Ecological Forecasting (EcoCasting)

Using Computer Models to Teach Ecological Concepts

Jon Pazol
West Leyden High School

Lisa del Muro
Wheeling High School

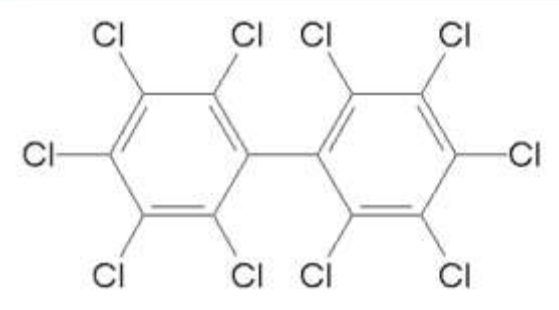
LIFE DISCOVERY – DOING SCIENCE
Exploring Biology for a Changing World
MARCH 15–16, 2013 – ST. PAUL, MINNESOTA

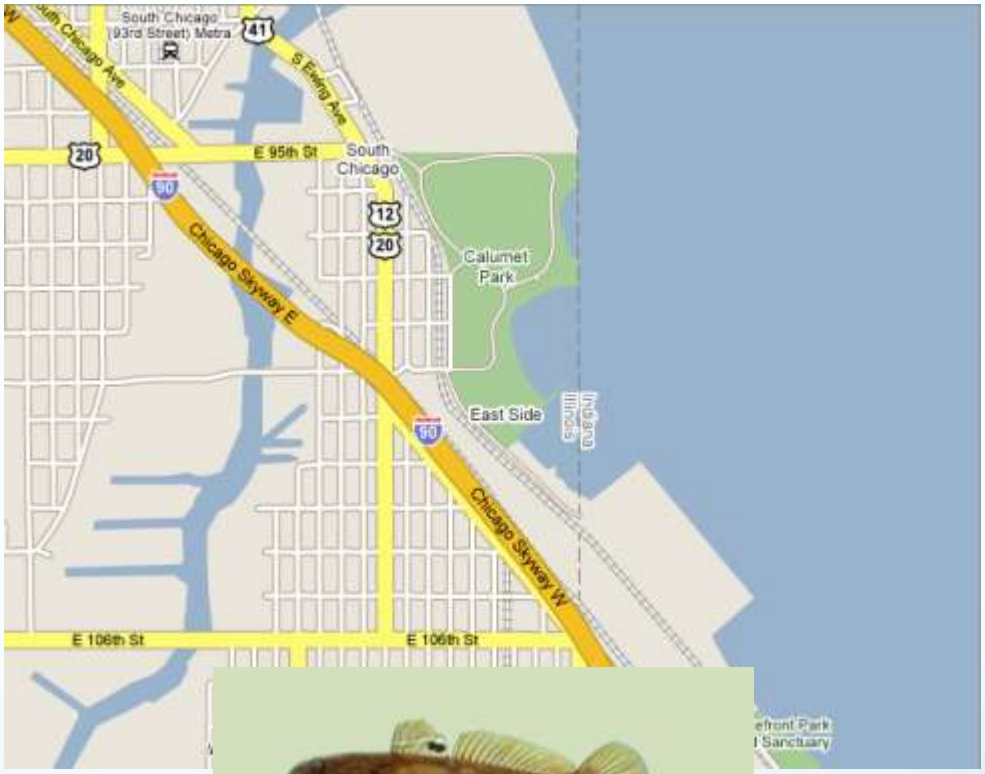
Ecocasting 2010

- 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 Geospatioal Simulations, ISSN1467-1298

