STREAM TO SEA ACTIVITY **Intermediate**

Turn down the volume!
The impact of sound on Harbour Porpoise

Prescribed Learning Outcomes and Curriculum Organizers

Grade 7 Science
Life Science
- Role of organisms as part of interconnected food web, populations, communities and ecosystems.
- Assess survival needs between organisms and environment.
- Assess requirements for sustaining healthy local ecosystems.
- Evaluate human impacts on local ecosystems.

Grade 7 Math
Patterns and Relations (Variables and Equations)
- Analyse relations graphically to discover how changes in one quantity may affect others.
- Graph relations, analyse results, and draw conclusions.

Grade 7 Social Studies
Skills and processes of Social Studies
- Use various types of graphs, tables, timelines and maps to obtain or communicate information.

English Language Arts 7
Comprehend and Respond *(Engagement and Personal Response)*
- Develop personal responses and offer reasons for and examples of their judgments, feelings, or opinions.

Comprehend and Respond *(Critical Analysis)*
- Express agreement or disagreement with information.

Communicate Ideas and Information *(Composing and Creating)*
- Summarize what they know about specific topics or issues and identify and address gaps in the information available.

Overview of Activity

The purpose of this activity is to create awareness about why harbour porpoise are considered a species of Special Concern in British Columbia. The lesson plan combines porpoise natural history with the effects of human activities, both positive and negative. The activity outlines the connectivity between the marine environment, biota and human influence, and emphasizes the importance of studying cryptic animals. The impact of sound on harbour porpoise, their conservation and student empowerment to make a difference are strong themes within the activity. The lessons integrate curriculum from Grade 7 Geography, Science, Math and English.

Content covered within the activity:

1. Review of mammalian characteristics and contrast general features to that of fish.
2. General natural history of harbour porpoise and cetacean taxonomy.
3. Differences between dolphins and porpoise.

Anna Hall et Jackie Hildering

4. Natural history of harbour porpoise in BC, including a contrast with BC's other porpoise species, the Dall's porpoise.
5. Dichotomous key and bar graph interpretation.
6. Review of human sensory capabilities (*e.g.* sight, touch, taste, hearing, smell) and contrast with cetaceans.
7. Echolocation and the different classifications of sound (*e.g.* infrasonic, sonic, ultrasonic). Sound travel in different states of matter.
8. The importance of conservation of cryptic organisms.
9. Understanding of the Species at Risk Act and the "Special Concern" designation.
10. The impact of sound on cetaceans. Includes an overview of odontocete hearing, functions of echolocation, and the potential difficulty of survival in a noisy ocean.
11. Identification of ways to help conserve porpoises in British Columbia. Consideration of the big picture while emphasizing local, individual actions.
12. Discussion of personal choices that both students and their families can make to contribute to the conservation of harbour porpoise, and their ocean habitats.

Estimate of time required:
Number of lessons: 5 lessons
Time required for each lesson:
Lesson 1: 1 hour
Lesson 2: 1 hour
Lesson 3: 45 min
Lesson 4: 2 hours
Lesson 5: 2 hours
Can be done**:** Anytime
Natural area required: Indoor activity

Overview of Materials and Resources Required

Lesson 1 - What is a Porpoise?
Additional photos:
- http://www.dfo-mpo.gc.ca/species-especes/species/species_harbourporpoise_e.asp
- http://www.pwlf.org/harbourporpoise/identification.htm - Identification guide from Pacific Wildlife Foundation
- http://www-comm.pac.dfo-mpo.gc.ca/publications/whalesdpbook/default_e.htm -Whales, Dolphins and Porpoises of British Columbia, Canada
- www.wildwhales.org - BC's Cetacean Sighting's Network information - Click on "BC's Cetaceans" and then the image of the harbour porpoise

Additional video:
- http://www.earthlingenterprises.ca/earthlingenterprises/SARA.html
- http://www.bostonharbor.com/HarborPorpoise.html
- http://www.arkive.org/species/ARK/mammals/Phocoena_phocoena/Phocoena_phocoena_00.html?movietype=wmMed

Lesson 2 – Natural history of harbour porpoise in British Columbia
- Atlas http://wildwhales.org/?page_id=55

Lesson 3 – Cryptic Animals: Harbour porpoise conservation status
- Link to DFO SARA backgrounder

Lesson 4 – Impact of sound
- Effects of anthropogenic sound on marine mammal

http://www.dosits.org/animals/effects/e1.htm
- Gallery of underwater sounds – anthropogenic and natural http://www.dosits.org/gallery/intro.htm
- How humans use sound in the sea http://www.dosits.org/people/intro.htm
- Needed for activities: tuning forks; metal wire string; coin or other metal object

Lesson 5 – How to help. I have the power!

- Marine Wildlife viewing guidelines http://www.whalemuseum.org/downloads/soundwatch/whaleposter-small.pdf
- See watershed resources and animations at www.earthlingenterprises.ca
- Great Canadian Shoreline Clean-up http://www.vanaqua.org/cleanup/

Suggested Assessment Activities

Questions provided at the end of each lesson.

Recommended Additional Resources and Optional Enrichment Activities

- American Cetacean Society's Cetacean Curriculum – subscribe for free access http://www.acsonline.org/education/curriculum/index.html
- Uko Gorter Natural History Illustrations ; images contributed for this lesson plan http://www.ukogorter.com

Lesson 1 - What is a Porpoise?

- Natural history of harbour porpoise http://www.earthlingenterprises.ca/earthlingenterprises/Harbour_porpoise.html
- Differences between porpoise and dolphins http://www.acsonline.org/education/curriculum/dolphins-porpoises.html http://www.theporpoisepage.com/porpvdolph.php

Lesson 2 – Natural history of harbour porpoise in British Columbia

- North American Universities Marine Mammal Research Consortium http://www.marinemammal.org/steller_sea_lion/harborporpoise/fastfacts.php
- Pacific Wildlife Foundation' - http://www.pacificwildlife.ca/harbourporpoise.htm
- Hybrid porpoise information form BC's Cetacean Sightings Network http://www.wildwhales.org/newsletter/2004Oct.htm

Lesson 3 – Cryptic Animals: Harbour porpoise conservation status

- Species at Risk report on the status of harbour porpoise. See first link at http://www.earthlingenterprises.ca/earthlingenterprises/Harbour_porpoise.html
- Harbour porpoise and entanglement http://www.hel.gda.pl/animals/oplanie.htm

Lesson 4 – Impact of sound

- Importance of sounds to marine mammals http://www.dosits.org/animals/import/1.htm
- Effects of anthropogenic sound on marine mammal http://www.dosits.org/animals/effects/e1.htm
- Hearing in cetaceans http://www.dosits.org/animals/produce/ceta.htm
- Samples of ocean sounds http://www.dosits.org/gallery/intro.htm and http://oceanexplorer.noaa.gov/explorations/sound01/background/seasounds/seasounds.html

Lesson 5 – How to help. I have the power!

- Listing of resources to help whales www.earthlingenterprises.ca "

- Enhance student understanding by reviewing food chains and introducing the concept of bioaccumulation. Resource available through DFO – "Bioaccumulation and BC's killer whales" see http://www-heb.pac.dfo-mpo.gc.ca/community/education/lessonplans/orca-bioacc/orca_bioacc_e.htm
- Have students calculate their ecological footprint.
- On-line calculators at Footprint Calculator: http://www.earthlingenterprises.ca/earthlingenterprises/Consumer_Awareness.html
- Action campaign: Ocean Defenders http://oceans.greenpeace.org/en/
- Great action ideas available through the Wild BC resource "Leap into Action" resource available through http://www.hctf.ca/wild/resources/leap/leap.htm
- Ten top ways lifestyle changes can be made to improve the state of the environment (David Suzuki Foundation)
- The EPA's "Make a Difference Campaign for Middle Schools" http://www.epa.gov/epaoswer/education/mad.htm - lots of helpful information on smart shopping, interesting environmental science projects, reducing waste and the life-cycles of everyday objects.
- The EPA's film for students explaining climate change http://www.epa.gov/climatechange/kids/global_warming_version2.html

Preparation and Background Information

Read BC's Cetacean Sighting's Network comprehensive harbour porpoise background

Teacher background information

Organism	A living thing be it plant, animal, protest, fungus or bacteria (monera).
Food Web	A food web is used to describe the connectivity and dependence of organisms upon on another. A food web demonstrates the relationships between producers and consumers. In general, an ocean food web depicts phytoplankton as the primary producers, and zooplankton, fishes and mammals as the consumers. Review material available in Lesson 2 of http://www-heb.pac.dfo-mpo.gc.ca/community/education/lessonplans/orca-bioacc/orca_bioacc_e.htm
Ecosystem	A complex set of relationships that describe the interactions between living organisms and their environment; and includes the populations and communities that make up specific food webs, and the abiotic factors with which they interact.
Survival	In ecological terms survival indicates a natural process by which organisms have adapted and evolved to be best suited to their environment.
Habitat	The home of an organism that includes all biological, physical, and chemical factors, both natural and non-natural. Understanding the habitat of a particular organism, allows comprehension of the survival challenges faced by that organism when humans degrade or destroy the area they live in.
Harbour Porpoise	A species of porpoise that is only found in the Northern Hemisphere. There are three recognized subspecies: Pacific harbour (*Phocoena phocoena vomerina*), Atlantic Harbour Porpoise *(Phocoena phocoena phocoena)* and the Black Sea Harbour Porpoise (*Phocoena phocoena relicta*).
Cetacean	Is a type of mammal that is aquatic and breathes through a blowhole which includes the whales, dolphins and porpoise.
Mysticete (Pronounced "*mist-i-seat*", with the "*i*" pronounced the	Is a type of cetacean that does not have any teeth. All mysticetes are whales that have a baleen filter in their mouths. Mysticete means "moustached". Grey whales and humpback whales are examples of mysticete cetaceans.

same as in "*is*")	
Odontocete (Pronounced "*o-donto-seat*", with the "*o*" pronounced the same as in "*old*")	Is a type of cetacean that has teeth. Some whales, all dolphins and all porpoises are odontocetes. The sperm whale and bottlenose dolphin are examples of odontocetes.
Phocoenidae	This is the term used to collectively describe the porpoise family (Family Phocoenidae). All porpoises share characteristics that set them apart from other cetaceans.
Delphinidae	This is the term used to collectively describe the dolphin family (Family Delphinidae). All dolphins have similar characteristics that identify them from other cetaceans.

