

# Ecological Forecasting (EcoCasting)

Using Computer Models to Teach Ecological Concepts



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West Leyden High School



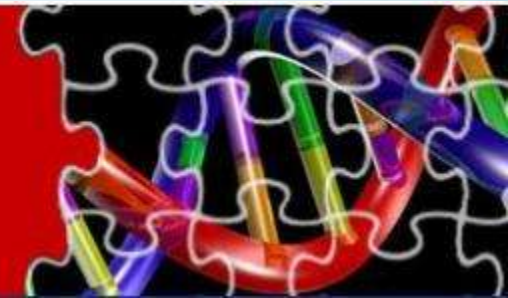
Lisa del Muro

Wheeling High School

**LIFE DISCOVERY – DOING SCIENCE**

***Exploring Biology for a Changing World***

**MARCH 15–16, 2013 – ST. PAUL, MINNESOTA**



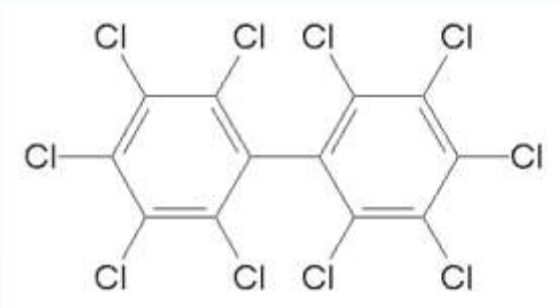
# Ecocasting 2010

- The Office of STEM Education Partnerships (OSEP) at Northwestern University has created these materials to help students learn about the scientific observations, measurement techniques, and computer models used in an ongoing National Ocean and Atmospheric Administration (NOAA) Ecological Forecasting project.

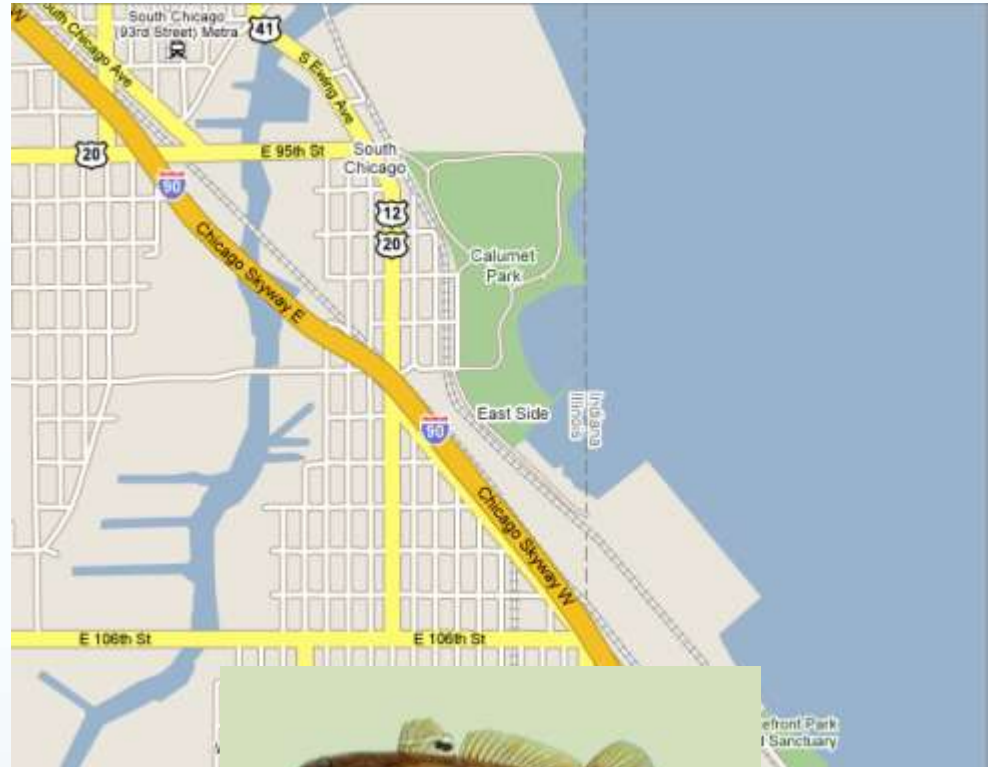


# NOAA Study on Calumet Harbor: A Highly Altered Great Lakes Ecosystem

- Legacy of PCB contamination.



- Invasive species
  - Zebra mussel
  - Round Goby



# Opportunity

- Provide the opportunity to engage with authentic data in the context of a real-world NOAA research project
- Increase student global environmental literacy as well as their understanding of the dynamics of the Great Lakes, an important local ecosystem and natural resource

