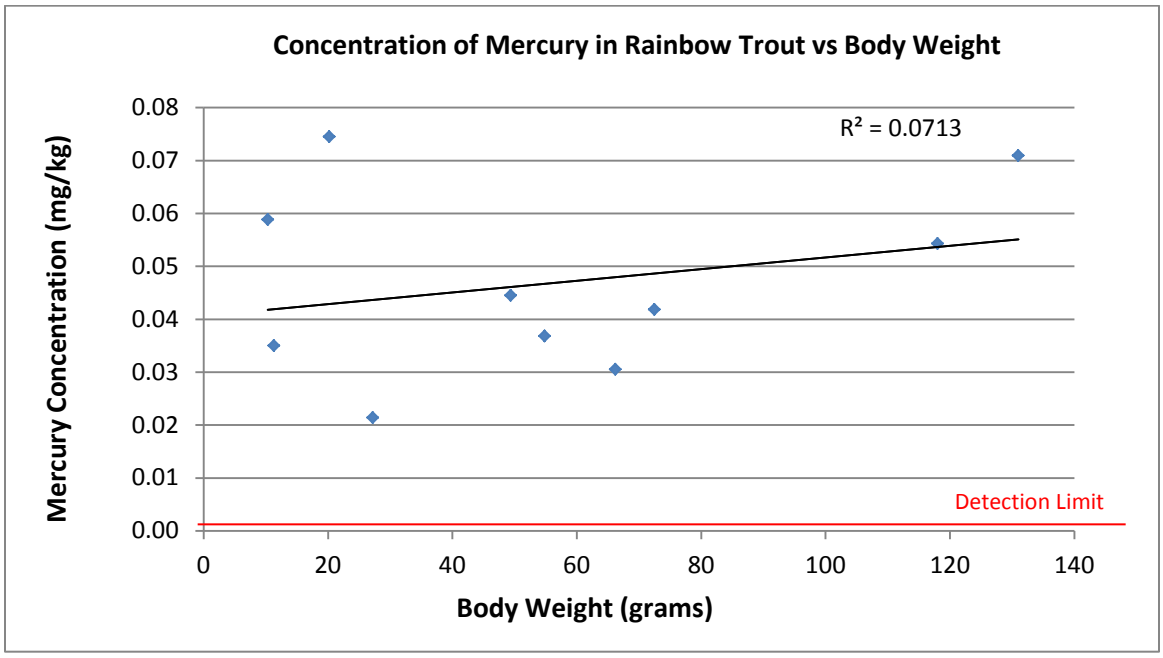


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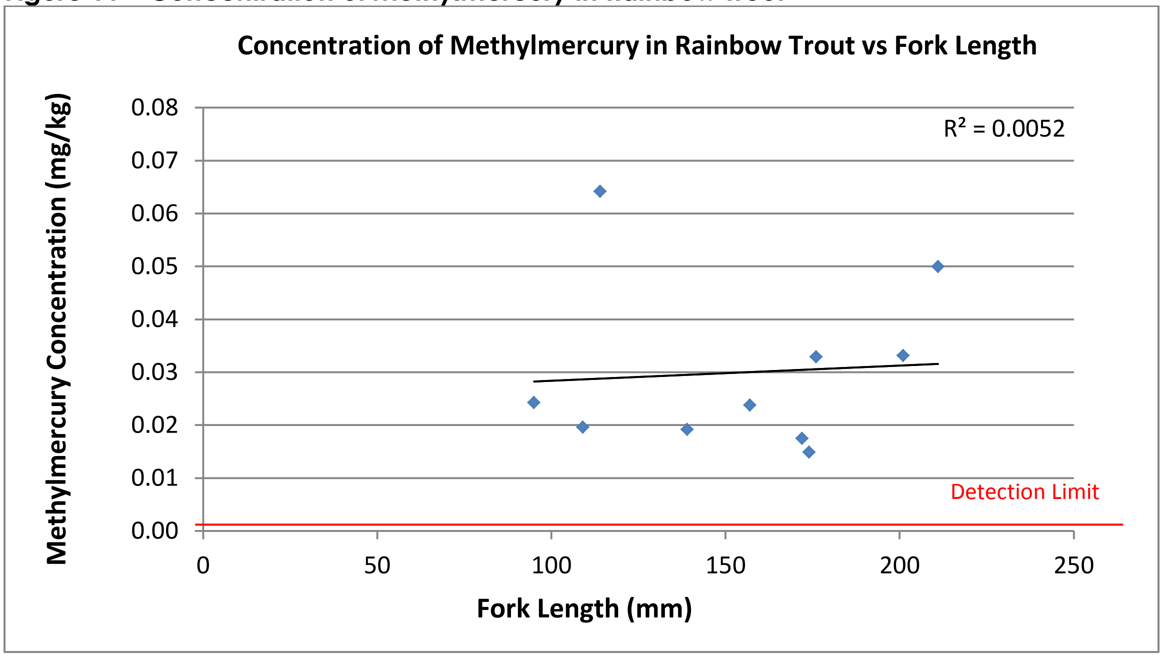
Figure 11 – Concentration of