Turn down the volume!
The impact of sound on Harbour Porpoise

Lesson 1 – What is a porpoise

Lesson 1: Activity Description

1. Present students with the images of a harbour porpoise and the video provided by Jeff Wonnenberg (Emerald Sea Charters). This video was taken in the waters of southern Vancouver Island in the summer of 2006. Further video links available via lesson plan resource list.
    - o Discuss any experiences the students have had in seeing porpoise.
    - o Discuss how this animal may be adapted for its habitat

2. Discuss with students the defining characteristics of a porpoise (Content of Lesson 1: Student Handout 1).
    - Mammals versus fish,
    - Cetacean characteristics that allowed adaptation to an aquatic existence,
    - Odontocetes versus mysticetes,
    - How to discern a dolphin from a porpoise,
    - Six porpoise species.

2. Provide a "Lesson 1: Student Handout 1" to each student
3. Have students answer the questions individually and discuss answers as a class.
4. Give students "Lesson 1: Student Handout 2" and have them determine the identities of the marine mammals.

Lesson 1: Student Handout 1
What is a porpoise?
Images of harbour porpoises:

Photo : Chris Hall

Image credit: Uko Gorter
Natural History Illustrations

Porpoises belong to a familiar class of animals known as mammals. However, unlike most mammals, porpoises are marine mammals specially adapted to live in the sea. Many people refer to all large animals that live in the sea as fish, but this is wrong. Fish and mammals are very different from each other. Some of the most basic differences are outlined in the following table:

Table 1.1

Fish	**Marine Mammals**
Most fish have scales (there are some exceptions).	Do not have scales. All mammals have hair at some stage in their lives. Whales, dolphins and porpoises have hair on their snouts as juveniles, but adults do not.
Do not produce milk to feed young. Usually very little or no parental care.	**All** female mammals produce milk for their young and nurse them.
To swim the tail has a lateral movement (from side to side).	To swim the tail moves vertically (up and down).
Have gills to get oxygen from the water and get rid of carbon dioxide.	Breathe air with lungs to pick up oxygen and get rid of carbon dioxide.
Are almost all cold-blooded (exothermic) which means they have an inner body temperature equal to the temperature of their surroundings	Are always warm-blooded (endothermic) which means they are able to maintain a constant inner body temperature.
Most fish are egg layers but a few give birth to live young.	Most give birth to fully developed young, (The exceptions are: marsupials like kangaroos which give live birth but the young are not fully developed; and monotremes like the spiny anteater which are egg layers. The spiny anteater is also called the echidna).

Some marine mammals, like seals, sea lions, walruses, sea otters and polar bears, spend part of their time in the sea and part of the time on land. The marine mammals known as cetaceans spend their entire lives in the sea. The cetaceans include all whales, dolphins and porpoise.

To be able to live their entire lives in the ocean, cetaceans have some unique “adaptations”; characteristics that let them survive in this environment. For example:

- They have a specialized way of breathing using blowholes located on the top of their heads. The blowholes close when the cetaceans are underwater.
- They can stay underwater for a long time because their blood can take up a huge amount of oxygen.

- They do not use hair to keep warm; instead they have a thick layer of fat called blubber, which functions to help insulate them from the cold ocean water. The blubber is also an energy store and helps the cetaceans stay afloat.
- They do not have hind legs.
- They are hydrodynamic; streamlined to be able to move efficiently in water.
- They have ways to be able to deal with the ocean's pressure.
- They have special glands that create an oil to protect the eyes from salt water.
- Their babies are born tail first so that once they are born they can quickly get to the surface to breathe.
- They do not have external ear flaps since they do not need to capture vibrating air in order to hear. Cetaceans do not have any ear openings on the sides of their heads either. This prevents water from getting into their ears, which could cause damage through pressure changes when they go on deep dives. Instead, cetaceans have developed a unique way of hearing the sound waves travelling in water! This great mystery will be solved in Lesson 4!

Some cetaceans have teeth, while others have baleen (a filtering apparatus). Toothed cetaceans are known as odontocetes (e.g. killer whales) and they have one blowhole. Cetaceans with baleen are known as mysticetes (e.g. grey whales and humpback whales) and all mysticetes have two blowholes that are side by side, just like your nostrils.

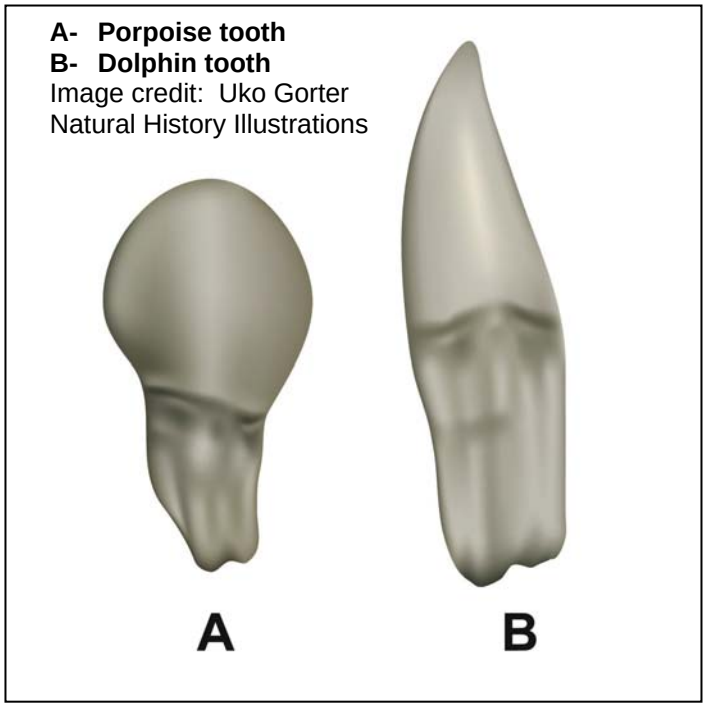
Porpoise and dolphins are odontocetes, but there are some significant differences between these two types of small cetaceans and, as a result they belong in two separate families - the Delphinidae (dolphin family) and the Phocoenidae (porpoise family). There are several other odontocete families.

Table 1.2:

	Dolphin	**Porpoise**
Teeth	All teeth have a conical (cone) shape.	Porpoise teeth are not cone shaped, but have a more flattened, spade shape. Their teeth are called "spatulate". See the following pictures.
Length	Usually between 1 and 10 metres long.	Most species are less than 1 metre in length. Porpoises are the smallest cetaceans.
Head	Often has a beaked shaped snout.	Porpoises have a blunt snout.
Dorsal fin (fin on the back surface)	Hooked or curved shape. (There are some exceptions like the Northern right whale dolphin that has no dorsal fin at all.)	Small and usually triangular shaped. (Again there exceptions, such as the finless porpoise.)
Sound production	Almost all sounds made can be heard by humans.	Most sounds are above what humans can hear.
Number of species	More than 30 species of ocean dolphin including the orca; the biggest member of the dolphin family. Also 5 species of river dolphin.	Only 6 in the world. They all live in the ocean.
Group size	Often seen in large groups even up to more than a 100 of animals together.	Small groups; usually no more than 10 animals together.
Behaviour	Often acrobatic. Repeatedly seen on the surface.	Not acrobatic. Seen only very briefly on the surface.

Harbour porpoise teeth

Photo credit: Anna Hall.



A- Porpoise tooth
B- Dolphin tooth
Image credit: Uko Gorter
Natural History Illustrations

The scientific name of harbour porpoise is *Phocoena phocoena*. The other five members of the scientific family are the:

- Vaquita (*Phocoena sinus*),
- Spectacled porpoise (*Phocoena dioptrica*),
- Finless porpoise (*Neophocaena phocaenoides*),
- Dall's porpoise (*Phocoenoides dalli*),
- Burmeister's porpoise (*Phocoena spinipinnis*)

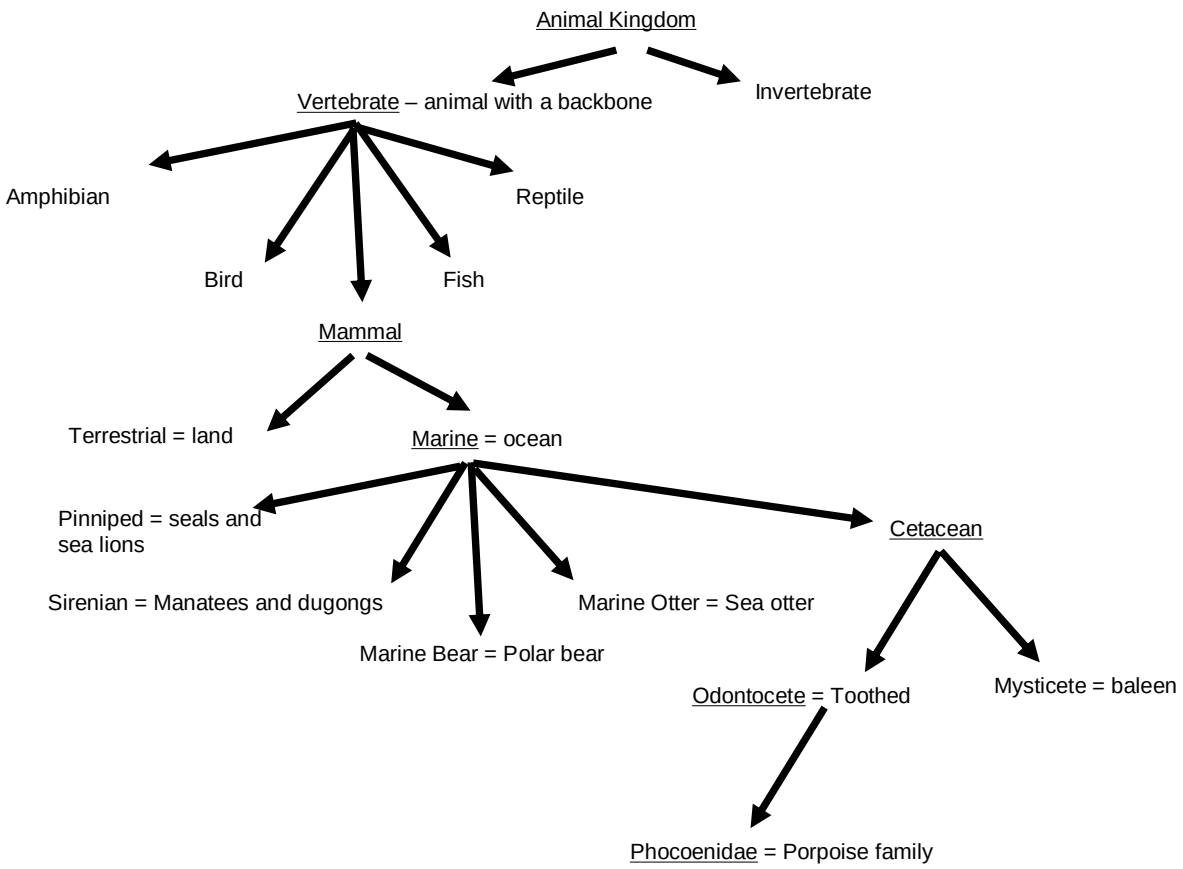
You, as a student, do not need to memorize these scientific names for the porpoise species but recognize that it can be very useful to know a species' scientific name, as often there is more than one common name for an animal. For instance, in eastern Canada, the harbour porpoise is often called a "herring hog", and in England it is called the "common porpoise". Scientific names allow people from different parts of the world to be able to communicate about an organism (living thing) no matter what the common name is. This is certainly important for scientists.

