Conserving Canada's Marine Biodiversity

A Curriculum Resource for Ontario Teachers

BEAN
Biodiversity Education and Awareness Network

Introduction

The national motto of Canada – *A Mari usque ad Mare;* From Sea to Sea, is certainly a fitting description of this majestic country, defined as much by its oceans as its land. Bounded by three oceans – Atlantic, Pacific, and Arctic, Canada has the longest ocean coastline in the world. For the seven million Canadians living in coastal communities, oceans provide recreational, environmental, employment, income, and cultural opportunities.

Canada has the potential to be a world leader in ocean conservation. The reality, however, is that the health of our marine environments is at risk or already declining. There are major declines in some fish stocks, changes in the structure of marine ecosystems, altered ocean chemistry, continued introduction of pollutants and invasive species, increasing numbers of marine species-at-risk, habitat alteration and degradation, and declining biodiversity and productivity. In recognition of the importance of oceans to biodiversity and to people, the United Nations has proclaimed May 22nd 2012 as "The International Day for Marine Biodiversity".

Most students in Ontario have little interaction with Canada's oceans, being hundreds of kilometres away from the nearest marine coastline. (Don't forget, Ontario is bordered on the north by marine coastline!) Despite this, or maybe because of it, students are often fascinated by sharks, puffins, and whales – all Canadian marine animals!

This package provides marine biodiversity activities for both elementary and secondary students in Ontario. As a multidisciplinary topic, Ontario curriculum connections are made for life sciences, chemistry, earth sciences, and mathematics. The intent of these activities is to help students become passionate about Canada's oceans, raise awareness of conservation issues, and bring Canada's oceans just a little bit closer to home.

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ROM Royal Ontario Museum Musée royal de l'Ontario

Ontario

Table of Contents

4. Good-bye Bycatch (pg. 30)

Students may be familiar with fishing from their own experiences, but commercial fishing is an entirely different matter. In this activity students will explore different fishing methods, determine which have the highest and lowest amounts of bycatch, and graphically display the results.

Curriculum Links:

- Grade 4 – Understanding Life Systems: Habitats and Communities
- Grade 4 – Mathematics: Data Management and Probability
- Grade 5 – Mathematics: Data Management and Probability
- Grade 6 – Understanding Life Systems: Biodiversity
- Grade 6 – Mathematics: Data Management and Probability
- Grade 7 – Understanding Life Systems: Interactions in the Environment
- Grade 7 – Mathematics: Data Management and Probability
- Grade 8 – Mathematics: Data Management and Probability

Secondary Activities (grades 9-12)

1. Ready, Set, Fish (pg. 38)

The goal of sustainable fisheries is to balance the harvest of seafood in a manner that meets the needs of the present without compromising the ability of future generations to meet their own needs. In this simulation game students will try and balance the environmental and economic conflicts faced in the creation of a sustainable fishery.

Curriculum Links:

- Grade 9 – Biology: Sustainable Ecosystems
- Grade 11 – Biology: Diversity of Living Things
- Grade 11 – Environmental Science: Scientific Solutions to Contemporary Environmental Challenges
- Grade 12 – Biology: Population Dynamics

2. Dissolving in an Ocean of Acid (pg. 47)

Increasing levels of carbon dioxide in the atmosphere are causing seawater to become more acidic. Canada's cold-water coral reefs fare poorly in acidic water because it is more difficult to build calcium carbonate skeletons and keep them from dissolving. In this lesson students will examine how adding CO_2 to water makes an acidic solution and observe how calcium carbonate behaves in water with different acidic pH's.

Curriculum Links:

- Grade 9 – Biology: Sustainable Ecosystems
- Grade 10 – Chemistry: Chemical Reactions
- Grade 10 – Earth and Space Science: Climate Change
- Grade 11 – Biology: Diversity of Living Things
- Grade 11 – Chemistry: Chemical Reactions
- Grade 11 – Chemistry: Solutions and Solubility
- Grade 11 – Environmental Science: Scientific Solutions to Contemporary Environmental Challenges
- Grade 12 – Biology: Population Dynamics
- Grade 12 – Chemistry: Chemical Systems and Equilibrium

Glossary (pg. 54)

WE ARE ALL CONNECTED

IN THIS LESSON

The Big Idea:

Because they are so far away from Canada's marine coastlines, it can be hard for students in Ontario to understand that their everyday activities can and do impact the world's oceans. This activity demonstrates how actions taken in their home town or city can have impacts hundreds or thousands of kilometres away. In the first activity, students create a model watershed and discover how activities at one location impact all areas downstream. In the second activity, students attempt to clean up water contaminated with various pollutants. In the third activity, students explore different initiatives to reduce water pollution entering their local watershed.

Learning Objectives:

- learn that a watershed is a fundamental geographic unit
- examine point source and non-point source pollution
- investigate processes used for separating different mixtures
- explore local initiatives to prevent pollutants from entering the watershed

Activity 1 – Our Local Watershed

Background Information:

A watershed is the area of land draining all precipitation and groundwater into a particular set of waterways. The limit, size, and shape of a watershed are determined by the highest elevations in the area. The watershed carries all the water that has been "shed" from the land. Every drop of water flows downhill, channelling through the soil, collecting in groundwater, flowing into streams, making its way into lakes and rivers, and eventually entering the ocean.

Ontario is divided into three large watersheds – (1) the Hudson Bay watershed drains northern Ontario into James Bay, Hudson Bay, and the Arctic Ocean, (2) the Nelson River watershed drains northwestern Ontario into the Nelson River in Manitoba and then into Hudson Bay. (3) The Great Lakes watershed drains the Great Lakes system into the St. Lawrence River and the Atlantic Ocean. The Great Lakes watershed is home to more than 90% of Ontario's population and eight of Canada's twenty largest cities.

Much of the water in a watershed originates as runoff. Runoff is the water that flows across the surface of the earth until it reaches a waterway. Many pollutants enter a waterway through runoff because runoff picks up contaminants. Depending on their origin, pollutants are categorized as either point source or non-point source. Point source pollution occurs when pollutants are released from a single (often identified) source, like a pipe. In contrast, non-point source pollution comes from many unidentified sources and often is spread out over a large area. Examples include salt from road salting or soapy water from washing the car at home. In the Great Lakes watershed, Lake Ontario is downstream from the other four Great Lakes, and receives pollution from the entire Great Lakes area. As a result of runoff and other sources of pollution, Lake Ontario's ecology has changed dramatically over the past two hundred years.

Time Needed: 1 period
Site Needed: Large outdoor space

Materials:

- Large clear/white plastic tarp or shower curtain
- Very large watering can
- Pollution simulators – cereal, food colouring, soil, salt, cooking oil, grass clippings

Activity Procedure:

1. Introduce the concept of a watershed to your students. *What streams and rivers are in your watershed? Find the limits of your watershed on a map. Which ocean does your watershed drain into? How far away is the nearest ocean coastline from the school?*

2. Have students identify what might be found in a watershed, both natural and manmade. *Items might include lakes, streams, forests, mountains, people, animals, schools, houses, factories etc.* Reinforce that we all share this watershed.

3. Go outside to a large open area. Have a group of volunteer students (4-8) sit on the ground and drape the tarp over them to create a watershed. Students use their arms and legs to create peaks and valleys in the watershed. Make sure that all arms and feet are kept under the tarp.

4. Have students predict where the water is going to flow once it starts to rain. Sprinkle water from the watering can onto the centre of the tarp and see where the water travels. *Were the predictions correct? Why is water collecting in some areas and not others? What about this model is accurate? What about this model is not accurate (i.e. compare absorbency of the plastic tarp to soil).*

5. Explain that this model represents an unpolluted watershed. Brainstorm different types of pollution that may enter a watershed *(i.e. soil and pesticides from fields, toxins from factories and mines).* Discuss that depending on their source, pollutants can be classified as either point source or non-point source. Have the students decide if each type of pollution is point source or non-point source.

6. Brainstorm different ways to show each pollution type on the watershed model *(i.e. soil erosion could be modelled by sprinkling soil over the tarp to simulate fields; a pool of oil could simulate a burst oil pipe).*

7. Sprinkle water on the tarp again and watch what happens as the water flows.

8. Examine the water collecting at the bottom of the tarp. *What pollutants are in the water? Did the pollution travel upstream or downstream? Is the pollution the same on all sides of the trap? Why or why not?*

9. Discuss which type of pollution is more difficult to control – point source or non-point source.

Activity 2 – Operation Watershed Cleanup

Background Information:

Water is a universal solvent, capable of dissolving and transporting many chemicals. What we put on the ground, from fertilizers to road salt, will be dissolved and carried in water and affect water quality downstream.

Wetlands are a natural way the environment controls runoff and maintains water quality. Wetlands are areas that form transitions between dry land and waterways. Although there are many types of wetlands, all serve similar ecological functions including flood prevention by catching, storing and slowly releasing excess water, and purifying water by retaining surplus nutrients, trapping sediments, and sequestering heavy metals.

Today, 70% of wetlands in southern Ontario have been lost or severely degraded. When we replace wetlands with roads, buildings, and parking lots, we create impervious surfaces that water cannot penetrate. Rain is quickly channelled away before soils can retain it, increasing the likelihood of flooding and erosion. This runoff (full of sediments and chemicals) flows into storm drains and then into connecting streams and rivers.

Unless the runoff is collected and treated, all these pollutants end up in the ocean. Contaminants from the Great Lakes journey almost 1200 km through the St. Lawrence River before ending up in the Atlantic Ocean. Garbage bags left at the beach after a picnic may be eaten by sea turtles who have mistaken them for jellyfish. Fertilizer washed away from fields carries excess nutrients that cause algal blooms which can smother coral reefs. Engine oil from vehicles causes liver disease in bottom-dwelling fish. Heavy metals released from metal processing plants are consumed by filter feeding zooplankton and accumulate to toxic levels in carnivores.

Time Needed: 1 period
Site Needed: Classroom
Group Size: 4

Materials:

- Large plastic cups to hold polluted water (2 per group)
- Pollutants – small pieces of plastic grocery bag, cooking oil, iron fillings, sand, food colouring
- Strong magnets (1 per group)
- Polypropylene cloth (like sock liners), cut into small pieces (1 piece per group)
- Bleach (see safety note below)
- Baking soda
- Coffee filters (1 per group)
- Elastic bands (1 per group)
- Spoons (1 per group)
- Tweezers (1 per group)
- Small cups to hold separated items
- Stir sticks (1 per group)
- Safety goggles (1 per student)
- Gloves (1 pair per student)

Safety note:
Gloves and safety goggles must be worn by students and teachers while handling the bleach. The teacher will dispense the bleach to each group. Ensure that students do not drink or taste their “purified” water because bleach can oxidize organic contaminants in the water forming carcinogens.

*** Students could develop their own methods of filtering out pollutants.*
*This procedure has the teacher lead the experiment.***

Activity Procedure:

1. Create some polluted water for each group. In a large cup filled with water, add some small pieces of plastic garbage bag, cooking oil, iron fillings, sand, and food colouring.

2. Give each group the polluted water that they need to clean. Have the students identify the various pollutants and what they might represent. *Bags represent plastic litter, iron filings represent metals from mines, cooking oil represents oil spills, soil represents erosion, and food colouring represents microorganisms.*

3. Discuss what impact each pollutant might have on the marine ecosystem.

4. Brainstorm ways to remove the pollutants and consider in which order they should removed. *Which materials will be the easiest to remove? Which will be the most difficult to remove? Why do some pollutants float and others sink?*

5. Use the tweezers to remove the plastic bags. This is called screening.

6. Use the spoon to carefully skim away the oil off the surface. If some oil remains use the sock liner to absorb excess oil. Place the excess oil in a small cup.

