Biomagnification of PCBs

Adapted from *Deadly Links - Project Wild* (PCB variation)
by Dana Haine of UNC Superfund Basic Research Program[1]

Overview:
Through a role-play activity, participants will experience how organisms are exposed to toxic chemicals by assuming the roles of different organisms in an aquatic food chain to witness how toxins become more concentrated (biomagnification) as ones moves up the food chain.

Objectives:
At the end of this activity, the learner will be able to:

1. give examples of the way contaminants enter food chains;
2. describe the process of biomagnification; and
3. identify which organisms will have the highest concentration of toxins in a food chain scenario.

Alignment to North Carolina Essential Standards for Science
This lesson addresses the specific learning objectives in:

8th Grade Science

- Objective 8.L.3.3: Explain how the flow of energy within food webs is interconnected with the cycling of matter (including water, nitrogen, carbon dioxide and oxygen)

Biology

- Objective Bio.2.1.1: Analyze the flow of energy and cycling of matter (water, carbon, nitrogen, and oxygen) through ecosystems relating the significance of each to maintaining the health and sustainability of an ecosystem.
- Objective Bio.2.1.3: Explain various ways organisms interact with each other (including predation, competition, parasitism and mutualism) and with their environments resulting in stability within ecosystems.
- Objective Bio.2.2.1: Infer how human activities (including population growth, pollution, global warming, burning of fossil fuels, habitat destruction and introduction of nonnative species) may impact the environment.

Earth and Environmental Science

- Objective EEn.2.4.1: Evaluate human influences on freshwater availability.
- Objective EEn.2.4.2: Evaluate human influences on water quality in North Carolina's river basins, wetlands and tidal environments

Materials:

- Small paper bags, one bag for each student assuming the role of zooplankton (18-20 bags)
- Pieces of multi-colored and plain pasta (30 pieces per student is recommended in a proportion of two-thirds plain and one-third colored).
- Signs or objects to identify students as zooplankton, fish, birds or fishermen (*signs provided on CD*).

Duration:
30 to 45 minutes

Key Vocabulary:
Biomagnification, polychlorinated biphenyls (PCBs), food chain, producer, primary consumer, secondary consumer, tertiary consumer, chemical, chemical exposure

[1] Original adaptation developed by Deborah Robertson of Wake County Parks, Recreation and Open Space

Background:
Tens of thousands of **chemicals** are used by U.S. industry. These chemicals and any by-products generated through their production can be released to the environment and their presence in the environment may impact wildlife and humans. **Biomagnification** is the process of increasing concentrations of contaminants through the **food chain. Polychlorinated biphenyls (PCBs)** are chemicals that were added to oil in transformers and other electrical equipment to retard fires until their manufacture was stopped in the United States in 1977. PCBs that were disposed of improperly may have contaminated soil and ground and/or surface water. PCBs do not readily break down in the environment and thus remain there for long periods of time. Furthermore, PCBs can travel long distances in the air and be deposited in areas far away from where they were released. In water, PCBs bind strongly to sediments but small amounts may remain dissolved in water. **Exposure** to PCBs results in contamination of the bodies of aquatic organisms and bioaccumulation of PCBs in the fatty tissues of these organisms and any humans who consume these aquatic organisms. Concentrations of PCBs in aquatic organisms may be 2,000 to more than a million times higher than the concentrations found in the surrounding water and sediment, with species at the top of the food chain having the highest PCB concentrations.

Role-play Activity:

1. Distribute pasta in a large open space (indoor or outdoor).

2. Identify one or two people (depending on size of group) as a Great Blue Heron, Osprey, Eagle or Fisherman/woman and have them stand at one end of the playing area. Divide the remaining people into 1/3 fish and 2/3 zooplankton. In a group of 26 people, there would be two “birds” or “fishers”, six “fish” and 18 “zooplankton.” Have each set of people easily identifiable with bandannas, signs with pictures around neck, etc.

3. Distribute a small paper bag to each student representing a zooplankton - the bag is to represent the gut of each animal. Review with students that zooplankton are microscopic animals that have structures that allow them to capture food (phytoplankton (**producers**) or other zooplankton and bacteria); thus, zooplankton represent **primary consumers** in this food chain.

4. Give the following instructions: The zooplankton will be the first to look for food. The fish, bird(s) and fisher(s) should wait during this time. At a given signal, the zooplankton enter the area and collect as much food (pasta) as they can, placing the food into their bags. At the end of a short time period (30 sec.) depending on the size of the area, direct zooplankton to stop searching for food.

5. Next, allow the fish to search for food (zooplankton) for approximately 15 seconds or longer depending on the size of the area. Zooplankton can continue to eat until caught. Birds (or fishers) should still wait off to the side. Each fish should have time to catch one or more zooplankton. Any zooplankton tagged or caught by a fish must give his/her bag to the fish and then proceed to the sidelines. Review with students that these fish represent **secondary consumers** in this food chain.