Little is known about porpoises compared to dolphins, since their small size makes them difficult to spot, their colour blends in with the sea surface, and because they are not acrobatic. Animals that are difficult to see and study are said to be "cryptic." A lot of their lives are unknown to us.

Even though the harbour porpoise of southern BC live in waters that are near Vancouver, Victoria and Nanaimo we know very little about their lives including how many live here or even which parts of the coast are important for their survival.

Harbour porpoise skull
Image credit: Uko Gorter
Natural History Illustrations

Summary of the classification of porpoise



Questions

1. List three differences between fish and marine mammals.
2. What is a cetacean? What are three cetacean adaptations for surviving in water?
3. Define “mysticete” and “odontocete” and give 3 example species for each group.
4. What does “dorsal” mean?
5. You have just seen a small cetacean from the shore! Name 4 things that would help you decide if it was a dolphin or a porpoise.
6. What can endothermic animals do that exothermic animals cannot do?
7. Decide which groups the following animals belong in. Note - they can belong in more than one group or to no group at all!

Polar bear; cat; sea lion; salmon; humpback whale; harbour porpoise; mushroom; vaquita

a. Animal
b. Mammal
c. Marine mammal
d. Cetacean
e. Toothed cetacean (odontocete)

Answer Key Lesson 1: Student Handout 1

A1. See table 1 in Lesson 1: Student Handout 1

A2. A cetacean is a name used to describe the group of marine mammals with a blowhole. This includes the whales, dolphins and porpoise. See list under Table 1.1 for adaptations.

A3. Mysticete is the group name for baleen cetaceans. Odontocete is the group name for toothed cetaceans. Mysticetes e.g. gray whale, humpback whale, blue whale, fin whale, sei whale, Minke whale, right whale, bowhead whale. Odontocetes e.g. killer whale (or orca); all dolphin species; beaked whales; sperm whales; porpoises; beluga; narwhal;

A4. Dorsal means “back “ (as in “on the back surface”).

A5. Dolphin

- More than 1 metre long,
- Hooked fin,
- Display surface acrobatics,
- Large group size
- Sometimes have a head with a beak shape

Porpoise

- Less than 1 metre
- Triangular fin
- Very little surface activity
- Small groups
- Blunt head shape

A6. Endothermic animals can maintain a constant internal temperature. This means they can live in a wider variety of environments, as they are not dependent on the surrounding temperatures.

A7. a. Animal - *Polar bear; cat; sea lion; salmon; humpback whale; harbour porpoise; vaquita*

b. Mammal - *Polar bear; cat; sea lion; humpback whale; harbour porpoise; vaquita*

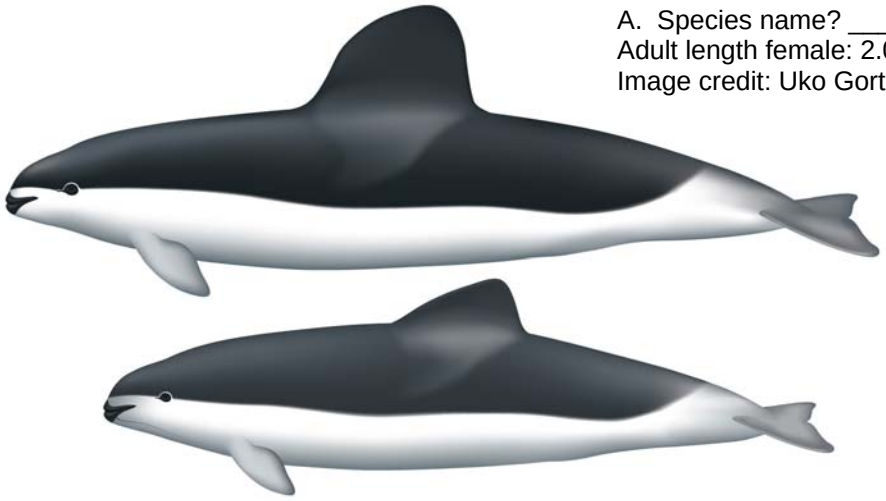
c. Marine mammal - *sea lion; humpback whale; harbour porpoise; vaquita*

d. Cetacean - *humpback whale; harbour porpoise; vaquita*

e. Toothed cetacean (odontocete) - *harbour porpoise; vaquita*

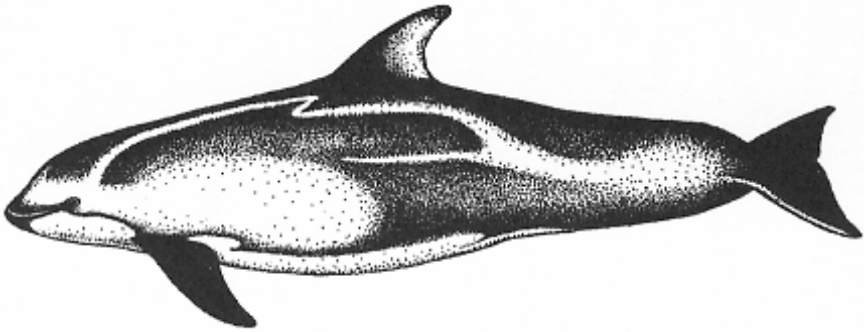
Lesson 1: Student Handout 2
Dichotomous Key – Identify the marine mammals!

Figure out who's who! You must start at number 1 in the key for identifying **each** animal! Fill in the species name under the animals.



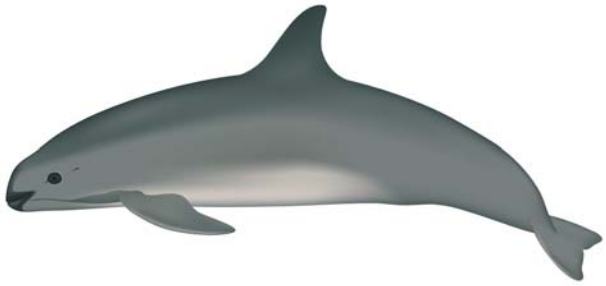
A. Species name? _____
Adult length female: 2.05 m maximum
Image credit: Uko Gorter, Natural History Illustrations

Species name? B._____
Adult length female: 2.36 m maximum
Image credit: Gloria Snively



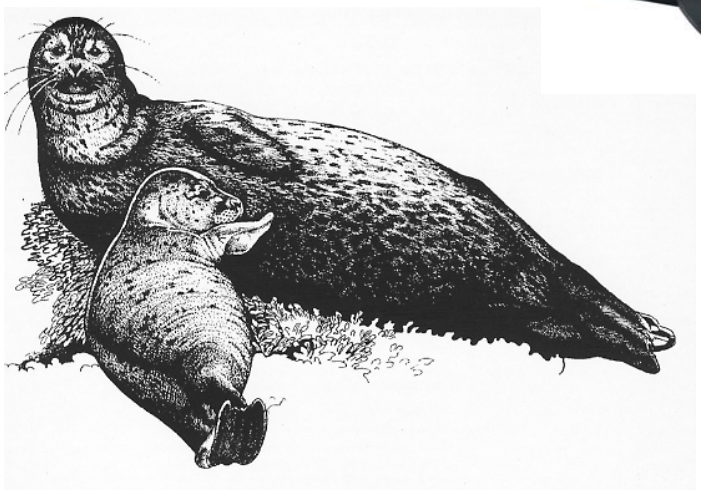
C. Species name? _____
Adult length female: 1.55 m maximum
(Yellow Sea population)
Image credit: Uko Gorter Natural History Illustrations

D. Species name? _____
Adult length female: 1.5 m maximum
Image credit: Uko Gorter, Natural History Illustrations



E. Species name? _____
Adult length female: 1.91 m maximum
Image credit: Uko Gorter, Natural History Illustrations

F. Species name? _____
Adult length female: 2.1 m maximum
Image credit: Uko Gorter, Natural History Illustrations



G. Species name? _____
Adult length female: 1.7m maximum
Image credit: Gloria Snively

H. Species name?_____
Adult length female: 1.68 m maximum
Image credit: Uko Gorter, Natural History Illustrations

Dichotomous Key – Use to identify the 8 marine mammals (A to H) on the 2 proceeding pages

1.
   a. Animal has no dorsal fin → go to number 2
   b. Animal has a dorsal fin → go to number 3
2.
   a. Animal is a cetacean → **Finless porpoise**
   b. Animal is not a cetacean → **Pacific harbour seal**
3.
   a. Adult female is 1.5 m or smaller → **Vaquita**
   b. Adult female is larger than 1.5 m → go to number 4
4.
   a. Dorsal fin is black and white → go to number 5
   b. Dorsal fin is all dark coloured → go to number 6
5.
   a. Animal has a triangular shaped dorsal fin → **Dall's porpoise**
   b. Animal has a hooked dorsal fin → **Pacific white-sided dolphin**
6.
   a. Animal's dorsal fin is in the middle of its back → go to number 7
   b. Animal's dorsal fin is well behind the middle of its back → **Burmeister's porpoise**
7.
   a. Animal has a large, rounded dorsal fin → **Spectacled porpoise**
   b. Animal has a small, pointed dorsal fin → **Harbour porpoise**

Answer Key Lesson 1: Student Handout 2

A = Spectacled porpoise
B = Pacific white-sided dolphin
C = Finless porpoise
D = Vaquita
E = Burmeister's Porpoise
F = Dall's porpoise
G = Harbour seal
H = Harbour porpoise

