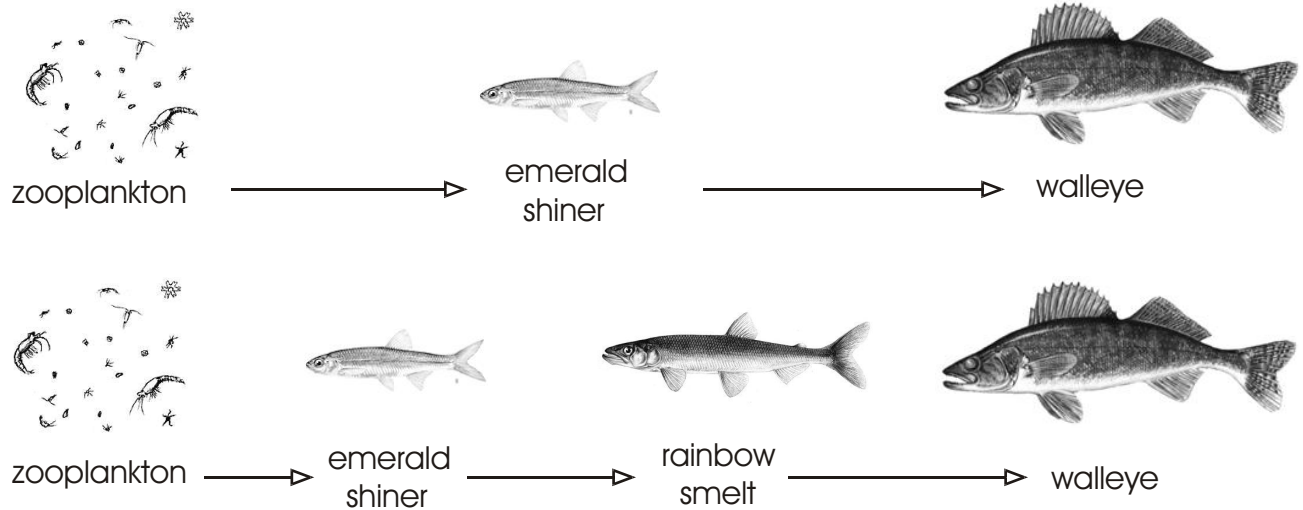


BIOACCUMULATION



Teacher's Instructions:

- recall food webs and food chains by asking students randomly if they can explain the concepts behind them
 - i.e. food chain is a path of how energy moves through organisms and a food web is many food chains hooked together
- look at the food chain from Lake Winnipeg or create one that could exist in Lake Winnipeg
 - examples:



- discuss bioaccumulation by reading the Background information and use the food chain above as an example of showing how contaminants move and collect in a food chain
- do the following activity

Activity:

- time: 30-45 minutes
- materials:
 - each student needs:
 - 40 coloured tokens (such as marbles, centicubes, beads, etc.), 4 of which must be red or tagged red, the rest can be any color other than red;
 - 1 small paper cup;
 - you will need
 - 1 hula hoop for every 4 students;
 - 1 armband or headband for every 5 students (for predators)
 - 1 larger paper or plastic cup (about twice the size of the small cup) for every 5 students (for predators)

BIOACCUMULATION



- procedure:

- select (or have the students select) one predator and prey relationship from the food chain created above (the prey should consume something small such as minnows or zooplankton as token will represent the prey's food)
- divide the class into predators and prey (there should be about 4 times more prey than predators)
- select a playing area to be a "lake", the area should have a boundary (a gym floor works well and the basketball court lines could be the boundary)
- place 5 hoops randomly in the lake and scatter the tokens (since there may be marbles involved the students should not run and be very careful where they walk)
- the prey is released into the lake and begin to collect the tokens (the tokens are plankton and the prey "eats" the plankton by putting the tokens into its cup)
- after a few minutes, the predators are released into the lake, they may eat some tokens but they should concentrate more on "eating" the prey (predators capture the prey by tagging them and then the prey empty their cup into the predator's cup)
- prey that has been captured or tagged remain in the lake after emptying their cup, they continue to "eat" plankton (this is because there are many more prey than predators)
- prey can "hide" in the hula hoops as they represent cover, however, only two prey can "hide" in one hoop at a time. and both feet of each prey must be in the hoop (obviously, students should be discouraged from remaining in the hoop for long periods of time as they will "starve")
- continue in this manner until there is a severe shortage of plankton, then stop and have the students sort their tokens according to color
- if some cups or "stomachs" are full, the students should continue to walk or "swim" until the game is over
- inform students that some of the food that they ate contains contaminants such as mercury, tell them that the red tokens represent how much mercury they have in their bodies
- return to the classroom and make a chart of how much mercury each student or "fish" had in its body