7. Use the magnet to remove the iron filings from the sand.

8. Use an elastic band to attach a coffee filter over the mouth of the second large plastic cup. Slowly pour the polluted water into the second cup to remove the sand. This is called filtration.

9. The teacher stirs in a spoonful of bleach to the water. Observe what happens. Stir in a spoonful of baking soda and observe. This is called disinfection.

10. Examine the remaining water. *How does it compare to pure water? How does it compare to the untreated water?* Stress that this water is not safe to drink because we have added the chemical bleach.

11. *Could these techniques be replicated on a large scale for cleaning a lake or even an ocean? Which steps would work and which would not? Why don't we clean the ocean? Are there any alternatives?*

Activity 3 – My Watershed, My Ocean

Background Information:

Everyone can help reduce non-point source pollution by simply being aware of our actions and making responsible choices. Instead of dumping soapy water down the storm drain, dump waste water down the sink (where it will be treated at a sewage treatment plant) or use a carwash (where there is special waste water drainage). Don't throw oil, antifreeze and paints into the garbage; make sure they are disposed of properly. Use biodegradable pesticides and fertilizers on the lawn and biodegradable cleaning products in the home.

Many communities have groups dedicated to helping Canadians understand that storm drains are directly connected to our rivers, lakes, and streams. By preventing pollutants from entering our storm drains, we are protecting and improving water quality and aquatic habitats. Trout Unlimited Canada designed and manages Yellow Fish Road, a nation-wide environmental education program. By painting yellow fish near storm drains, they serve as a reminder that anything entering the storm drains flows directly and untreated into the local waterbody. Some municipalities adhere plastic information discs next to storm drains. They also distribute fish-shaped brochures, so that residents know why yellow fish have appeared in their neighbourhood. Other municipalities, including Ottawa and Toronto, have sewer grates with fish designs to remind us that anything dumped down the grate ultimately ends up untreated in our rivers and oceans.

Time Needed: 1 period + time for assignment
Site Needed: Classroom, local neighbourhood

Materials:

- Clipboard for taking notes
- My Watershed, My Ocean Observation chart (see below)

Activity Procedure:

1. Brainstorm different ways pollution can enter the school's watershed *(e.g. excess fertilizer from fields, oil from roads, dog feces from lawns).*

2. Go for a walk around the school's neighbourhood looking for sources of pollution. Have the students keep track of their observations and determine if the pollution is point source or non-point source.

3. Look for indications that conservation groups or government groups are trying to make people aware of how easily pollution can enter the watershed.

Reflection Activity:

Have the students create a brochure that could be distributed to the local community describing:

1) What is a watershed
2) What bodies of water make up their local watershed
3) Different types of pollution students saw entering their local watershed (data obtained from the walk around the area)
4) What impacts this pollution can have on the local watershed and the ocean
5) Suggest ways for people to prevent water pollution.

Extension Ideas:

- Visit the local water purification plant to learn how drinking water is treated.
- Visit a local lake or river and examine water being discharged from storm drains. Collect samples and conduct tests to see how clean it is.
- Have students research the Great Pacific Garbage Patch and its effects on marine biodiversity. Students should also propose ways to 1) prevent it from growing, and 2) remove the garbage that has already collected.

My Watershed, My Ocean Observation chart:

As you walk around your neighbourhood, look for different sources of water pollution and fill in the following chart.

Description of Pollution	Source of Pollution	Pollution Type
		☐ Point source ☐ Non-point source
		☐ Point source ☐ Non-point source
		☐ Point source ☐ Non-point source
		☐ Point source ☐ Non-point source
		☐ Point source ☐ Non-point source
		☐ Point source ☐ Non-point source

Did you find any indications that conservation groups or government groups are trying to make people aware of how easily pollution can enter the watershed?

Curriculum Links:

Grade 4 – Understanding Life Systems: Habitats and Communities

- analyse the positive and negative impacts of human interactions within natural habitats and communities

Grade 5 – Understanding Earth and Space Systems: Conservation of Energy and Resources

- analyse the long-term impacts on society and the environment of human uses of natural resources, and suggest ways to reduce these impacts

Grade 5 – Understanding Matter and Energy: Properties of and Changes in Matter

- assess the environmental impact of using processes that rely on chemical changes to produce consumer products
- use scientific inquiry/experimentation skills to determine how the physical properties of materials make them useful for particular tasks

Grade 6 – Understanding Life Systems: Biodiversity

- analyse a local issue related to biodiversity, propose action that can be taken to preserve biodiversity, and act on the proposal

Grade 7 – Understanding Life Systems: Interactions in the Environment

- describe ways in which human activities alter balances and interactions in the environment

Grade 7 – Understanding Matter and Energy: Pure Substances and Mixtures

- follow established safety procedures for handling chemicals and apparatus
- investigate processes used for separating different mixtures
- use scientific inquiry/experimentation skills to investigate the properties of mixtures and solutions
- describe the processes used to separate mixtures or solutions into their components, and identify some industrial applications of these processes

Grade 8 – Understanding Earth and Space Systems: Water Systems

- investigate how municipalities process water and manage water
- use scientific inquiry/research skills to investigate local water issues
- demonstrate an understanding of the watershed as a fundamental geographic unit, and explain how it relates to water management and planning

BIG SHARK, BIG LOSS, BIG IMPACT

IN THIS LESSON

The Big Idea:

Students are fascinated by dangerous sharks, but may not realize the key role they play in marine ecosystems. Large predatory fish populations have plummeted over 90% in the last decade. This decline has the potential for serious and cascading effects on Canada's marine ecosystems. Through two simulation games, students will learn why apex predators are necessary for functioning ecosystems.

Learning Objectives:

- analyse positive and negative impacts of humans hunting sharks within marine communities
- describe energy transfer in a food chain and explain the effects of the elimination of apex predators
- collect data by conducting an experiment to do with the environment and record observations
- read, interpret, and draw conclusions from data presented in charts, tables, and graphs

Background Information:

Canada's three oceans, Atlantic, Pacific and Arctic, are home to 41 species of sharks including the Shortfin Mako, Greenland, Sleeper, Basking, Smooth Hammerhead, and even the Great white shark! Sharks often fill the role of "apex" or top predators in their ecosystems because of their large size and few natural predators. As apex predators, sharks feed on animals below them in the food web, and help regulate and maintain the balance of marine ecosystems. Most sharks have diverse diets and switch prey species when certain populations are low. By switching to more abundant prey, they allow low populations to rebound and prevent abundant species from monopolizing a limited resource. Others scavenge the sea floor to feed on dead carcasses. Apex predators also influence spatial distribution of prey species through intimidation and keep them from overgrazing certain habitats.

The unfortunate reality of course is that humans are the ocean's true apex predators, killing more than 100 million sharks each year. Fishing has reduced many large predatory shark populations worldwide by 90% over the past century. Sharks now represent the largest group of threatened marine species on the International Union for Conservation of Nature's (IUCN) Red List of threatened species, yet only three of the 350 shark species (Basking, Whale and White), are protected from the pressures of international trade. The remaining species are ignored or seen as low priorities despite their vulnerability to overfishing and their important role in their ecosystems. In Canada there are ten species of sharks designated at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). These include White, Brown Cat, Tope, Bluntnose Sixgill, Blue, Basking, Porbeagle, Spiny dogfish, Shortfin Mako, and Spotted Spiny Dogfish.

Some fisheries directly target sharks as their intended catch, but other fisheries accidentally capture sharks as "bycatch", a term used for unintended catch. These unwanted sharks are thrown overboard, often dead or injured. It is estimated that tens of millions of sharks are caught as bycatch each year, which is nearly half of the total shark catch worldwide.

Between 26 and 73 million sharks are killed annually for their fins globally (caught both specifically and as bycatch). Once a delicacy and sign of prestige in Asian cultures, shark fin soup consumption is on the rise. A single bowl of soup can cost up to $100 making the fins the most commercially valuable part of a shark. Since the rest of the shark is less valuable and bulky, the fins are removed and the carcasses thrown overboard. This practice, known as "shark finning," only uses between one and five percent of the shark. Shark finning is prohibited in Canadian waters since 1994.

In December 2011, Canadian MP Fin Donnelly introduced a private member's bill that would ban the import of shark fins into Canada. Canada imports around 77 000 kilograms of fins each year. The practise of shark finning is already illegal in Canadian waters, but there is no law to prevent importation. If the ban is implemented, those in violation could face jail time or a fine of up to $100 000. Some Ontario municipalities have already taken steps in this direction –Toronto, Oakville, and Brantford have already banned the sale of shark fins.

Time Needed: 1 period + time for graphing assignment
Site Needed: Large open space where it is safe to run
Group Size: 20-30

Simulation 1 – Sharks are apex predators

Background Information:

The overfishing of apex predators can lead to serious consequences for many other ocean species, in ripples called "cascades". Comparisons of areas with and without apex predators have shown that apex predators maintain greater biodiversity and higher densities of individuals, while areas without apex predators experience species absences. Without apex predators there is the potential for unchecked predation by lower predatory species and overgrazing of vegetation by herbivorous prey species.

The following is a simplified Atlantic food web: Shortfin Mako sharks are apex predators and eat Bluefish (known in Canada as Pollock). Bluefish are medium sized piscivores weighing as much as 18 kg. They eat smaller fish like Atlantic Herring. Herring are small forage fish that eat plankton.

Reproductive rates vary widely between these different fish species. Shortfin Mako sharks bear between 4 and 18 young once every 3 years. Bluefish spawn once a year with females producing about one million eggs per year. Atlantic Herring can spawn from April to November in Canadian waters. A fully mature female can produce upwards of 260 000 eggs at a time.

Materials:

- 100 tokens to represent plankton (plastic poker chips, small pieces of construction paper etc)
- 5 arm bands (or smocks etc) in one colour
- 2 arm bands (or smocks) in a second colour
- 2 arm bands (or smocks) in a third colour
- Data tables for simulation 1 (see below)

Procedure: Human Activities are Absent

1. Discuss sharks as apex predators in marine ecosystems. The first simulation will represent an ecosystem where apex predators are present and human activities are absent.

2. Scatter 100 plankton tokens on the ground in the designated play area. This represents the food for the herring.

3. Select ~15 students to play the role of herring. Record this number in the data table for round 1. They must collect their food – plankton, and avoid being eaten by Bluefish. If tagged they must give the Bluefish their plankton cards and go to an area designated as the fish cemetery.

4. Select ~5 students to play the role of Bluefish and give each a matching armband. Record the number of Bluefish in the data table for round 1. They must hunt their food – herring, by tagging herring and taking their plankton cards. Bluefish must avoid being eaten by Shortfin Mako sharks. If tagged they must give the sharks their plankton cards and go to an area designated as the fish cemetery.

Procedure (cont'd):

5. Select ~ 2 students to play the role of Shortfin Mako sharks and give each a matching armband. Record the number of sharks in the data table for round 1. They must hunt their food – Bluefish, by tagging Bluefish and taking their plankton cards. As apex predators they have no predators.

6. Reinforce the rules to prevent the game from getting rough and outline consequences for improper behaviour.

7. The simulation only takes about 45 seconds. Release the herring, followed by the Bluefish, followed by the sharks with 5 seconds between each group's release.

8. After 45 seconds, have your students rejoin you (living and dead). Any fish that does not have a plankton card in its hands has died of starvation.

