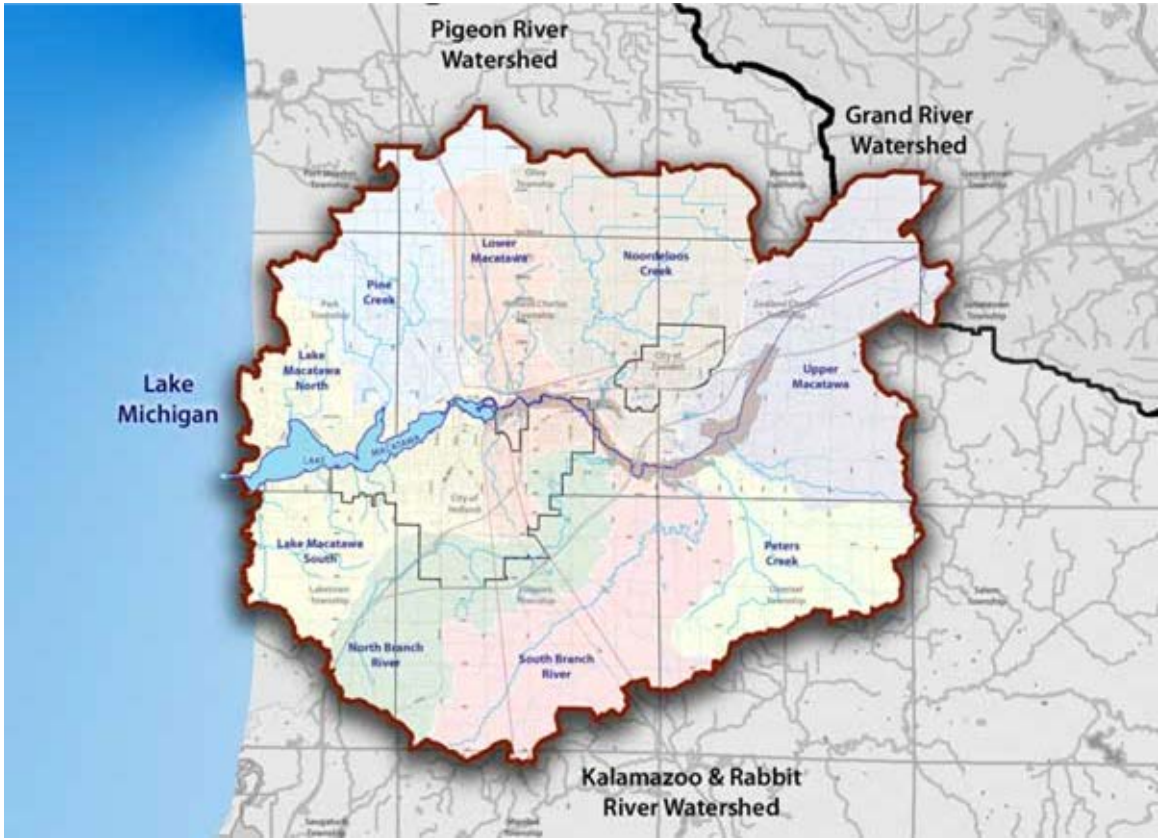
Bioaccumulation of heavy metals in channel catfish and yellow perch in the Lake Macatawa Watershed