# How do we do this?

When change is

- Slow
- Dynamic

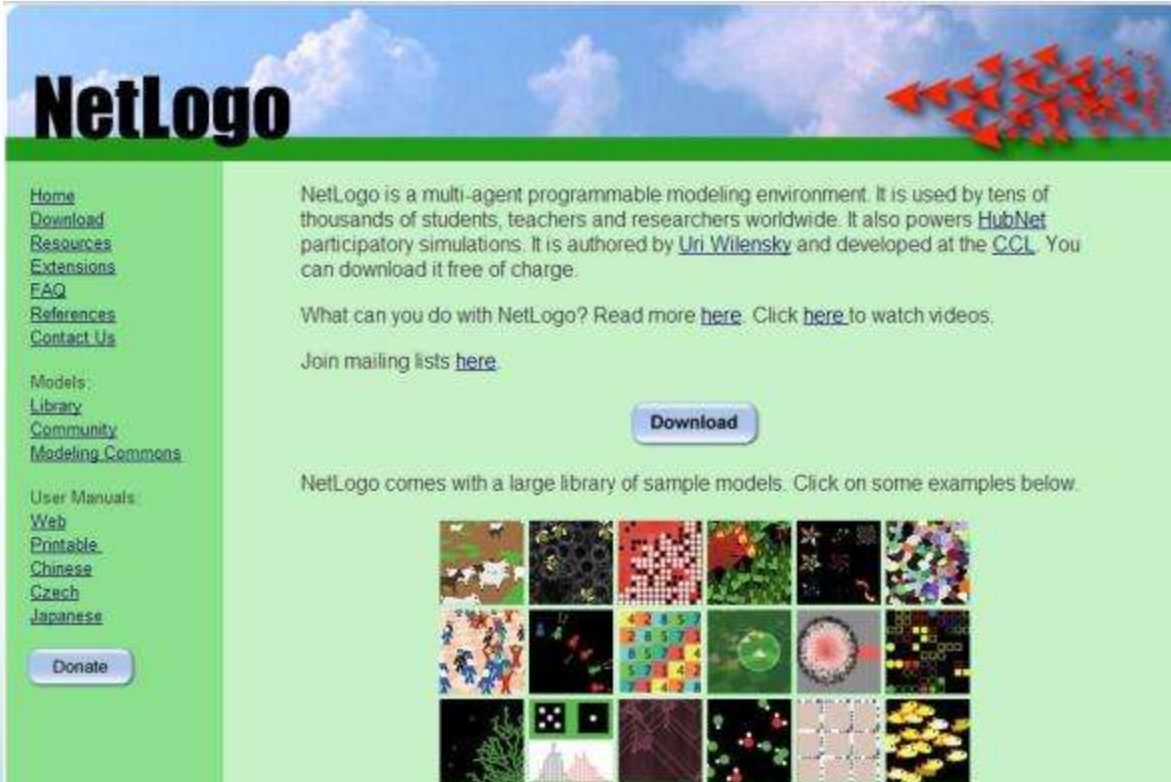
# Use- Agent Based Modeling

- Model is a simplified reality.
- Agents are
  - Autonomous-capable of processing information and exchanging information with other agents in order to make independent decisions.
  - Active- they exert independent influence on a simulation.
  - Goal-directed, having goals to achieve with respect to their behaviour.
  - Mobility- roam the space within a model.

(source: Principles and Concepts of Agent-Based Modelling for Developing Geospatial Simulations, ISSN1467-1298)

# The Net Logo Model

- <http://ccl.northwestern.edu/netlogo/>



The screenshot shows the NetLogo website homepage. At the top, the word "NetLogo" is written in a large, bold, black font against a blue sky background with white clouds. To the right of the title is a graphic of a flock of red arrows pointing towards the right. Below the title is a green horizontal bar. On the left side, there is a vertical green sidebar containing a list of links: Home, Download, Resources, Extensions, FAQ, References, Contact Us, Models, Library, Community, Modeling Commons, User Manuals, Web, Printable, Chinese, Czech, Japanese, and a "Donate" button. The main content area has a light green background. It contains a paragraph of text describing NetLogo as a multi-agent programmable modeling environment, used by students, teachers, and researchers. It mentions that it powers HubNet and is authored by Uri Wilensky and developed at the CCL. Below this text is a "Download" button. Further down, there is another paragraph of text stating that NetLogo comes with a large library of sample models and a "Click on some examples below" instruction. Below this text is a grid of 18 small thumbnail images showing various simulations and models, such as a flock of birds, a traffic simulation, a forest fire, and a cellular automaton.

**NetLogo**

[Home](#)  
[Download](#)  
[Resources](#)  
[Extensions](#)  
[FAQ](#)  
[References](#)  
[Contact Us](#)

Models:  
[Library](#)  
[Community](#)  
[Modeling Commons](#)

User Manuals:  
[Web](#)  
[Printable](#)  
[Chinese](#)  
[Czech](#)  
[Japanese](#)

[Donate](#)


NetLogo is a multi-agent programmable modeling environment. It is used by tens of thousands of students, teachers and researchers worldwide. It also powers [HubNet](#) participatory simulations. It is authored by [Uri Wilensky](#) and developed at the [CCL](#). You can download it free of charge.

What can you do with NetLogo? Read more [here](#). Click [here](#) to watch videos.

Join mailing lists [here](#).

[Download](#)

NetLogo comes with a large library of sample models. Click on some examples below.



# Goals of Modeling

- Provide hands-on inquiry activities on ecosystems, food webs and bioaccumulation for use in high school environmental science and biology classes.
- Provide techniques for guiding students to actively construct their own knowledge through visualization, data analysis and interpretation of scientific processes, all of which contribute to improved conceptual understanding of complex systems.



# Accessing Curriculum

<http://ecocasting.northwestern.edu/curriculum/>

[Home](#) [Curriculum](#) [Scientific Resources](#)

## Curriculum

- [Toxic Fish](#)
- [Food Chains](#)
- [Bioaccumulation](#)
- [Invasive Species](#)
- [NetLogo Models](#)
- [Standards](#)

## Curriculum

The EcoCasting curriculum is aligned to the Illinois State Science Standards, the College Readiness Standards, and the NRC's National Science Education Standards. For a complete listing of the standards this curriculum address, [click here](#).

Download the whole curriculum here:

[Complete Curriculum](#) (all files updated July 29, 2011)

[Student guides only](#)

**Note:** The documents are formatted for double-sided printing; if you print them single-sided there will be extra blank pages.

A short description of each investigation follows. To download copies of individual investigations, simply click the title of the activity you are interested in. The documents are formatted for double-sided printing; if you print them single-sided there will be extra blank pages.

**Investigation I** is an introductory activity that will help the students to see relevance of the unit through a connection with a major current event, the 2010 BP oil spill in the Gulf of Mexico.

In **Investigation II**, students will be introduced to the concepts of trophic levels, predator-prey interactions, food chains and food webs. Students will use the NetLogo Aquatic Food Chain model to explore population changes among the primary species of the Calumet Harbor food web.

The objective of **Investigation III** is to familiarize students with bioaccumulation, persistent organic pollutants (POPs), polychlorinated biphenyls (PCBs), and the dangers these pollutants pose to living organisms. Students will quantitatively model bioaccumulation and biomagnification using the NetLogo Aquatic Bioaccumulation model and create tables and graphs to analyze their data.

**Investigation IV** explores how the introduction of a new species into a food web can change feeding relationships amongst the native organisms, and how such invasions can alter the process of PCB bioaccumulation in the food web. Students will use the NetLogo Aquatic Invasive Species model to detect any cause-and-effect relationships focused around the invasion of a new species into an already established environment.

[Contact Us](#) [OSEP](#)

All of the Netlogo models used in this curriculum are inspired by the Netlogo Wolf and Sheep Predation model developed by the Center for Connected Learning at Northwestern University. Copyright 1997 Uri Wilensky. All rights reserved. See <http://ccl.northwestern.edu/netlogo/models/WolfSheepPredation> for terms of use.