9. If both sharks died of starvation, replace them with one new shark (student from the fish cemetery) because the shark moved into the area because there was no competition.

10. Each survivor now has the potential to reproduce. In this simulation, herring spawn twice a year and Bluefish spawn once a year. Alternating between two surviving herring and one surviving Bluefish (i.e. two herring reproduce, one Bluefish reproduces, two herring reproduce, one Bluefish reproduces etc), each living fish chooses one person from the fish cemetery to become a baby of the same species as the person who selected him/her. After all herring and Bluefish have reproduced, any living sharks will reproduce by selecting a baby from the fish cemetery. There will probably not be enough students in the fish cemetery for everyone to reproduce; start by alternating herring and Bluefish until you run out of students. Count the new population of living herring, Bluefish, and sharks and record it on the data table for round 2.

11. Play round two following the same rules as before. Collect the plankton cards from the students and scatter them on the ground again. Release the students and after 45 seconds of game play allow the survivors to reproduce and record the new populations on the data table. Play the game for at least three additional rounds, recording the population numbers on the data table.

Human Activities are Present:

12. Introduce two hunters who hunt sharks. The hunters wear the third coloured armbands and tag sharks. If any sharks die of starvation in this new environment, they will not be replaced because there are not enough sharks remaining in the ocean to move in and replace those that have been hunted. Play at least five rounds and record the numbers on the data table.

13. Gather the students and reflect on what happened.
    - *How were the two versions of this game the same?*
    - *How were they different?*
    - *What happened to the food chain when the apex predators were removed?*

Simulation 2 – Sharks change prey behaviour

Background Information:

The following is a simplified Pacific food chain. The Harbour Seal has a wide diet which includes Pacific Herring and Alaska Pollock. Pacific herring are fatty fish, congregate near the surface of the water, and are widely dispersed. Alaska Pollock are larger, found in deeper water, and have a more continuous distribution. Which fish species the seals prey upon depends on the presence or absence of Sleeper sharks. Even though Sleeper sharks consume few seals, their mere presence alters seal behaviour. Sleeper sharks prefer deep water and therefore when sharks are present seals prefer to hunt in shallow water. This increases herring mortality and decreases pollock mortality.

When sharks are absent, seals increase their consumption of pollock and decrease their consumption of herring. This causes herring numbers to rise and pollock numbers to drop. Other animals connected to these fish through the food web (either as predators or prey) are affected by these changes leading to a cascade response.

Materials:

- 200 tokens representing herring (plastic poker chips, small pieces of construction paper etc)
- 200 tokens representing pollock (plastic poker chips, small pieces of construction paper etc)
- Long piece of rope (twine, skipping ropes etc)
- 5 arm bands (or smocks etc)
- Data tables for simulation 2 (see below)

Procedure: Human Activities are Absent

1. Set up this simulation. Explain the diet of the Harbour seals and how they select their prey depending on whether Sleeper sharks are present or absent.

2. Use the rope to divide the designated playing area into two equal sections that represent surface water and deep water.

3. Evenly distribute 50 pollock cards in the deep water area.

4. Unevenly distribute 50 herring cards in the surface water area.

5. Select 20 students to be Harbour seals. Their job is to collect fish tokens (herring and pollock) as food. Seals must avoid being eaten by Sleeper sharks. If tagged they must give the shark their fish cards and go to an area designated as the seal cemetery.

6. Select 5 kids to be Sleeper sharks and give them arm bands for identification. Sleeper sharks hunt seals by tagging the seals and collecting their fish cards. Because sharks prefer deeper water, four sharks will patrol the deep water and one will patrol the surface water.

7. Reinforce the rules to prevent the game from getting too rough and outline consequences for improper behaviour.

8. The simulation only takes about 30 seconds. With short lags (5 seconds) between each group, release the seals, followed soon after by the sharks.

9. After round one, have your students rejoin you (living and dead).

Procedure (cont'd):

10. Each surviving fish now reproduces. Double the number of fish remaining for each type and return them to their respective sections in the ocean playing field with the correct distribution. Record the number herring and pollock on the data table. Select 15 students to be seals and five students to be sharks (four deep water and one surface water). Because the sharks rarely kill the seals in the real food web, the number of seals will not change in our simulation.

11. Play round two following the same rules as before. After 30 seconds record the number of survivors on the data table and allow the surviving fish to reproduce. Play the game for at least three more rounds, recording the number of fish on the data table.

Human Activities are Present:

12. Hunters have reduced the number of sharks in the ocean. Instead of having five sharks, there will now only be two sharks, one in the surface water and one in the deep water. The number of fish will return to previous levels of 50 herring and 50 pollock with the same distributions as before. The number of seals will remain at 15. The rest of the rules remain the same as before.

13. Play at least five rounds with the reduced shark population and record the number of surviving fish on the data table.

14. Reflect on what happened.
    - *How were the two versions of this game the same?*
    - *How were they different?*
    - *Where did the seals prefer to hunt – surface water or deep water?*
    - *Why did they choose that layer of the ocean?*
    - *What happened to the food chain when the shark numbers were lowered?*
    - *Which fish had higher survival rates when five sharks were present?*
    - *Which fish had higher survival rates then only two sharks were present?*

Reflection Activity:

Have students create a series of graphs (bar, line etc) showing how prey populations changed in response to changes in predator populations. Exactly how the graphs are presented will depend on the level of your class. Below is one suggestion.

Simulation 1: Sharks are apex predators

- Graph # 1 – Use a triple line graph or triple bar graph to show how many Herring, Bluefish, and Shortfin Mako sharks were alive at the beginning of each round before shark hunting was allowed. Place the round number on the x-axis and the number of Herring, Bluefish, and Shortfin Mako sharks on the y-axis.
- Graph # 2 – Use a triple line graph or triple bar graph to show how many Herring, Bluefish, and Shortfin Mako sharks were alive at the beginning of each round after shark hunting was allowed. Place the round number on the x-axis and the number of Herring, Bluefish, and Shortfin Mako sharks on the y-axis.

Simulation 2: Sharks change prey behaviour

- Graph # 1 – Use a double line graph or double bar graph to show how many Pacific Herring and Alaska Pollock were alive at the beginning of each round before sharks were removed. Place the round number on the x-axis and the number of herring and pollock on the y-axis.
- Graph # 2 – Use a double line graph or double bar graph to show how many Pacific Herring and Alaska Pollock were alive at the beginning of each round after sharks were removed. Place the round number on the x-axis and the number of herring and pollock on the y-axis.

After graphing the data, have students interpret and draw conclusions from the data.

- *What consequences did shark removal have on the fish populations?*
- *Did all populations behave the same way?*
- *Why did some populations drop while others grew larger?*

Data Tables for Simulation 1: Sharks are apex predators:

Unaltered Environment – No Shark Hunting			
Round	# of Herring	# of Bluefish	# of Shortfin Mako Sharks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Altered Environment – Sharks Hunted by Humans			
Round	# of Herring	# of Bluefish	# of Shortfin Mako Sharks
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

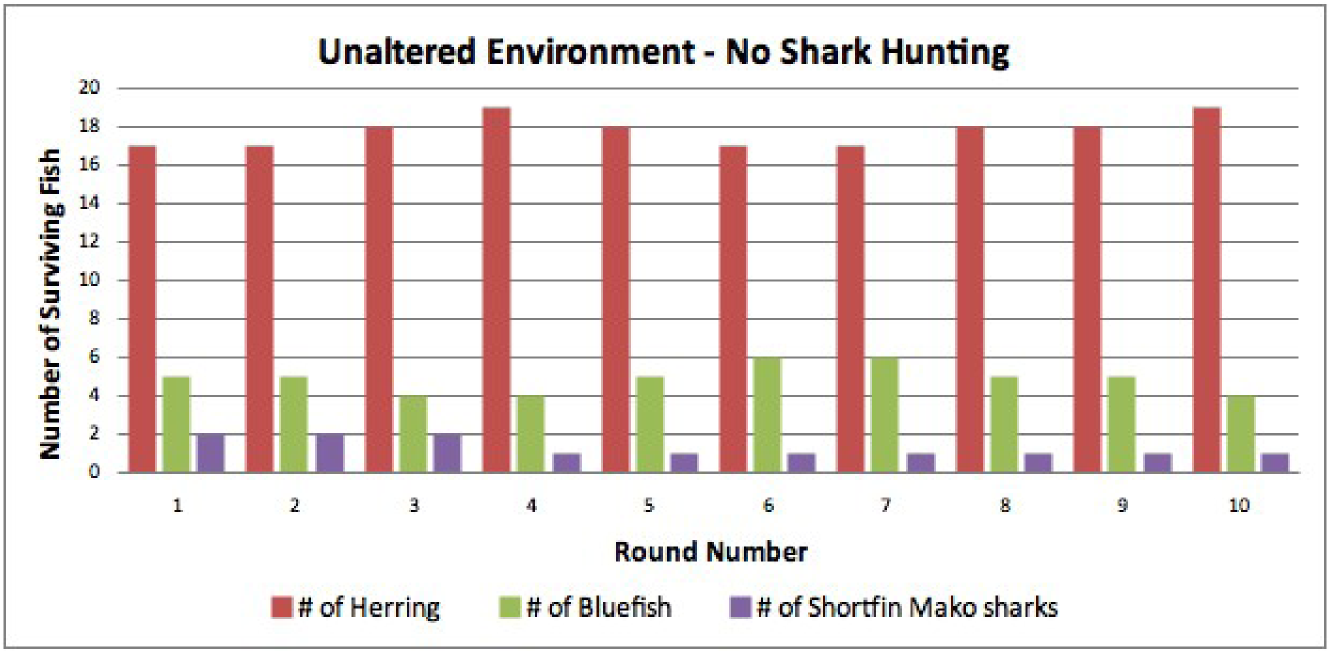
Data Tables for Simulation 2: Sharks change prey behaviour:

Unaltered Environment – No Shark Hunting		
Round	**# of Pacific Herring**	**# of Alaska Pollock**
1	50	50
2		
3		
4		
5		
6		
7		
8		
9		
10		

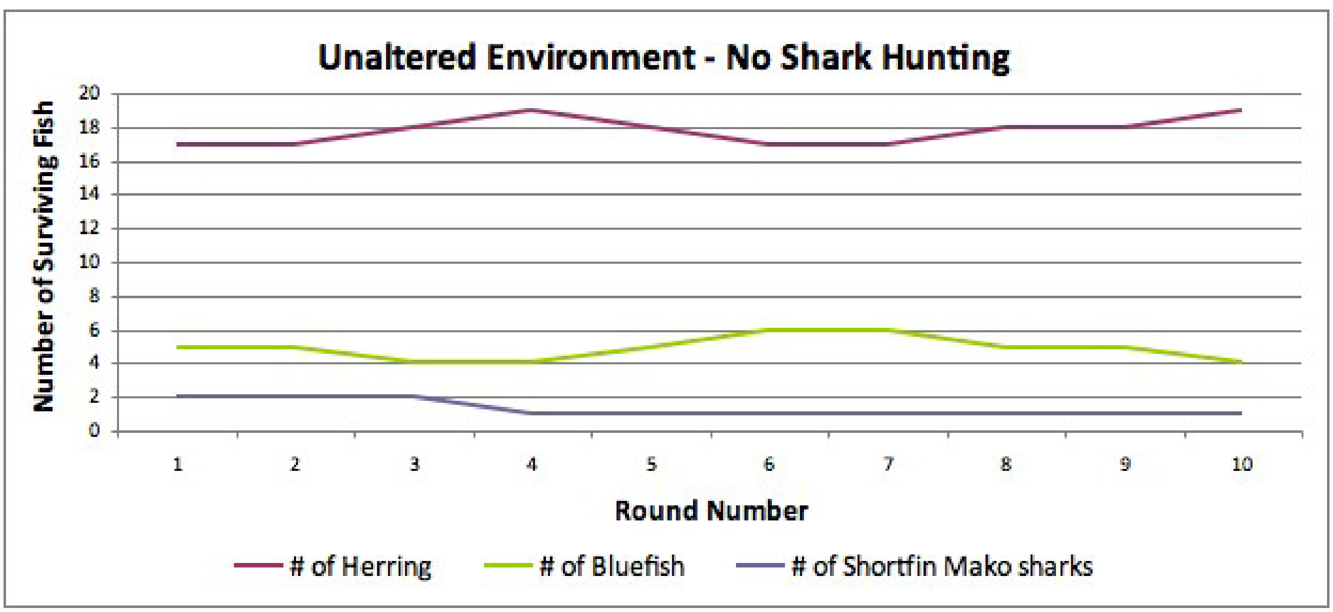
Altered Environment – Sharks Reduced due to Hunting		
Round	**# of Pacific Herring**	**# of Alaska Pollock**
1	50	50
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sample graphs:

Simulation 1: Sharks are apex predators
Data displayed using triple bar graph:



Simulation 1: Sharks are apex predators
Data displayed using triple line graph:



Curriculum Links:

Grade 4 – Understanding Life Systems: Habitats and Communities

- analyse positive and negative impacts of human interactions within natural habitats and communities
- identify reasons for the depletion/extinction of an animal species, evaluate the impacts on the rest of the natural community, and propose possible actions for preventing such depletions/extinctions from happening
- build food chains consisting of different plants and animals, including humans
- identify animals that are carnivores, herbivores, or omnivores

Grade 4 – Mathematics: Data Management and Probability

- collect data by conducting an experiment to do with the environment and record observations
- collect and organize data and display the data in charts, tables, and graphs that have appropriate titles, labels, and scales that suit the range and distribution of the data, using a variety of tools
- read, interpret, and draw conclusions from primary data presented in charts, tables, and graphs

Grade 5 – Mathematics: Data Management and Probability

- collect data by conducting an experiment to do with the environment and record observations
- collect and organize data and display the data in charts, tables, and graphs that have appropriate titles, labels, and scales that suit the range and distribution of the data, using a variety of tools
- read, interpret, and draw conclusions from data presented in charts, tables, and graphs
- compare similarities and differences between two related sets of data, using a variety of strategies

Grade 6 – Understanding Life Systems: Biodiversity

- describe ways in which biodiversity among communities is important for maintaining the resilience of these communities

Grade 6 – Mathematics: Data Management and Probability

- collect data by conducting an experiment to do with the environment and record observations
- select an appropriate type of graph to represent a set of data, graph the data using technology, and justify the choice of graph
- read, interpret, and draw conclusions from data, presented in charts, tables, and graphs
- demonstrate through investigation, an understanding of how data from charts, tables, and graphs can be used to make inferences and convincing arguments

Grade 7 – Understanding Life Systems: Interactions in the Environment

- describe the transfer of energy in a food chain and explain the effects of the elimination of any part of the chain
- describe how matter is cycled within the environment and explain how it promotes sustainability
- describe ways in which human activities alter balances and interactions in the environment

Grade 7 – Mathematics: Data Management and Probability

- collect data by conducting an experiment to do with the environment and record observations
- select an appropriate type of graph to represent a set of data, graph the data using technology, and justify the choice of graph
- identify and describe trends, based on the distribution of the data presented in tables and graphs, using informal language
- make inferences and convincing arguments that are based on the analysis of charts, tables, and graphs

Grade 8 – Mathematics: Data Management and Probability

- collect data by conducting an experiment to do with the environment and record observations
- select an appropriate type of graph to represent a set of data, graph the data using technology, and justify the choice of graph
- identify and describe trends, based on the rate of change of data from tables and graphs, using informal language
- make inferences and convincing arguments that are based on the analysis of charts, tables, and graphs

WHAT AM I WORTH?

IN THIS LESSON

The Big Idea:

Conservation groups frequently focus their efforts on popular animals like pandas and whales. But what about organisms that are not so photogenic? How do they get much needed attention and conservation funding? In this activity students will attempt to raise (fake) money for an assigned marine species. With no information provided, students will have to depend on their animals' superficial charms. After researching their animals, students will again try and raise money for their animals. This time, however, the students will have a better understanding of what role their animals plays in the marine environment and perhaps they will now convince classmates of the value of their animals.

Learning Objectives:

- demonstrate an understanding of biodiversity as the variety of life on earth
- investigate a variety of Canadian marine animals
- identify reasons for the depletion of marine species, evaluate the impacts on the rest of the natural community, and propose possible actions for preventing such depletions or extinctions from happening
- use appropriate science vocabulary in oral and written communication

Background Information:

Biodiversity is the variety of life on Earth. Scientists argue over how to best measure how many species there are on Earth and in the ocean, and estimates vary greatly. A conservative estimate of life on land and in the water would be approximately 8.7 million eukaryotic (organisms whose cells contain organelles enclosed within membranes) species (give or take 1.3 million). The number of species actually identified and classified is much lower, only 1.2 million. This means that an incredible 86% of all terrestrial species and 91% of all marine species have not yet been discovered. In Canada more than 16 000 marine species have been identified, and there may be at least 2-10 times as many species still to be found.

Alarmingly, an estimated 30 000 species per year are going extinct. By the end of this century, about half of Earth's species could be gone! With so few species identified, this means that species are going extinct before they have even been identified. The current extinction rate is between one thousand and ten thousand times higher than the background extinction rate putting us in the middle of the world's sixth mass extinction. Unlike previous mass extinctions (like the extinction of the dinosaurs 65 million years ago), humans are wholly responsible for this crisis. This accelerated loss is due to factors such as habitat loss, introduction of invasive species, pollution, human population growth, over-consumption, and climate change.

Species whose numbers are known to be declining are listed on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. This list is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. Yet, of the over 50 000 species monitored by the IUCN, only 5% are marine species. In Canada, threatened species are identified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Of the 635 listed Canadian species, only 116 (less than 20%) are marine species.

One reason for marine life's poor representation is that they are simply more difficult to study. Marine species investigated and identified on the IUCN Red List and by COSEWIC tend to be those that live in near-shore habitats or spend significant time at the surface of the water or on land, and are therefore easier to monitor. Many marine organisms can only be studied using expensive technology and exploring these environments is a slow and difficult undertaking.

Time Needed: two 30 minute sessions (one at the beginning of the unit, one at the end of the unit) + time to complete the assignment
Site Needed: Classroom

Materials:

- Pictures and names of 40 Canadian marine animals
- 100 dollars of fake money for each student broken into smaller bills like five, ten, and twenty dollar bills
- Envelopes (1 for each student)

Thirty-five suggested marine animals are:

Fish	American Plaice, Arctic Char, Bluefin Tuna, Atlantic Cod, Atlantic Halibut, Coho Salmon, American Smelt, White Shark, Greenland Shark, Swordfish, Spiny Dogfish, Pacific Sardine
Crustaceans	Snow Crab, Green Crab, Northern Shrimp, American Lobster, Dungeness Crab, Red Rock Crab
Molluscs	American Oyster, Neon Flying Squid, Surf clam, Quahaug, Periwinkle, Octopus
Echinoderms	Red Sea Urchin, Giant Red Sea Cucumber, Green Sea Urchin
Mammals	Atlantic Walrus, Orca, Narwhal, Harp seal, Bowhead Whale, Sea Otter, Steller Sea Lion
Birds	Ivory Gull, Roseate Tern, Short-tailed Albatross, Marbled Murrelet, Pink-footed Shearwater
Reptiles	Leatherback turtle

These animals represent a mix of famous and lesser known animals; vertebrates and invertebrates; and endangered, common, and invasive species.

Procedure:

Introductory Activity (to be done near the beginning of the biodiversity unit):

1. Assign each student a marine animal.

2. Give each student 100 dollars in fake money.

3. Explain that with no other information about their species, each student must try and raise as much money as possible for his/her organism's conservation.

4. Students spend 10 minutes circulating around the classroom meeting other species and deciding where to spend their money. If he/she would like to sponsor a particular species, he/she gives some money to the person representing that species. Any money raised is placed in that species' envelope. Students cannot give away money that has been donated to their species (they can only spend the $100 initially given to them). They can donate their money to their own species.

5. After 10 minutes have the students count how much money they have raised.

6. Put the results on the board.
    - *Which species raised the most money?*
    - *Which raised the least?*
    - *Group similar organisms together. Do you see any trends?*
    - *Why did some species make lots of money and others very little?*
    - *Did anyone donate to their own species? Why or why not?*

Assignment:

- After completing the introductory activity students research their respective organisms. Their reports could include the animal's description (and classification for grades six and up), where it is found in Canada, habitat, diet, reproduction, conservation status, and any conservation efforts directed to that animal.
- Information for all these animals can be found at http://www.dfo-mpo.gc.ca/species-especes/aquatic-aquatique/browse-eng.htm or http://www.sararegistry.gc.ca/species/schedules_e.cfm?id=1. Data sheets could be printed out and given to students to make sure that all have access to reliable information

Concluding Activity (to be done near the beginning of the biodiversity unit):

1. This time each student is very familiar with the animals he/she represents. Have each student create a sales pitch for his/her animal. *Why should the other students give your species money? What makes this animal unique? What would happen if this animal went extinct?*

2. Each student again receives $100 dollars to distribute to the animals they want to support. As before, students spend 10 minutes circulating around the classroom meeting other species, hearing sales pitches, and deciding where to donate their money.

3. After 10 minutes students count how much money they have raised.

4. Put the results on the board.
    - *Which species raised the most money?*
    - *Which raised the least?*
    - *How do these numbers compare to before?*
    - *Which species had the largest increase in money raised?*
    - *What persuaded people to donate where they had not before?*

5. Discuss how conservation groups often use high impact animals like pandas and whales as their mascots because they are beloved, easily recognizable, and people want to help them.
    - *Which species raised the most money?*
    - *Is this a good idea?*
    - *Do these animals deserve special attention?*
    - *How can marine animals which are often scaly, slimy, and not huggable get the funding they desperately need?*

Curriculum Links:

Grade 4 – Understanding Life Systems: Habitats and Communities

- identify reasons for the depletion or extinction of species, evaluate the impacts on the rest of the natural community, and propose possible actions for preventing such depletions or extinctions from happening
- use appropriate science vocabulary in oral and written communication
- identify factors that affect the ability of animals to survive in a specific habitat
- describe structural adaptations that allow animals to survive in specific habitats

Grade 6 – Understanding Life Systems: Biodiversity

- investigate organisms found in specific habitats and classify them according to a classification system
- use appropriate science vocabulary in oral and written communication
- demonstrate an understanding of biodiversity as the variety of life on earth
- describe interrelationships between species and between species and their environment, and explain how these interrelationships sustain biodiversity

Grade 7 – Understanding Life Systems: Interactions in the Environment

- use appropriate science vocabulary in oral and written communication
- describe the roles and interactions of producers, consumers, and decomposers within an ecosystem
- describe the transfer of energy in a food chain and explain the effects of the elimination of any part of the chain
- describe ways in which human activities alter balances and interactions in the environment

GOODBYE BYCATCH

IN THIS LESSON

- Curriculum Links at the end of section

The Big Idea:

Every year, 30 million metric tons of fish are thrown back, dead, into the water. These fish, along with all other marine organisms accidentally caught in fishing gear are called bycatch. These unintended deaths may cause many species including sharks, cetaceans, turtles, and birds to disappear from our oceans. In this activity students will explore different fishing methods, play a simulation game to determine which have the highest and lowest amounts of bycatch, and graphically display their results.