By: Andrew Klein, Analise Sala, and Cleveland Tarp

Targeted Area Of Study

Lake Macatawa Watershed: 110,000 acres in Ottawa and Allegan Counties



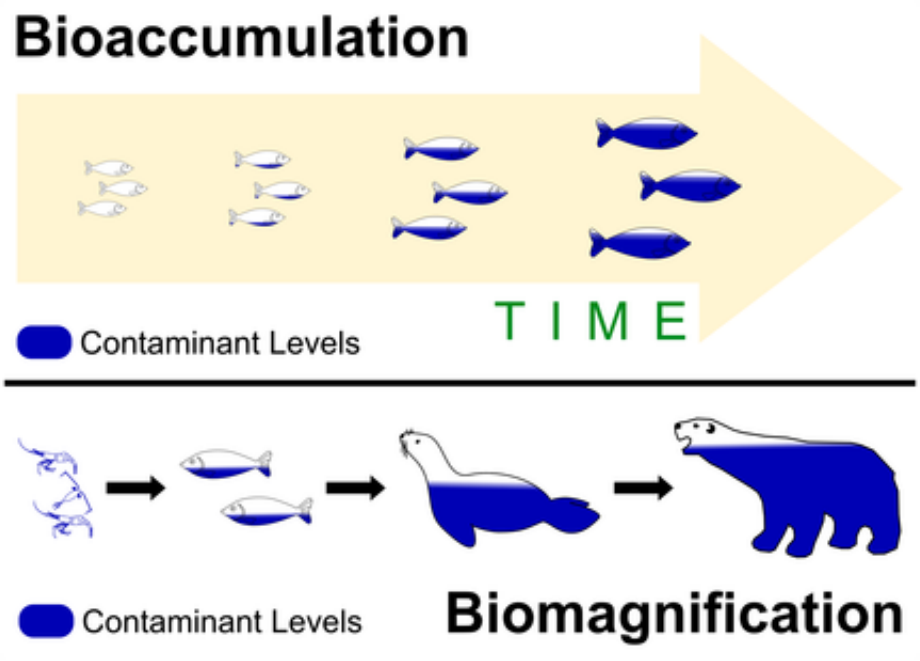
Source: https://outdoordiscovery.org/conservation/macatawa-greenway/macatawa-watershed/macatawa-watershed-map/

Targeted Species of Study

- Sample organisms: Channel Catfish (*Ictalurus punctatus*) and Yellow Perch (*Perca flavescens*)
- Relevance
  - Perch are the most frequently caught game fish in Michigan (DNR)
  - Little is known about bioaccumulation potential
  - Commonly consumed by humans
  - Ease of access
  - Perch remain active in winter months (DNR)

Source: https://nature.mdc.mo.gov/discover-nature/field-guide/channel-catfish

Source: http://www.iowadnr.gov/Fishing/Iowa-Fish-Species/Fish-Details/SpeciesCode/YEP



Source: https://newbreweress.weebly.com/aquatic-bioaccumulation.html

How Do Heavy Metals Enter Fish?

Are Heavy Metals Dangerous?

- Health implications
  - Disrupt functions of vital organs
  - Children and pregnant women are most susceptible
- The Lead and Copper Rule passed in 1991 designed to minimize general lead and copper intake
- World Health Organization/Food and Agriculture Organization (WHO/FAO) recommended heavy metal levels in fish (Afua and Tiimub, 2013):
  - Cd - 0.2 ppm
  - Pb - 1.0 ppm
  - Cu - 40 ppm
  - Fe - 43 ppm

	Cadmium (Cd)	Lead (Pb)	Iron (Fe)	Copper (Cu)
Possible anthropogenic sources	- Cadmium enters air from smelters, metal processing burners - Coal/oil burning (Fassett, 1975). - Agricultural runoff	- Antifouling marine paints (Johnsen and Engoy, 1999). - Agricultural runoff	- Coal burning - Production of iron and steel (Sullivan, 1969). - Agricultural runoff	- Burning of fossil fuels - Production of metal, appliances, pesticides, etc. (Kutlu and Seker, 2014). - Degradation of pipes -Agricultural runoff

West Michigan specific: Padnos Scrap Yard, Consumers Energy J.H. Campbell Generating Complex, James De Young Power Plant (closed)

Previous Studies and Experimentation

- Expansion of previous work by Hope College Student Researchers in 2013
  - “Bioaccumulation of Lead in *Neogobius melanstomus* (Round Goby) within Lake Macatawa”
    - Nick Blogin, Austin Krehel, and Kelly Krueger
  - Lead concentrations significantly higher near marinas