The EcoCasting Project: Ecological Forecasting: Framework to Evaluate the Effects of Multiple Stresses on Lake Michigan Food Webs and Guide Remediation is supported in part by the National Oceanic and Atmospheric Administration under grant NMFS-HCPO-2009-2002033 to Kimberly Gray. However, any opinions, findings, conclusions, and/or recommendations are those of the investigators and do not necessarily reflect the views of the Administration.

# Curriculum Sequencing

Start with basics move to complex

- Food Chain
- Food Web
- Biomagnification
- Bioaccumulation
- Invasives
- Interactions

# Pick Your Content



Invasives Defined



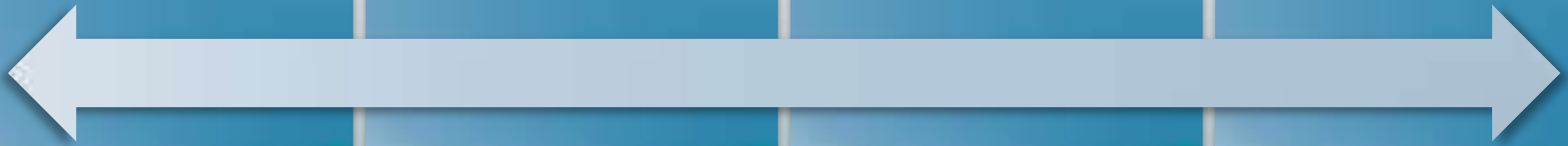
Food Chain/Web



Bioaccumulation/  
Biomagnification



Invasives  
Species Modeled



# Investigation I: Is Fish Safe to Eat, or Is It a Toxic Risk?

- Teacher Overview
- Student Guide Part 1: *K-W-L Chart*
- Student Guide Part 2: *Toxic Fish in the News?*
- Student Response Sheet Part 1 (for KWL)
- Student Response Sheet Part 2 (for fish)
- Answer Key
- Reading: *Scientists Say Gulf Spill Altering Food Web*

# Reading

**YAHOO!** NEWS

**AP** Associated Press

## Scientists say Gulf spill altering food web

By MATTHEW BROWN and RAMIT PLUSHNICK-MASTI, Associated Press Writers



This June 15, 2010 photo provided by the University of California Santa Barbara, shows pyrosomes- cucumber-shaped, gelatinous organisms fed on by endangered sea turtles, pulled up after a deep cast in the vicinity of the oil spill in the Gulf of Mexico. Scientists are seeing early signs that the massive Gulf spill is altering the food web, by killing or tainting creatures that form the foundation of marine life and spurring the growth of others more suited to a fouled environment. (AP Photo/David L. Valentine, Department of Earth Science, University of California Santa Barbara)

Wed Jul 14, 9:04 am ET

**NEW ORLEANS** – Scientists are reporting early signs that the Gulf of Mexico oil spill is altering the marine food web by killing or tainting some creatures and spurring the growth of others more suited to a fouled environment.

Near the spill site, researchers have documented a massive die-off of pyrosomes — cucumber-shaped, gelatinous organisms fed on by endangered sea turtles.

Name \_\_\_\_\_ Date \_\_\_\_\_ Class \_\_\_\_\_

### Investigation I: Is Fish Safe To Eat, Or Is It A Toxic Risk?

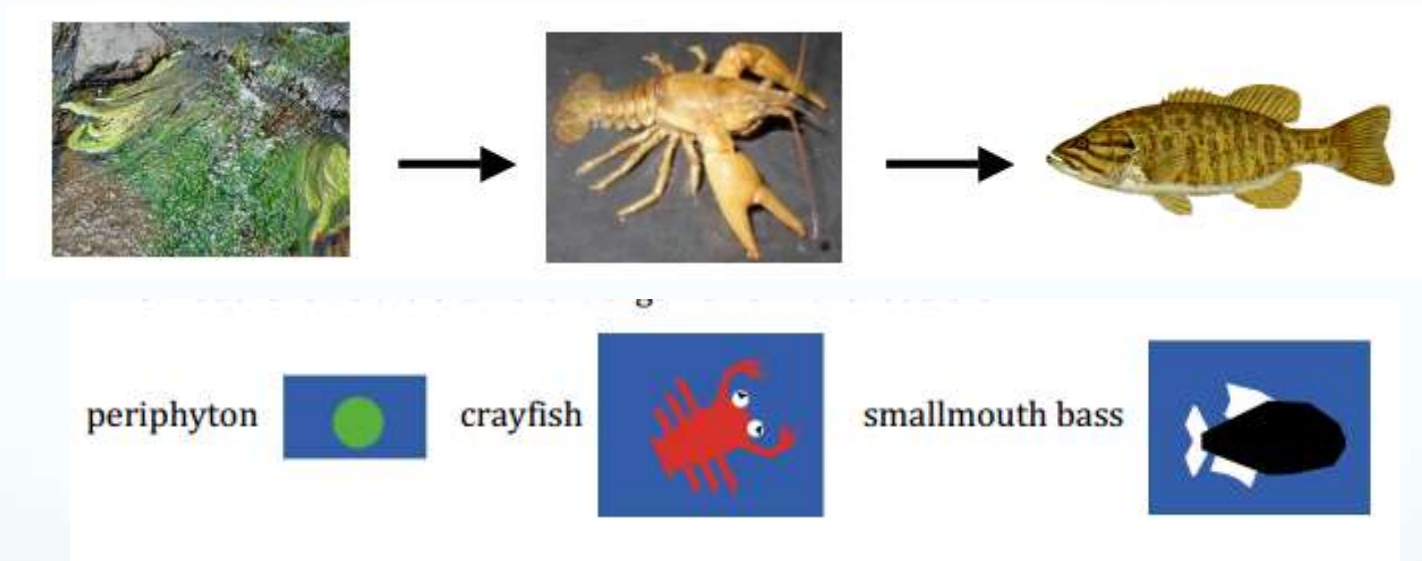
#### Part 1: K-W-L

What do we already know?	What do we want to know more about?	What have we learned?