Learning Objectives:

- learn that bycatch is any marine creature accidentally caught in fishing gear intended for another species
- explore different fishing techniques and evaluate ways of minimizing their impacts on the environment
- collect and organize data and display the data in charts, tables, and graphs
- compare similarities and differences between two related sets of data, using a variety of strategies

Background Information:

Every year, 30 million metric tons of fish (that's 25% of all fish caught in the world) are thrown back, dead, into the water. These fish, along with all other marine organisms accidentally caught in fishing gear, are called bycatch. Bycatch includes anything unwanted – fish that are too small, fish that are under moratoria, marine mammals, turtles, birds, cold-water corals, and other bottom-dwelling organisms dredged up by fishing equipment. In the fisheries off Canada's Grand Banks, bycatch should legally not make up more than 5% of a total catch, yet rates routinely exceed this limit and can reach up to 80%.

Bycatch is widespread, wasteful, slows the recovery of some species at risk, and drives other species to extinction. The numbers don't lie. Annually 300 000 small whales, dolphins and porpoises die as a result of becoming entangled in fishing gear. The World Wildlife Fund (WWF) estimates that six cetacean species may disappear in the next decade due to fishing gear entanglement – there are probably fewer than 100 Maui's dolphins remaining in New Zealand because of high entanglement rates in nets. Similar threats have significantly reduced populations of the Gulf Porpoise in the Gulf of California and the Harbor Porpoise in the Baltic Sea.

Despite the known consequences of bycatch, it remains prevalent for many reasons. In some cases, bycatch is sold. Many tropical shrimp fisheries generate bycatch of juvenile and small fish that are marketed giving little incentive to reduce bycatch levels. Endangered species caught accidentally as bycatch are sold even though specifically fishing for that species is banned. Poorly managed fisheries can do little to minimize bycatch. Although devices to minimize turtle bycatch are required in some fisheries, their use is not always enforced – longlines still catch more than 250 000 Loggerhead and Leatherback sea turtles per year. Some policies created to manage fish populations actually create incentives to discard unwanted fish as bycatch. If fishermen can only catch species for which they have a quota, they dump the smaller, less valuable fish overboard.

The primary reason that bycatch occurs is because modern fishing gear is very strong, often covers a wide area, and can be highly unselective – it catches not only the target species but many other creatures as well.

Background Information (cont'd):

Fishing gear types that are referenced in this activity are:

Trolling lines – a line with baited hooks trailed near the surface behind a vessel. Several lines are often towed at the same time. The lines are hauled by hand or with small winches. Trolling lines have low levels of bycatch. It is a very selective fishing method and bycatch can be returned alive to the ocean. Other fishing methods with low levels of bycatch include fish traps, jigging, harpoons, hook and line, and tongs.

Purse seines – a long wall of netting framed with floatline (which floats at the surface of the water) and leadline (which sinks under the water). The purse seine is positioned around a school of fish and the net is closed underneath the school effectively scooping up all the fish. Purse seines have moderate levels of bycatch because the net is not species specific. Dolphins are frequently caught and special techniques have been developed to reduce bycatch of dolphins. Other fishing methods with moderate levels of bycatch include weirs and pots or traps.

Deep sea trawling – a large cone-shaped bag made of metal mesh is dragged along the bottom to catch shellfish. Deep sea trawling has high levels of bycatch. It impacts the sea floor and the benthic organisms living there including flatfish, corals, sponges, and other invertebrates. Other fishing methods with high levels of bycatch include gillnetting, longlining, and dredging.

Time Needed: 1 period + time to complete the assignment
Site Needed: Classroom
Group Size: 4 students per group

Materials:

- Large plastic bowls (1 per group)
- Jumbo box of roundish cereal (like Cheerios), not a flaky cereal or a fine cereal
- 500 medium plastic beads of the same size and colour – represents target species of Bluefin Tuna
- 400 large plastic beads in a second colour – represents bycatch of Great White Sharks
- 400 medium plastic beads in a third colour – represents bycatch of Leatherback Turtle
- 400 small plastic beads in a fourth colour – represents bycatch of Snow Crab
- Small spoons (like measuring spoons) (12) – simulates trolling lines (low levels of bycatch)
- Soup spoons (12) – simulates purse seines (medium levels of bycatch)
- Salad tongs (12) – simulates deep sea trawling (high levels of bycatch)
- Small cups to put catch into (1 per student)
- Medium bowl holding extra beads
- Data tables (see below)

Procedure:

1. Create one ocean for each group. Fill the large plastic bowls with cereal represents water. Add 50 Bluefin Tuna beads to the mixture. These represent the target species that students will be fishing for. Add ten of each bycatch beads to the mixture. These numbers are recorded on the data tables for round one. For older students you could increase the number of bycatch species which would make the graphing exercise more complicated.

2. Discuss with students the concept of bycatch. *Why can mammals, birds, and reptiles not survive tangled in nets underwater? Explore different fishing methods including trolling lines, purse seines, and deep sea trawling. Which method will catch the most target fish? Which fishing method will have higher bycatch? Why?*

3. Give each group their ocean. Explain which beads represent the target species, which beads represent bycatch, and that the cereal represents water. Give each group a bowl filled with extra beads from all four species.

4. In order to make the supplies needed reasonable, have some groups start with the first simulation, and others start with the second or third simulation and then switch.

5. In the first simulation students simulate trolling lines. Trolling will be simulated using small spoons. Students have 30 seconds to catch as many Bluefin Tuna as possible. Each student collects animals and water using the small spoons and deposits them in their respective cups. After 30 seconds the students stop.

6. The students put all the water (cereal) they collected back in the ocean. Any organisms (beads) they caught go into the extra bead bowl.

7. The surviving organisms will now reproduce. Remove all the surviving animals from the ocean. Double the number of survivors (i.e. if there were three surviving snow crabs, add three new snow crabs so there are now six snow crabs) and return them to the ocean bowl. The beads being added are taken from the extra bead bowl. Enter the population numbers into the data table for round two.

8. The students fish four more times, each time doubling the survivors before the next round and recording the new starting population.

9. In the second simulation students simulate purse seines. Students fish using soup spoons. The same rules as before apply (reproducing after every round).

10. Fish using purse seines for five rounds, recording data for every round.

11. In the third simulation students simulate deep sea trawling. Students fish using salad tongs. The same rules as before apply (reproducing after every round).

12. Fish using deep sea trawling for five rounds, recording data for every round.

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Reflection Activity:

Have students create a series of graphs (bar, line etc) showing how species abundance changed with different fishing methods. Exactly how the graphs are presented will depend on the level of your class. Below is one suggestion.

- Graph # 1 –Trolling lines. Graph how many of each species were alive at the beginning of each round. Use different colours for the different species. Place the round number on the x-axis and the number of organisms on the y-axis.
- Graph # 2 – Purse seines. Graph how many of each species were alive at the beginning of each round. Use different colours for the different species. Place the round number on the x-axis and the number of organisms on the y-axis.
- Graph # 3 – Deep sea trawling. Graph how many of each species were alive at the beginning of each round. Use different colours for the different species. Place the round number on the x-axis and the number of organisms on the y-axis.

After graphing the data, have the students interpret and draw conclusions from the data.

- *Which fishing method(s) maintained a balanced marine habitat?*
- *Did any species go extinct? Did the size (small, medium, large) of the bycatch make a difference?*
- *If you were a fisherman, which method would you pick (keep in mind that more fish means more money but you run the risk of collapsing the fish population)? Should the Canadian government ban certain fishing methods in Canadian waters?*

Extension Ideas:

- Repeat the game with each member of the group acting selfishly. Each member can choose their preferred fishing method.
- Have the group fish five rounds and record what happened. *Did everyone pick the same method? Was the end result fair? Did the marine environment suffer?*
- Have each group work together to draft a resolution describing how to limit bycatch *(i.e. ban certain fishing types, limit fish catches, punish fishermen if there is too much bycatch).* Have each group fish five rounds following their new rules and record what happened. Did it work? *What would happen if someone from another country does not follow your rules and starts fishing in your water?*

Data tables:

Colour of Bluefin Tuna Beads: __________
Colour of Great White Shark Beads: __________
Colour of Leatherback Turtle Beads: __________
Colour of Snow Crab Beads: __________

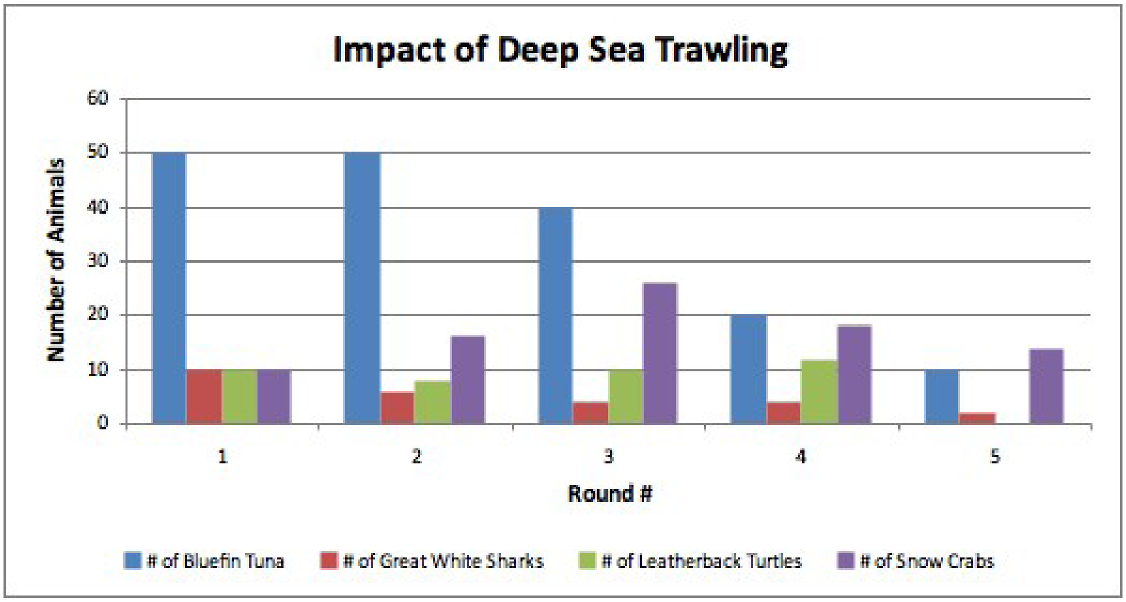
Trolling lines				
Round	# of Bluefin Tuna	# of Great White Sharks	# of Leatherback Turtles	# of Snow Crab
1	50	10	10	10
2				
3				
4				
5				

Purse Seines				
Round	# of Bluefin Tuna	# of Great White Sharks	# of Leatherback Turtles	# of Snow Crab
1	50	10	10	10
2				
3				
4				
5				

