Assignment #1

Bioaccumulation: A Case Study
of British Columbia's Killer Whales

Stream to Sea Intermediate

Lesson 4: Activity Description
Bioaccumulation and Killer Whales

1. Review with students concept of bioaccumulation.
    - What is bioaccumulation
    - What persistent organic pollutants can do to an organism
    - Where POPs come from
    - That PCBs in different whale populations were measured
    - How levels of toxins in organisms increase up the food chain
2. Provide "Student Handout: Lesson 4" to each student.
3. Have students do questions 1 to 7 in class. Questions 5 to 7 can be adapted to be class discussion questions.
4. Play the "Food Chain Game with Toxins".
5. Have students complete question 8.

Lesson 4: Student Handout
Bioaccumulation and Killer Whales

What is bioaccumulation?

Many chemicals we use in our daily lives are toxic. Toxic chemicals include pesticides, engine products and many household cleaners. Most toxins are made by humans; they do not occur naturally.

Some of these toxins are **persistent**. This means that they do not break down and as a result they build up in the food chain, usually in the fat of organisms. Mother's milk of mammals has lots of fat in it. Persistent toxins are also known as Persistent Organic Pollutants (**POPs**).

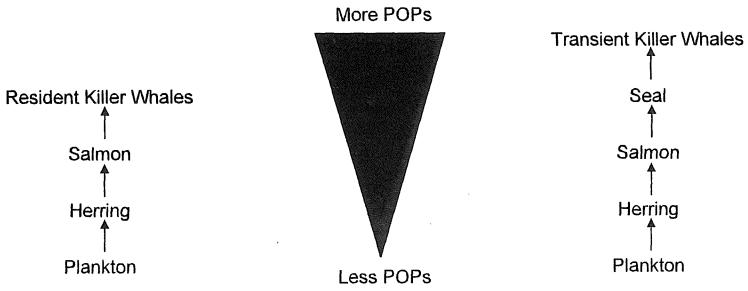
The build up of persistent toxins in the food chain is known as **bioaccumulation**.

Persistent toxins can cause the following problems:

- Reproductive failure
- Birth defects
- Immune system disorders (cancers and weakness to disease)
- Behaviour and learning disorders
- Death

Persistent toxins are also known as Persistent Organic Pollutants (POPs).

The more toxins an organism has, the greater its problems. The diagram below shows what bioaccumulation means for killer whales. Transient killer whales contain more persistent toxins because they are higher in the food chain than resident killer whales. Since resident killer whales and seals are both 4th order consumers, if they had the same range, it would be expected that they would have the similar levels of persistent toxins.



We (humans) may use toxins on land, but they can travel through the soil in groundwater into waterways and into the ocean. All persistent toxins eventually end up in ocean food chains. It is not only local sources of toxins that affect killer whales. Persistent toxins accumulate in cold countries

like Canada by evaporating and condensing again and again (this is known as global distillation). It has been proven that it only takes 5 to 10 days for toxins to come from as far away as Japan into British Columbia's waters.

Source: Dr. Peter Ross' research

Persistent Chemicals in the Food Chain

How can it be that we allow these chemicals to go into the environment and build up in the food chain? We made mistakes in the past with chemicals like the pesticide DDT and PCBs. People thought these were "super chemicals", great inventions that solved problems (DDT kills mosquitoes; it was used to kill bugs that might be carrying disease. PCBs conduct electricity, insulate, don't burn and don't corrode; they were used in everything from electrical lights to paint and printing ink.) These "super chemicals" were not tested for their long-term effects before they were put to use.

Look at the diagram to see how chemicals like PCBs move into and through the food chain.

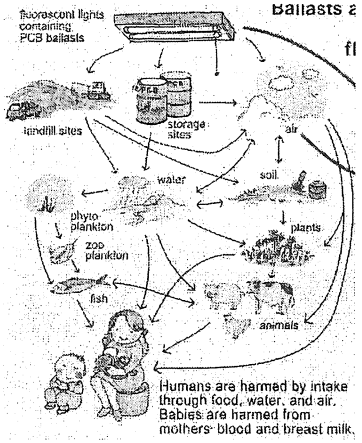


Diagram: Japan Offspring Fund
www.tabemono.info/english

The table below shows more of these persistent toxins. These are known as the "Dirty Dozen". Notice that 9 of these 12 toxins are pesticides!