- example:

Name	Species	Red Tokens
Tim	walleye	3
Mark	minnow	1

- discuss the impact rainbow smelt has on bioaccumulation (see Rainbow Smelt Background)
- have the students complete the following assignment (the student handout begins on page 4)
 - be sure to explain the Sport Fishing Consumption Guide

BIOACCUMULATION



Rainbow smelt background:

Introduced to Lake Winnipeg in 1991, rainbow smelt is thought to increase the accumulation of contaminants in its predators such as walleye. This would occur because smelt feed at a higher trophic position than other food sources of walleye. The smelt prey on the minnows and then the walleye feed on rainbow smelt that prey on those minnows. Thus, instead of eating smaller, lower species of minnows, walleye choose to consume bigger rainbow smelt. This causes the bioaccumulation of contaminants to increase in walleye.

Sport Fishing Consumption Guide: on page 5 of the students' assignment

Unrestricted Consumption	Limited Consumption		No Consumption
	200g of fish per week	140g of fish per week	
less than or equal to .0005g/kg	.0005g/kg to .001g/kg	.001g/kg to .0015g/kg	over .0015g/kg
one red token or less	two red tokens	three red tokens	four red tokens or more

Unrestricted Consumption: fish may be consumed freely. Fish in this category have mercury concentrations less than or equal to .0005 g/kg

Limited Consumption: fish may be consumed but only in certain amounts over specific periods of time

Group 1 - 200g of fish per week: fish in this group have mercury concentrations between .0005 and .001 g/kg and people can eat up to 200 g of fish in this category per week.

Group 2 - 140 g of fish per week: fish in this category have mercury concentrations of .001 to .0015 g/kg and people should eat no more than 140 g of fish in this category per week.

No Consumption: no fish from this category should be consumed. Fish in this category have mercury concentrations greater than .0015 g/kg

BIOACCUMULATION



Objectives:

- to describe bioaccumulation and explain its potential impact on consumers

Tasks:

- recall food chains and food webs, create a food chain for Lake Winnipeg
- participate in the activity
- learn how rainbow smelt affects bioaccumulation
- complete the following assignment

Key Terms:

- bioaccumulation: increase in concentration of a pollutant (contaminant) from the environment to organisms in a food chain
- biomagnification: increase in concentration of a pollutant (contaminant) from one link in a food chain to another; as you move up the food chain the concentration of pollutants increases

Background

In the late 1960s, the government became aware that harmful substances were entering the food web. Some of these substances include: DDT, lead, dioxin, PCBs, PAHs, and heavy metals such as mercury. These substances are called contaminants and last a long time in the environment. In large quantities, these contaminants are harmful to organisms health (including humans who eat organisms with high concentrations of these pollutants in them).

Organisms store these contaminants in their fat cells and are not released until the fat is burned and even then some still remains. Usually, organisms lower in the food chain do not bioaccumulate very many contaminants. However, when an organism consumes many of these lower species, it also consumes the contaminants that are in it. This is what is mean by bioaccumulation - how contaminants enter and get passed along in a food chain. Obviously, the higher up the food chain an organism is, the greater the bioaccumulation.. This is called biomagnification. So, higher level consumers have the greatest chance of having a lot of contaminants bioaccumulate in their bodies.

Contaminant	Explanation	Come From	Used For	Health Effects
DDT	Dichloro Diphenyl Trichloroethane	chlorinated hydrocarbon	insecticide	low toxicity to humans
PCB	Polychlorinated Biphenyl	transformer coolant, insulation	no longer used	brain defects, cancers
PAH	Polynuclear Aromatic Hydrocarbons	petroleum products	by-product	carcinogenic (causes cancer)
Heavy Metals	mercury, lead, copper, zinc	mining, metal processing	by-product	harms nervous system and reproduction

BIOACCUMULATION



Assignment: (30)

- 1) How much mercury did you have in your stomach? In other words, how many red tokens did you have in your cup? (1)
- 2) With the rest of the class, chart how much "mercury" each student or "fish" had in their cup or "stomach". (5)
- 3) The Sport Fishing Consumption Guide places restrictions on eating fish with certain amounts of mercury in them (for health reasons). The Guide is as follows:

Unrestricted Consumption	Limited Consumption		No Consumption
	200g of fish per week	140g of fish per week	
less than or equal to .0005g/kg	.0005g/kg to .001g/kg	.001g/kg to .0015g/kg	over .0015g/kg
one token or less	two tokens	three tokens	four tokens or more