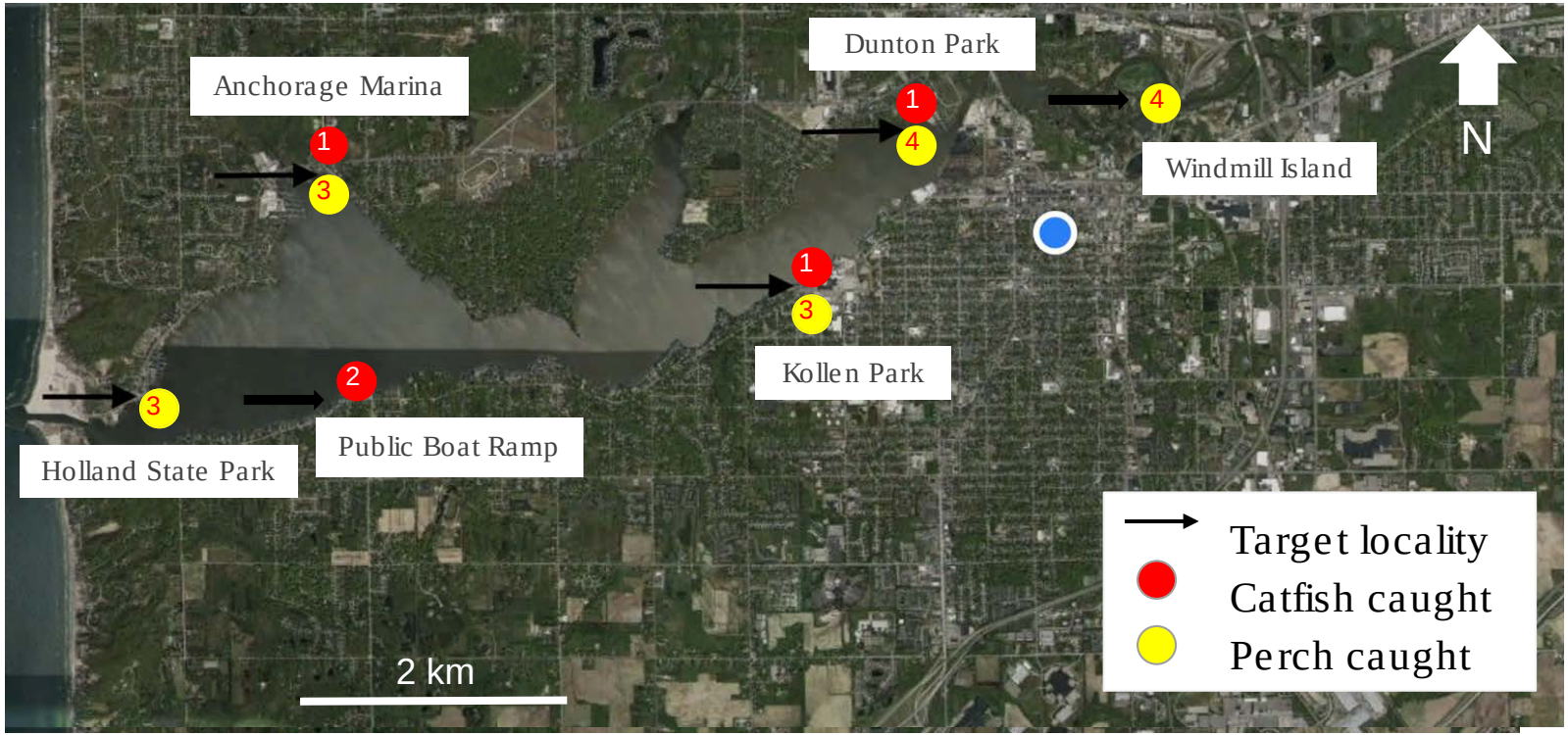
Source: http://www.eldean.com/Photo/index.htm

Project Goals

Source. http://www.fukuleaks.org/web/?p=11774

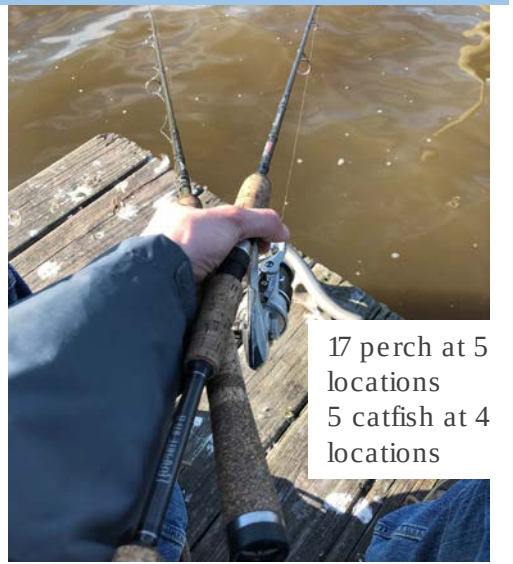
- To determine the *heavy metal concentrations* in commonly consumed fish species within the Lake Macatawa Watershed
- To better understand the *factors that contribute* to heavy metal levels in the local Holland community
- To *identify potential sources* of heavy metals in the surrounding region