6. Next, allow the birds (or fishers) to catch the fish. The same rules are followed. Any fish still alive may hunt for zooplankton. If a bird catches a fish, the fish must give his/her bag(s) to the bird/fisher and then proceed to the sidelines. Review with students that these fishers represent **tertiary consumers** in this food chain. At the end of the time period, ask all participants to come together in a circle with their bags of collected food.

7. Ask any participants holding bags to count the total # of colored pasta pieces they ingested. For each animal represented in the food chain, record the number of colored pasta pieces ingested on an overhead or dry erase board so everyone can see the results.

8. Next, inform students that the colored pasta pieces represent PCBs. Any surviving animal that has colored pasta now carries PCBs in their fatty tissue (where PCBs are stored). Notice that the fish should have more PCBs than the zooplankton, and the birds/fishers should have even more. This is called biomagnification.

Follow-Up Activities

- Have students draw and describe a food chain for Lake Crabtree that includes native aquatic species and humans.
- Invite students to check the NC Department of Health and Human Services website for fish consumption advisories stemming from contaminants in the environment and ask them to list and determine the source of any contaminants of concern (*current contaminants include PCBs, Dioxins and Mercury*). Site-specific fish consumption advisory information can be found at: http://www.epi.state.nc.us/epi/fish/index.html
  As of June 2008, fish advisories due to PCB contamination have been issued for Crabtree Creek, Lake Crabtree, Brier Creek Reservoir, Brier Creek, and Little Brier Creek, all of which are in Wake County.
- Invite students to investigate why farm-raised salmon may have higher levels of PCBs than their wild counterparts.

Follow-Up Activities for Advanced Students

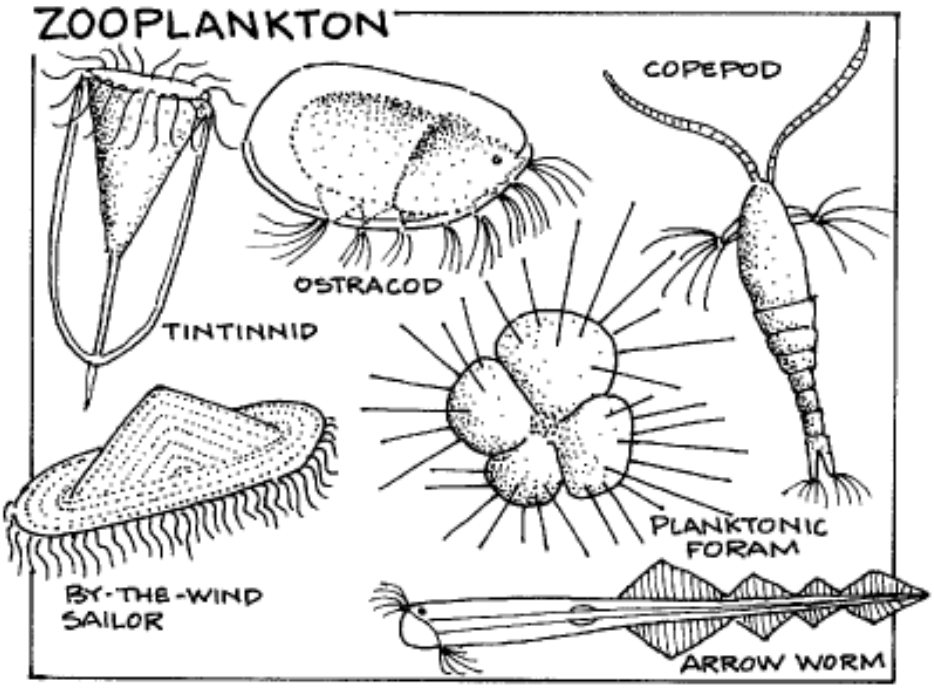
- Invite students to read Chapter 6 from the book *Our Stolen Future* (1996) by Theo Colburn, Dianne Dumanoski, and John Peterson Myers. This chapter traces the path a PCB molecule takes from its place of manufacture in the US to the fatty tissue of a polar bear living in the arctic.
- Have students determine the potential health and reproductive effects of PCBs by reviewing published scientific studies that investigated the effect of PCBs on fish, birds, or mammals, including humans. For example, a study by NCSU researchers used a common clam species (*Corbicula fluminea*) as a model to determine the effects of PCBs on bivalves native to waters affected by the Ward Transformer Superfund site (Lehmann, D.W., J.F. Levine and J.M. Law. 2007. Polychlorinated biphenyl exposure causes gonadl atrophy and oxidative stress in *Corbicula fluminea* calms. Toxicologic Pathology 35: 356-365).