- a) determine how many fish are in each of the categories in the chart above. (4)
- b) calculate the percentage of fish in each category (4)
- c) were you safe to eat? (1)

Unrestricted Consumption	Limited Consumption		No Consumption
	200g of fish per week	140g of fish per week	
_____ fish	_____ fish	_____ fish	_____ fish
_____ %	_____ %	_____ %	_____ %

BIOACCUMULATION



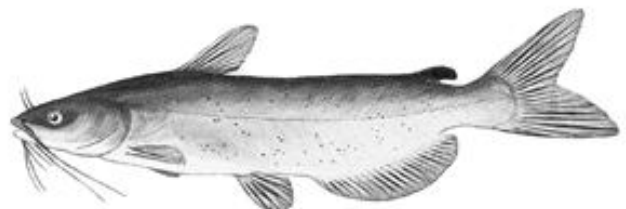
4) We determined how much mercury was in these “fish” by looking at its stomach’s contents. However, anglers and fishermen cannot examine the fish’s stomach without harming it so they need another way of determining if a fish is edible, that is, it contains low amounts of mercury. It is known that the larger the fish, the greater the chance of bioaccumulation. This is because bigger fish have eaten more food and the risk of accumulating mercury increases. Thus, the Sport Fish Consumption Guide has found that certain amounts of mercury in fish corresponds to the size of that fish for specific species. The following is a chart that shows what size of fish is suitable for consumption.

Fish Species	Unrestricted Consumption	Limited Consumption		No Consumption
		200g of fish per week	140g of fish per week	
Walleye	under 41 cm	41-51 cm	51-58 cm	over 58 cm
Channel Catfish	under 59 cm	59-72 cm	72-80 cm	over 80 cm

a) The following is a list of fish caught. The people that caught would like to know if these fish are suitable for eating. Use the chart on the next page to categorize these fish . (8)

- channel catfish 73 cm
- channel catfish 57 cm
- walleye 41 cm
- walleye 58 cm
- channel catfish 50 cm
- walleye 59 cm
- channel catfish 45 cm
- channel catfish 53 cm
- walleye 47 cm
- walleye 37 cm

- channel catfish 83 cm
- walleye 57 cm
- channel catfish 60 cm
- walleye 30 cm
- walleye 40 cm
- channel catfish 67 cm
- walleye 42 cm
- channel catfish 71 cm
- walleye 50 cm
- walleye 43 cm



BIOACCUMULATION



Fish Species	Unrestricted Consumption	Limited Consumption		No Consumption
		200g of fish per week	140g of fish per week	
Walleye				
Channel Catfish				

5) answer the following questions about the chart above

- a) if these people never eat more than 140g of fish per week, how many of the fish they caught are safe for them to consume? (1)
- b) if these people eat more than 200 g of fish per week, how many of the **catfish** they caught are safe for them to consume? (1)
- c) if these people never eat more than 200 g of fish per week, how many of the **walleye** they caught are safe to eat? (1)
- d) how many of the fish they caught are totally unsafe to eat, no matter how much they eat per week? (1)

5) What happens to the amount of mercury in walleye if they choose to feed on rainbow smelt instead of minnows? Why and how does this occur? (3)

BIOACCUMULATION



ANSWER KEY: (30)

1) to 3) You will have to create a chart of the class and the mercury content of each student. Then, you can use that information to create an answer key for these questions. (15 marks)

4) (8 marks)

Fish Species	Unrestricted Consumption	Limited Consumption		No Consumption
		200g of fish per week	140g of fish per week	
Walleye	4	4	2	1
Channel Catfish	4	3	1	1

a) if these people never eat more than 140g of fish per week, how many of the fish they caught are safe for them to consume? **18 - one mark**

b) if these people eat more than 200 g of fish per week, how many of the catfish they caught is safe for them to consume? **4 - one mark**

c) if these people never eat more than 200 g of fish per week, how many of the walleye they caught is safe to eat? **8 - one mark**

d) how many of the fish they caught are totally unsafe to eat, no matter how much they eat per week? **2 - one mark**

5) What happens to the amount of mercury in walleye if they choose to feed on rainbow smelt instead of minnows? Why and how does this occur? (3 marks)

The amount of mercury increases. This occur because rainbow smelt feed at a higher trophic level than the minnows. Thus, they bioaccumulate the mercury from the minnows. Then, the walleye eat the smelt and their mercury level increases too. The key is that the higher the trophic level the more bioaccumulation occurs. (Note: you can refer to the food chain diagrams on page 1 when you are correcting this.)