Turn down the volume!
The impact of sound on Harbour Porpoise

Lesson 2 – Natural history of harbour porpoise in British Columbia

Lesson 2: Activity Description

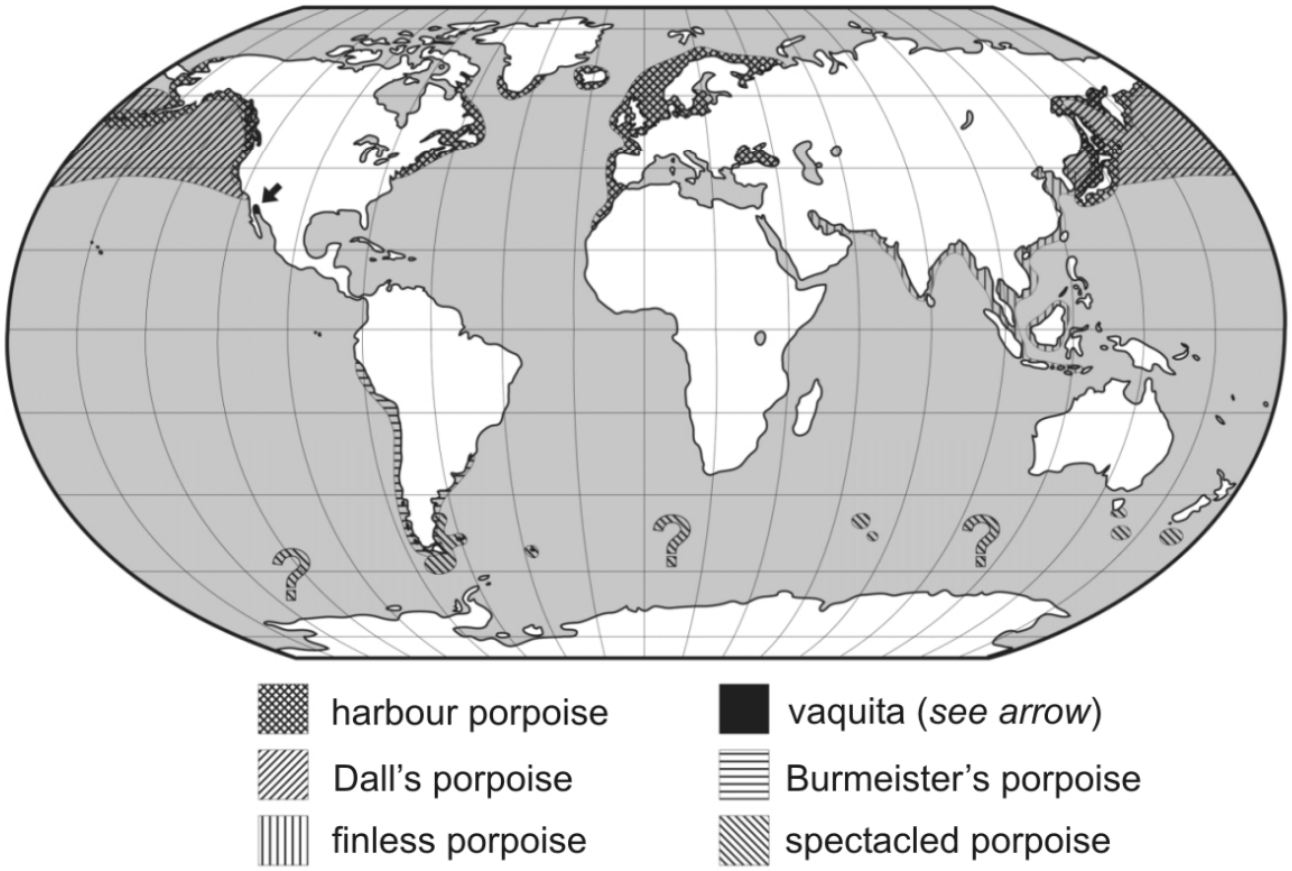
1. Provide "Lesson 2: Student Handout 1" and do the exercise.
2. Discuss the natural history of harbour porpoise in British Columbia. Discussions should include life history, prey species, predators, and threats. (Content of Lesson 2: Student Handout 2).
3. Provide "Lesson 2: Student Handout 2" to each student
4. Have students answer questions individually and discuss answers as a class.

By Anna Hall and Jackie Hildering

Lesson 2: Student Handout #1
World map

Challenge questions!

Study the world map showing where harbour porpoise are found. You will note that they are only in the northern hemisphere in sub-arctic and cold temperate waters.
Map by Uko Gorter, Natural History Illustrations.



1. Define the following geographical terms:
   - Circumpolar
   - Temperate

2. Use a highlighter pen to colour in the global range of the harbour porpoise

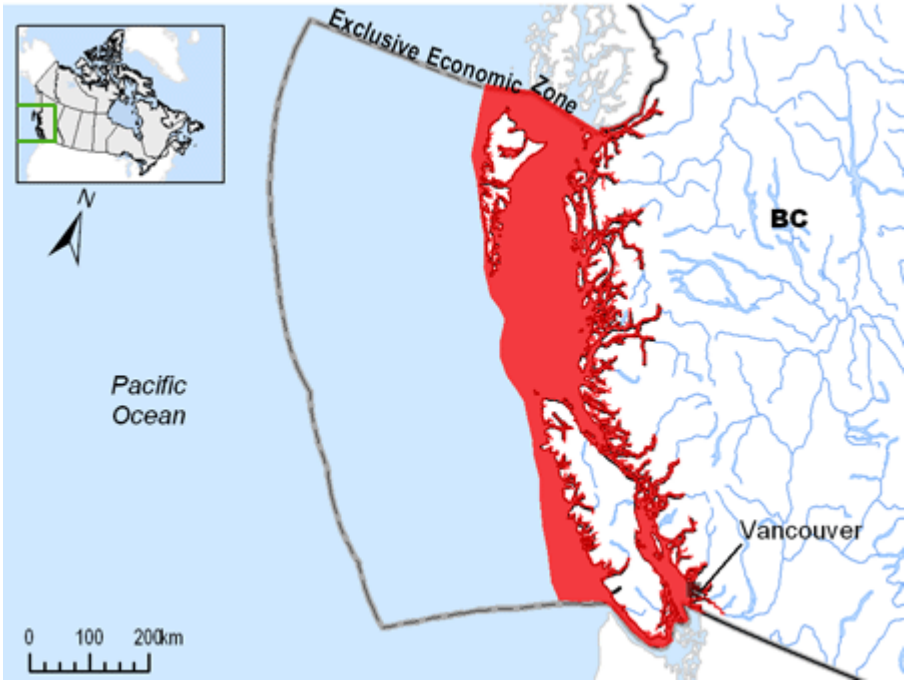
3. Use an atlas to locate and label the following on the map
   - States: Alaska; Washington; California; Maine
   - Provinces: British Columbia, Nova Scotia
   - Countries: Russian Federation, Faeroe Islands, Greenland, Iceland, United Kingdom, Norway
   - Water bodies: Mediterranean Sea, North Sea, Bay of Fundy

4. There are three major isolated populations of harbour porpoise. Label and put a circle around each of the following to show these three areas:
   - Black Sea and Azov Sea (one circle)
   - North Pacific ocean
   - North Atlantic ocean

Lesson 2: Student Handout 2
Natural history of harbour porpoise in British Columbia

As you discovered in Student Handout 1 for this lesson, there are three major isolated populations of harbour porpoise: the North Pacific, the North Atlantic, and the Black and Azov Seas. Since they are geographically isolated, no mating occurs between these populations.

Harbour porpoise have the widest distribution of any of the 6 porpoise species, meaning that they are found in more areas of the world than any of the others. Within the eastern North Pacific, four populations of harbour porpoise are recognized: Alaska, British Columbia, Washington and California. It is believed these animals do not travel from one population to another. So harbour porpoise that live in British Columbia, may spend their entire lives here!



Source: http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=493

Dall's porpoise are the only porpoise species to have an overlapping range with the harbour porpoise: Both are found in British Columbia coastal waters. Harbour porpoise are usually found in waters that range from about 25 to 125 metres depth. Dall's porpoise prefer deeper waters ranging from about 150 metres to over 300 metres depth. The harbour porpoise's preference for shallow water is reflected in its name – *harbour* porpoise. However, these animals are not restricted to these depth ranges. So sometimes, harbour porpoise may venture into deep waters, and Dall's porpoise into shallow. We know for sure that they are occasionally together in the same habitat, at least in southern BC, since harbour porpoise and Dall's porpoise sometimes mate to produce hybrid calves!

Dall's porpoise can be easier to find than harbour porpoise because Dall's porpoise will sometimes come to a boat to ride in its bow wave or they will surf in a boat's wake! Harbour porpoise do not approach boats, especially when the motors are running. Dall's porpoise are bigger and the black and white colouring of their dorsal fin can sometimes make them easier to spot. They can go very fast, even up to 55 km/hr! When they travel at this speed you often see a very distinct splash on the surface this also makes them much less cryptic than the harbour porpoise.

By Anna Hall and Jackie Hildering

The only other smaller cetacean regularly seen in BC's waters is the Pacific white-sided dolphin that you identified in Lesson 1: Sheet 2. Review this sheet to be sure you can identify the Dall's porpoise and Pacific white-sided dolphin.

Although harbour porpoise are marine mammals, they have been known to go up rivers on occasion. There is one report of a harbour porpoise going more than 50 km up the Fraser River, probably in search of food.

Harbour porpoise reach between 1.5 and 1.8 m in length making them BC's smallest cetacean, and they weigh 45 to 60 kg at maturity. Female harbour porpoise are slightly larger than males. There is no difference in colour or body shape between males and females so it is difficult for scientists to know the sex of living wild porpoise except when a female has a calf at her side. So some scientists use a retractable dart system to collect a skin sample from the porpoise to figure out if it is male or female from the DNA in the cells collected.

From the time they are born, harbour porpoise have a greyish-brown to almost black colouration on the dorsal (upper) surface of their heads, backs and tails. On their ventral side (underside) they are white.

