EcoCasting: Investigating aquatic ecosystems using models

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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.
Office of STEM Education Partnerships

• Our mission: Connecting students, teachers, and parents to the world-class science and education resources of Northwestern University and other higher education institutions
• Partner with faculty and researchers to develop and deliver educational outreach related to their research
• Develop our own grant-funded research projects
• Long-term goal: Create sustainable STEM education programs for K-12 teachers and students.
Office of STEM Education Partnerships

Strengthening K-12 STEM Education

- Teacher training and development of research-based curricula
- Providing out-of-school learning opportunities for students
- Supporting faculty participation in K-12 programs
- Facilitating partnerships that support STEM education
Teaching Systems Thinking to Understand the Hydrosphere

• Students understand environmental issues within greater context of an entire ecosystem
• Specific case study: Calumet Harbor is a unique ecosystem, exhibits symptoms of issues that affect larger Great Lakes ecosystem (invasive species, toxic pollution)
Characteristics of Systems Thinking

- EcoCasting addresses all:
  - ability to identify components of a system
  - ability to identify relationships among components
  - ability to organize components and processes within a hierarchy of relationships
  - ability to make generalizations
  - ability to identify dynamic (i.e., not static) relationships within system
  - understanding hidden dimensions of system (those not apparent at first glance, such as groundwater in the hydrosphere)
  - ability to understand cyclic nature of systems
  - thinking temporally: retrospection and prediction
NRC: Practices for K-12 Classrooms

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
EcoCasting Project Summary

• Environmental Engineers in the Lake Michigan region are studying fish and foodwebs for PCB toxin accumulation.
  • Anomalous data found in fish gut analyses prompted them to reevaluate accepted foodweb models
• Original study performed in Calumet Harbor, next step is to replicate analysis in Green Bay
Calumet Harbor: A Highly Altered Great Lakes Ecosystem

- Legacy of PCB contamination.

- Invasive Species:
  - Round Goby
  - Zebra Mussels
  - Quagga mussels - watch
Traditional Food Webs

- Aquatic food webs typically have 4 “levels.”
- Energy (nutrients) are transferred through predator-prey links from base to top predator.
- Contaminants bioaccumulate along these routes.
Actual Food Web Structure of Calumet Harbor

The diagram illustrates the trophic levels of various species in Calumet Harbor. Species are represented by different symbols and colors, indicating their position in the food web. The x-axis represents primary producers (PP), zebra mussels (ZM), bivalves (BI), crayfish (CR), round gobies (RG), and smallmouth bass (SMB). The y-axis indicates trophic level (L). The diagram shows the feeding relationships and energy flow among the species in the ecosystem.
How Detritus, Seasonality and Fish Size Affect Calumet Harbor Food Web
Results: Feedback Loops Amplify PCB Bioaccumulation

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.
- Important implications for public health, since round goby are prey to popular sport fish.
EcoCasting Development

Science
- Data collection and analysis of PCBs in invaded aquatic ecosystems (Calumet Harbor)

Technology
- Designed 3 online models for student investigation

Curriculum
- Created activities to teach Ecosystem content to high school classes
- All activities available to download from http://ecocasting.northwestern.edu
## EcoCasting for Students

<table>
<thead>
<tr>
<th>Content</th>
<th>Technology</th>
<th>Grade Level</th>
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</thead>
<tbody>
<tr>
<td>Aquatic food webs</td>
<td>Agent-based models (NetLogo)</td>
<td>High school Biology and/or</td>
</tr>
<tr>
<td>Bioaccumulation</td>
<td></td>
<td>Environmental Sci.</td>
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<tr>
<td>Invasive Species</td>
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## Curriculum Outline

<table>
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<th>Activities</th>
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<td>1. Is Fish Safe to Eat, or is it a Toxic Risk?</td>
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<tr>
<td>2. Aquatic Food Chains, Food Webs, and Modeling</td>
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<tr>
<td>3. Bioaccumulation</td>
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<td>4. Invasive Species</td>
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1. Is Fish Safe to Eat?

Introductory Activity

• KWL Chart

• Reading and response to article on the 2010 BP oil spill

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
2. Aquatic Food Chains, Food Webs, and Modeling

...In reality, the way organisms eat is more like that old children’s poem, “There Was an Old Lady Who Swallowed a Fly…”

Periphyton  crayfish  Smallmouth Bass
Question: Answer on the Student Response Sheet

3. Now that the model is set up, which organism is missing from the image? Why is this?

3. Click on the button in the upper left corner of the screen to start the model running. This button will both start and stop the model from running.

Watch what happens to the population size for each of the organisms as you let the model run. You will need to focus your attention on the line graph labeled "Population Size" on the left of the screen.

*NOTE: Let the model run to at least 100 on the time axis in the "Population Size" graph before stopping it or recording any observations.*
EcoCasting Models

- NetLogo agent-based models allow students to manipulate the food web and investigate bioaccumulation and invasive species
- Posted online as Java web-applets
Aquatic Food Chains

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

http://ecocasting.northwestern.edu/NetLogo/Bioaccumulation.html
Invasive Species

http://ecocasting.northwestern.edu/NetLogo/Invasive%20Species.html
Standards Aligned

- College Readiness Standards
- Illinois State Standards
- NRC’s National Science Education Standards
EcoCasting Resources

To download curricular materials and find links to models, visit:

http://ecocasting.northwestern.edu