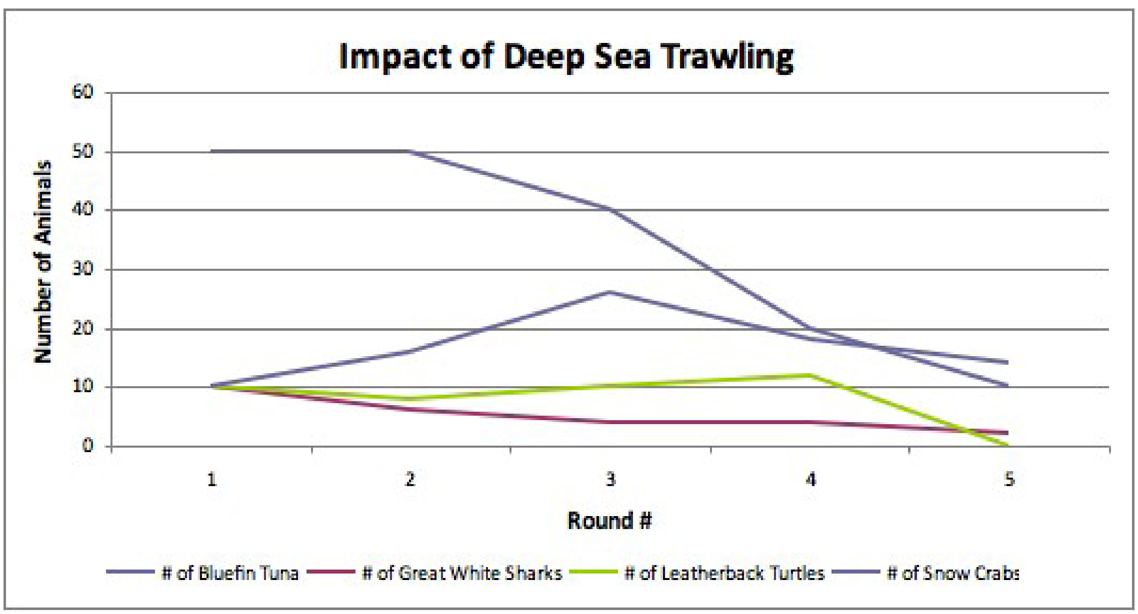
Deep Sea Trawling				
Round	# of Bluefin Tuna	# of Great White Sharks	# of Leatherback Turtles	# of Snow Crab
1	50	10	10	10
2				
3				
4				
5				

Sample graphs:

Data displayed using a bar graph:



Data displayed using a line graph:



Curriculum Links:

Grade 4 – Understanding Life Systems: Habitats and Communities

- analyse positive and negative impacts of human interactions within natural habitats and communities and evaluate ways of minimizing the negative impacts
- identify reasons for the depletion or extinction of an animal species, and propose possible actions for preventing such depletions or extinctions from happening

Grade 4 – Mathematics: Data Management and Probability

- collect data by conducting an experiment to do with their environment and record observations
- read, interpret, and draw conclusions from primary data, presented in charts, tables, and graphs
- compare similarities and differences between two related sets of data, using a variety of strategies

Grade 5 – Mathematics: Data Management and Probability

- collect data by conducting an experiment to do with their environment and record observations
- read, interpret, and draw conclusions from primary data presented in charts, tables, and graphs
- compare similarities and differences between two related sets of data, using a variety of strategies

Grade 6 – Understanding Life Systems: Biodiversity

- analyse a local issue related to biodiversity, propose action that can be taken to preserve biodiversity, and act on the proposal

Grade 6 – Mathematics: Data Management and Probability

- collect data by conducting an experiment to do with their environment and record observations
- collect and organize primary data and display the data in charts, tables, and graphs that have appropriate titles, labels, and scales that suit the range and distribution of the data, using a variety of tools
- read, interpret, and draw conclusions from primary data, presented in charts, tables, and graphs

Grade 7 – Understanding Life Systems: Interactions in the Environment

- assess the impact of selected technologies on the environment
- describe ways in which human activities and technologies alter balances and interactions in the environment

Grade 7 – Mathematics: Data Management and Probability

- collect and organize primary data and display the data in charts, tables, and graphs that have appropriate titles, labels, and scales that suit the range and distribution of the data, using a variety of tools
- read, interpret, and draw conclusions from primary data presented in charts, tables, and graphs
- identify and describe trends, based on the distribution of the data presented in tables and graphs, using informal language

Grade 8 – Mathematics: Data Management and Probability

- collect and organize primary data and display the data in charts, tables, and graphs that have appropriate titles, labels, and scales that suit the range and distribution of the data, using a variety of tools
- read, interpret, and draw conclusions from primary data presented in charts, tables, and graphs
- identify and describe trends, based on the rate of change of data from tables and graphs, using informal language

READY, SET, FISH

IN THIS LESSON

- Curriculum Links at the end of section

The Big Idea:

The goal of sustainable fisheries is to balance the harvest of seafood in a manner that meets the needs of the present without compromising the ability of future generations to meet their own needs. Canada has the potential to be world leader in sustainability but is definitely not there yet. In this simulation game students will examine the conflicts in creating a sustainable fishery – balancing the economic needs of people with the health of the ocean.

Learning Objectives:

- learn that sustainability is the ability to balance the needs of the present without compromising the ability of future generations to meet their own needs
- assess the impact of overfishing and its impact on sustainability in an aquatic ecosystem
- identify major contemporary environmental challenges, and explain their causes and effects
- analyse social and economic issues related to overfishing and sustainable fishing

Background Information:

With the world's longest coastline and 7.1 million square kilometres of ocean area, Canada supports hundreds of different fisheries. The variety of organisms fished in Canada is impressive, ranging from fish like cod and tuna, to invertebrates like crabs, lobsters, and shrimp. Commercial fisheries play a vital role in Canada's economy, particularly for coastal regions. Commercial fishery operations employ approximately 130 000 people, and fish and seafood exports reached $5 billion in 2010 (our second largest food export, second only to wheat).

The goal must be to create and maintain sustainable fisheries – the ability to harvest seafood in a manner that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable fisheries are possible. A movement has begun toward a sustainable seafood supply and many programs from world leading NGOs are driving positive change. One of these, the Marine Stewardship Council (MSC), uses ecolabels and fishery certification programmes to recognise and reward sustainable fishing practices. By selecting seafood with an MSC label, consumers can be confident they are supporting sustainable fisheries.

Sustainable fisheries, however, are not a reality in most parts of the world. Seventy percent of the world's fisheries are now either fully-exploited, over-exploited, or have already collapsed. We are currently removing two and a half times what the ocean can sustain. Canada's current management plans are not adequately dealing with the challenges of modern oceans management. Marine fishes in Canada's oceans are estimated to have declined in abundance by an average of 52% from 1970 to the mid-1990s. Without extensive improvements in current fishing practices and immediate remedial actions to allow endangered fish stocks to regenerate, the world's fisheries face possible collapse.

Two major factors threaten the sustainability of fish stocks: overfishing and the impact of human activities. Between 1970 and 1990, the size of the world's fishing fleet increased at twice the rate of the increase in the global marine catch. In some fisheries, government subsidies and over-investment have lead to fishing fleets which are too large. Many boats are now aging and economically inefficient to operate. To break even, they must bring in ever-larger catches. Many fleets continue to operate only with the support of government subsidies; government subsidies worldwide to the fishing industry total $54 billion annually.

Sound fisheries conservation and management practices are needed if the demand for seafood is to be met over the next twenty years. This will only come through better knowledge of marine resources and environments, more targeted fishing practices, and improved training for personnel responsible for managing and conserving marine resources. Decisions based on sustainability will help Canadians fully realize the potential of their oceans and achieve a healthy environment, a prosperous economy, and a vibrant society for current and future generations.

Time Needed: 1 period
Site Needed: Classroom
Group Size: 4 students per group

Materials:

- Calculators (1 per student)
- Data sheets (1 complete set for each student) (photocopy the unlabelled round sheet 9 times)
- Situation cards (1 set for each group)

Procedure:

1. Students work in groups of four, with each student acting as a fisherman in the Grand Banks of Newfoundland and Labrador. Each group will have the same starting environment, but as the game progresses each ocean will evolve independently.

2. This is a competition; the goal of the game is for each fisherman to make as much money as possible (just like real life).

3. The ocean initially contains with 100kg of each animal (American Eel, American Shad, American Smelt, Northern Shrimp, Redfish, Alewife, and Blue Shark). Each student has access to 25% of the ocean. Each animal population is divided equally amongst the four fishermen (i.e. if there are 50 kg of Redfish in total, each fisherman has access to 12.5 kg).

4. In secrecy, each student decides how many kilograms of each animal population they are going to catch. Fill in the Round 1 Fishing Data Table (remember there is no discussion between group members).

5. After fishing, students will reveal how much of each animal they removed from the population and how much money they made (the game needs to be competitive). Determine how many fish are left in the ocean. Put this number into the Round 1 Population Impacts Table.

6. Each student now selects a situation card, reads it aloud, and follows the card's instructions. If it affects the amount of money, make the appropriate changes. Like real life, students can have negative amounts of cash. If any cards affect an animal's population, make any changes in the Round 1 Population Impacts Table. Population impact cards could impact just one person or could impact everyone equally. Animal amounts can only go as low as zero kilograms. Continue filling in the Round 1 Population Impacts Table to determine how many fish are left in total in the ocean for each species.

7. To keep the game competitive, the fisherman who makes the most money in the round can (if they chose) trade their situation card with any other group member. If there is a tie for most money, no card trading takes place. Once the cards have been used they are placed to the side.

8. The animals now reproduce. Double the number of animals left in the ocean after the effects of the situation cards. Finish filling in the Round 1 Population Impacts Table to determine how many fish are left in total in the ocean.

9. Fill in the ocean amounts into the Round 2 Fishing Data Table. Repeat all the steps from before (remember to keep decisions secret).

10. Complete 10 rounds in all.

11. Discuss what happened with your students.
    - *Who made the most money? How did they accomplish this?*
    - *What techniques did students try?*
    - *Did any species go extinct?*
    - *What impacts did the situation cards have? Is this game realistic?*

*** Please note that in Canada it is illegal to fish for Blue Shark fins. Shark finning is prohibited in Canadian waters since 1994. Blue shark fins are included in this game because shark finning is a global problem and shark fin soup is available in most Canadian cities.***

Extension Ideas:

- Students replay the game following the same rules as before. The only difference is that this time students are allowed to talk and plan with each other. Can the students create a sustainable fishery that balances both economic and environmental concerns?
- Discuss what happened with your students. *How did this version of the game differ from the previous version? Who made the most money? How did they accomplish this? What techniques did students try? Did any species go extinct? What impacts did the situation cards have? Which version best represents a sustainable fishery?*

Data Charts:

Round 1 Fishing Data Table						
Animal	Starting amount in ocean (kg)	My share (kg) (starting amount/4)	Amount I will remove (kg)	Value of animal ($/kg)	Money made (removed amount x value)	My share remaining in ocean (kg) (star-ing amount – amount removed)
American Eel	100 kg	25 kg		$9.00/kg		
American Shad	100 kg	25 kg		$2.50/kg		
American Smelt	100 kg	25 kg		$1.25/kg		
Northern Shrimp	100 kg	25 kg		$1.35/kg		
Redfish	100 kg	25 kg		$0.20/kg		
Alewife	100 kg	25 kg		$0.65/kg		
Blue shark (fin)	100 kg	25 kg		$100.00/kg		

Money made (add up value of animals caught) = $________________

Money made after consequences of situation cards =$________________

The Population Impacts Table will be the same for every group member (students could work together to finish this chart). For each animal, determine the amount remaining in the ocean by adding together everyone's remaining share.