The Net Logo Model

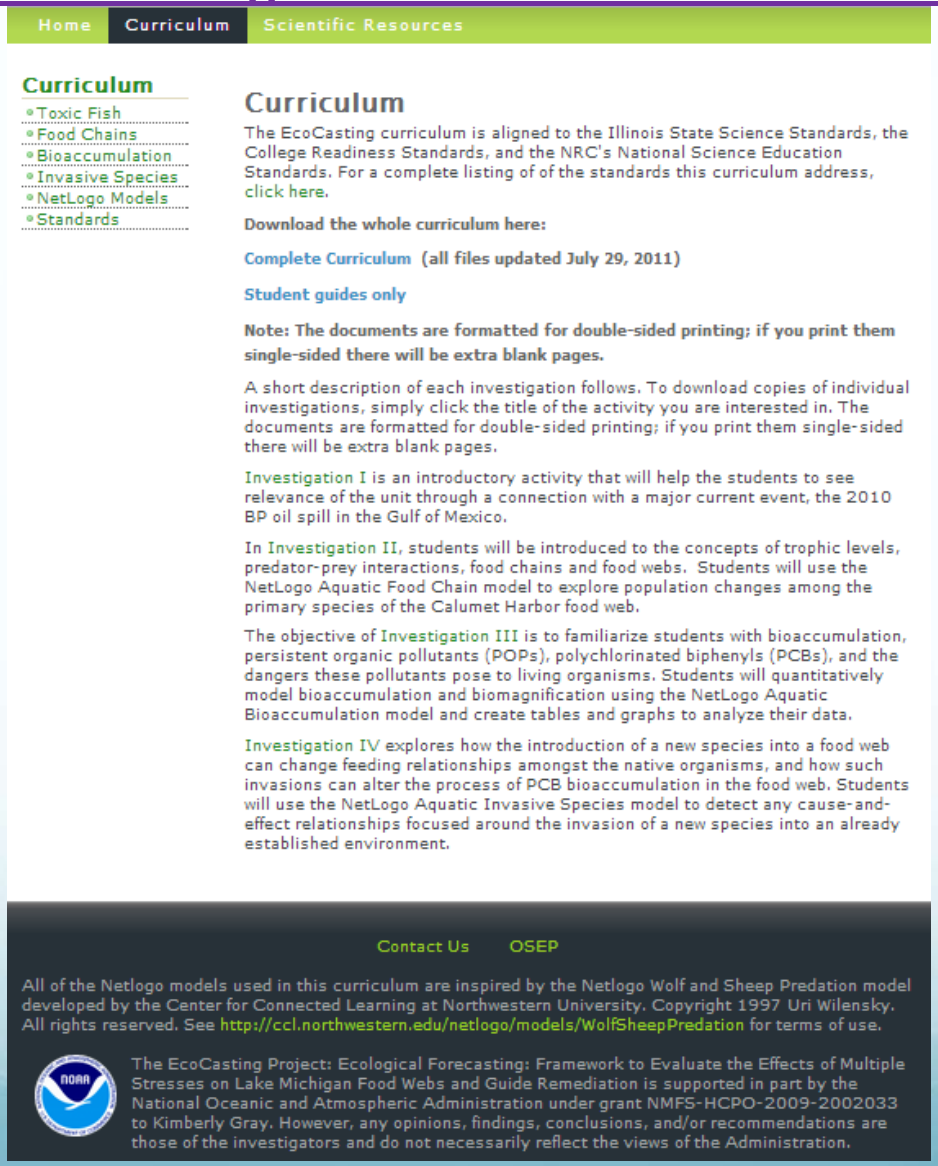
- http://ccl.northwestern.edu/netlogo/

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/



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

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 —

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?

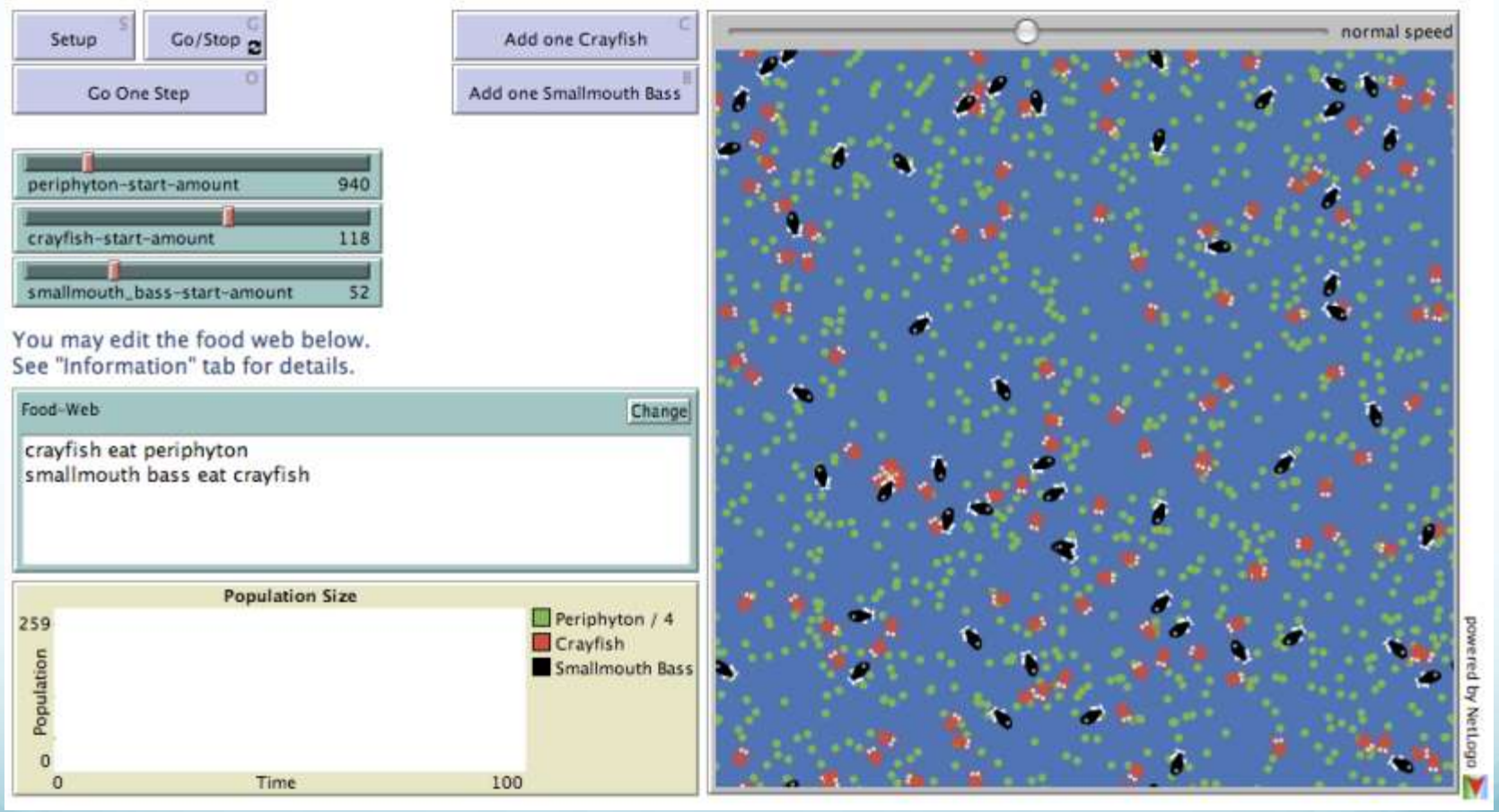
Investigation II: Aquatic Food Chains, Food Webs, and Modeling