# Investigation II: Aquatic Food Chains, Food Webs, and Modeling

- Teacher Overview
- Student Guide Part 1: *Introduction to Aquatic Food Chains and Food Webs*
- Student Guide Part 2: *Modeling an Aquatic Food Chain Using NetLogo*
- Student Response Sheet Part 1
- Student Response Sheet Part 2
- Answer Key

# Run Food Chain



- <http://ecocasting.northwestern.edu/NetLogo/Food%20Chain.html>

# NetLogo

The NetLogo interface is divided into several sections:

- Control Panel:** Includes buttons for "Setup", "Go/Stop", "Go One Step", "Add one Crayfish", and "Add one Smallmouth Bass".
- Sliders:** Three sliders control the initial amounts: "periphyton-start-amount" (940), "crayfish-start-amount" (118), and "smallmouth\_bass-start-amount" (52).
- Food-Web:** A text box showing the relationships: "crayfish eat periphyton" and "smallmouth bass eat crayfish". A "Change" button is located to the right.
- Population Size Graph:** A line graph with "Population" on the y-axis (0 to 259) and "Time" on the x-axis (0 to 100). A legend indicates: Periphyton / 4 (green square), Crayfish (red square), and Smallmouth Bass (black square).
- Main Simulation Window:** A large blue area containing many small green dots (periphyton), red dots (crayfish), and black shapes (smallmouth bass). A "normal speed" slider is at the top right.

You may edit the food web below.  
See "Information" tab for details.

powered by NetLogo



# Run 1

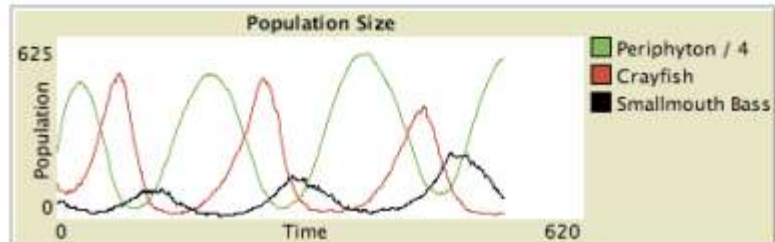
Setup  Go/Stop    
Go One Step



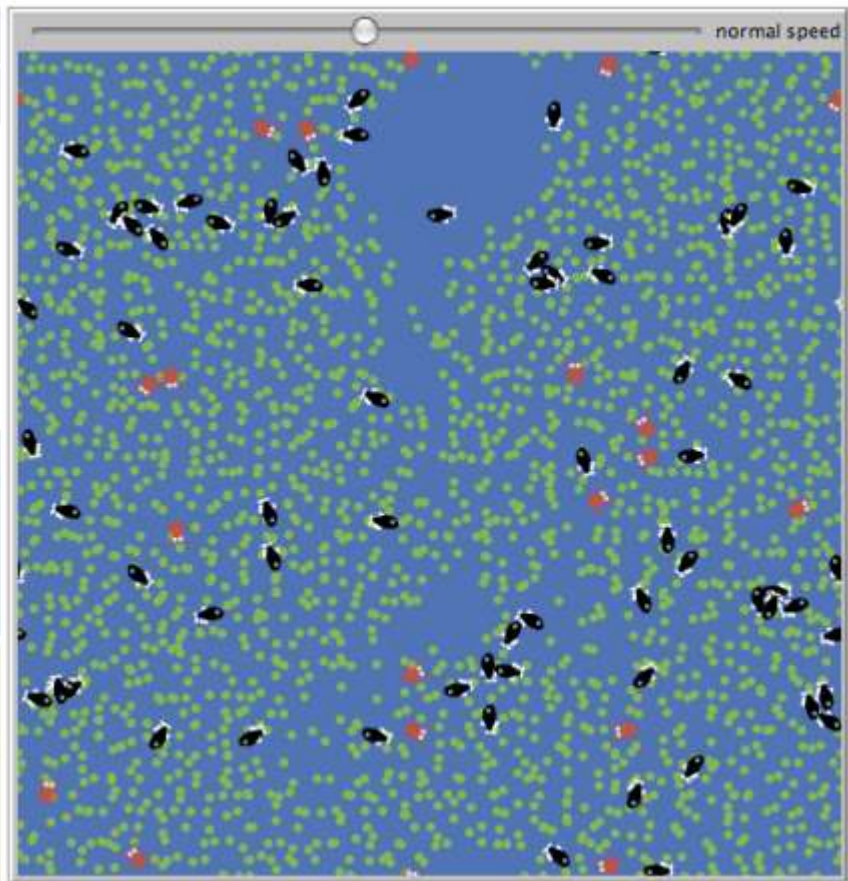
You may edit the food web below.  
See "Information" tab for details.

Food-Web

crayfish eat periphyton  
smallmouth bass eat crayfish



Add one Crayfish   
Add one Smallmouth Bass



# Run 2

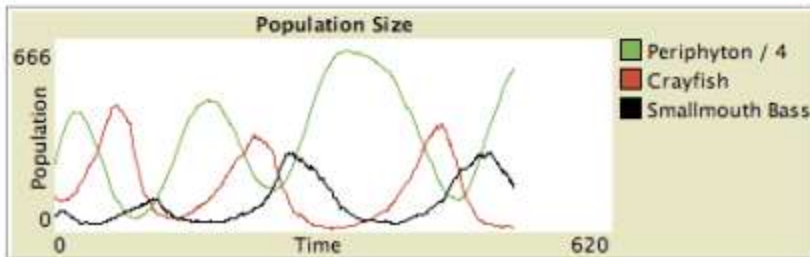
Setup <sup>S</sup>    Go/Stop <sup>G</sup>  
Go One Step <sup>O</sup>

periphyton-start-amount    3070  
crayfish-start-amount    66  
smallmouth\_bass-start-amount    28