Studies on populations of harbour porpoise in other parts of the world have concluded:

- Harbour porpoise mature between the ages of 3 and 6 years. There is a lot of variation between different populations. For instance, in the North Atlantic, harbour porpoise mature between ages 3 to 4 years, but in the North Sea they do not mature until they are between 5 to 6 years old. We do not know the maturity age range for the British Columbian populations.
- Female harbour porpoise give birth to single calves about every two years. It takes approximately 18 months for the calf to become independent of its mother. During weaning the calf eats small shrimp-like animals (called euphausiids) in addition to milk. As adults, harbour porpoise eat small fish (10 to 25 cm) and squid. Some of their main prey includes small, non-spiny fish like herring and sand lance. They also eat market squid, which is more commonly known as calamari.
- Harbour porpoise are thought to live between 11 and 20 years with there being big differences between populations around the world.

Compared to eastern Canada and Europe, very little research has been done on BC harbour porpoise. As a result, we know very little about how often they have calves, how long they live, or even what they eat.

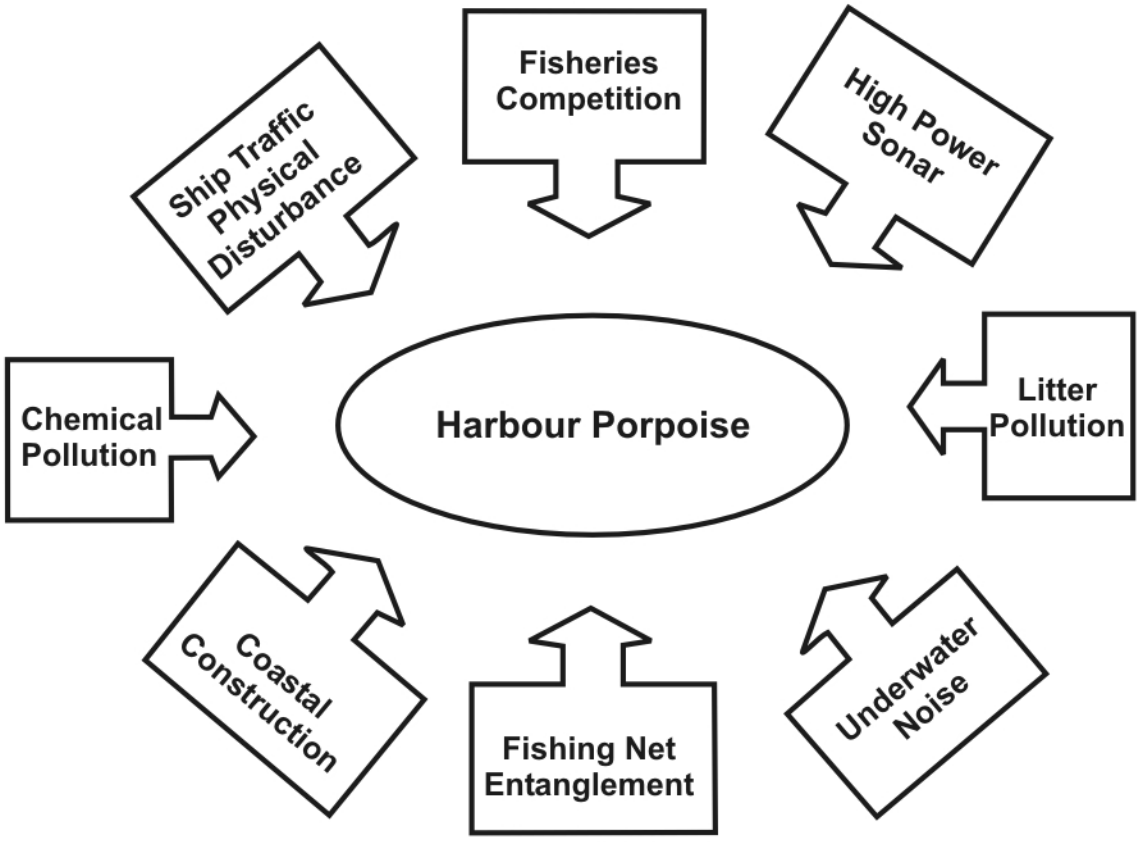
Some marine mammals, like Pacific white-sided dolphins or humpback whales are known for their acrobatic behaviours like jumping out of the waters (called breaching). These surface-active behaviours help researchers find where the animals are, what habitats they are using, and how they interact with each other. Harbour porpoise are not acrobats. They very rarely jump out of the water. Mostly, harbour porpoise surface with a gentle rolling motion and infrequently display any active behaviour above the surface of the water. However, when they are feeding in tide lines, they will surface more quickly creating a low splash.

The social organization of harbour porpoise is also not well known. In BC, it is common to find groups of three, especially during the summer and early fall months. These clusters appear to consist of two adults and one calf. The sexes and relationship of the two larger animals to each other and to the calf are unknown.

In British Columbia, the most common predators of harbour porpoise are transient killer whales. Some sharks, such as the great white shark will also prey on harbour porpoise in other parts of the Pacific and Atlantic Oceans.

Harbour porpoise survival is also threatened by human activities. Specific threats include entanglement in fishing nets, competition with fisheries, habitat degradation due to chemical and noise pollution, habitat loss, and vessel collision. The exact effects of such threats are unknown.
Unfortunately, it does appear that harbour porpoise are seen less frequently in southern BC than they were only 50 years ago.

Summary of threats faced by harbour porpoise:



Questions

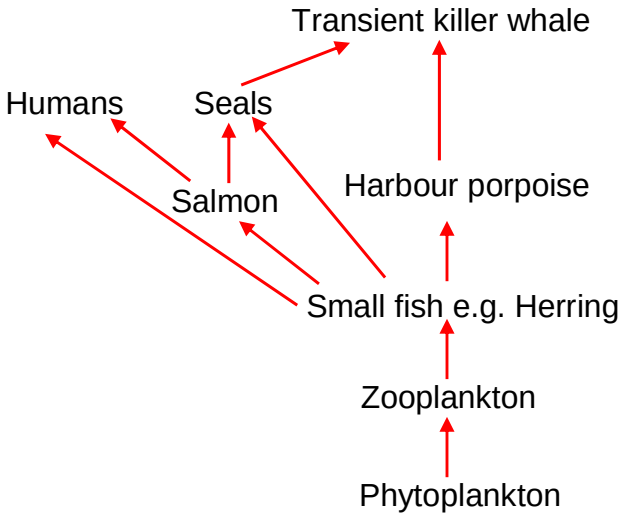
1. Why is it important to understand harbour porpoise habitat use when trying to protect them from human threats?
2. How can scientists determine if a harbour porpoise is male or female? Explain.
3. You are working as a naturalist on a whale watching boat. You have made the following sightings. Which of BC's three small cetacean species do you think each sighting could be?
    a. A very large group of small cetaceans jumping out of the water.
    b. Extremely fast animals in a group of 10 to 15 riding along at the front of the boat but not jumping out of the water. They are black and white and have a triangular fin.
    c. A quick flash of small dark brown animals, maybe 4 of them together. You saw them and then they seemed to disappear.

By Anna Hall and Jackie Hildering

4. Study the following food web.

a. From this food web, draw a food chain for harbour porpoise.
b. Name three competitors for harbour porpoise's prey
c. Name the harbour porpoise's predator.
d. Name the producer in the food web.

Food Web



Answer Key Lesson 2

A1. You need to know where an animal lives before you can determine the specific threats that it may face during its life.

A2. If there is a calf right beside the adult, it is likely a mature female. Otherwise, because males and females look the same, scientists obtain a DNA sample from skin cells – acquired using a retractable dart system.

A3. a) Pacific white-sided dolphin, b) Dall's porpoise, c) harbour porpoise

A4.

a. Phytoplankton → zooplankton → herring → harbour porpoise
b. Salmon, humans, seals
c. Transient killer whale
d. Phytoplankton

Turn down the volume!
The impact of sound on Harbour Porpoise

Lesson 3 – Cryptic Animals and Harbour Porpoise Conservation Status

Lesson 3: Activity Description

1. Review with the students why it is difficult to observe and study harbour porpoise. Emphasize that cryptic animals deserve as much conservation effort as those which are readily observed or more easily found; that they are not immune to human influence and that, in addition to the impacts on their survival being more difficult to notice, cryptic species may also serve as an indicator for environmental problems. (Content of Lesson 3: Student Handout). Key points include:
    - Physical characteristics contributing to cryptic nature,
    - Behavioural characteristics contributing to cryptic nature,
    - Proximity of harbour porpoise to major BC urban centres,
    - Lack of awareness of most BC citizens of this species very existence,
    - Overlap of human activity, like sewage dumping, and harbour porpoise distribution,
    - Conservation status both global and provincial.

2. Provide a "Lesson 3: Student Handout" to each student.
3. Have students answer questions in class, and discuss answers as a group.

By Anna Hall and Jackie Hildering

Lesson 3: Student Handout
Cryptic Animals: Harbour Porpoise Conservation Status

Harbour porpoise can be very difficult to observe in the wild. This is partly due to their very small size and because their dorsal surface is brownish-grey. This colour blends in with the surface of the ocean very well. What also makes it difficult to observe wild harbour porpoise is that the dorsal fin rarely makes an exit or entry splash; it is very small at only 15 to 20 cm in height. Their fins have no distinctive pigmentation patterns that would make them stand out and the blow is rarely visible too.

It is possible that some of the BC harbour porpoise population(s) never leave BC waters. They can live less than a couple of kilometers offshore from where people live, yet most British Columbians do not even know they exist, or that they need protecting. Some cities, like Victoria, have sewage outfalls right in harbour porpoise habitat!

It is unfortunate that the harbour porpoise's preference for shallower water means they are often closer to humans than some other marine mammals. As a result, they are often subject to greater human pressures than those marine mammals that live farther from shore.

Even though harbour porpoise are small and difficult to see, we need to protect them from harmful human activities. Just because they are difficult to find, doesn't mean that we're not affecting them.

Are we up to the challenge of understanding what these animals need and making changes that will protect them? In Canada, we have the Species At Risk Act (SARA), which provides laws designed to protect wild plants and animals. However, if we do not know enough to understand why the animal is at risk, it is difficult to use the laws to protect them.

The Committee on the Status of Wildlife in Canada (COSEWIC) advises the government about how "at risk" they believe an animal or plant is. The more "at risk", the more the Species at Risk Act is designed to offer protection.

Species Can Be Listed As:

- **Extinct:** no longer found anywhere on the planet; or
- **Extirpated:** no longer in the wild in Canada, but existing in the wild elsewhere.
- **Endangered:** a wildlife species facing imminent extirpation or extinction. (The species could soon become extirpated or extinct).
- **Threatened:** likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
- **Special concern:** a wildlife species that may become a threatened or endangered species because of a combination of biological characteristics and identified threats.