Persistent organic pollutant (POP) name	Pesticide	Industrial Chemical	By-product
1. Aldrin	√		
2. Chlordane	√		
3. DDT	√		
4. Dieldrin	√		
5. Endrin	√		
6. Heptachlor	√		
7. Mirex	√		
8. Toxaphene	√		
9. Hexachlorobenzene	√	√	√
10. PCBs		√	√
11. Dioxins			√
12. Furans			√

After years of using these chemicals, animals in the food chain started having problems. For example, with DDT, the egg shells of large birds were so weak that they would be crushed by the weight of the adult birds. When the chemicals were tested, it was discovered that they bioaccumulate.

So we learned our lesson right?

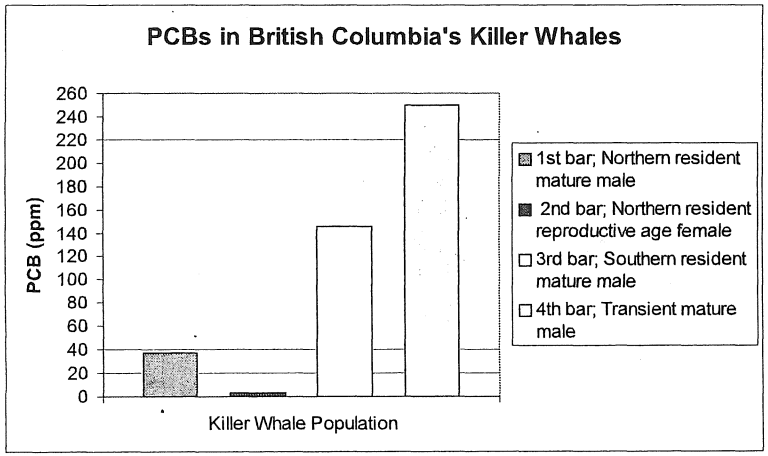
No. We have definitely not learned our lesson.

- Many countries still use the chemicals that have been proven to bioaccumulate.
- These chemicals are stored all over the world and are often not properly disposed of.
- Canada and America do not have laws that insist on the testing of new chemicals that are not used in food. In fact, of some 85,000 chemicals used in North America, only 10% have been tested for their environmental effects (Source: Chemical Trespass).
- Of 300,000+ chemicals used in N. America, about 400 are "emerging chemical contaminants" (ECC) and can bioaccumulate. 75% have not been studied. (Source: Derek Muir, Environment Canada, Feb 2008).
- There is a new group of chemicals that is being produced in North America that has already proven to bioaccumulate. These are the PBDEs, a group of chemicals that are of use to humans because they don't burn. They are fire retardants. There are alternative fire retardants that do not bioaccumulate. Europe has banned PBDEs. North America has not.

The "PBDEs" are a group of chemicals that contain the chemical bromine and stop fires. They have been proven to be persistent organic pollutants and are found in furniture, televisions and computers.
PBDE = polybrominated diphenyl ethers

Persistent Toxins and British Columbia's Killer Whales

Dr. Peter Ross studied the amount of toxins in the blubber of British Columbia's resident and transient killer whales. The blubber samples were used for both DNA and toxin research. The samples were collected by using a retractable dart system that removed a sample the size of a pencil eraser. Dr. Ross' studies are summarized in the chart below; the units of measurement are parts per million (ppm).



Questions

1. Use the "PCBs in British Columbia's Killer Whales" graph to fill in the following table:

	Northern resident mature male	Northern resident female of reproductive age	Southern resident male	Transient mature male
Estimate of amount of PCBs in blubber (ppm)		3		

Use the graph and the table to answer the following questions.

2. Researchers found that beluga whales in the St. Lawrence River had PCB loads of about 79 ppm. These animals had malformed skeletons and cancers and their population was severely endangered (*Source: Muir et al*). In ringed seals, a level of 77 ppm causes reproductive problems (*Source: Oceana*). Which killer whale populations are above these levels?

3. A level of 16.5 ppm causes immune system problems in harbour seals (*Source: Oceana*). Which killer whale populations are above this level?

4. A level above 50 ppm, is considered toxic waste by Canadian guidelines (*Source: Oceana*). Which killer whale populations are above this level?

5. In Canada, the action level for PCBs is 2 ppm. This is the amount that is too high for humans to eat food with this level of PCBs. Which killer whale populations are above this level?

6. Approximately how many times greater is the level of PCBs in Northern resident males than Northern resident females of reproductive age? Why do you think the males might have so many more toxins like PCBs?