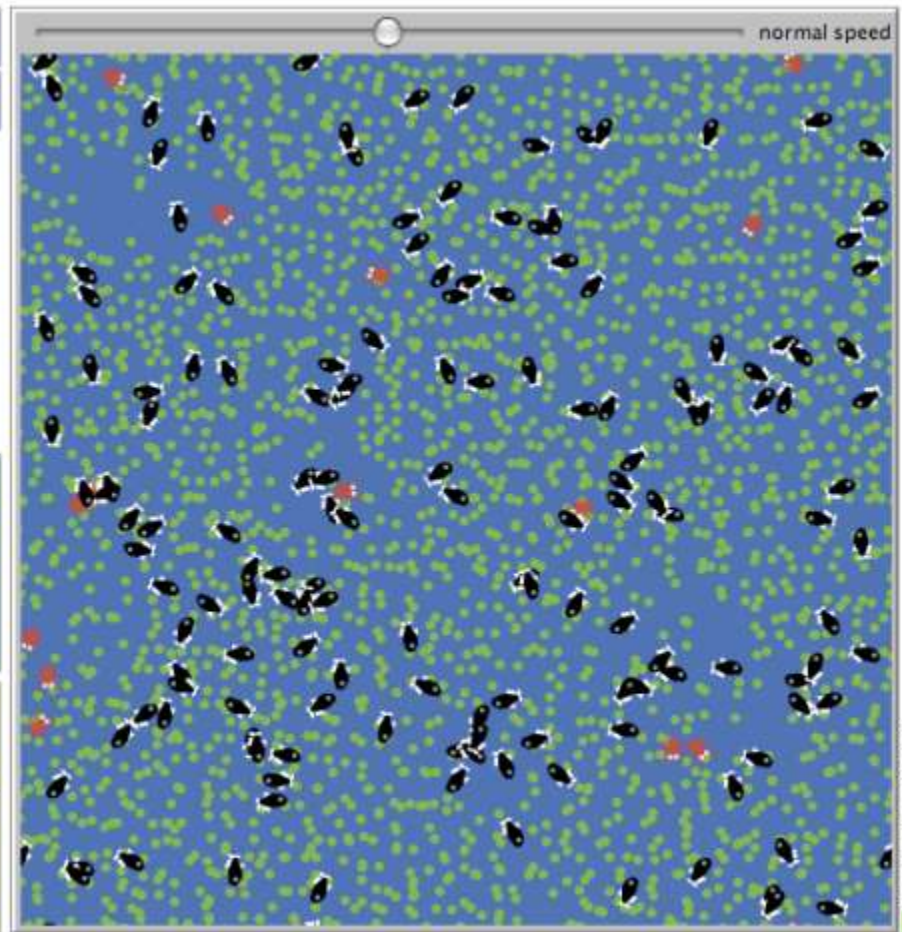
You may edit the food web below.  
See "Information" tab for details.

Food-Web Change

crayfish eat periphyton  
smallmouth bass eat crayfish

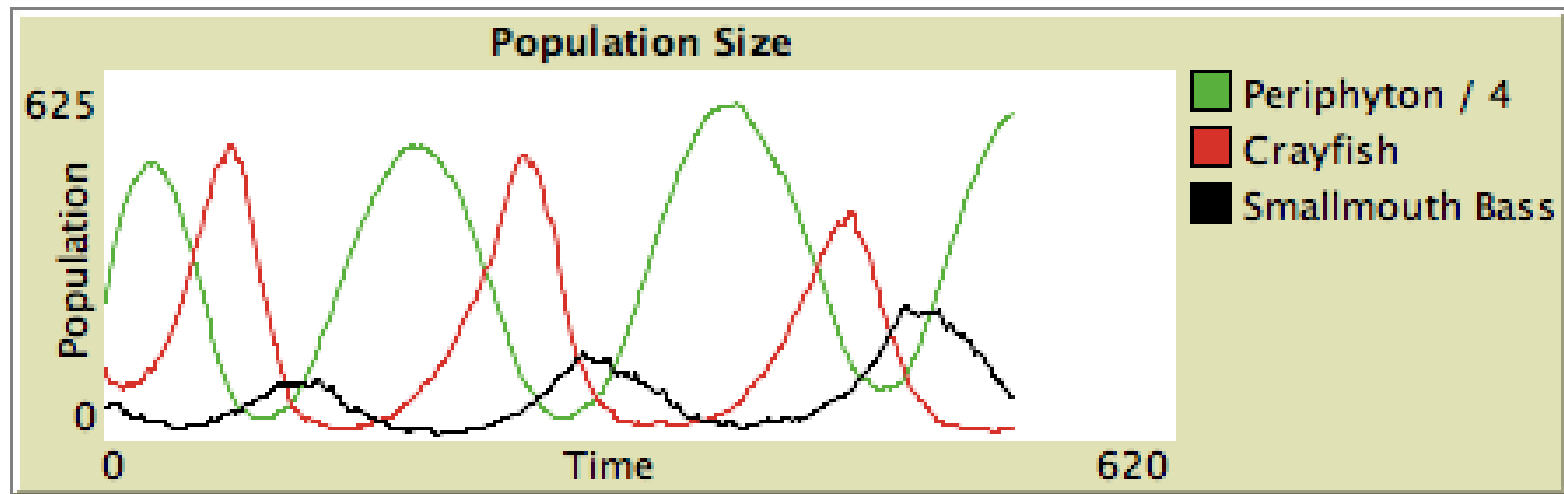


Add one Crayfish <sup>C</sup>  
Add one Smallmouth Bass <sup>B</sup>



# Model Run

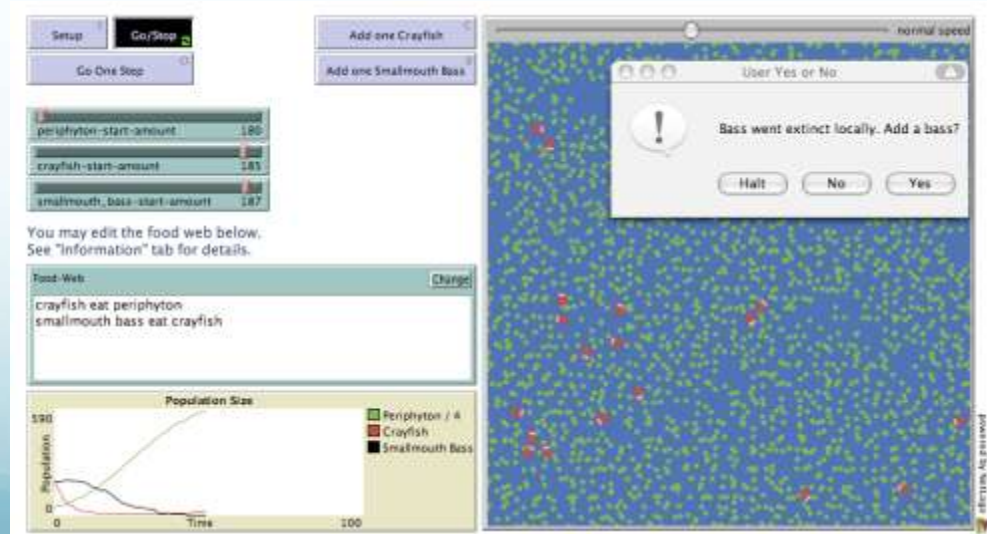
- Cyclic pattern of predator – prey occurs.
- *They followed each other with a time-lag- Matt*