Increasing level of risk

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) declared BC harbour porpoise a species "Of Special Concern" in November 2003. This listing was given because BC's harbour porpoise "appear to be particularly sensitive to human activities, and are prone to becoming entrapped and killed in fishing nets. They are a short lived shy species that are now rarely seen at the highly developed areas of Victoria and Haro Strait. Continued development and use of its prime habitat by humans are some of the main threats. They are

By Anna Hall and Jackie Hildering

displaced by underwater noise, and could be affected by contaminants in their food chain" (COSEWIC).

Canada's Species at Risk Act does recognize BC's harbour porpoise as a species of "Special Concern" but as such they do not get the same level of protection as those animals and plants recognized as being threatened or endangered.

A question we must ask ourselves is:

> At which point on the road to extinction do we decide to study, protect and respect the wild species of our country? It makes sense that providing more protection to "Special Concern" species means a lower chance of their becoming more *At Risk*.

Threats to harbour porpoise:

- Entanglement – Unfortunately, harbour porpoise, as well as many other small cetaceans become entangled in fishing nets. Usually they die from drowning, as they cannot disentangle themselves. They usually need human help to get out of the nets alive.
- Competition with fisheries – as we learned earlier, harbour porpoise like to eat small fish such as herring. Humans also like to eat these fish. Since we both like the same fish, we end up competing indirectly with each other.
- Disease e.g. Cryptococosis. Sometimes people and porpoises get the same airborne diseases. Cryptococosis is a respiratory infection that several porpoises and people have died from in British Columbia.
- Loss of habitat - With a name like harbour porpoise, it is not difficult to imagine that these animals were once seen more often from shore. In some areas they still are, but many inshore habitats are no longer available because we've built busy harbours, installed bridges, and built marinas and ferry terminals. We've changed these habitats so much that the porpoises are forced to move to other areas further from human activity, but shallow waters away from human activity are becoming fewer and fewer. As you know, it is not the preferred habitat of British Columbia's harbour porpoise to move to deeper water.
- Climate change – Humans have an impact on how the climate is changing and this too can impact harbour porpoise survival. For example, using fossil fuels contributes to if changing global temperatures which would make it more difficult for small fish to survive and porpoises would have less prey to eat.
- Noise – This will be the focus of Lesson 4.

Questions

1. Explain why human activities may affect harbour porpoise more than some other cetacean species?
2. Define the word "cryptic."
3. List 4 reasons why harbour porpoise are considered a cryptic species.
4. List at least 4 reasons why COSEWIC gave BC's harbour porpoise a "Special Concern" status?

Answer Key Lesson 3

A1. Harbour porpoise

- Live in inshore areas that are often close to our cities and towns
- Eat food that people also like to eat e.g. Herring,
- Live in shallow habitats near where people build marinas and have ferry terminals.

A2. Cryptic means inconspicuous or hidden, difficult to find.

A3. Any four of: small body size, small dorsal fin, do not create sounds we can easily hear, live in small groups, do not approach boats, do not jump out of the water, have a colouration that blends in well with the ocean colour.
A4. Harbour porpoise:

- Appear to be particularly sensitive to human activities,
- Can become entangled and die in fishing nets,
- Are short-lived,
- Are difficult to study (reflected in the statement that porpoises are “shy”),
- Seem to be in reduced numbers in the highly developed areas of Victoria and Haro Strait,
- Continue to be threatened by human development and use of its prime habitats,
- Are displaced by underwater noise,
- Could be affected by contaminants in their food chain.

Turn down the volume!
The impact of sound on Harbour Porpoise

Lesson 4 – Impact of Sound

Lesson 4: Activity Description
Impact of Sound

1. Discuss with students how porpoise hear and create sound and contrast cetacean hearing with human hearing. Include a discussion of other sounds in the ocean (natural and non-natural) and how they can interfere with porpoise acoustics (content of Student Handout: Lesson 4). If possible, share with students the animations of echolocation at: http://www.dosits.org/animals/use/2a.htm and the sound samples found at http://www.dosits.org/science/ssea/2.htm And the animations of human hearing at: http://www.dizziness-and-balance.com/disorders/hearing/hearing.html http://www.bbc.co.uk/science/humanbody/body/factfiles/hearing/hearing.shtml
2. Provide a "Student Handout: Lesson 4" to each student.
3. Have students answer questions in class individually and discuss answers as a class.

Lesson 4: Student Handout
Impact of Sound

Of the aquatic adaptations that cetaceans have developed, one of the most important is their ability to create and use underwater sound. Sunlight only penetrates the very top layers of the ocean; so much of their aquatic habitat is very dark. Even the upper layers can be difficult to see through if there is a lot of plankton or a lot of turbulence stirring up the bottom. If cetaceans only relied on their eyes, they often wouldn't be able to see where they were going during the day, and they wouldn't be able to see anything while moving about at night. However, toothed cetaceans have evolved an amazing ability to see their world by using sound. We'll learn how porpoises find their way with sound waves.

Porpoises use sound for navigating, communicating and finding prey. They make two types of sound that sound like clicks and whistles. The whistles are used more for communicating whereas the clicks, known as echolocation, are used more for navigating, and finding prey. Echolocation may possibly also have a role in communication. Human ears can hear the whistles produced by harbour porpoise, however very few people have ever heard them. To hear a harbour porpoise, you need to have a hydrophone (an underwater microphone) and you have to be in the right place at exactly the right time.

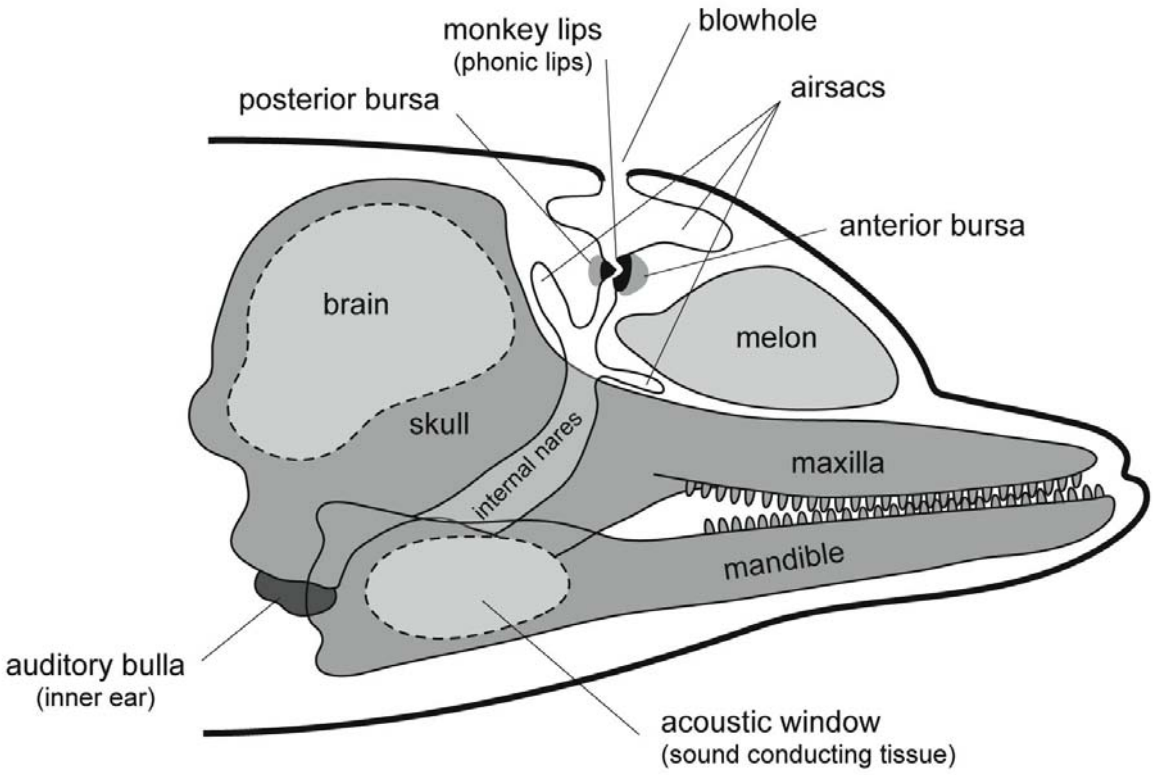
The sounds harbour porpoise make, are not sent into the environment through their mouths, but rather out through their foreheads. When porpoises breathe in through their blowhole (on top of their head) the air travels through the blowhole, down a short passage and into an area where there are some small air sacs. The region where the air sacs are is called the "Monkey Lips Dorsal Bursae" - "Monkey Lips" or "MLDB" for short. When the air passes through the top opening of this region, the MLDB vibrate and sound is produced. The sound wave is moved forward through the animal's head toward its forehead, where there is a large fat filled organ

By Anna Hall and Jackie Hildering

that is called the melon. The melon acts like a lens, and it is used to focus the sound wave out into the environment.

Porpoises, and other odontocetes, can open and close the Monkey Lips and therefore create discrete clicks. This very sophisticated sound production system is one of the characteristics that have allowed these mammals to adapt to an aquatic environment. To think of how this works, imagine blowing up a balloon, and making it squeak by holding the opening closed and forcing their air through.

Schematic illustration of a dolphin's head anatomy



Sound generator: The Monkey Lips/Dorsal Bursae Complex (MLDB)

Modified and adapted from Cranford et al. 1996

Image credit: Uko Gorter Natural History Illustrations. Modified and adapted from *Cranford, T. W., Amundin, M. and Norris, K. S. (1996), Functional morphology and homology in the odontocetes nasal complex: implications for sound generation. *J. Morphology*. 228, 223-285

The use of echolocation has helped the porpoises and other odontocetes become better able to know what is happening in their aquatic environment. Although cetaceans have excellent eyesight, light does not travel very far in the ocean. We know this because if you open your eyes underwater, even with a snorkel mask on, you can't see very far. However, sound is conducted very well through water. Have you ever noticed how

- Speed of sound in seawater 1531 m/s.
- Speed of sound in air (20°C) 344 m/s.
- Sound travels 4.5 times faster through water than through air.

noisy it can seem at the swimming pool? That is because the sounds (talking, laughing, jumping in water) are transmitted very well across the surface of the water. Sound travels just as well *through* the water as it does across its surface. In fact, sound travels 4.5 times faster through water than through air!

