Science Unit: **Marine Biodiversity: Global Ocean to the Salish Sea Ocean**
Lesson #5: **Energy Tag**

Summary:	Students explore how energy is transferred through trophic levels in the ocean through an engaging game of trophic tag.
Lesson type:	Kinetic learning
Grade level:	Presented to grade 3; appropriate for grades 2 – 10 with age appropriate modifications
Duration of lesson:	75 min
Developed by:	Jonathan Kellogg (Scientist); Andrea Teschner and Gillian Wilson-Haffenden (Teachers)
Developed for:	Lord Kitchener Elementary
School Year:	*2016-2017*
Notes:	Activity best done in a large space (i.e. basketball court) to allow for movement Need various objects to help students identify which species they are and the energy that they have.

Connections to BC Curriculum
Transfer of energy through the ecosystem

Objectives

a) Students will examine one food chain and explore how energy transfers through different trophic levels.
b) Students will have a basic understanding of bioaccumulation and natural toxins in the environment

Materials

- Class set of role identification (painted paper headbands, pinnies, wrist bands, or some other colouring that is visible)
  - 16 diatoms (primary producer)
  - 8 copepods (primary consumer)
  - 4 herring (secondary consumer)
  - 2 salmon (tertiary consumer)
  - 1 killer whale (quaternary consumer)
- ~250-500 energy markers (2 types divided with 2/3 type A and 1/3 type B) (painted cardstock w/ dots vs stripes for different energy types or different coloured paper works)
- Bag for students (optional)
- Bag for collection of “waste”

Background Information for the Teacher

Food energy transfers from plant to animal and animal to animal every time an organism is consumed, however, this energy transfer is inefficient. Energy is lost during the transfer in the form of heat, waste (excretion or defecation), respiration, decay, and death. The result of this inefficiency is that nature is unable to supply the energy needed for the same number of individuals that are higher on the food chain as are lower on the food chain.

For example, we know that there are more ants in the world than there are anteaters and there are more anteaters than there are big cats. The reduction in the number of individuals with each higher trophic level creates what is called a "trophic pyramid." Basically, the largest number of individuals are producers, with a smaller number of primary consumers, and still a smaller number of secondary consumers, with reducing numbers of individuals all the way up to top level consumers.

The shape of the pyramid is slightly different for each ecosystem, for biomass, or for the energy available at each level in those different ecosystems. Exploring the relationship between the number of individuals and these other parameters is a clear way to extend this lesson and to test student assumptions and thinking about how organisms relate to their environment. Search "trophic pyramid" or "ecological pyramid" online for additional resources.

This lesson focuses on the simple food chain of Diatoms – Copepods – Herring – Salmon – Killer Whale. The number of individuals decreases with each higher level of the food chain similar to how it would in the natural environment. Also, using two distinguishable markers for energy allows for the introduction of bioaccumulation as a topic.

Bioaccumulation may occur with both natural and human derived chemicals in the environment and may cause serious harm to higher trophic level predators. While there are many stories of human toxins in the environment, it is also notable that in 2015, the largest phytoplankton bloom on record occurred on the North American west coast from Mexico to Alaska. A large number of the phytoplankton species blooming were producing neurotoxins that are known to be harmful to humans. These natural toxins forced the shutdown of the coastal Dungeness crab fishery in CA, OR, WA, and BC for much of the summer. It was also suspected to be the cause of the seizures observed in sea lions and was found present in a majority of the numerous fin whale carcasses that washed ashore in Alaska that summer.

Vocabulary

- **Primary Producer** – Any organism that can take nutrients and convert it to complex organic compounds like sugars, carbohydrates, and fats. Ex. Phytoplankton and algae
- **Primary Consumer** – An organism that consumes primary producers in order to sustain life.
- **Consumer** – Any organism that eats other organisms to sustain life.
- **Food chain** – Sequence of multiple higher order consumers that are sequential predators of each other. The base of the food chain should be a primary producer.
- **Food web** – Network of organisms made up of multiple interacting food chains.
- **Predator** – A consumer

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- **Prey** – An organism that is eaten by another animal
- **Decomposer** – An organism that breaks down discarded organic matter into smaller molecules
- **Trophic level** – The position an organism occupies in a food chain relative to the primary producer (level 1).
- **Bioaccumulation** – accumulation of substances, or toxins, in an organism at a rate faster than the substance can be lost via excretion or catabolism.