Sites of Study



Methodology

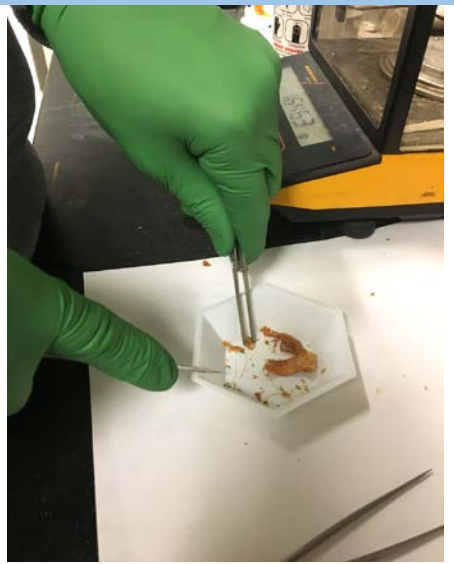
Fish caught, filleted, rinsed with RO water, and stored



17 perch at 5 locations
5 catfish at 4 locations

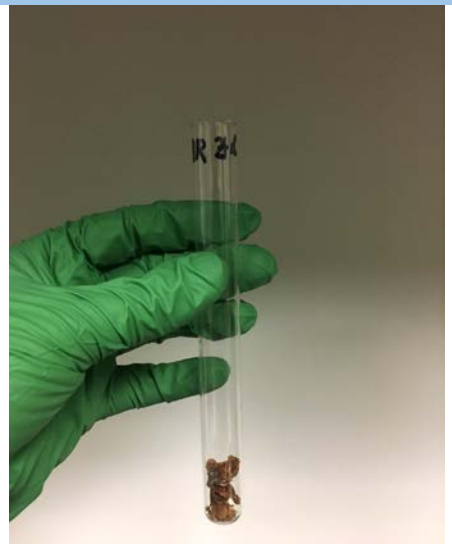
Fish tissue dried at 65℃ until consistent weight

1gram of each sample weighed for digestion



Methodology

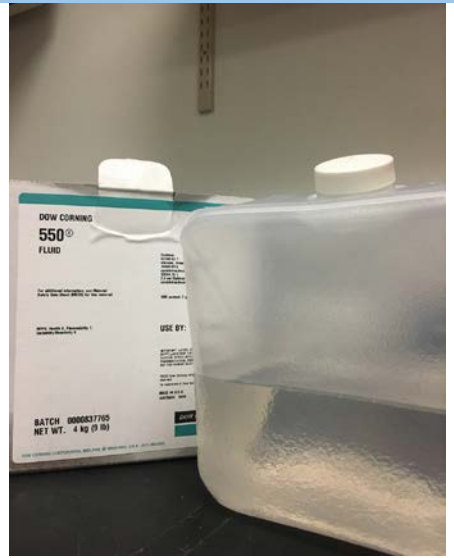
Each sample placed in labeled test tube



10 mL of concentrated 69% HNO^3 added to test tubes

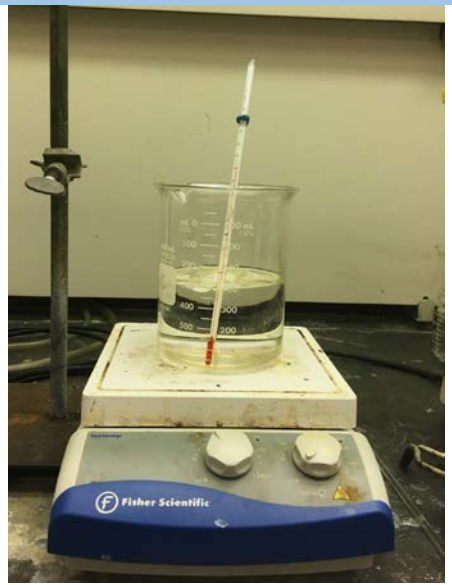
Source: https://www.mysafetylabels.com/chemic al-label/nitric-acid-nfpa-flammable-label/sku-lb-1591-093.aspx