Methylmercury in Rainbow Trout



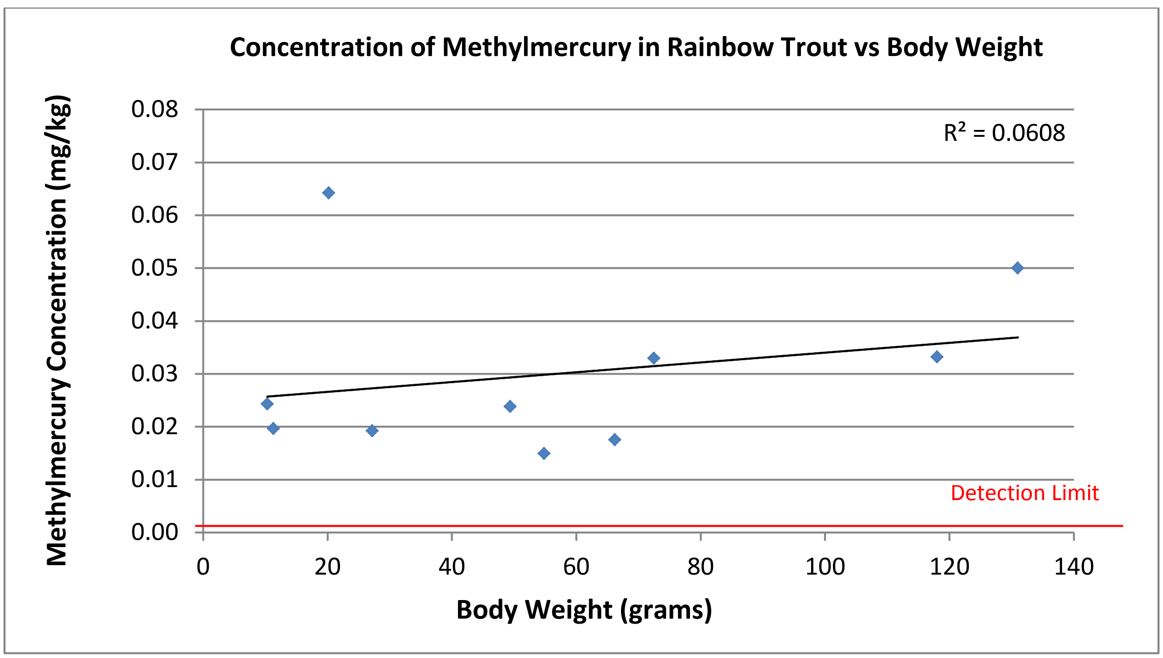


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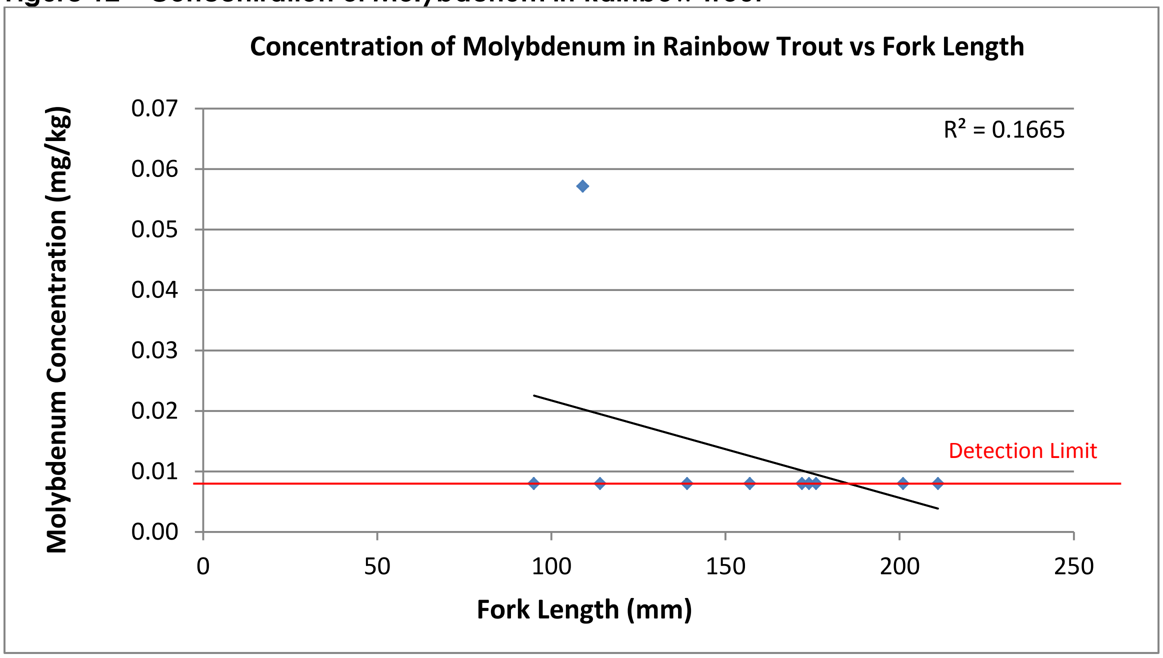
