

# Evaluation of the Hazard of Microcystis Blooms for Human Health through Fish Consumption

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## Overview

Human exposure to the cyanobacterial toxin *Microcystin* occurs through drinking water and recreational contact in waters with *Microcystis* blooms, but dietary exposure may be another route not widely investigated. *Microcystin*, a hepatotoxin, has been documented to accumulate in the livers of many animals. In Great Lakes recreational fish such as yellow perch and bluegill, it is unknown how much toxin is present in edible muscle tissues. The main goal of this project is to address the potential for human exposure to cyanobacterial toxins by measuring *Microcystins* levels in wild-caught fish. A secondary goal is to conduct laboratory experiments to investigate the kinetics of toxin accumulation in fish tissue. The rate at which a fish accumulates and eliminates *Microcystin* determines what period during and after a bloom it could potentially be a route by which humans would ingest this toxin.



## Objective

- Increase number of regional coastal and marine ecosystems delineated with approved indicators of ecological health and socioeconomic benefits that are monitored and understood.
- Determine timing for uptake and depuration of algal toxin *Microcystin* in the tissues of recreationally-important fish
- The ultimate goal is to forecast whether the amount of *Microcystin* that accumulates in fish tissue during a *Microcystis* bloom will be harmful to human health.

## Proposed Work

### *Microcystin* Toxicokinetics Experiments

Past experimentation of dosing perch with known amount of *Microcystin* and measuring the amount in tissues will be repeated, narrowing our time frame on the 24 hour window and increasing the number of fish per treatment. We will again use young yellow perch that have been farm-raised. We will also dose the perch with a range of *Microcystin* concentrations to determine if the depuration and accumulation rates are constant. *Microcystin* concentrations in the perch liver and muscle will be measured both by ELISA (the standard technique used for the summer 2007 samples) as well as by the protein phosphatase inhibition assay. This second assay measures phosphatase enzyme depletion, which will be affected by both bound and unbound *Microcystin*, thus providing some measure of the unextractable, presumably less hazardous form.



We sampled fish monthly of edible size in Muskegon Lake throughout the summer of 2007. *Microcystin* concentrations were measured in the liver and muscle tissue of these fish, and in samples collected monthly from the benthos and water column. There was a very significant bloom in Muskegon Lake in the summer of 2007, with *Microcystin* concentration in scums as high as 900 µg/L (the recreational limit being 20 µg/L). We have processed most of the samples from this summer and found significant concentrations of *Microcystin* in fish liver and measurable concentrations in fish tissue. The data suggests that even when there are high water column *Microcystin* concentrations, the amount of *Microcystin* in fish tissues is not a human health threat.

### Accomplishments

- We conducted two laboratory experiments in the summer 2007, dosing yellow perch with a known amount of *Microcystin* and monitoring the uptake into the liver and muscle tissues over a 12 day period. Concentrations of soluble *Microcystin* in the tissues peaked at 8 hours and decreased to near-initial values by 48 hours. *Microcystin* concentrations in the tank water were also measured in order to get a rough mass balance of the fate of *Microcystin* in the fish. *Microcystin* concentrations in the fish tissue, feces and tank water only accounted for about 7% of the amount dosed, suggested that a very large fraction of *Microcystin* remains in the fish in a bound, unextractable form.

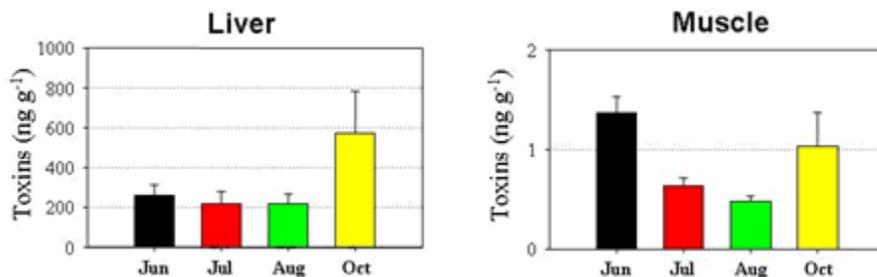
This has also been documented in other studies (Adamovsky et. al 2007). This data is interesting both in the timing of uptake and the large amount of *Microcystin* that is not detected using standard extraction methodology.

- Data from summer 2006 and 2007 suggests *Microcystin* concentrations in fish livers could be a human health risk, but *Microcystin* concentrations in the muscle tissue of fish of edible size are not high enough to be an acute threat to human health.
- Experiment conducted summer 2007 showed that peak toxin concentrations in perch liver and muscle was 8 hrs after exposure and decreased rapidly by 12 hrs

## Scientific Rationale

Blooms of *Microcystis* are increasingly prevalent in western Lake Erie and many smaller inland lakes (Murphy et al 2003). The production of hepatotoxin *Microcystin* (toxin) may have significant impacts on animal and human health. In mammals, *Microcystin* inhibits serine/threonine protein phosphatases (Dawson 1998) which causes disintegration of the liver structure, liver necrosis, and internal hemorrhage in the liver that can lead to death (Dow and Swoboda 2000). Most human exposure occurs through contact with contaminated drinking water and inhalation/ingestion of *Microcystin* in aquatic recreation.