- 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

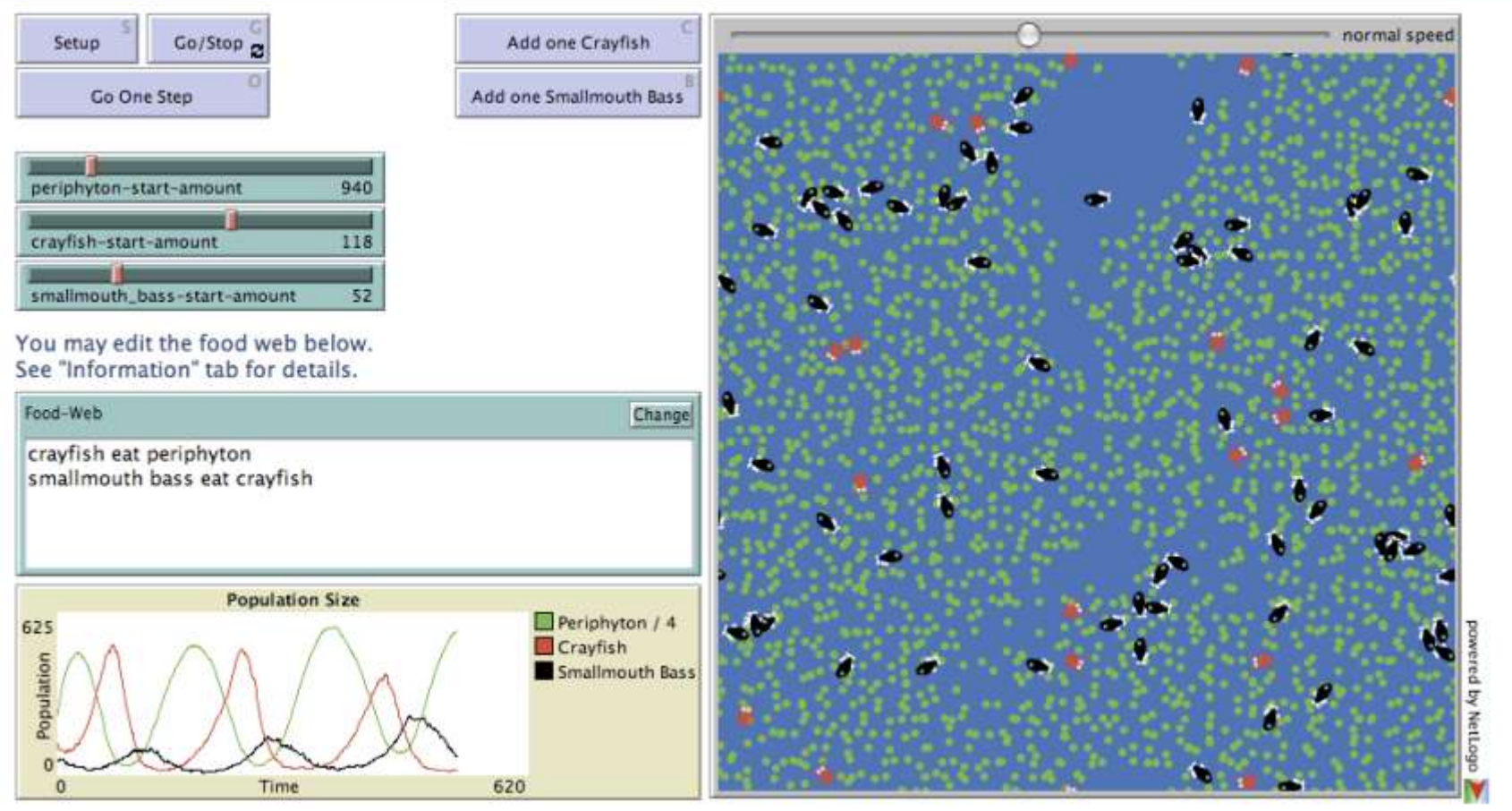
Run Food Chain

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

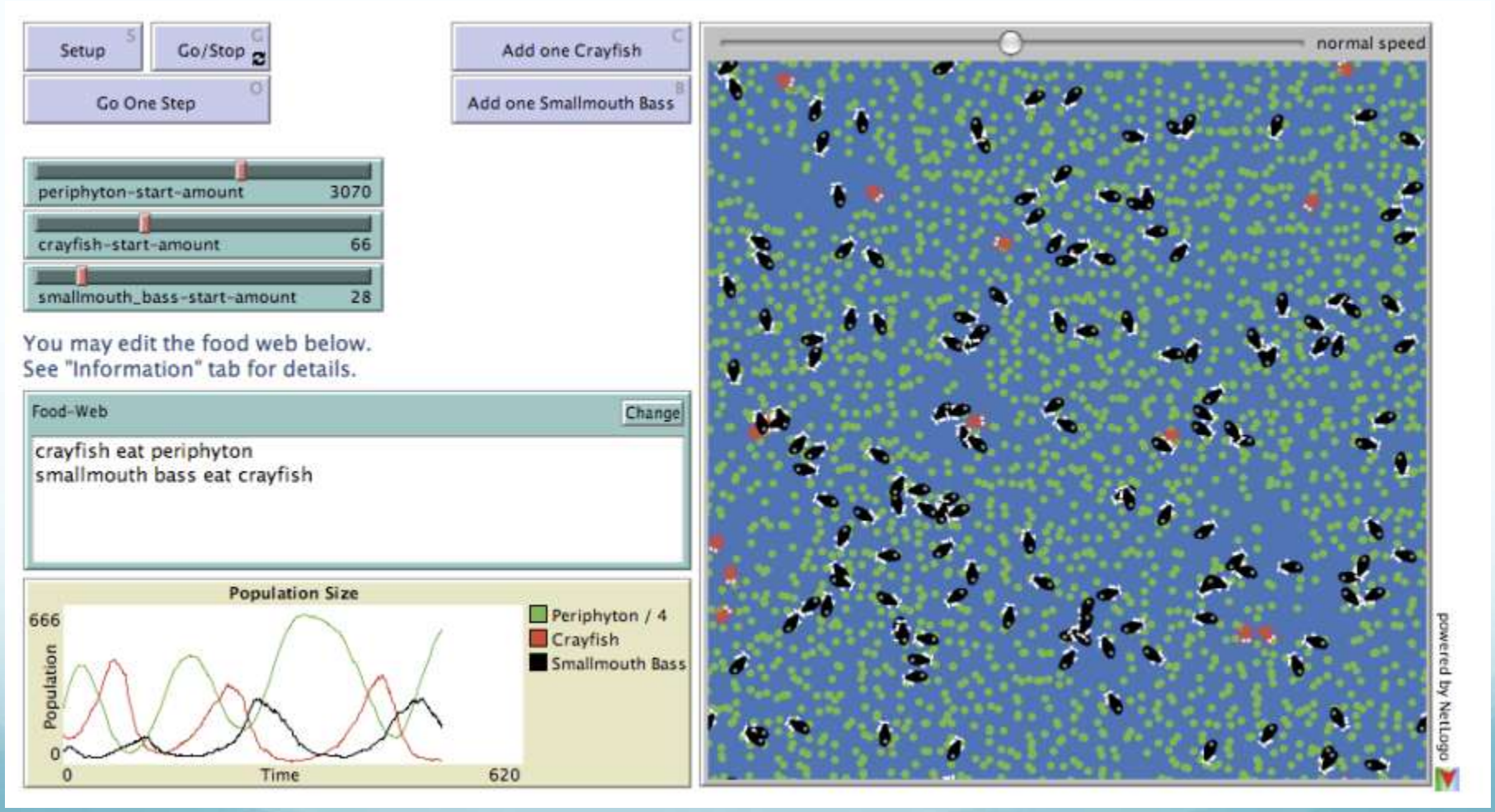
NetLogo


Setup
Go/Stop
Go One Step
Add one Crayfish
Add one Smallmouth Bass
normal speed
periphyton-start-amount 940
crayfish-start-amount 118
smallmouth_bass-start-amount 52
You may edit the food web below.
See "Information" tab for details.
Food-Web
Change
crayfish eat periphyton
smallmouth bass eat crayfish
Population Size
259
Population
0
0
Time
100
Periphyton / 4
Crayfish
Smallmouth Bass
powered by NetLogo

Run 1

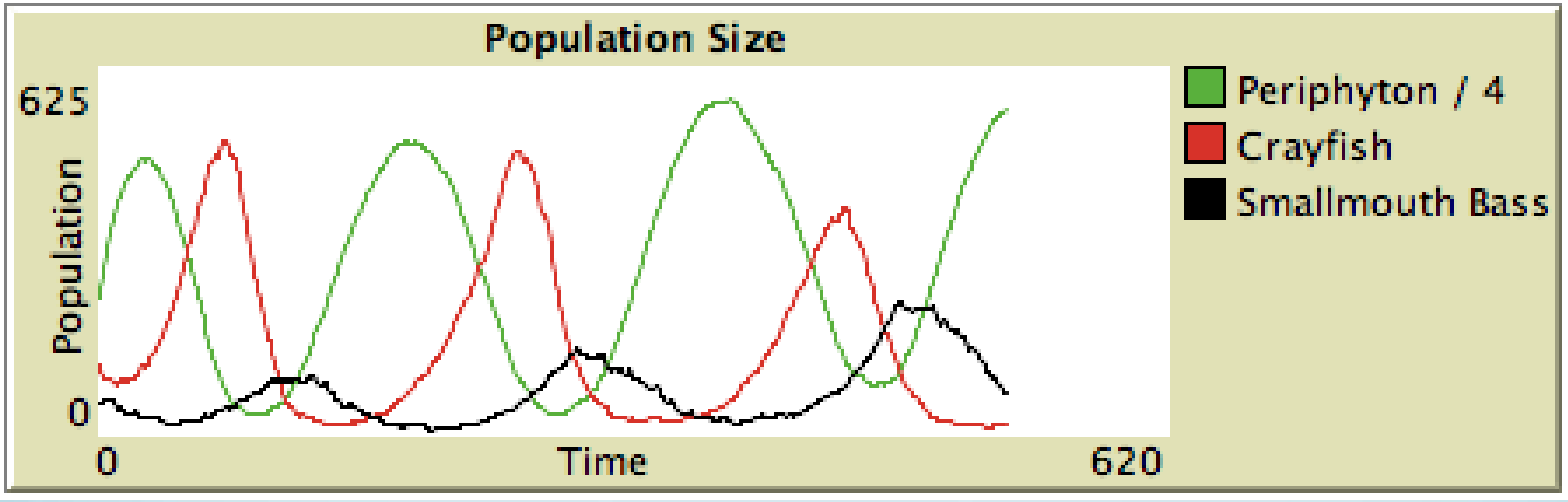

Setup
Go/Stop
Go One Step
Add one Crayfish