Figure 12 – Concentration of Molybdenum in Rainbow Trout



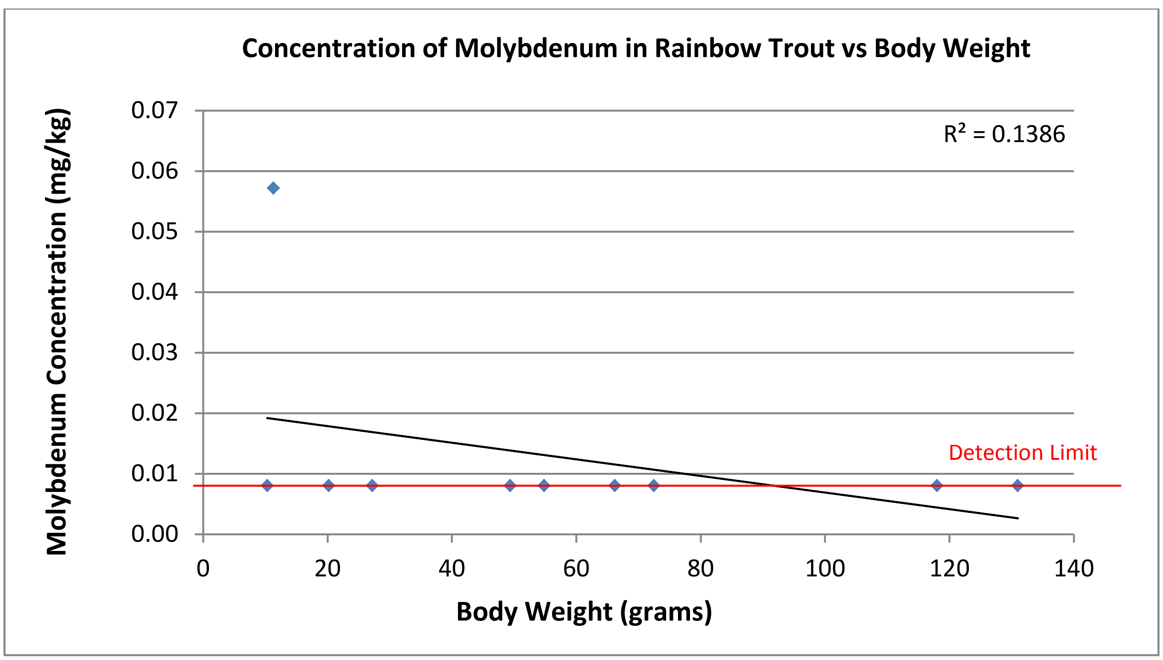


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