# Crash!

## Student Responses

- *You can get a population to crash by not providing enough food for the population to grow. Setting up a condition does not guarantee a result. There are always variables in the environment that can affect the growth or decline of a population.- Esperanza*
- *You can get a population to crash by changing a food source.- Eric*

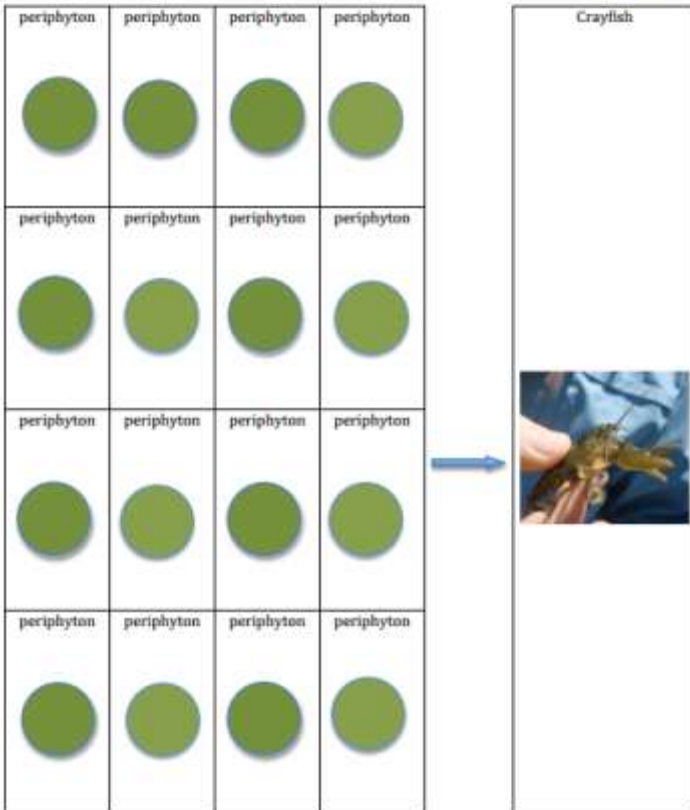


# Investigation III: Bioaccumulation

## Teacher Overview for Parts 1-6

- Part 1: What Do I Know About Pollutants?
  - Teacher Overview
  - Pre-Test
  - Answer Key
- Part 2: What is POP (don't you mean soda)?
  - Teacher Overview
  - Student Guide and Graphic Organizer
  - Reading: *Persistent Organic Pollutants: A Global Issue, A Global Response*
- Part 3: How Are We Exposed to Chemicals?
  - Teacher Overview
  - Student Response Sheet
  - Answer Key
- Part 4: What is a PCB?
  - Teacher Overview
  - Student Guide
  - Answer Key
- Part 5: Pre-Modeling Activity
- Teacher Overview
  - Student Guide
  - Student Response Sheet
  - Answer Key
- Part 6: NetLogo Bioaccumulation model- What is the Difference between
  - Bioaccumulation and Biomagnification?
  - Teacher Overview
  - Student Guide
  - Answer Key