There is circumstantial evidence of exposure and toxicity to humans consuming contaminated fish (Dawson 1998) and measured concentrations in fish tissues that would exceed acceptable daily intake levels (de Magalhaes et al. 2001, 2003). For an average individual (weighing 60 kg), this would correlate to a fish *Microcystin* concentration of 12.3 ng g<sup>-1</sup> based on the current WHO value of 0.04 µg kg<sup>-1</sup>d<sup>-1</sup> and a fish meal corresponding to ½ pound fresh fish. However, after reviewing data from Heinze (1999), EPA lower the recommended limit for chronic exposure to 0.003 µg kg<sup>-1</sup>d<sup>-1</sup>. This would correspond to a fish *Microcystin* concentration of 0.92 ng g<sup>-1</sup>, given the same constraints as above. To better estimate the levels of concern for communities who eat large quantities of fish, we used the Washington State Fish (Keill and Kissinger 1999) consumption data for native peoples. The median consumption of fish for these communities is 43 g d<sup>-1</sup>, which would correspond to a maximum recommended fish *Microcystin* concentration of 4.9 ng g<sup>-1</sup>. However, most (90%) of the people in these communities eat up to 127 g d<sup>-1</sup>, in which case fish *Microcystin* concentrations of less than 1.65 ng g<sup>-1</sup> are necessary to prevent potential human illness. Thus, the potential of fish in the Great Lakes to serve as a source of contamination to humans should be evaluated.



**Figure 1:** Monthly averages (Jun-Oct 2006) of *Microcystin* concentrations in yellow perch from western Lake Erie (from presentation by Wilson)

The focus of most of the research of algal toxins on fish has been in tissue accumulation as a mode of human exposure, but the toxicokinetics of *Microcystin* accumulation in fish have not yet been established. An inherent difficulty in trying to correlate *Microcystin* concentrations in fish tissue to exposure is that the mobility of fish allows them to spend time in and out of *Microcystis* blooms. While measurements of *Microcystin* concentrations in field-collected fish are useful in identifying whether this is a potential route for human exposure, it reveals less about the mechanism of accumulation. Understanding the rates of *Microcystin* uptake, transfer efficiency into the tissues and depuration rates are essential to predicting potential human health impacts through fish consumption following a *Microcystis* bloom.

### **Governmental/Societal Relevance**

The presence of *Microcystis* in the Great Lakes since the invasion of the zebra mussel has been well documented. The WHO has set standards for human health for both drinking water and recreation and the concentration for daily consumption. The concentrations in water exceed the WHO standards but the information on the consumption route through fish remains unknown. This work will help establish whether or not this route must also be considered for protection of human health in the Great Lakes.

### **Relevance to Ecosystem Forecasting**

Predicting the risk to human health depends on establishing exposure conditions that occur in the environment. Specific predictions of the potential for human health effects from *Microcystin* depend on forecasting the extent of harmful algal blooms. Predictions also depend on the development of the relationship between the extent of the bloom and the exposure to fish, and the link between exposure concentrations and the accumulation of the toxin in the edible tissue of fish. While predictions can then be made based on the WHO limits for chronic ingestion of *Microcystin*, additional development of the specific factors such as ingestion rates for the local population and the toxicokinetics of *Microcystin* in fish would lead to a more sound exposure scenario. This project is the first step in developing a risk assessment prediction by developing the link between the concentrations in the ecosystem and those in consumable parts of the food web. Once we establish that sufficient concentrations of *Microcystin* can be found in fish, we can establish the relationship between exposure to *Microcystis* and fish tissue concentrations.

### **Products**

#### **Presentations**

Dyble, J., Fahnenstiel G., Millie, D., and Gossiaux, D. 2007. Integrating Environment and Human Health, National Council for Science and the Environment 7th annual conference. *The impacts of Harmful Algal Blooms on human health in the Great Lakes*, 1-2 Feb 07, Washington, DC

Dyble, J., Fahnenstiel G., Millie, D., and Gossiaux, DOHH Annual Meeting, *Current successes, challenges, and going forward at the Center of Excellence for Great Lakes and Human Health* 25 March 2007, WHOI.

Landrum, P.F. and D.C. Gossiaux. *Evaluation of the hazard of Microcystis blooms for human health through fish consumption*. Ocean and Human Health All PI Meeting, January 17-20, 2006, Charleston, SC.

Sedgman, E. 2006. *Evaluation of the Hazard of Microcystis Blooms for Human Health through Fish Consumption*. NOAA Hollings Fellow Conference. Silver Springs, Maryland.

## **Publications**

Wilson, A.E., Gossiaux, D.C., Hook, T.O., Berry, J.P., Landrum, P.F., Dyble, J. and S.J. Guildford. Submitted, *Canadian Journal of Fisheries and Aquatic Science*, Evaluation of the human health threat associated with the hepatotoxin *Microcystin*, in the muscle and liver tissues of yellow perch (*Perca flavescens*).

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