Add one Smallmouth Bass
normal speed
periphyton-start-amount 940
crayfish-start-amount 118
smallmouth_bass-start-amount 52
You may edit the food web below.
See "Information" tab for details.
Food-Web
Change
crayfish eat periphyton
smallmouth bass eat crayfish
Population Size
625
Population
0
0
Time
620
Periphyton / 4
Crayfish
Smallmouth Bass
powered by NetLogo

Run 2


Setup
Go/Stop
Go One Step
Add one Crayfish
Add one Smallmouth Bass
normal speed
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
Population Size
666
Population
0
0
Time
620
Periphyton / 4
Crayfish
Smallmouth Bass
powered by NetLogo

Model Run

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

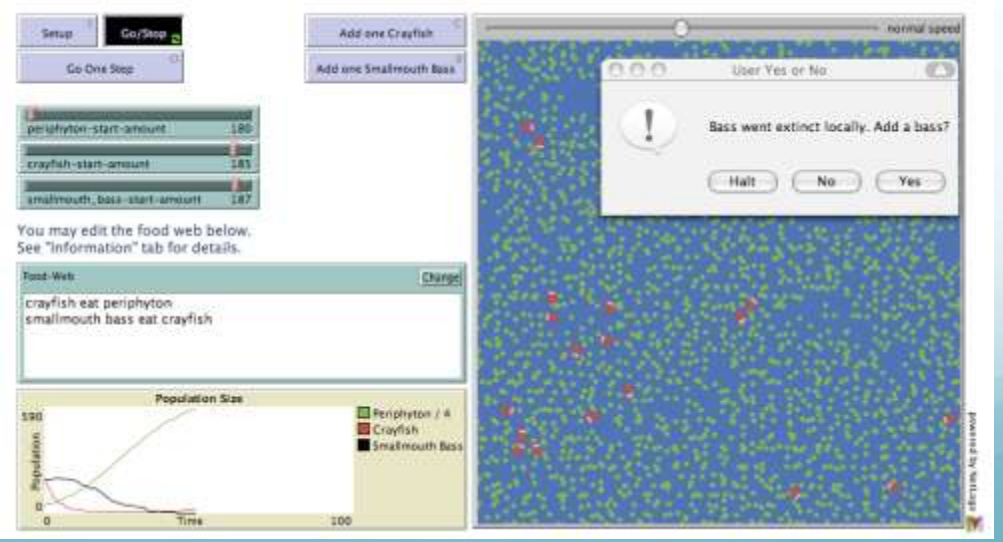


Crash!