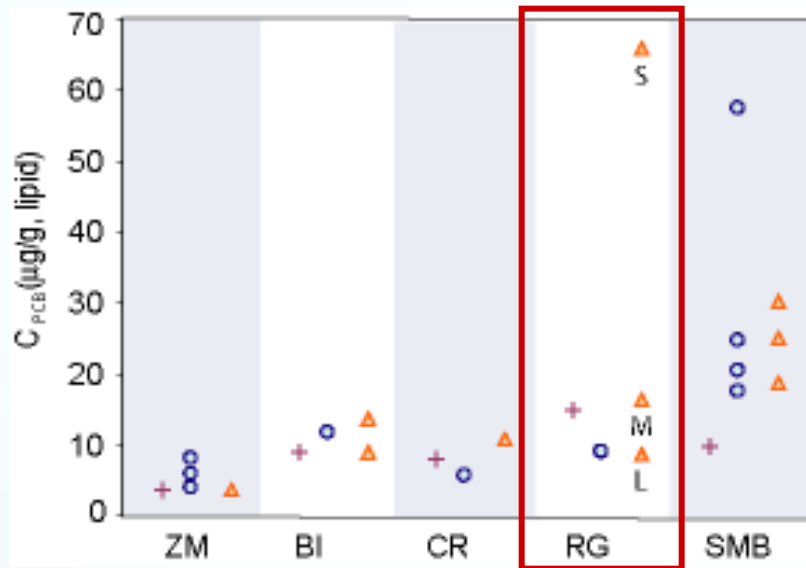
# Physical Model



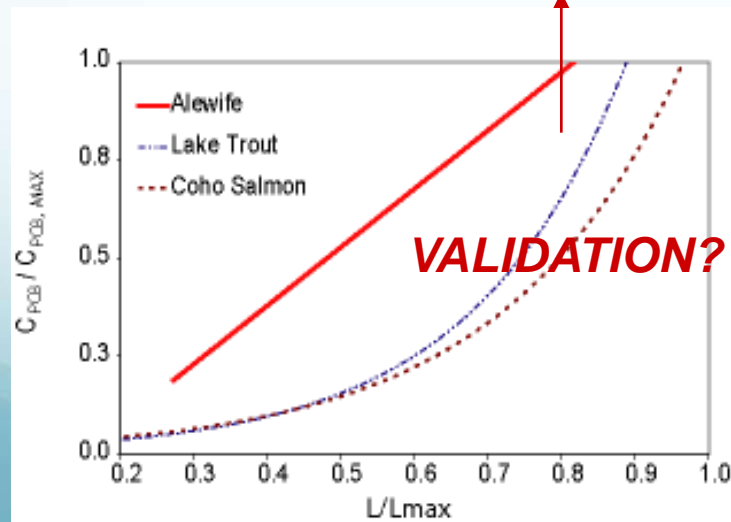
Smallmouth Bass



# Results: Feedback Loops Amplify PCB Bioaccumulation



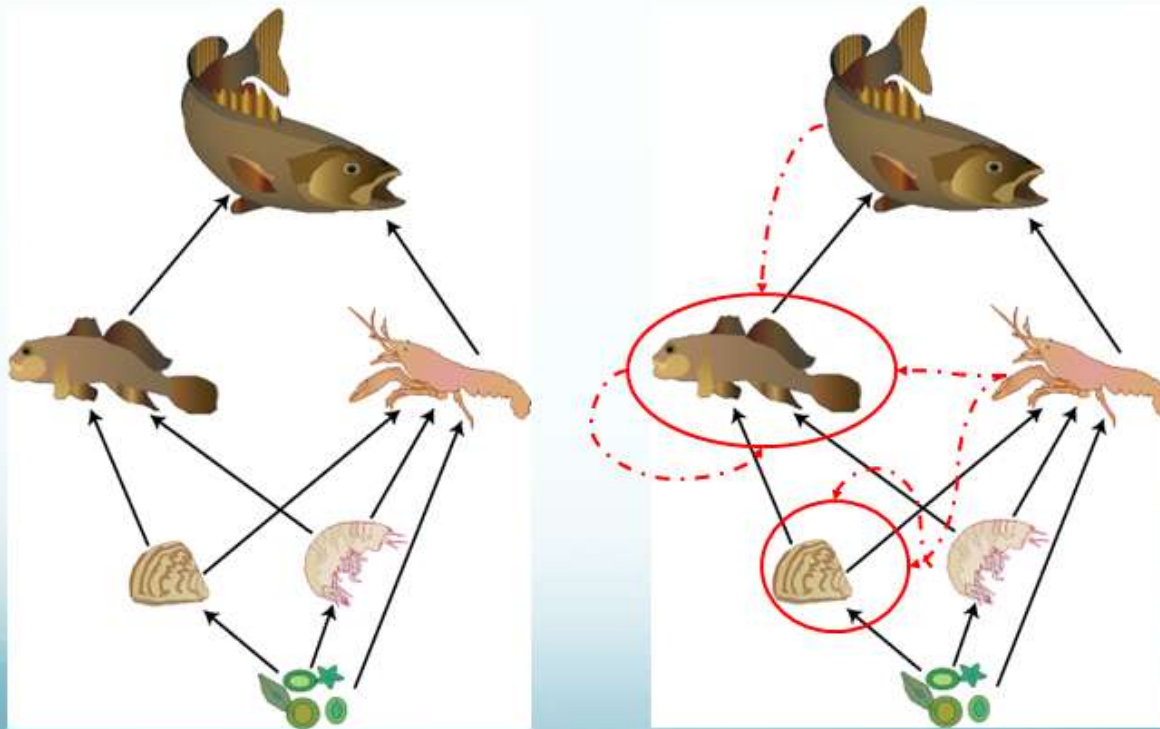
- Including seasonal and ontogenetic details of Calumet species' diets, we can predict top predator PCB concentrations more accurately than with a simple "average" model.
- Recycling of nutrients in harbor creates *Trophic Feedback Loops* that increase PCB biomagnification.
- Round goby accumulation trends run counter to expected notions of increasing concentration with size.



# Run Bioaccumulation Model

- <http://ecocasting.northwestern.edu/curriculum/bioaccumulation/>

How Detritus, Seasonality and Ontogeny Affect Calumet Harbor Trophic Structure





# Example- Bioaccumulation

Setup <sup>S</sup>    Go/Stop <sup>G</sup>  
 Go One Step <sup>1</sup>

Add one Crayfish <sup>C</sup>  
 Add one Smallmouth Bass <sup>B</sup>

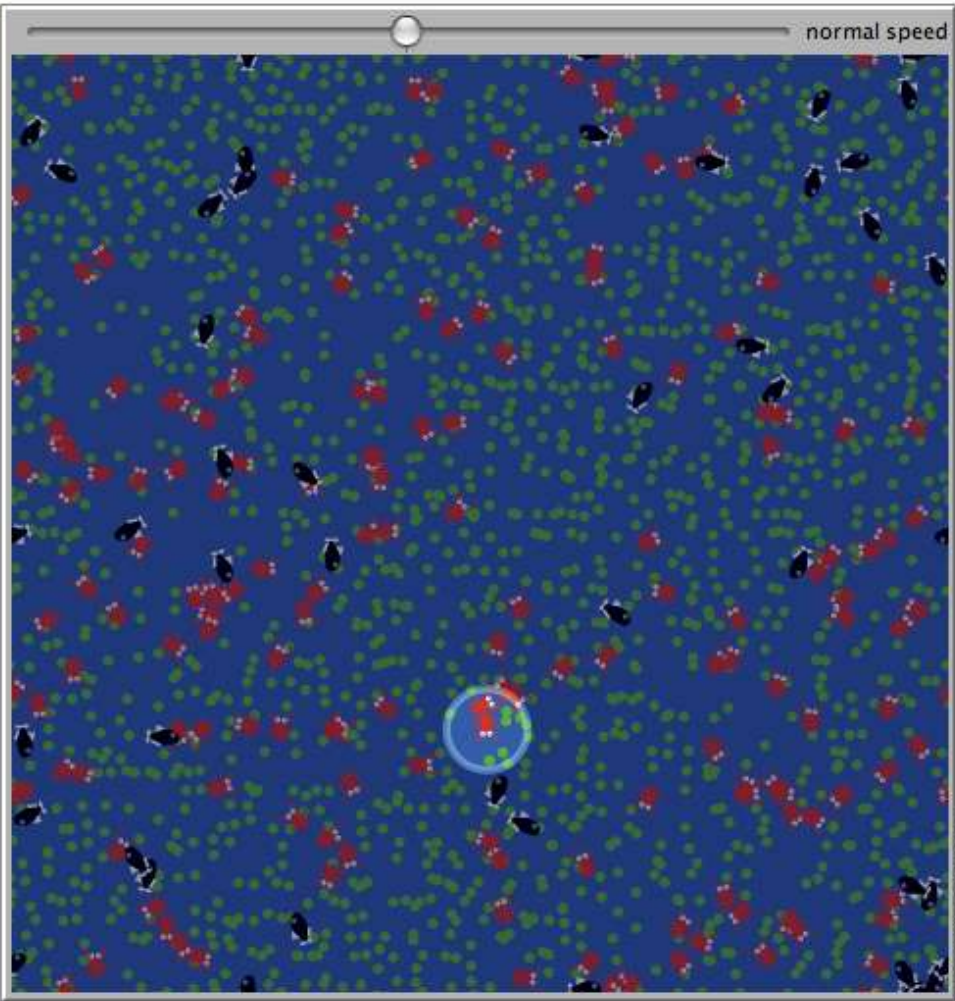
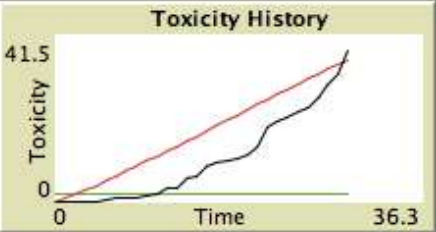
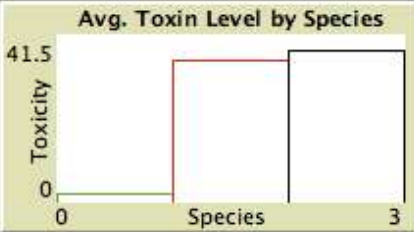
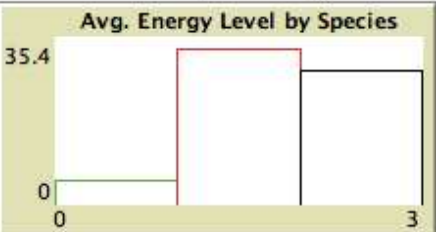
Energy/Toxicity of watched/followed creature