440 mL of Dow Corning 550 mineral oil placed into 800 mL beakers

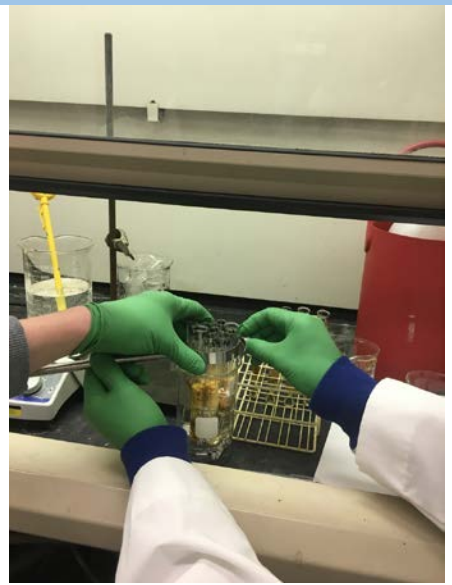


Methodology

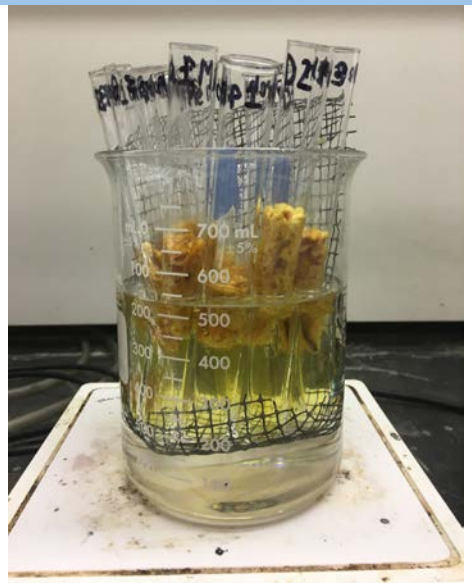
Stir bar placed in beakers and beakers placed on heat/stir plates



Test tubes put in beakers at 40℃ for 1 hour and gradually brought to boil



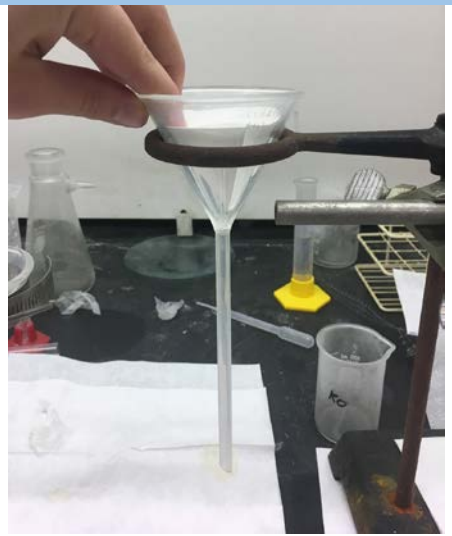
Tissue digested for 5 hours (stirring with glass rod) until fully dissolved



Methodology

Samples filtered using 0.45 micron syringe filters and diluted with 15 mL RO water

Diluted samples filtered with Whatman No. 1 grade filter paper



Standards produced and samples analyzed using AAS

Results

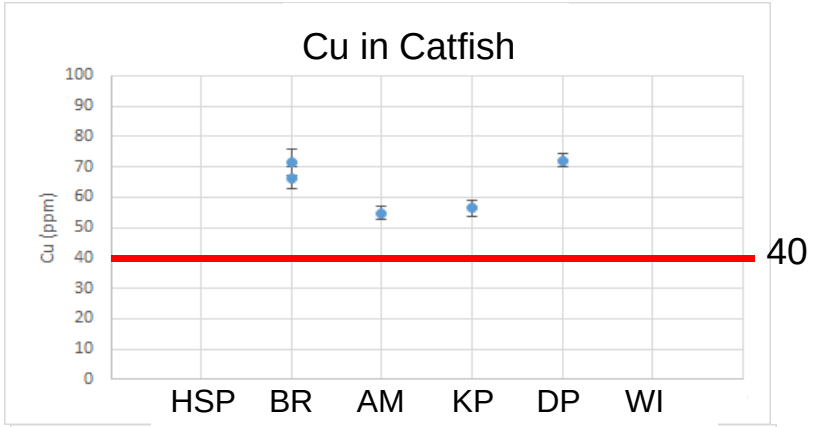
1. Average Concentration of Cu, Pb, Cd, and Fe in each fish
2. Comparison Between Findings and WHO/FAO Recommended Levels
3. Relationship between heavy metal concentration and:
    a. Sample location
    b. Fish species