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 variable 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*

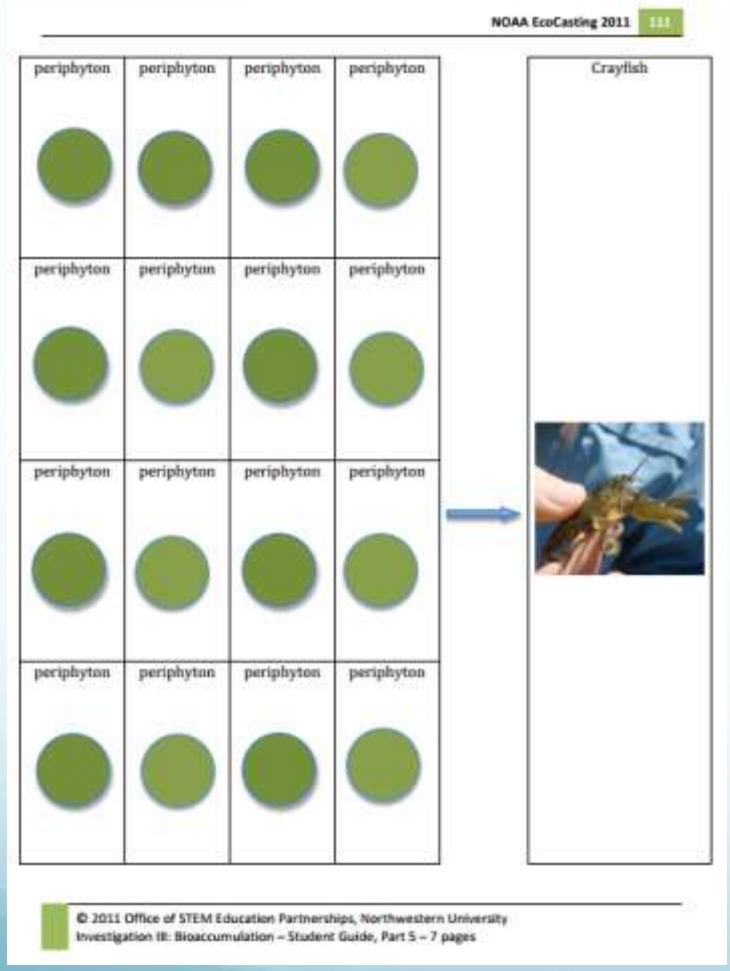


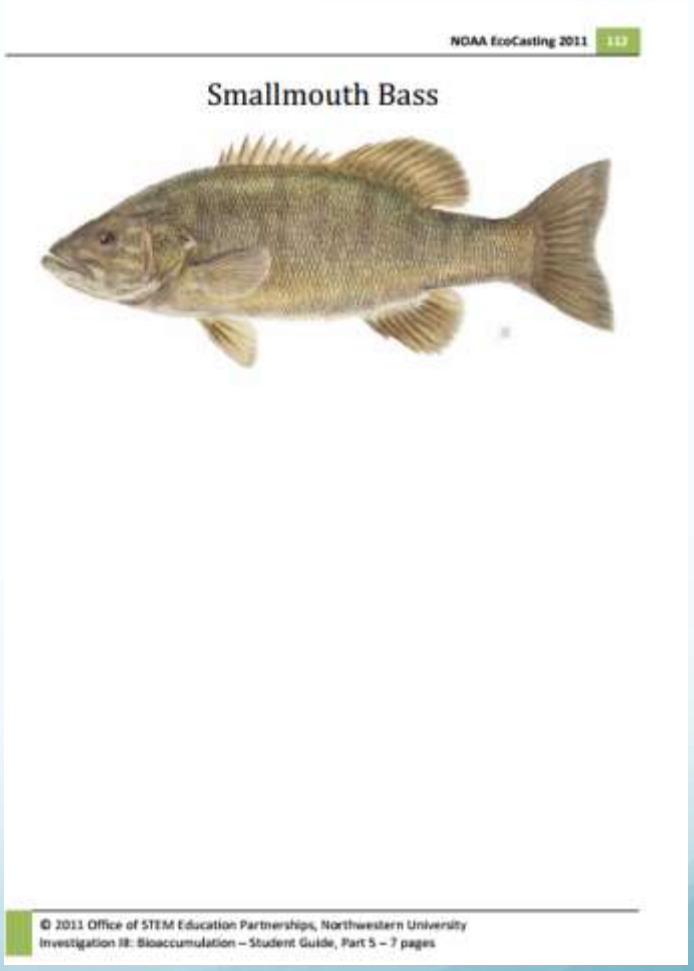
Investigation III: Bioaccumulation

Teacher Overview for Parts 1-6

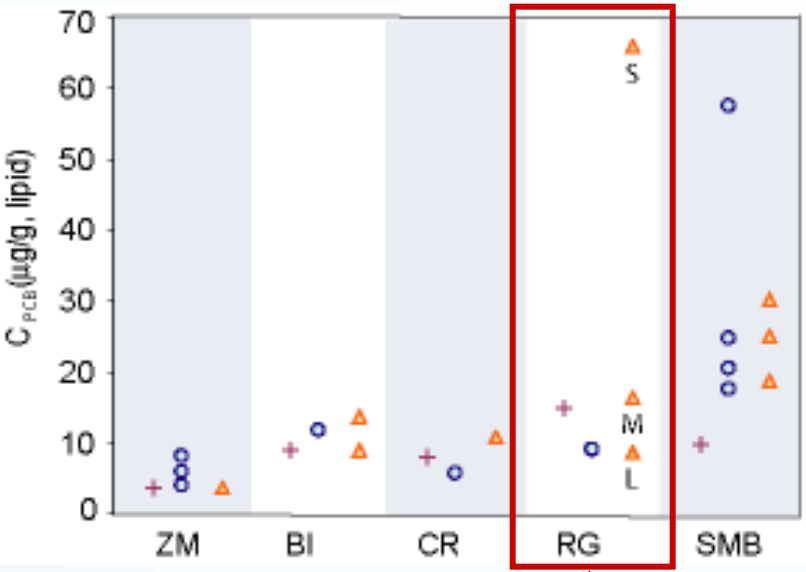
- Part 1: What Do I Know About Pollutants?
  - Teacher Overview
  - Pre-Test
  - Answer Key
- Part 2: What is POP (don't you mean soda)?
  - Teacher Overview
  - Student Guide and Graphic Organizer
  - Reading: *Persistent Organic Pollutants: A Global Issue, A Global Response*
- Part 3: How Are We Exposed 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