Energy	Toxicity
78	40

You may edit the food web below.  
 See "Information" tab for details.

Food-Web Change

crayfish eat periphyton  
 smallmouth bass eat crayfish

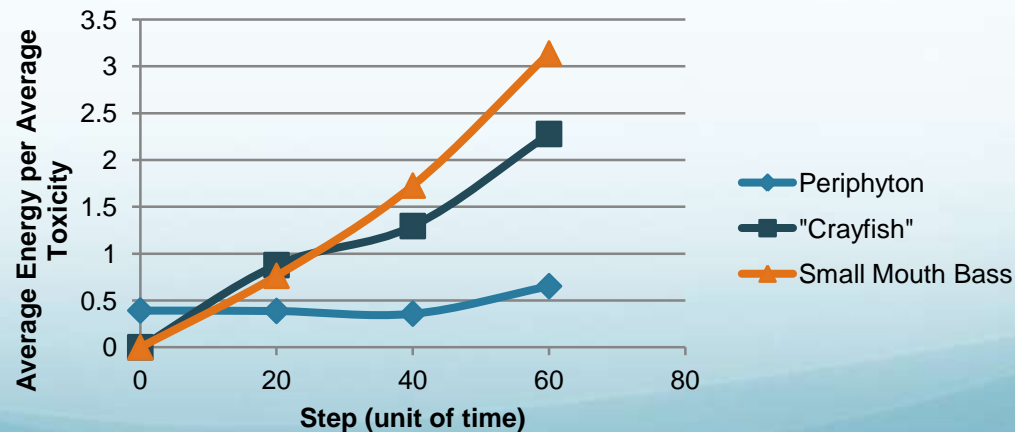


# Student response

*Overall the small mouth bass had the steepest slope for toxicity level and average energy level- Esperanza*

Step	Periphyton			crayfish			Smallmouth bass		
	Avg. Energy level	Avg. Tox. level	Tox/energy	Avg. Energy level	Avg. Tox. level	Tox/energy	Avg. Energy level	Avg. Tox. level	Tox/energy
0	5.1	2.0	0.39	4.0	0	0	20.9	0	0
20	4.9	1.9	0.39	26.1	22.9	0.88	21.9	16.7	0.76
40	5.3	1.9	0.36	35.0	45.3	1.29	43.2	74.6	1.77
60	4.6	3.0	0.65	25.9	59	2.28	66.6	209	3.14

**Average Toxicity versus Average Energy Versus Unit of Time**



# Invasive Species

- **Investigation IV: Invasive Species**
- Teacher Overview
- Student Guide Part 1: What is an Invasive Species and How Can it Affect a Food Web?
- Student Guide Part 2: Investigating How an Invasive Species Can Affect Toxin Transfer
- Student Response Sheet Part 1
- Student Response Sheet Part 2
- Answer Key

# Run invasive

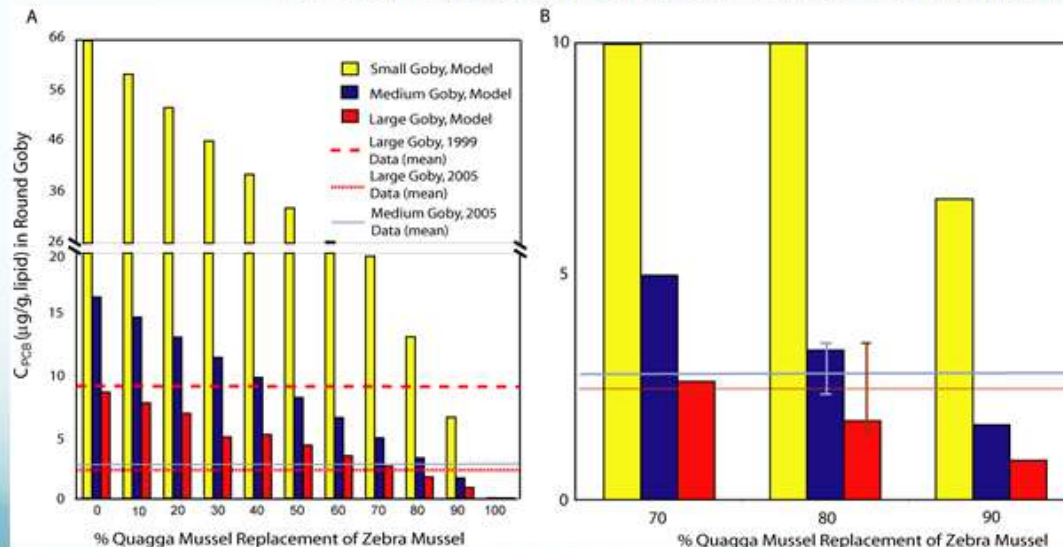
<http://ecocasting.northwestern.edu/NetLogo/Invasive%20Species.html>

## Calumet Harbor, 2005: Zebra Mussel → Quagga Mussel Succession



Zebra Mussels appear to facilitate the arrival of their Dresseinid cousin, the Quagga Mussel.

The only significant difference is *habitat preference*.



# Thanks to all the contributors

## **Principal- and Co-Investigators:**

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4. Park Ridge, Illinois
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For more information, please visit <http://osep.northwestern.edu>

<http://ecocasting.northwestern.edu>

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EcoCasting would like to extend special thanks to the NetLogo creators and developers for their contributions to this project.

# Kim's Video

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