Round 1 Population Impacts Table				
Animal	Amount remaining in ocean (kg)	Amount after situation cards (kg)	Amount after repro-duction (kg) (multiply amount remaining by 2)	Amount in ocean for next round (kg)
American Eel				
American Shad				
American Smelt				
Northern Shrimp				
Redfish				
Alewife				
Blue shark (fin)				

Data Charts:

Round ____ Fishing Data Table						
Animal	**Starting amount in ocean (kg)**	**My share (kg) (starting amount/4)**	**Amount I will remove (kg)**	**Value of animal ($/kg)**	**Money made (removed amount x value)**	**My share remaining in ocean (kg) (star-ing amount – amount removed)**
American Eel				$9.00/kg		
American Shad				$2.50/kg		
American Smelt				$1.25/kg		
Northern Shrimp				$1.35/kg		
Redfish				$0.20/kg		
Alewife				$0.65/kg		
Blue shark (fin)				$100.00/kg		

Money made in this round (add up value of animals caught) = $________________

Money made in this round after consequences of situation cards =$________________

Money from previous round(s) = $ ________________

Total money made in game so far = $________________

The Population Impacts Table will be the same for every group member (students could work together to finish this chart). For each animal, determine the amount remaining in the ocean by adding together everyone's remaining share.

Round ____ Population Impacts Table				
Animal	**Amount remaining in ocean (kg)**	**Amount after situation cards (kg)**	**Amount after repro-duction (kg) (multiply amount remaining by 2)**	**Amount in ocean for next round (kg)**
American Eel				
American Shad				
American Smelt				
Northern Shrimp				
Redfish				
Alewife				
Blue shark (fin)				

Situation Cards (cut along the lines):

You use aggressive fishing techniques and take more than your fair share from the ocean. Take $25 from each player.	Your fishing fleet needs repairing. You lose $250 to repair it.	You discover a school of fish that none of your competitors found. You make an extra $75.
Your boat capsizes. Loose all the money you made this round.	Bad weather stops you from going fishing every day. Lose half the money you made this round.	Your net broke. You did not catch any sharks. You make no money from the sharks you caught.
You have a faster boat than your competitors. You make an extra $50.	You wander into international waters and your catch is confiscated. Lose your entire catch.	You have new equipment. You earn an extra $60.
Oil spill! All the Northern Shrimp you caught are now dead and worthless. You make no money on shrimp this round.	Shark finning is illegal. Pay a $1000 fine.	A parasite is killing the Blue sharks. The total amount of sharks in the ocean is now half of what it was.
The Blue shark is widely distributed. A new population has moved into the area. Add 40 kg of sharks to the total shark population.	Oil spill! The alewives have ingested oil and are sick. The total amount of alewife in the ocean is now only 75% of what it was.	Blue sharks are killed as bycatch. Remove 30 kg of Blue sharks from the ocean.
Foreign fishers are illegally killing Blue Sharks. Remove 25 kg of Blue sharks from the ocean.	Conservation groups are working to save the Blue shark. Add 100 kg of Blue sharks to the ocean.	American Eels are receiving Canadian protection. Double the amount of eels in the ocean.
Few American Eel stocks receive the attention necessary for effective management. The total amount of eels in the ocean is now half of what it was.	Invasive species are reducing the population of American Eel. The amount of eels is now 50% of what it was.	American Eel habitat has been damaged. Lose half your eel catch for this round.
Hydroelectric dams are killing migrating American Eels. Remove 15 kg of eels from the ocean.	Low sea temperatures have increased American Eel landings. Everyone makes an extra $35.	The demand for caviar from American Shad is up. You make an extra $100.
The demand for caviar is reducing the American Shad population. Remove 30 kg of American Shad from the ocean.	The decline of large piscivores has caused an increase in the American Shad population. Double the amount of American Shad in the ocean.	Streams where American Shad spawn are being restored by conservation groups. Increase the amount of American Shad in the ocean by 50 kg.

Situation Cards (cut along the lines) cont'd:

Construction of large-scale tidal hydroelectric projects disrupts American Shad migration patterns. Remove 25 kg of American Shad from the ocean.	Fishways help American Shad migrate up rivers and streams. You make an extra $15.	American Smelt are afflicted by parasites. Remove 30 kg of smelt from the ocean.
The decline of large piscivores has caused an increase in the American Smelt population. Increase the amount of American Smelt in the ocean by 40 kg.	Sport fishermen are reducing the amount of American Smelt available. You lose half of the money you made on American Smelt this round.	You found a school of American Smelt. You make an extra $20.
A build up of sediment has increased American Smelt egg mortality. Remove 5 kg of Smelt from the ocean.	The Northern shrimp have moved deeper in the ocean to where it is cooler and they are harder to catch. Everyone loses half their shrimp catch.	Harp seal populations are growing and they are eating Northern Shrimp. Remove 30 kg of shrimp from the ocean.
Northern shrimp stocks are in good condition. Add 50 kg of Northern Shrimp to the ocean.	The decline of fish like cod and redfish (shrimp predators) means that Northern Shrimp populations are growing. Add 30 kg of Northern Shrimp to the ocean.	Your fishing fleet has been MSC certified for Northern Shrimp! You fish sustainably and will be rewarded! You earn an extra $300.
You hunt at night when Redfish are near the surface. You make an extra $90.	Foreign vessels are also fishing for Redfish. Redfish stocks fall. Remove 15 kg of Redfish from the ocean.	Redfish stocks are in good condition. Everyone makes twice what they would have on their Redfish catch.
Controls imposed by the Canadian government restrict catches of Redfish by other countries. Increase Redfish amounts in the ocean by 60 kg.	Low food levels are killing juvenile Alewife. Remove 20 kg of Alewife from the ocean.	Alewife can spawn more than once and this helps stabilize their numbers. Add 20 kg of Alewife to the ocean.
Alewives have died because of fluctuating water temperatures. You lose $15.	Fish passages at obstructions to fish migration such as mill and hydroelectric dams are aiding Alewife. Add 40 kg of Alewife to the ocean.	Foreign high seas fishing fleets heavily exploit alewives and have reduced the amount of Alewife. Remove 30 kg of Alewife from the ocean.

Curriculum Links:

Grade 9 – Biology: Sustainable Ecosystems

- assess the impact of a factor related to human activity that threatens the sustainability of an aquatic ecosystem
- analyse the effect of human activity on the populations of aquatic ecosystems by interpreting data and generating graphs
- identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

Grade 11 – Biology: Diversity of Living Things

- analyse some of the risks and benefits of human intervention to the biodiversity of aquatic ecosystems
- explain why biodiversity is important to maintaining viable ecosystems

Grade 11 – Environmental Science: Scientific Solutions to Contemporary Environmental Challenges

- analyse social and economic issues related to a particular environmental challenge
- analyse ways in which societal needs or demands have influenced scientific endeavours related to the environment
- identify some major contemporary environmental challenges, and explain their causes and effects
- describe a variety of human activities that have led to environmental problems and/or contributed to their solution

Grade 12 – Biology: Population Dynamics

- analyse the effects of human population growth, personal consumption, and technological development on our ecological footprint
- describe the characteristics of a given population, such as its growth, density, distribution, and minimum viable size
- explain how a change in one population in an aquatic ecosystem can affect the entire hierarchy of living things in that system

DISSOLVING IN AN OCEAN OF ACID

IN THIS LESSON

- Curriculum Links at the end of section

The Big Idea:

The cold-water coral reef, one of Canada's most biologically diverse ecosystems, is also one of its most threatened. Increasing levels of carbon dioxide in the atmosphere are causing seawater to become more acidic. The more acidic the water, the more difficult it is for corals to build their calcium carbonate skeletons, as well as keep them from dissolving. In this lesson students will examine how adding CO_2 to water makes an acidic solution, and observe how calcium carbonate behaves in water with different levels of acidity.

Learning Objectives:

- assess the impact of ocean acidification on coral reef ecosystems
- analyse how an understanding of the properties of chemical substances and their reactions can be applied to solve environmental challenges
- analyse the impact that climate change might have on the diversity of living things
- prepare solutions of a given concentration by diluting a concentrated solution
- investigate the process of acid–base neutralization

Background Information:

Cold-water coral ecosystems are found throughout the world's oceans, usually between 200 and 1000+ metres in depth, in areas where rocky or hard-bottom substrate is exposed to rich ocean currents. In Canada, cold-water corals are found in the Atlantic Ocean. They can live for hundreds of years and may cover more ocean floor than warm-water coral reefs. Whether tropical or cold-water, coral reefs cover only 0.2% of the ocean floor, yet are home to almost a quarter of all marine species.

Corals are tiny animals related to jellyfish and sea anemones. These animals use their tentacles to catch prey such as zooplankton. They live in colonies made of many individuals, with each individual called a polyp. Polyps secrete a hard calcium carbonate ($CaCO_3$) skeleton, which acts as a base for the colony. $CaCO_3$ is secreted at the base of the polyps, so the living coral colony is found at the surface of the skeletal structure, completely covering it.

Increasing levels of atmospheric carbon dioxide (CO_2) from fossil fuel burning are causing seawater to become more acidic. The concentration of atmospheric CO_2 is now approximately 385 parts per million and is likely to increase at 0.5% per year throughout the 21st century. This rate is 100-times faster than anything that has occurred in the past 650 000 years. The ocean acts as a sink for excess atmospheric CO_2 and absorbs it through the air-water interface. Oceans have already taken up nearly half of the atmospheric CO_2 that humans have produced over the last 200 years and will continue to do so as emissions increase.

The ocean's uptake of CO_2 cushions climate change, but changes ocean chemistry through the following simple chemical reactions:

$$CO_2 + H_2O \leftrightarrow HCO_3^- + H^+ \leftrightarrow CO_3^{2-} + 2H^+$$

It is estimated that the oceans have become 30% more acidic since the beginning of the industrial revolution. Ocean pH has already fallen by 0.1 units and will probably drop 0.3-0.4 units by the end of the century, a 150% increase in acidity since the industrial revolution. By 2050 ocean pH will be at its lowest level in the last 20 million years.

As oceans become more acidic, shell and skeleton-bearing organisms like corals, clams, and oysters will have increasing difficulty building and maintaining their carbonate structures and keeping them from dissolving. The excess hydrogen ions (H^+) produced during ocean acidification react with $CaCO_3$ in the following chemical reaction:

$$CaCO_3 + H^+ \rightarrow HCO_3 - + Ca2^+$$

Background Information (cont'd):

At projected future pH levels, coral reefs will erode faster than they can build up, leading to a net loss of coral reefs and the species they support. Cold-water corals form perhaps the most vulnerable marine ecosystems to ocean acidification. Cold, deep waters are already lower in pH than water in shallow reefs, and projections indicate that 70% of cold-water corals could experience corrosive conditions by the end of this century.

Thirty-seven industrialized countries and the European community pledged to reduce greenhouse gas emissions by signing the Kyoto Protocol. Canada signed and adapted the Kyoto Protocol in 1997 and set greenhouse gas targets at 6% below 1990 levels. By 2008, Canada's emissions were 24% above 1990 levels. The Canadian Government announced that it would not try to meet its Kyoto target. In 2007, a 'Made-in-Canada' solution was proposed: Canada would reduce its emissions to 3% below 1990 levels by 2020. Canada officially withdrew from the Kyoto Protocol on December 12th 2011.