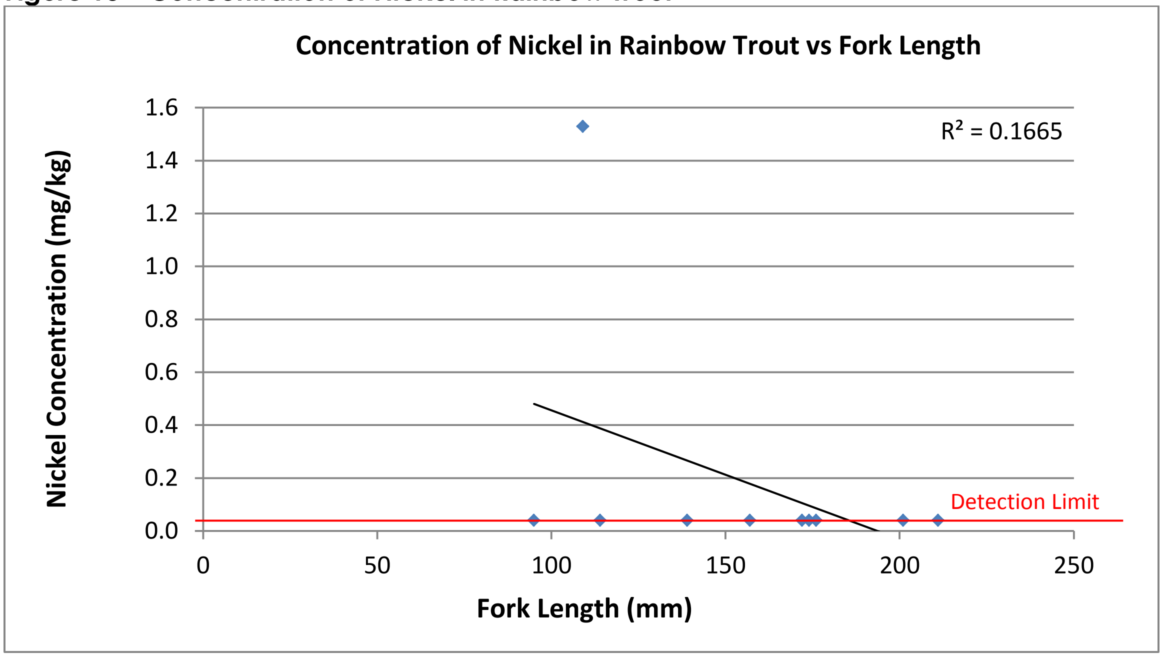
Figure 13 – Concentration of Nickel in Rainbow Trout



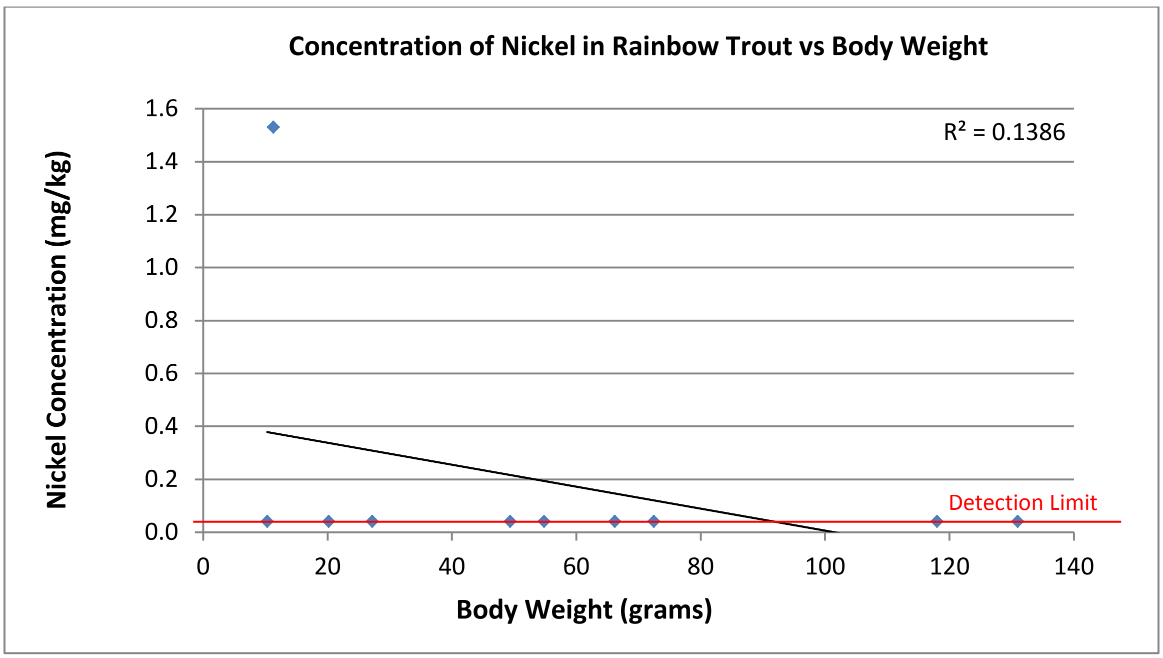


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