Sound is a form of energy. For terrestrial animals and people sound is transmitted through vibration of air molecules. Our ears detect these vibrations and conduct them from our ears to our brains. For aquatic animals, sound is conducted through the vibration of water molecules. These molecules are closer together in liquids like water, than air, so the sound energy is conducted more efficiently. This is why sounds are louder and travel further and faster in water.

The echolocation clicks cannot be heard by people because they are at a frequency which is higher than what people can hear. People can hear sounds between about 2 to 20 kHz (kilohertz), this is known as the sonic range. Some animals, like elephants and fin whales use sounds below this range – these are known as infrasonic sounds. Other animals, like harbour porpoise and some bats, use sounds above this range. These are called ultrasonic sounds. The energy of a harbour porpoise click is centred around 120 kHz – definitely above what humans can here!

Generally, toothed cetaceans (odontocetes) make higher frequency sounds while baleen cetaceans (mysticetes) make lower frequency sounds that can travel much further.

Porpoises use echolocation clicks to help them acoustically "see" under water. The porpoise creates a click and sends it out focused at an object, such as a school of fish, an underwater rock or even a boat. The sound waves travel through the water, hit the object and bounce back creating an echo. This is exactly the same principle as when you shout into a canyon, and a few seconds later you hear your own echo. The longer it takes the echo to come back, the further an object is away. We use sonar (SOund Navigation And Ranging) on boats to find things underwater just like the odontocetes use their echolocation. In fact, echolocation is also known as biosonar.

Porpoises do not receive sounds through their ears on the outside of their head like we do, instead they receive the sound through their lower jaw. The lower jaw of odontocetes is hollow, and filled with a fatty substance. Just like in the melon, the fatty material helps to conduct sound. The sound wave is received by the lower jaw, and transmitted to the middle ear. Odontocetes have ears very different to ours. As you know, our ears are directly connected to our heads, but the porpoise ears are not. The ear structure ("bulla" in the diagram) is outside the skull and surrounded by bone and more fatty material. This protects the ear from pressure changes if the animal goes on a deep dive, but also serves to isolate sounds coming from the jaw so they are not lost amongst other sound waves travelling through the ocean. Essentially, the porpoise is most sensitive to sounds that come from ahead of the animal as these reach the ear via the jaw. Their brains process these sounds to interpret the world around them. Porpoises can adjust not only the rate at which they produce echolocation clicks but also the frequencies used. In this way, they avoid interference with their next set of outgoing clicks.

The frequency of sound is measured in units called hertz (Hz) or kilohertz (kHz). Hertz = the number of vibrations per second. Think of twanging your ruler on the side of your desk. If it vibrates a lot, it makes a high frequency sound. If it vibrates slowly, the frequency is lower.

By Anna Hall and Jackie Hildering

When we hear sounds, the vibrating air from the source of the sound goes into our ears via our earflaps, down the ear canal and then to the eardrum in the middle ear. The vibrations from the moving eardrum are magnified with tiny bones and passed on to the nerve cells in our inner ear. The nerve cells are specific for sound frequencies, and when stimulated by receiving the vibrations, the nerve cells pass the message to the brain.

For cetaceans, sounds vibrate from a source like a boat engine, or another porpoise, through the water to the jaw. The sounds are then transmitted through the fat tissues in the lower jaw directly to the middle and inner ear structures. The ear canals of cetaceans are full of wax, and are thought not help with transmitting the vibrations. The eardrum in the middle ear transmits the sound to the inner ear. Just like for humans, in the inner ear, there are many little nerve cells that are specific for receiving certain frequencies. There is a lot of variation amongst animals with regard to the numbers of nerve cells in their ears and the frequencies they can hear. These nerves actually detect the movement of the incoming sound wave and transmit that information to the brain.

The sensitivity of the nerve cells in the ears of animals (including humans) generally corresponds to the frequencies that each animal produces. This is like the keys of a piano; there is a nerve cell for each frequency. So animals like the harbour porpoise have more nerves in their ears that are tuned to very high frequencies (since they make lots of high frequency sounds) unlike an animal such as a blue whale, which is tuned to lower frequencies (since the sounds they make are of lower frequency).

Exposure to loud sounds can cause damage to the nerve cells in the ears of humans and other animals. Damage can result in two ways; from an intense brief impulse (e.g. an explosion) or from continuous exposure to a sound (working on a machine with a noisy engine or by listening to loud music with headphone). For instance, if you listen to loud sounds, like at a concert, you may find that your ears are ringing for several days. This indicates that the nerve cells in your ears have been damaged by the sounds. Your body usually repairs this short-term damage. However, if you were to hear these loud sounds everyday, your body cannot continually repair the damage and eventually your ears loose their ability to hear certain frequencies. Basically, the damaged nerve cells can no longer vibrate in response to incoming sound waves. Therefore, no signal is passed along to the brain for interpretation. The result is that incoming sounds with a frequency corresponding to the damaged nerve cells are not heard. Damaged nerve cells mean the animal cannot hear as well as before the damage was done.

This hearing loss is a handicap for humans and other animals. Cetaceans rely on sound since they cannot depend on being able to see well through water. If the nerve cells in the harbour porpoise ears become damaged, their ability to communicate, navigate and find food is seriously affected. This can have dire consequences. If the damage is severe, the porpoises can die as a result of the loud sounds. There is concern that very powerful sounds, like some military vessel sonar, may be linked to hearing damage in cetaceans. It is suspected that the military sonar could be a factor in some cases of cetaceans stranding themselves on shore. Examples of strandings in which mid-frequency sonar is suspected to have a role as the strandings occurred in association with naval training exercises:

1. In 1996, a mass stranding of beaked whales in the Mediterranean Sea (Source: Frantzis, A. 1998. Does acoustic testing strand whales?)
2. In May 2000, 17 species of cetacean stranded in the Bahamas (Source: Balcomb, K. 2001. A Mass Stranding of Beaked Whales in the Bahamas).
3. In September 2002, 14 beaked whales stranded in the Canary Islands (Source: Martel, V.M. 2002. Summary of the report on the atypical mass stranding of beaked whales in the Canary Islands in September 2002 during naval exercises).

4. From May 2nd to June 2nd 2003, multiple harbour porpoise were found stranded in Puget Sound, Washington (Source: American Cetacean Society. Summary of the Preliminary Report on the investigation of harbour porpoise stranded in Washington around May 2003).
5. On January 15th and 16th 2005, 36 cetaceans of 3 different species stranded in North Carolina (Source: NOAA report. Multi-species Unusual Mortality Event in North Carolina).

Table 4.1:

	Humans	**Odontocete**
Ear flaps	Present	Absent
Vocal cords	Present	Absent. Use their air sacs to make sound.
Incoming sound transmission to the ear drum	Through the ear canal	Through the lower jaw. Ear canal plugged so no water gets in.
Outgoing sound transmission	Through the mouth	Through the forehead (melon)

Some natural events are extremely noisy in the ocean. Earthquakes, underwater landslides, rain, wind, and glaciers calving (creating icebergs) are all very noisy events. Even some animals can produce very loud sounds (e.g. blue whales and snapping shrimp). However, humans are increasing the amount of sound in the ocean, sometimes dramatically. Some of our noisy activities include boats, especially deep-sea vessels, like freighters; military sonar; offshore drilling; and seismic exploration.

Note that the unit for measuring the intensity of sound is the decibel (dB). Whispering is about 40 dB; normal conversation is usually about 60 dB and a refrigerator hum is about 40 dB. Sounds above 80 dB are believed to lead to human hearing loss. Ear pain in humans is felt at about 120 dB. Examples of sounds in air (approximations):

- Lawnmower = 90 dB
- Sounds in a wood working shop = 110 dB
- Rock concert = 100 dB
- Firecrackers, jets at takeoff, gunshots and motorcycles have sound intensity above 120 dB.

*Note that sound intensity in air is not the same as sound intensity in water e.g. 180 dB in water =118.5 dB in air.

Table 4.2: Examples of ocean noise.
You can listen to these sounds at http://www.dosits.org/gallery/intro.htm

Source	Sound intensity in water* (maximum underwater dB at 1 m)
Natural sounds:	
White-beaked Dolphin Echolocation Clicks	219

Bottlenose Dolphin Whistles	173
Gray Whale Moans	185
Humpback Whale Fluke and Flipper Slap	192
Snapping Shrimp	189
Ice breaking	193
Sea floor volcanic eruption	255
Lightening strike on the ocean's surface	260
Heavy rain	35
Human made ocean sounds	
Airgun array (36 guns) used for seismic testing (low frequency)	180 to 200 (total sound of array)
Single airgun for seismic testing (low frequency)	234
Tug and barge (18 km/hour)	171
Mid frequency military sonar	235
Large Tanker	186

Loud sounds can physically harm a porpoise, but even lower levels of sound can disrupt their lives. If the environment is noisy because of human activities (e.g. drilling for coastal constructions such as ferry terminals, marinas etc) the porpoises may not be able hear each other, or even themselves. High levels or long-term exposure to noise can create stress and prevent a porpoise from being able to navigate away from dangers, find food or even find members of its family.

Of course, we cannot stop all noisy activities in the ocean, but we can try to ensure that we avoid making noises in marine mammal habitats. One way of avoiding disturbing marine mammals is to have trained observers watching for them. If marine mammals are sighted, potentially disruptive activities should stop until they have left the area. Though the intentions are good, in practice this does not always work. Therefore we need to work together to reduce ocean noise levels.

Remember, harbour porpoise are particularly sensitive to human activities and noise. They do not seem to like to live in habitats where there are loud noises, or lots of boats. We don't know to what degree the noise hurts them or if it makes it too difficult for them to use their own sounds, but we do know when loud sounds or lots of human activity are in the same area as harbour porpoise, the porpoise leave. Sometimes they come back, and sometimes they don't.

Humans can choose how much noise they put into the oceans. There are a lot of different human generated sound sources. Not all sounds are present all the time. In southern BC, there often is a higher level of sound in the ocean because there is more coastal activity than in most of northern BC. Storms are very noisy, but they typically only last a couple of days. Sometimes people choose to do things that are extremely noisy. For a while in British Columbia, fish farms were allowed to put acoustic alarms on their underwater pens to try to

scare the seals away. Unfortunately, these alarms were so effective they also scared the porpoises and killer whales away too. These alarms are no longer used currently in our province, but other sound technologies are.

It is extremely important that we make sure that all the sounds we produce are at a low enough level that we are sure that there are no disruptions to marine mammals.