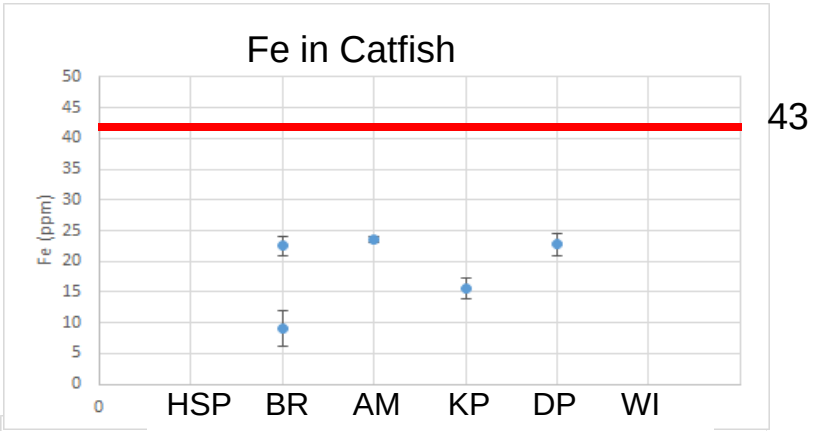
Average Concentration of Heavy Metals

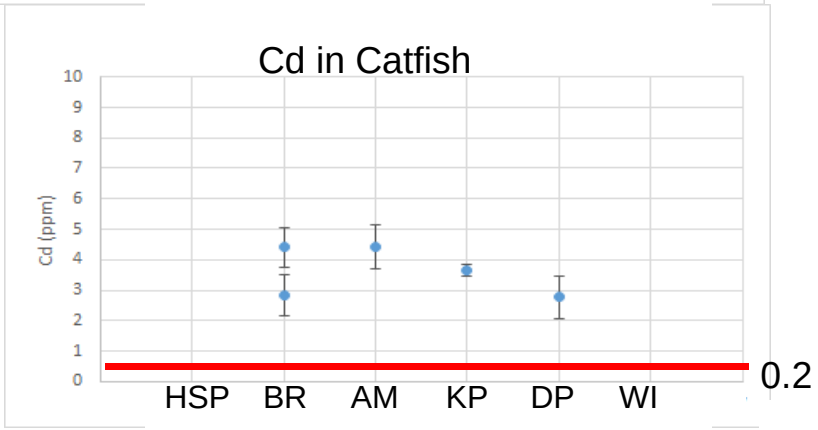
Analyte	WHO/FAO Recommended (ppm)	Catfish Average Concentration (ppm)	Perch Average Concentration (ppm)
Pb	1.0	2.97 *102 (SD)*	15.28 *9.42 (SD,*
Cd	0.2	4.06 *0.77 (SD)*	4.59 *0.85 (SD,*
Cu	40	64.19 *7.98 (SD)*	55.33 *4.89 (SD)*
Fe	43	21.94 *6.08 (SD)*	10.79 *7.13 (SD)*

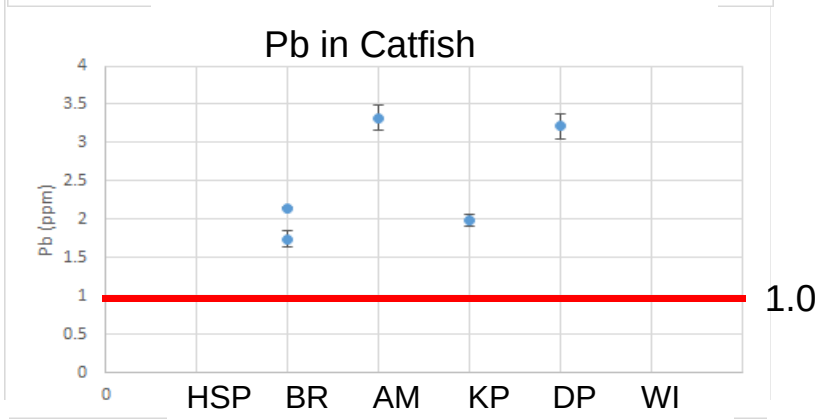
(Tiimub & Dzifa Afua, 2013)