Resources

Agency for Toxic Substances and Disease Registry (ATSDR) PCB Fact Sheet (pdf)
http://www.atsdr.cdc.gov/tfacts17.pdf

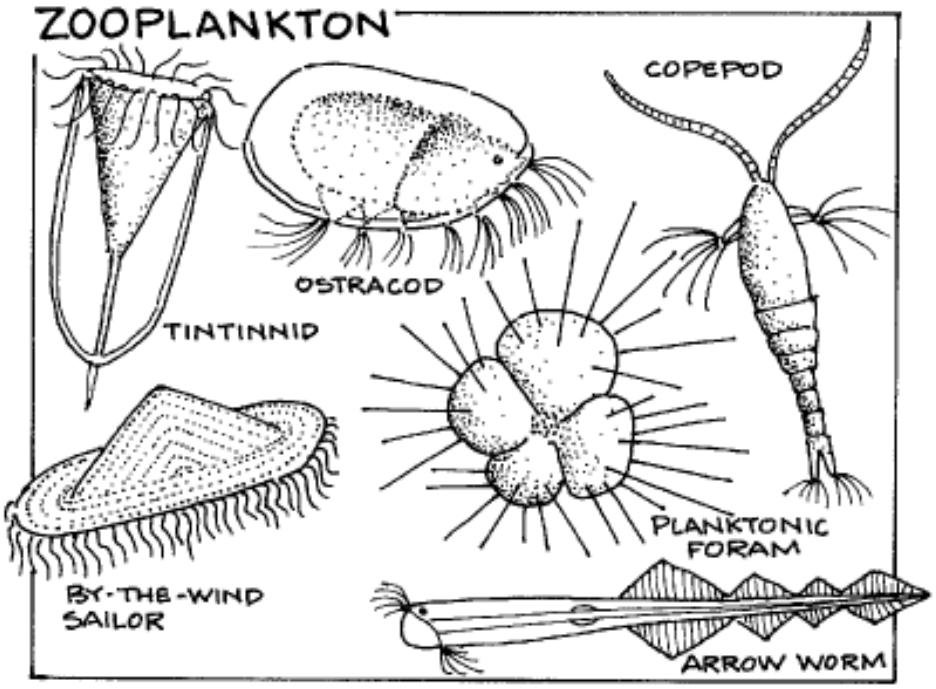
Lake Crabtree and PCBs Brochure, 2012 (pdf)
http://www.wakegov.com/parks/lakecrabtree/Documents/LCCP%20PCB%20Brochure%202012.pdf

NC Department of Health and Human Services: Fish Consumption Advisories
http://www.epi.state.nc.us/epi/fish/index.html



Zooplankton

http://drake.marin.k12.ca.us/stuwork/rockwater/PLANKTON/zooplankton.html



Zooplankton

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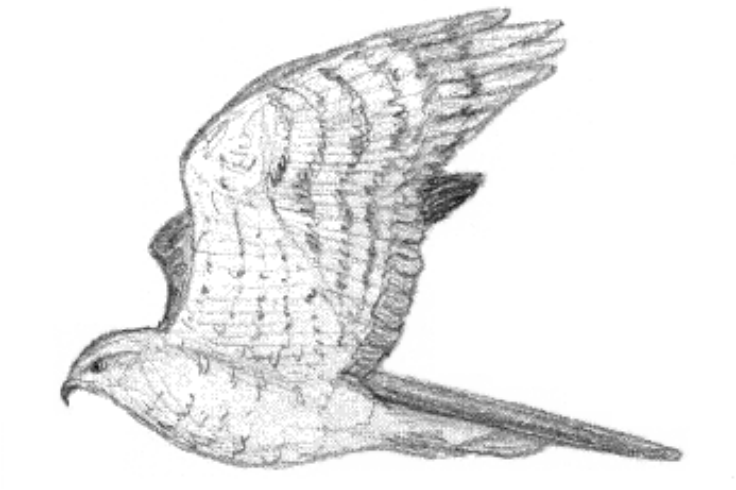
Fish – Carp

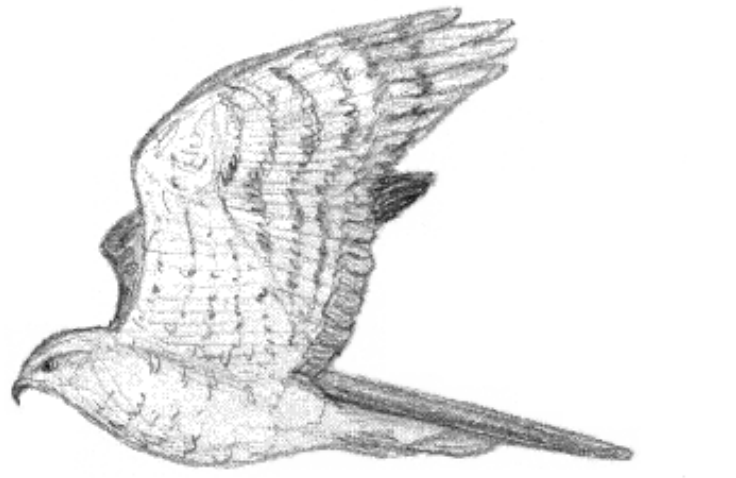
Fish – Carp

Fish –Catfish

Fish –Catfish



Bird



Bird

Fisherman

Fisherman

Enter Number of PCBs acquired during activity