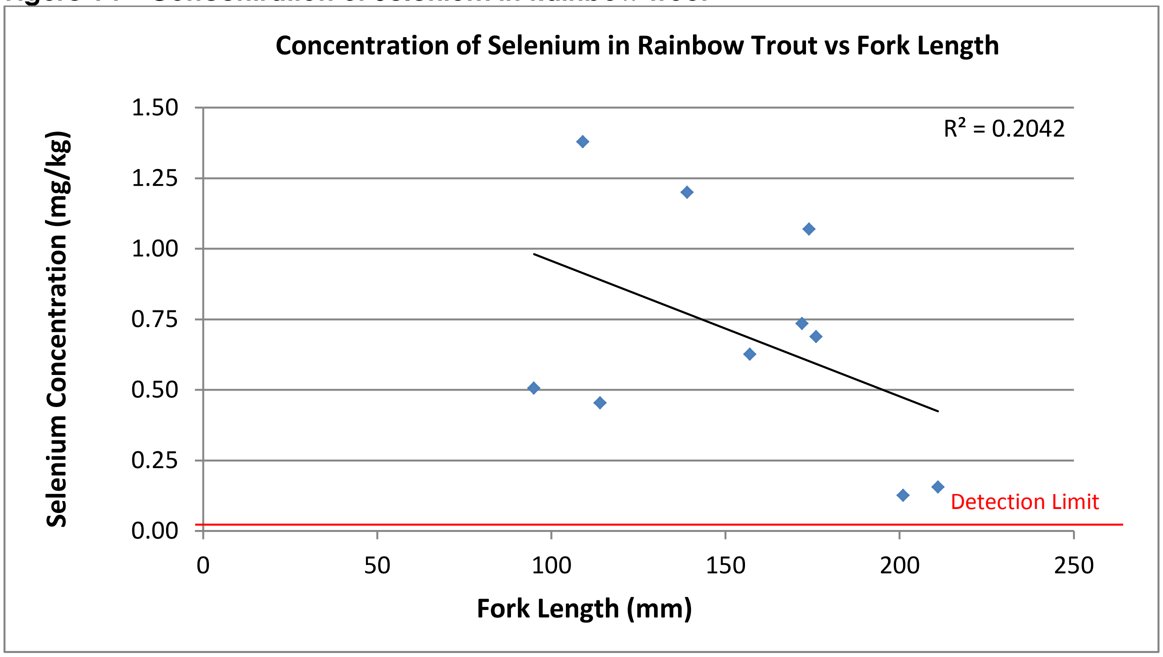
Figure 14 – Concentration of Selenium in Rainbow Trout



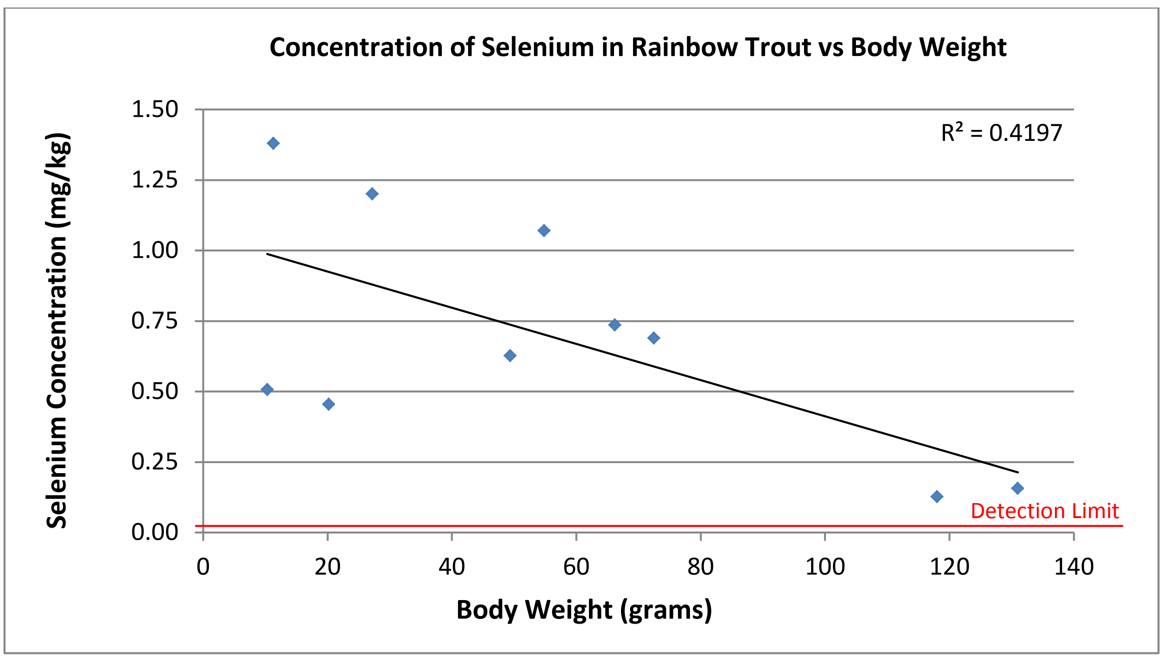