Classroom Set-up

- For the activity, it is best to have a large space (i.e. basketball court sized) where students will be comfortable running. However, use some judgment for what is the right size space for your numbers and age group since too large a space will cause the game to be time consuming or unsuccessful.

Lesson Detail

Introduction

Remind students of food chains and explain the concept of a trophic level. Ask them to think about how many individuals there are in each trophic level. An idea is to do this section as a think pair share where students consider different shapes (rectangle, triangle, oval, etc) representing the number of individuals at each trophic level. Ask students to explain their reasoning and use their experience to guide them towards the triangle.

Activity

1. For the activity, assign students their respective organism and give each of the diatoms ~20-50 randomly distributed energy markers. Since they are the primary producers, they are the only ones that start the game with energy. Do not tell them what the different markings are on the energy.
2. As in the real food chain, each animal is only allowed to feed on the trophic level below it. So copepods are only allowed to feed on (tag) diatoms, herring are only allowed to feed on (tag) copepods, and so on up the food chain. When each student is killed/tagged, they must hand over ~1/4 of their acquired energy chits. Collect the remaining 3/4 of the 'waste' energy chits in a basin.
3. For the game to work properly, students must be sent out to the playing field in stages. Diatoms go out first and are allowed to distribute and shortly followed by copepods. When ~2-4 diatoms remain, send in the herring. Continue releasing the next higher trophic level when ~1-2 of the lower trophic levels remain. Remind students that even though they may quickly transition from predator to prey over the course of the game, they should continue to try to kill their own prey to collect more markers.
4. Stop the game when there is still one salmon remaining (and hopefully one of each other species too).
5. When the game is complete, gather students and discuss their observations. Create a table that looks like:

Organism	# Surviving	Energy/animal	Energy/Species	Marked Energy	Live/Die
Killer whale	1				
Salmon					
Herring					
Copepod					
Diatom					

6. You may wish to reveal the last two columns only after having discussed the findings from the total energy in each animal and each species. Do these results match the trophic pyramid? Why or why not?
7. When that discussion is complete, reveal that there are differences between the energy and ask students to count those energy that were marked as toxins and record. Here are some suggested levels at which the organisms would survive, would have compromised immune or reproductive systems, or would die. These numbers may need adjusting depending on how many energy markers initially start with the diatoms.

Organism	Survives	Reproductive or Immune Problems	Death
Herring	<3	3	≥4
Salmon	<4	4-5	≥6
Killer Whale	<5	5-7	≥8

8. Ask the students to suggest reasons why larger organisms might have higher levels of toxins and why they are able to cope with them.

Closure Discussion

Examples of questions to help students share their results and observations…

1. Revisit the trophic pyramid. Is it a good representation of the energy at each level? (In reality, only ~10% of energy is transferred from one trophic level to another vs. the 25% used in the game.)
2. Explore what bioaccumulation means for top-level predators in an ecosystem. What does bioaccumulation mean for humans?

Extensions of Lesson

1. Repeat the game multiple times to see if there are different outcomes.
2. Repeat the game with transient killer whales that eat sealions vs. resident killer whales that eat salmon. (Transient killer whales feed another trophic level higher on the food chain so there is less energy available to them.)
3. Explain how reproduction allows females of a species to offload some of their toxins to their young through gestation and breastfeeding.

References

This lesson was created using the following resources:

<http://www.cfep.uci.edu/cspi/docs/lessons_secondary/energy%20biomass%20pyramids.pdf>
Energy and Biomass Pyramids, University of California Irvine (Accessed 20 April 2016).

<http://www.pac.dfo-mpo.gc.ca/education/documents/whale-epaulard/Foodchaingame.pdf>
Hildering, J. (2008) *Lesson 2 – Student activities: Food Chain Game* (Accessed 20 April 2016)

<http://www.pac.dfo-mpo.gc.ca/education/documents/whale-epaulard/Foodchaingametoxins.pdf>
Hildering, J. (2008) *Lesson 4 – Student activities: Food Chain Game with Toxins* (Accessed 20 April 2016)