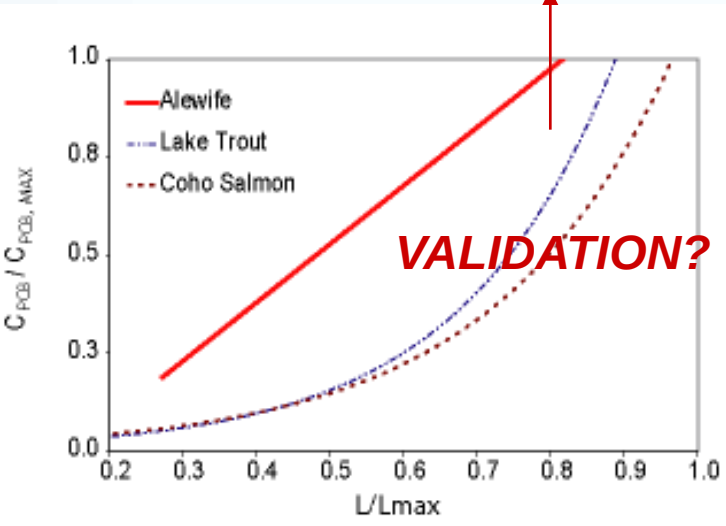
Physical Model





Results: Feedback Loops Amplify PCB Bioaccumulation

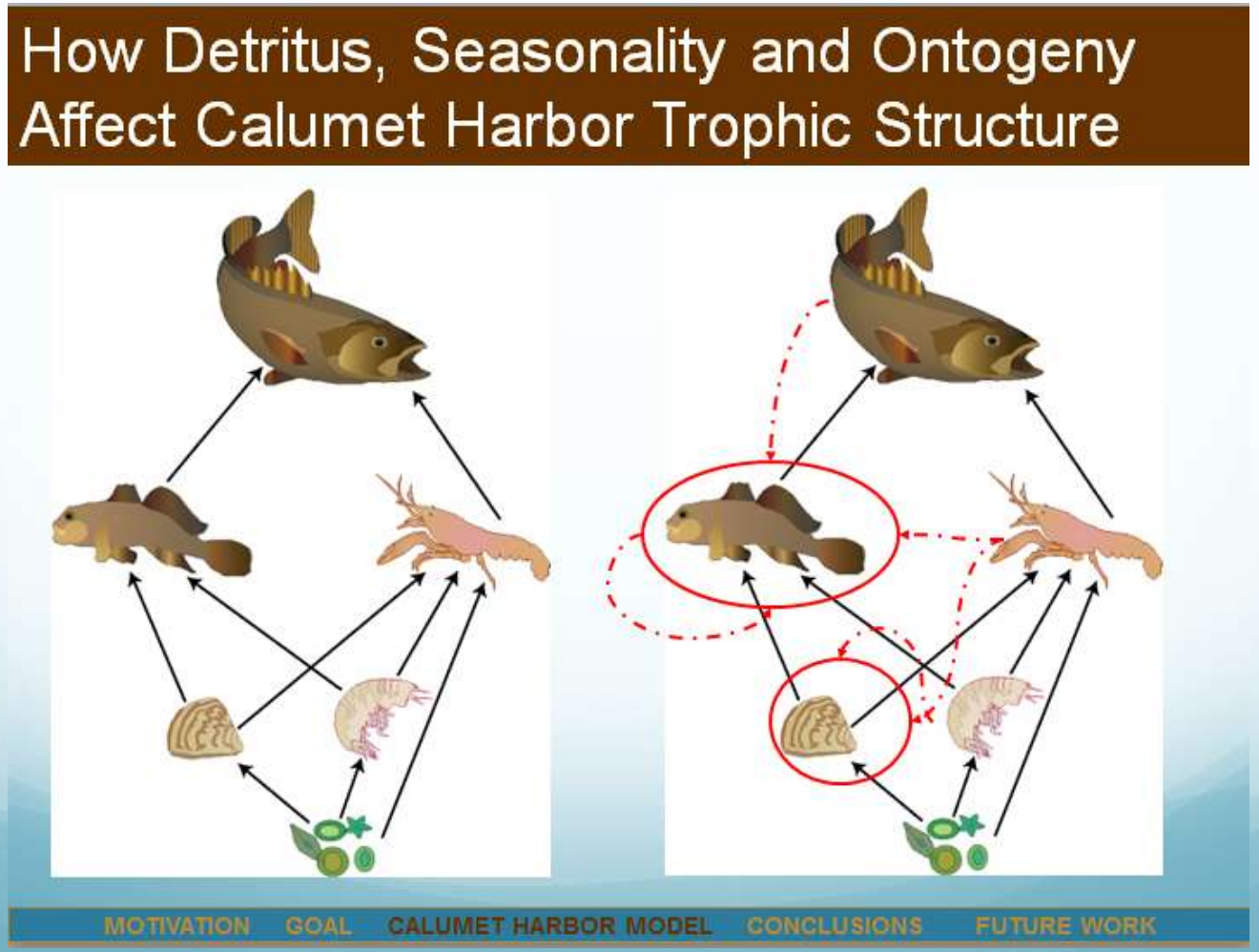




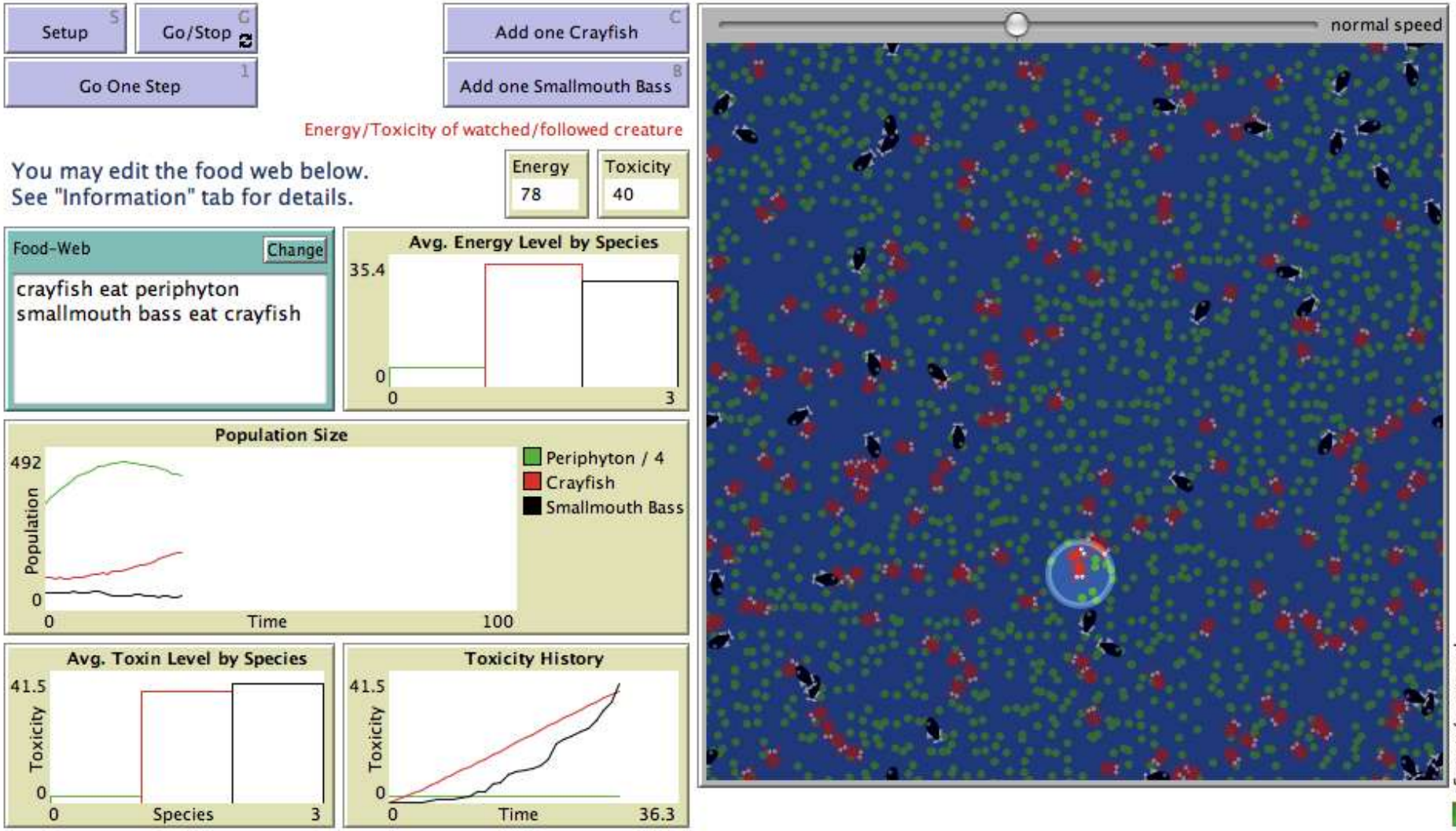
- Including seasonal and ontogenetic details of Calumet species' diets, we can predict top predator PCB concentrations more accurately than with a simple "average" model.
- Recycling of nutrients in harbor creates *Trophic Feedback Loops* that increase PCB biomagnification.