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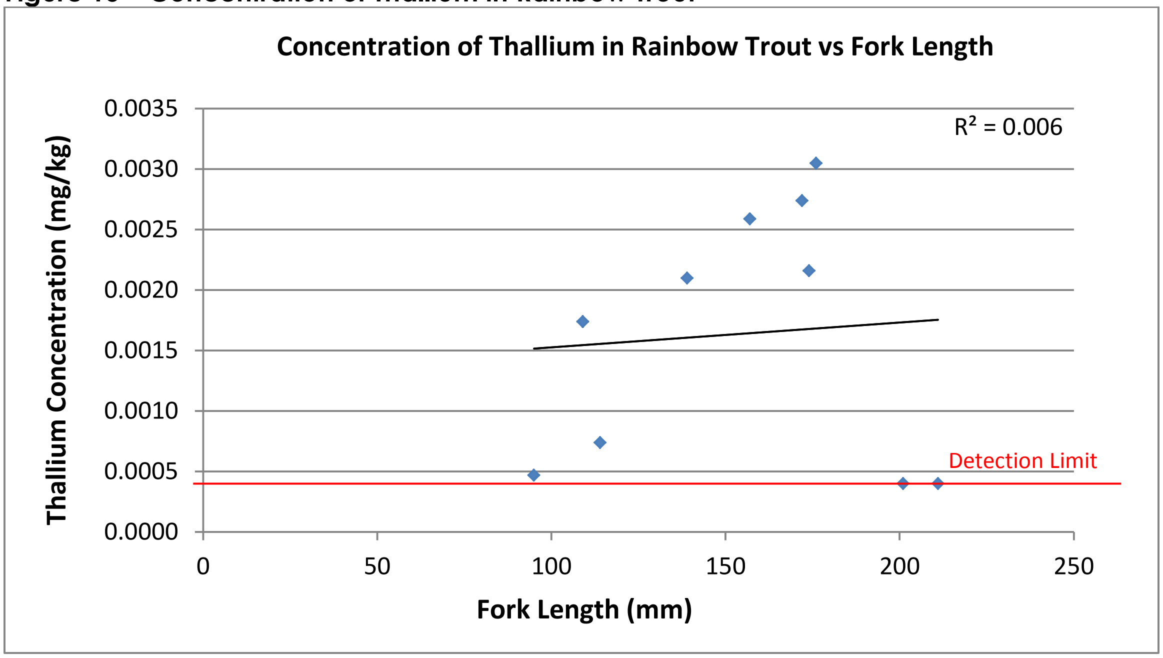
Figure 15 – Concentration of Thallium in Rainbow Trout