Time Needed:1 period for main experiments, 10 minutes a day for the rest of the week (start experiment on Monday and finish observations on Friday) + time for assignment
Site Needed: Classroom
Group Size: 2–4 students per group

Materials:
Experiment 1:

- White vinegar (acetic acid and water solution)
- Distilled water (available at grocery store)
- Universal indicator solution
- Test tube rack (1 per group)
- Test tubes (6 per group)
- 50 mL beakers (2 per group)
- Pencils or waterproof markers (1 per group)
- 10 mL Graduated cylinders (2 per group)
- 1 mL Graduated pipettes (3 per group)
- Glass stir stick (1 per group)
- Spray bottle filled with distilled water (1 per group)

Experiment 2:

- 1 kilogram of dry ice (in small pellets)
- Cooler (to transport and store dry ice in)
- Universal indicator solution from experiment 1
- 1 mL Graduated pipettes (1 per group) from experiment 1
- Tongs for handling dry ice
- Thick work gloves
- Beakers (1 per group) from experiment 1

Experiment 3:

- Small seashells (can be purchased at dollar and craft stores) (6 shells per group)
- Electronic balance
- Calculators (1 per group)
- Tweezers (1 per group)

Procedure:

1. Review the concepts of climate change, greenhouse gases, ocean acidification, coral reefs, acids and bases, neutralization reactions, and the pH scale.

2. Review lab safety. When handling dry ice protective gloves and tongs must be used. Holding dry ice can cause frostbite.

Experiment 1:

3. Review procedure and equipment with the students. Remind students that one graduated cylinder and one graduated pipette are for vinegar only and one graduated cylinder and graduated pipette are for distilled water only. Each group receives one labelled beaker containing vinegar and one labelled beaker containing distilled water.

4. Label one test tube "100% vinegar solution" using the pencil or marker. Measure 10 mL of vinegar in a graduated cylinder and pour it into the test tube. Put the test tube in the test tube rack.

5. Label one test tube "80% vinegar solution." Measure 8 mL of vinegar into a graduated cylinder and pour into the test tube. Measure 2 mL of distilled water into the test tube using a graduated pipette. Put the test tube in the test tube rack.

6. Label one test tube "60% vinegar solution." Measure 6 mL of vinegar into a graduated cylinder and pour into the test tube. Measure 4 mL of distilled water into the test tube using a graduated cylinder. Put the test tube in the test tube rack.

7. Label one test tube "40% vinegar solution." Measure 4 mL of vinegar into a graduated cylinder and pour into the test tube. Measure 6 mL of distilled water into the test tube using a graduated cylinder. Put the test tube in the test tube rack.

8. Label one test tube "20% vinegar solution." Measure 2 mL of vinegar into a graduated pipette and pour into the test tube. Measure 8 mL of distilled water into the test tube using a graduated cylinder. Put the test tube in the test tube rack.

9. Label one test tube "0% vinegar solution." Measure 10 mL of distilled water into the test tube using a graduated pipette. Put the test tube in the test tube rack.

10. Use a clean graduated pipette to add 10 drops of universal indicator to each vial.

11. Mix each solution using a glass stir stick. Between each mixing, rinse the stir stick with distilled water from the spray bottle.

12. Compare the colour of solutions with the indicator scale to determine the pH of each solution. Record the pH on the data chart.

Experiment 2:

13. Clean out a beaker from experiment 1 using distilled water.

14. Add 30 mL of distilled water to the beaker.

15. Use a clean graduated pipette to add 10 drops of universal indicator to the beaker. *What is the pH of distilled water?*

16. Add 1 pellet of dry ice (use heavy gloves to handle dry ice) to the distilled water. Explain that dry ice is solid CO_2 and as it sublimates CO_2 bubbles are dissolving in the water.

17. Discuss what happens. *What is the pH of the water now? Has the water become acidic, basic, or neutral? Write the chemical equation for this reaction.*

18. If desired, add some more dry ice to the beaker and observe further changes in the pH.

Experiment 3:

19. Obtain six small seashells. Weigh each seashell on the electronic balance. Record the weight on the data chart (Weight of Shell Day 1) and add one shell to each test tube filled with vinegar solution from experiment 1.

20. Put the test tubes (in the test tube rack) someplace secure because they will be needed for the remainder of the week.

21. Each day for the rest of the week, remove the shells using tweezers, weigh the seashells, record their weights in the data table, and return the shells to the appropriate test tubes.

22. After the weights have been recorded for five straight days, calculate daily percentage lost and daily percentage remaining. What is the pH of each solution now?

Reflection Activity:

- Create a line graph or bar graph with day on the x-axis and percentage remaining on the y-axis. Students could 1) graph each solution independently or 2) graph all six solutions on the same chart using different colours for each solution.
- *What type of chemical reaction was occurring in the test tubes? Write the equation for this reaction. What effect did increasing vinegar concentration have the seashells' dissolving? Did the pH of the solution change? Why or why not? How might marine biologists use data from experiments like this one to help with ocean conservation projects?*

Extension Ideas:

- Have the students write up this activity as a formal lab report. A formal lab report would include an introduction (describe the environmental problem, hypotheses as to what will happen), methods (describe the procedure), results (display data in tables and graphs), and discussion (interpretations from the data, how this experiment could be used by conservation biologists, possible next steps).

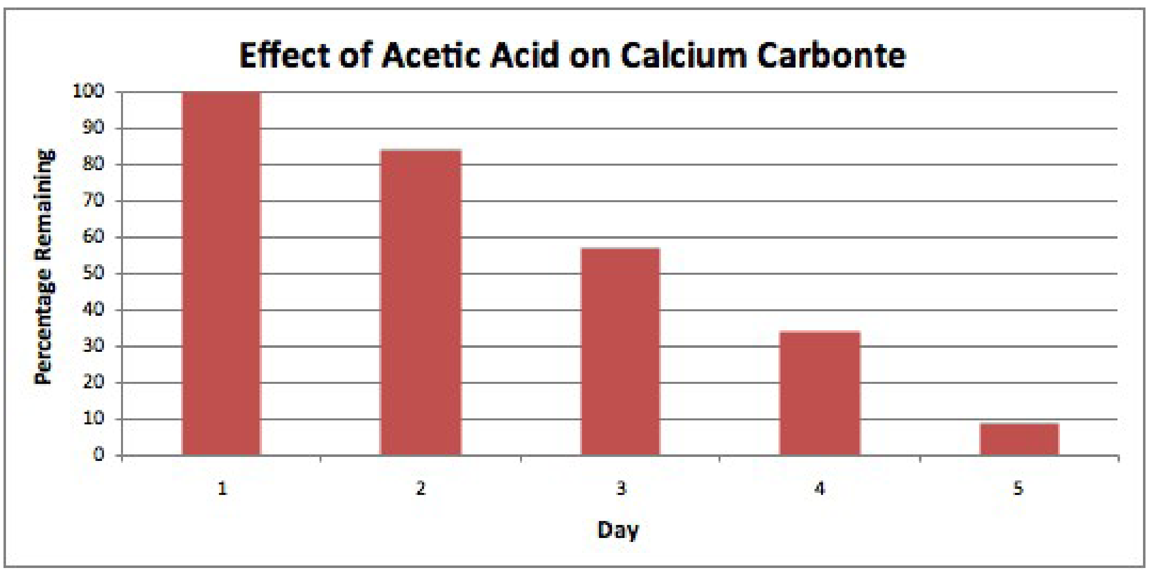
Data Chart:

Data Chart									
Solution	**Volume of Vinegar (mL)**	**Volume of Distilled water (mL)**	**pH (on Day 1)**	**Weight of Shell Day 1 (g)**	**Weight of Shell Day 2 (g)**	**Weight of Shell Day 3 (g)**	**Weight of Shell Day 4 (g)**	**Weight of Shell Day 5 (g)**	**pH (on Day 5)**
100% vinegar	10	0							
80% vinegar	8	2							
60% vinegar	6	4							
40% vinegar	4	6							
20% vinegar	2	8							
0% vinegar	0	10							

$$\text{Percentage lost} = \frac{(\text{Initial weight from Day 1} - \text{Final weight from day 5}) \times 100\%}{\text{Initial weight from Day 1}}$$

Percentage remaining = 100% - Percentage lost

Sample Graph:



Curriculum Links:

Grade 9 – Biology: Sustainable Ecosystems
- assess the impact of a factor related to human activity that threatens the sustainability of an aquatic ecosystem
- plan and conduct an investigation into how a human activity affects water quality, and explain the impact of this activity on the sustainability of aquatic ecosystems

Grade 10 – Chemistry: Chemical Reactions
- analyse environmental issues associated with chemical reactions and their reactants and/or product(s)
- analyse how an understanding of the properties of chemical substances and their reactions can be applied to solve environmental challenges
- investigate simple chemical reactions
- describe the process of acid–base neutralization

Grade 10 – Earth and Space Science: Climate Change
- analyse current and/or potential effects, both positive and negative, of climate change on human activity and natural systems
- describe the principal sources and sinks, both natural and/or anthropogenic, of greenhouse gases

Grade 11 – Biology: Diversity of Living Things
- analyse the risks and benefits of human intervention to the biodiversity of aquatic ecosystems
- analyse the impact that climate change might have on the diversity of living things

Grade 11 – Chemistry: Chemical Reactions
- write balanced chemical equations to represent reactions
- investigate neutralization reactions
- explain the chemical reactions that result in the formation of acids and bases from non-metal oxides

Grade 11 – Chemistry: Solutions and Solubility
- prepare solutions of a given concentration by diluting a concentrated solution
- write balanced net ionic equations to represent neutralization reactions
- explain the Arrhenius theory of acids and bases

Grade 11 – Environmental Science: Scientific Solutions to Contemporary Environmental Challenges
- identify some major contemporary environmental challenges, and explain their causes and effects
- describe human activities that have led to environmental problems and/or contributed to their solution

Grade 12 – Biology: Population Dynamics
- analyse the effects of human population growth, personal consumption, and technological development on our ecological footprint

Grade 12 – Chemistry: Chemical Systems and Equilibrium
- assess the impact of chemical equilibrium processes on various biological, biochemical, and technological systems
- solve problems related to acid–base equilibrium

Glossary:

Apex predator – a predator that does not have any predators of its own; found at the top of its food web

Biodiversity – the variety of life on Earth

Bycatch – any marine creature accidentally caught in fishing gear intended for another species

COSEWIC (The Committee on the Status of Endangered Wildlife in Canada) – the committee that designates the conservation status of wild species in Canada, and determines which species are at risk of becoming endangered or extinct

Eukaryotic – organisms whose cells contain organelles enclosed within membranes

Food web – feeding connections in an ecological community

Invasive species – introduced species that negatively affect the habitats they invade

IUCN (International Union for Conservation of Nature) – an international organization dedicated to finding solutions for environment challenges; they publish the IUCN Red List which is the world's most comprehensive inventory of the conservation status of species

Kyoto Protocol – protocol developed by the United Nations Framework Convention on Climate Change aimed at fighting global warming

Non-point source pollution – pollutants from many unidentified sources, often spread out over a large area (e.g. salt from road salting or soapy water from washing the car at home)

pH – measure of the acidity or basicity of a solution

Point source pollution – pollutants released from a single (often identified) source (e.g. a pipe)

Runoff – the water that flows across the surface of the earth until it reaches a waterway

Shark finning – the practise of removing shark fins and throwing the remaining carcasses overboard; this uses between one and five percent of the shark

Sustainability – the ability to balance the needs of the present without compromising the ability of future generations to meet their own needs

Watershed – the area of land draining all precipitation and groundwater into a particular set of waterways

Wetland – areas that form transitions between dry land and waterways; examples include marshes, swamps, and bogs