- Round goby accumulation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

Run Bioaccumulation Model

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



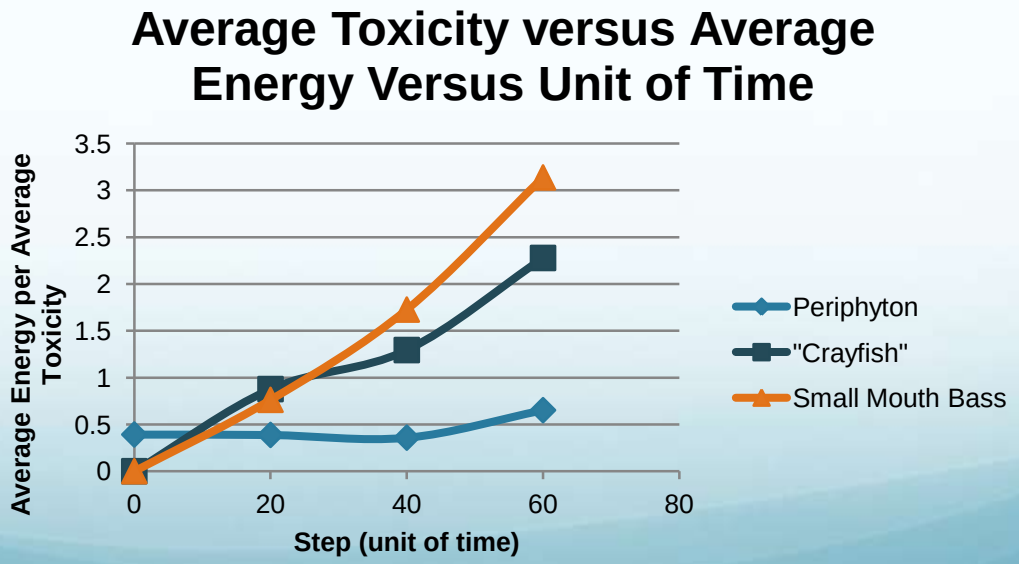
Example- Bioaccumulation



Student response

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

	Periphyton			crayfish			Smallmouth bass		
Step	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