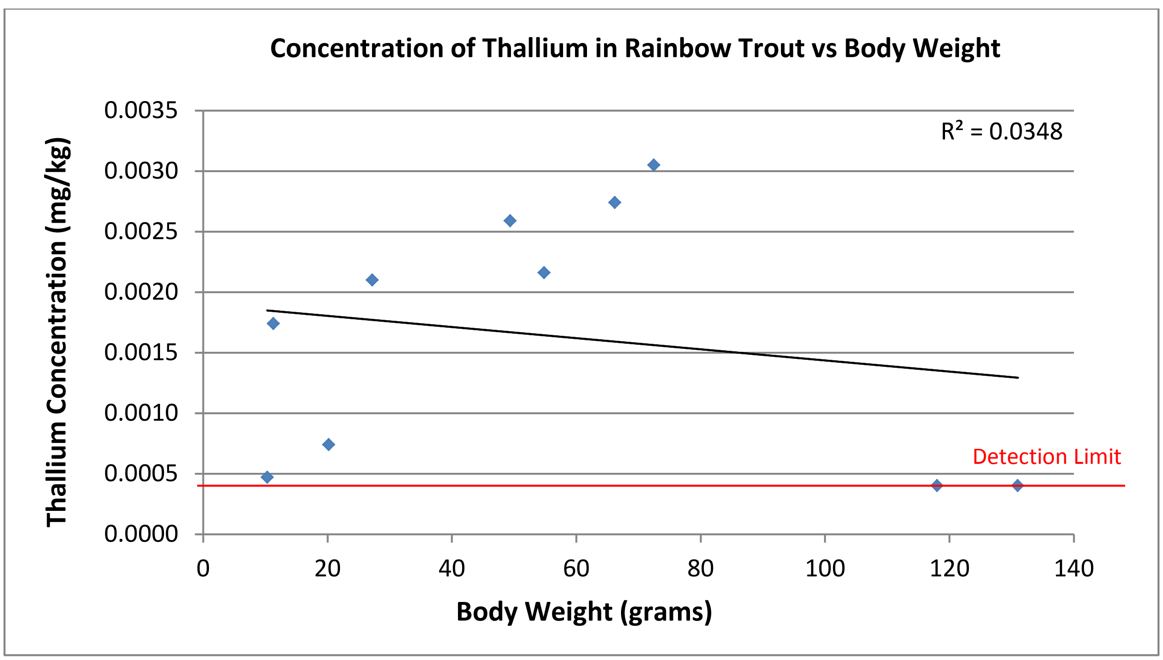


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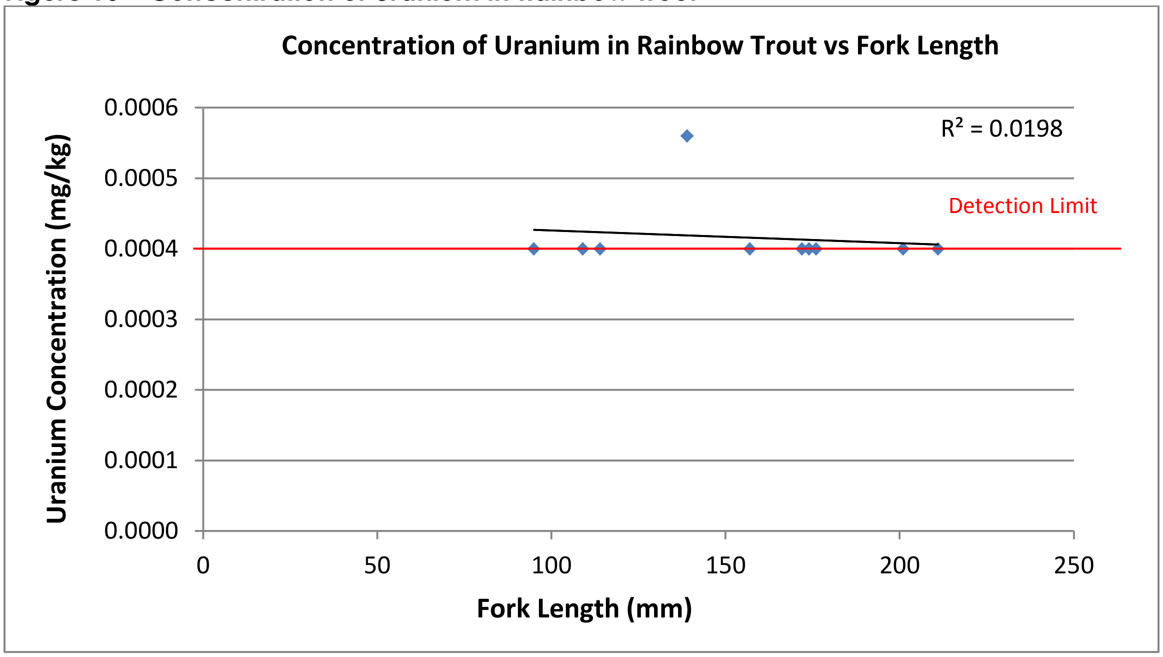
Figure 16 – Concentration of Uranium in Rainbow Trout