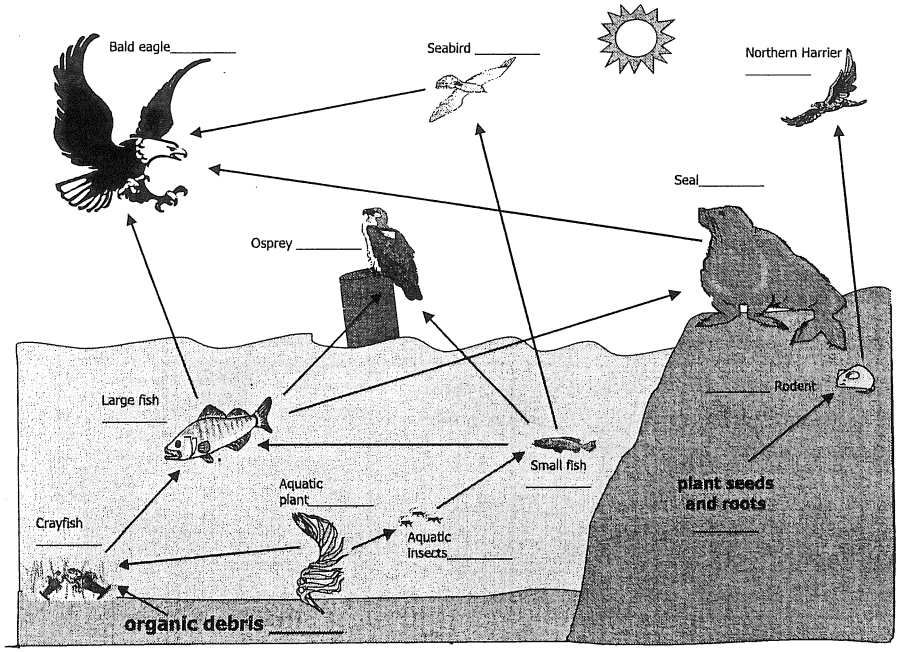
7. Knowing what you do now about toxins in killer whales, explain why males might live much shorter lives.

8. Approximately how many times greater is the level of PCBs in Southern resident males than Northern resident males? Why do you think the southern residents might have so many more toxins like PCBs?

9. Summary: For each topic, check the selection that is most likely to have more toxins

Type of Killer whale	Gender	Birth Order	Range
1. Resident	1. Male	1. Firstborn calf	1. Near big cities
2. Transient	2. Female	2. Not firstborn calf	2. Further away from cities

Assignment #2



USGS Data Exploration Unit: Lesson 2 Activity Food Webs and Bioaccumulation

Introduction

In this activity you are going to analyze a food web to determine which organisms in the food web accumulate the greatest concentration of chemicals in their tissues and consider which organisms in a food web might be most affected by the introduction of a toxic chemical to their habitat. You will need to refer to your class notes to complete this activity.

When an animal consumes food having DDT residue, the DDT accumulates in the tissue of the animal by a process called **bioaccumulation**. The higher an animal is on the food chain (e.g. tertiary consumer such as seals), the greater the concentration of DDT in their body as a result of a process called **biomagnification**. In this activity you will identify the way in which DDT might move through a food chain.

Based on the food web relationships denoted by the arrows in the food web diagram, label each plant/animal with one of the following labels: primary producer, primary consumer, secondary consumer or tertiary consumer. Next rank the relative concentration of DDE in each plant/animal using the following scale: 1 = lowest concentration - 10 = highest concentration. Finally, answer the five questions following the food web diagram.

Questions

1) What is the difference between bioaccumulation and biomagnification?

2) Plants/animals from which of the following groups are most susceptible to problems from DDE: primary producer, primary consumer, secondary consumer or tertiary consumer. Why?

3) What are some differences between the food chain of ospreys and the food chain of northern harriers? How might these differences in the diet of osprey and northern harriers result in exposure to different amounts of DDE?

4)

a) Suppose an osprey eats 300 g of fish per day. The fish tissue consumed by the osprey has an average DDE concentration of 0.1μg/g. How much DDE is the osprey consuming in one day?

b) Now suppose a bald eagle also eats 300 g of food per day. But, the bald eagle eats seal carcasses that have washed up on the beach. The seal had eaten fish-eating fish with 1.0 μg/g DDE in their tissue. Much of the seal's body is made of blubber (a fatty substance) and the DDE bioaccumulates in the seal. So, the seal has 2.0 μg/g DDE in its tissue. If the bald eagle eats 300 g of seal, how much DDE does the bald eagle consume in one day?

5) Taking all factors into account, rank the following for likelihood of bioaccumulation: bald eagles, osprey, seals, and northern harriers.