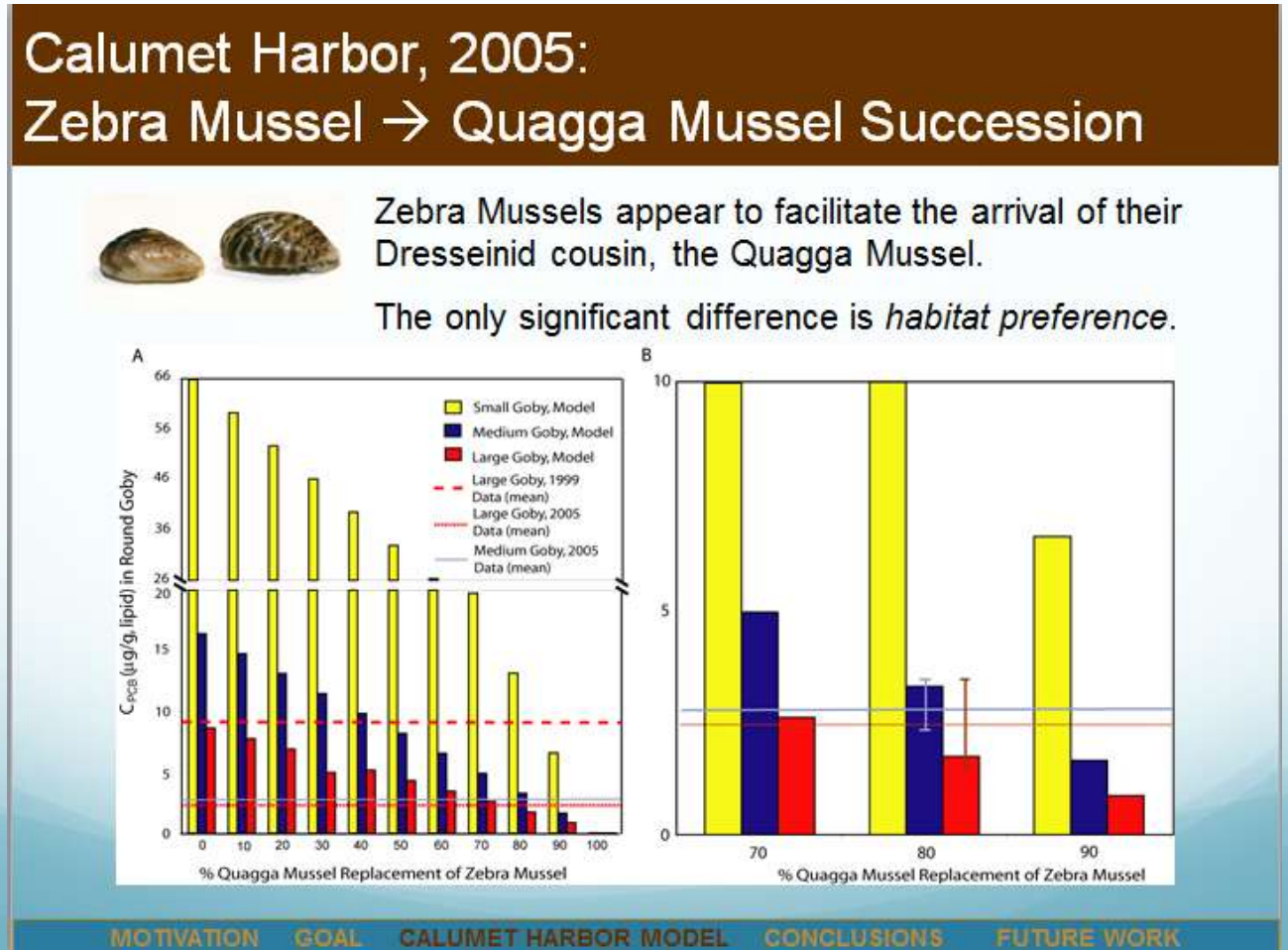


Invasive Species

- **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



Thanks to all the contributors

Principal- and Co-Investigators:
Kimberly A. Gray (Northwestern University)

Martin B. Berg (Loyola University of Chicago)

Neal Blair (Northwestern University)

Jean-François Gaillard

John Janssen (University of Wisconsin-Milwaukee, Great Lakes Water Institute)

Kemi Jona (Northwestern University)

Adilson Motter (Northwestern University) i

Project Manager: Colleen Buzby[1]

Software Developer: David Maidment[3,4] Colin Sheaff[1]

- **Authors and Contributors:** Jill Burns[5] Lisa Del Muro[5] Jon Pazol[6] Margaret Waldron[1]

1. Northwestern University
2. National Geographic Society University of Texas at Austin The Consortium of Universities for the Advancement of Hydrologic Science, Inc.
3. Maine South High School,
4. Park Ridge, Illinois
5. Wheeling High School, Wheeling, Illinois
6. West Leyden High School, Northlake, Illinois

For more information, please visit http://osep.northwestern.edu http://ecocasting.northwestern.edu

Or contact: c-buzby@northwestern.edu

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

Kim’s Video

Our emails

Jon Pazol- Leyden High School

jpazol@leyden212.org

Lisa del Muro- Wheeling High School

lisa.delmuro@d214.org