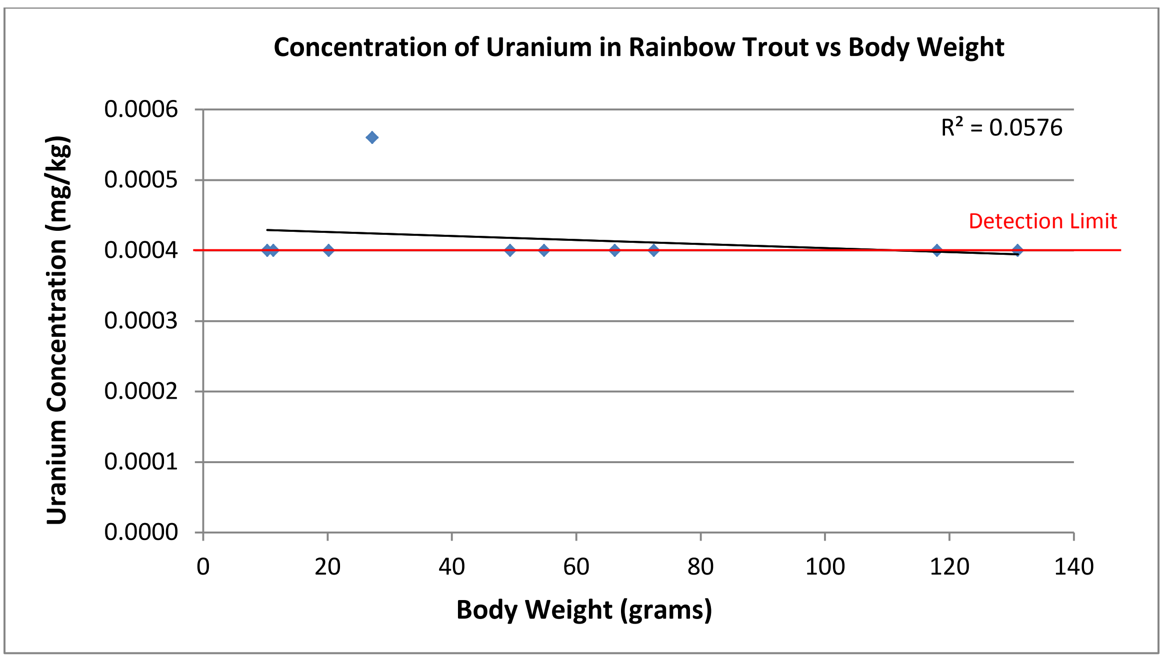


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Figure 17 – Concentration of Zinc in Rainbow Trout