Heavy Metals in Catfish with Respect to Location

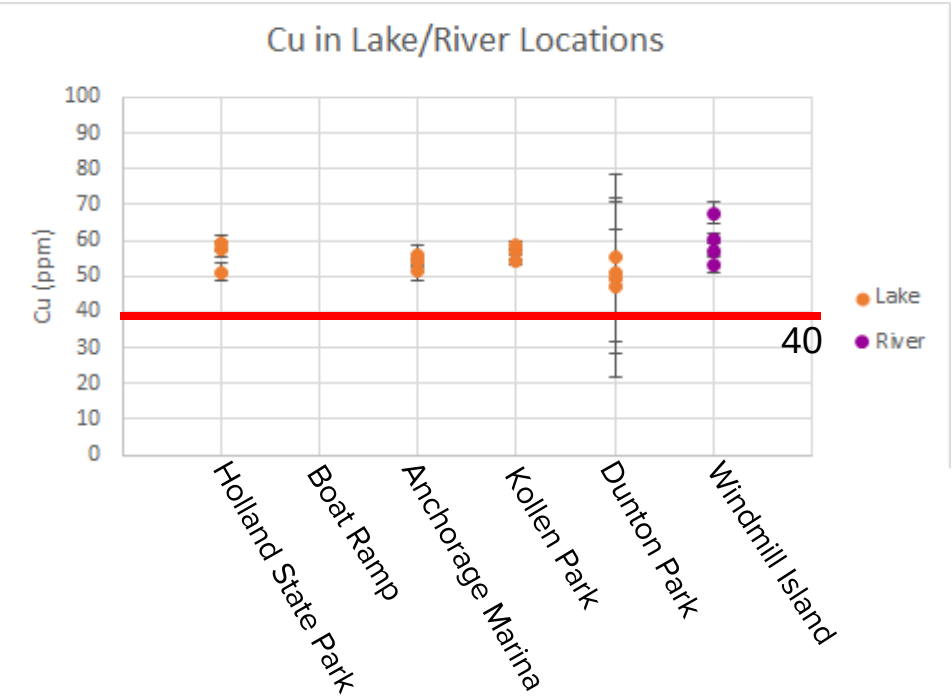


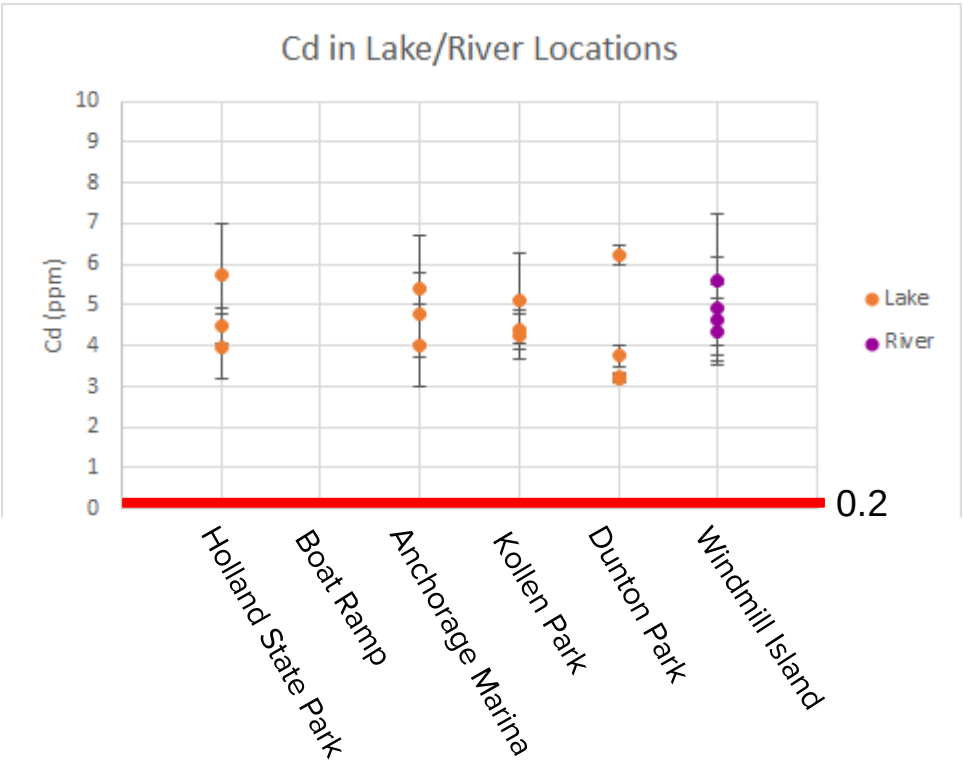




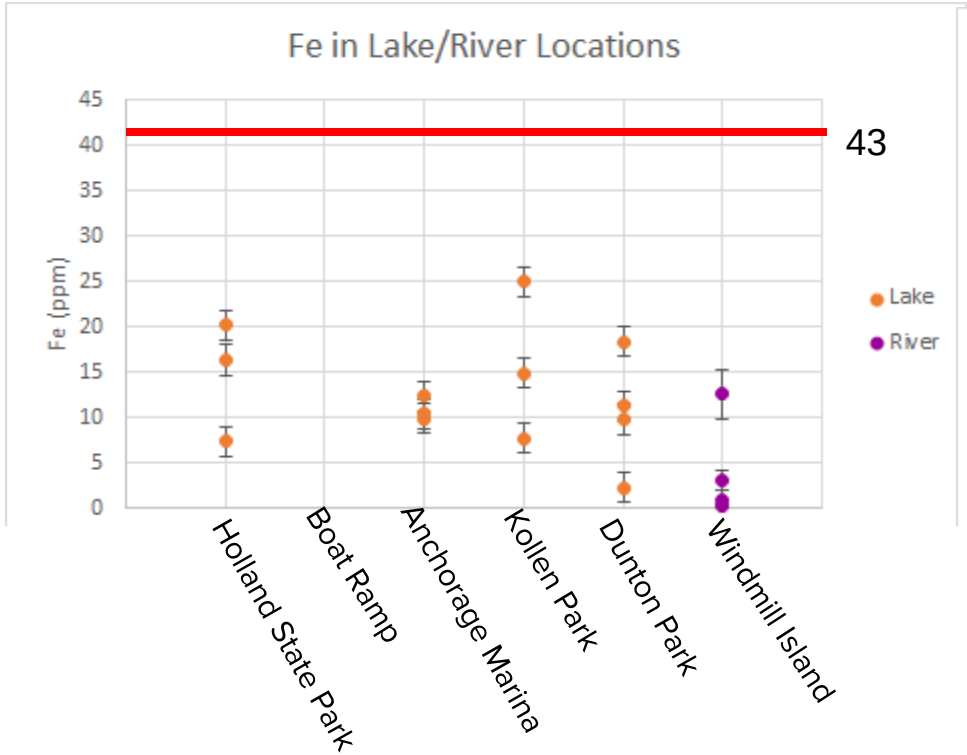


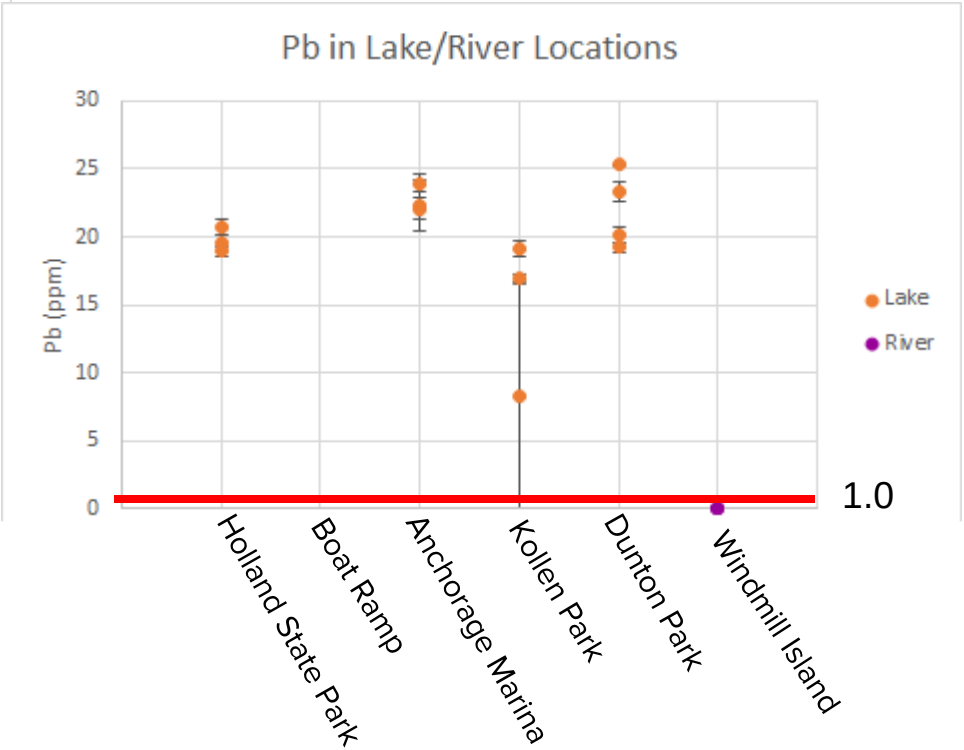
Cu/Cd in Perch with Respect to Location





Fe/Pb in Perch with Respect to Location





Conclusions and Future Work

- Pb, Cd, Cu or Fe were present in all samples
- Pb, Cd, and Cu exceeded the WHO/FAO recommended levels
- Pb and Fe concentrations were lowest in Windmill Island perch
- Obtain a larger sample size
- Analyze sediments and water samples

Acknowledgements

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- Hope College Geology and Environmental Sciences Department
- Hope College Chemistry Department
- Previous student researchers: Nick Blogin, Austin Krehel, and Kelly Krueger

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Questions?