Cetaceans have survived millions of years in the world's oceans. Some can tolerate significant changes, whereas others, like the harbour porpoise, appear to be more sensitive. Humans are changing the world in many ways with our innovative technologies, global community and quest for knowledge. We must never forget that our activities not only affect our lives, but the lives of the other inhabitants of this planet. Animals like the harbour porpoise, may be difficult to find, and their activities may never change or even influence our busy lives, but we *are* changing theirs. They serve as indicators of how we might be changing the planet, not only for them, but for other organisms too. We need to work together to ensure we are changing it for the better and even though most of us may never get a good look at a harbour porpoise, isn't it good to know they live in our coastal waters and are our wild, aquatic neighbours?

A Noise Case Study: The Proposed Batholiths Project, 2007

Sound can be used when scientists want to learn about geological processes; much the same way a doctor uses sound (e.g. an ultrasound machine) to see inside your body.

Canadian and U.S. scientists are planning to try to understand the processes that generate the Earth's crust by examining the Coast Mountains of British Columbia in the fall of 2007.

Scientists want to study geological features known as batholiths. A batholith is a large volume of previously molten rock, which has solidified and through erosion is now visible at the surface. There are a lot of batholiths in the Coast Mountains of BC, so this is a good place to study them.

As part of the Batholiths project, Canadian and U.S. scientists propose to use a seismic ship in Douglas, Burke and Dean Channels to learn more about batholiths and the Coast Mountains. Seismic sampling uses sound waves to "see" into the Earth's rocks; just the same way that porpoises use sound to "see" through the dark ocean. Using seismic technology the scientists can determine what rock formation changes occur 40 to 50 km into the earth!

This amazing technology helps us understand the physical processes that shape our Earth and is the same technology that is used for earthquake hazard assessment.

Update: March 2007

Batholiths Project postponed due to uncertain potential effects from airguns on SARA listed marine mammals

The research expedition is planned for three weeks in September and October 2007. In order for the scientists to use seismic technology they have to produce sound. The research plan involves the use of 36 air guns which will create a pulse of sound by releasing compressed air 5 to 10 metres below the surface every 20 to 60 seconds (or 50 to 150 metres based on far the boat travels between blasts). The scientists will listen and record the reflected sounds using hydrophones. The sounds are up to 200 dB at the source radiating out hundreds to thousands of metres.

Harbour porpoise and other marine mammals, such as humpback and killer whales, use these same channels. As a result, there is concern about the seismic testing being conducted in this area.

By Anna Hall and Jackie Hildering

Update: March 2007
The seismic component of the Batholiths Project has been postponed due to the uncertain potential effects from airguns on SARA listed marine mammals.

For background on this project:
A brochure, the draft environmental assessment report and PPT presentations explaining the project are available at http://www.geo.arizona.edu/tectonics/Ducea/Batholiths/index.html. Information from the standpoint of those concerned about the impact of noise can be found at http://www.ecojustice.ca/media-centre/media-backgrounder/batholiths-background/

Questions
1. What two types of sounds do porpoises make?
2. From your answer in #1, which can be heard by humans?
3. What activities do harbour porpoise use sound for?
4. Connect the following terms:

a. Infrasonic	b. Range of sounds humans can hear (2 – 20 kHz).
c. Sonic	d. Sounds above what humans can hear.
e. Ultrasonic	f. Sounds below what humans can hear.

5. From this lesson, name an animal that uses infrasonic sounds.
6. Name the region in the porpoise's head where sound is produced.
7. Imagine you are in charge of all construction activities on the coast of British Columbia and a company said they were going to use underwater blasting in a coastal area of 25 to 125 m depth. The company said they went looking for harbour porpoise on a windy day and didn't see any, so they want to start blasting immediately. Would you let them use the explosives? Why?
8. Name an ear structure that can be damaged by sound.
9. Use graph paper to draw a bar graph of the data in the table below. Put "Decibels (dB)" on the y-axis and "Human-made ocean sounds" on the x-axis. You should go up by units of 20 on the y-axis. Make sure you label each of the 4 bars in your graph clearly.

Challenge question!

Human-made ocean sound	Sound intensity in water dB (rounded off)
Seismic testing (airgun array)	200
Tug and barge	170
Mid-frequency military sonar	235
Large Tanker	185

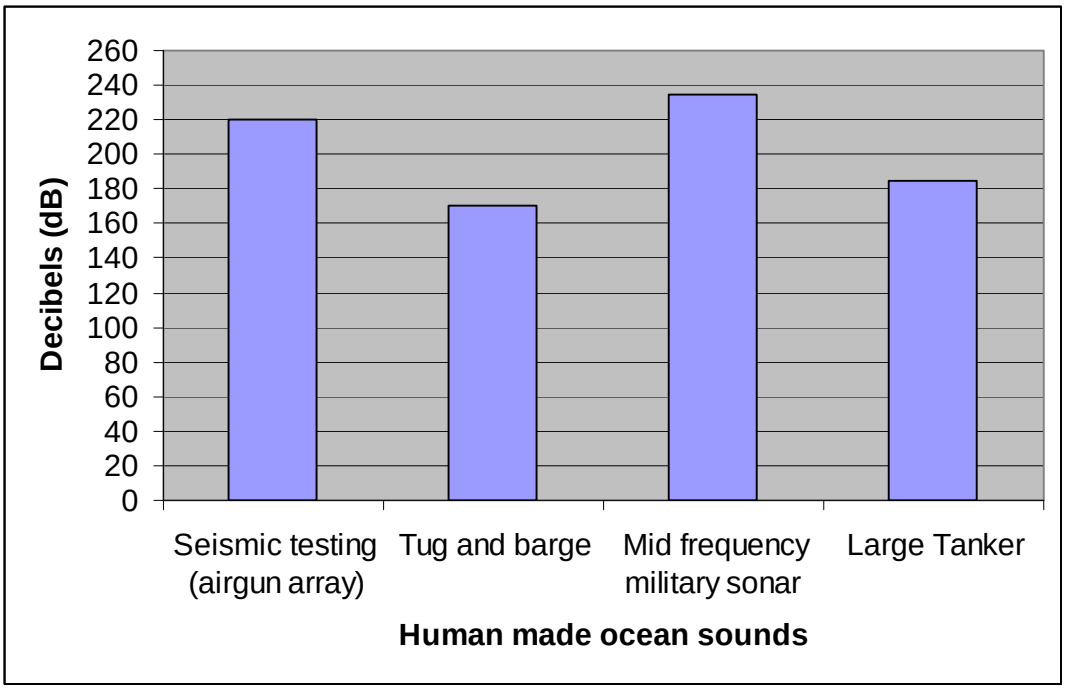
Answer Key Lesson 4
A1. Clicks and whistles.
A2. Whistles.
A3. Navigating, communicating, hunting.
A4.

a. Infrasonic	f. Sounds below what humans can hear.

By Anna Hall and Jackie Hildering

c. Sonic	b. Range of sounds humans can hear (2 – 20 kHz).
e. Ultrasonic	d. Sounds above what humans can hear.

A5. Either the fin whale or elephant.
A6. Monkey Lips Dorsal Bursae
A7. Students should include that porpoises are cryptic and difficult to see, especially on a windy day. The animals could be there and just not detected, especially as it is in a coastal region with habitats that harbour porpoise prefer. The underwater blasting could interfere with navigation, communication and hunting. It could also frighten the animals out of the area and they may never return. The sound waves could physically damage porpoise ears, and this could eventually kill them.
A8. Nerve cells, ear drum
A9.



Lesson 4 – Supplementary Activities

1. Hear like a harbour porpoise
Needed: Spool of metal wire (around 18 gauge) Length of about a metre per every group of 2 or 3 students; 1 coin or other metal object per group.

- Have a student in the group wrap about 20 cm of the end of the wire around each index finger.
- The student holds out the wire suspended from both fingers so that the wire is not touching anything other than the student's index fingers. Another student taps the wire with the coin and everybody in the group notes what the sound is like.
- Now, to hear like a harbour porpoise, the wire is going to be connected to the student's ears as if it were the harbour porpoise's jaw bone. They each take turns wrapping about 20 cm of wire around their index fingers and gently putting their index finger in their ears. They make sure the wire is not touching anything else as this would mean the loss of sound vibrations. Another student taps the wire with the coin just as they did before. Each student gets a turn at trying out the jaw bone and

being the one doing the tapping. They should try to explain how the sound was different that the first time.

Discussion:

- What was the journey of the sound vibrations in each case? *When the wire was not connected to the ears, sound vibrations could only be heard because the vibrating wire made the air vibrate. The vibrating air was picked up by your ear flaps, moved down the ear canal, to the ear drum and to your nerve cells. When the wire was connected like a jaw bone, the vibrations were connected to your inner ear through the solid of the wire rather than through the air. Less sound energy was lost.*
- How was the sound different when we used the wire like a jaw bone? *Less vibrations were lost so the sound is louder.*

2. Do you hear what I hear?

Needed: Tuning fork. It will be necessary to wash the end of the tuning fork after each student has carried out the experiment.

Discuss with students how, if they have ever heard a recording of their voice, they probably don't believe it was their own but everyone else says your voice sounds the same as always.

This happens because you hear your voice differently than others do. Your hear your voice by sound coming to your ear from your ear flaps but also by sound vibrating through your bones (just like cetaceans!) Some sound vibrations pass through your own bones and vibrate to the inner ear directly. Therefore, you hear your voice in a way that no one else does since they only get your sound vibrations through their ear flaps, down their ear canal. To find out how this works, you need a tuning fork and another metal object.

- Hit the tines of the tuning fork on a metal object and hold the fork next to your ear. Listen to the sound produced.
- As soon as the sound fades, put the end of the tuning fork (the handle) between your teeth and bit firmly on it. Listen to the sound produced!

Discussion:

1. With the tuning fork between your teeth, did you still hear a sound? *Yes*
2. Was the sound the same or different than what you hear through your ear flaps? Try to describe the difference. *Different. It was louder.*
3. Does sound pass through your teeth and the bones of your skull? *Yes. This is what made the sound different and why I also hear my own voice differently than other people do. This is also hope harbour porpoise and other cetaceans have some move to their inner ear – just through the jaw bone!*
4. This also shows that vibrations get passed on differently through different substances. The sound vibrations that passed through your ear canal moved through air. The sound vibrations that passed through your skull moved through a solid. Give an example of things sounding different because sound vibrations had to pass through something other than air. *Sounds when you have your head underwater in the bathtub; sounds made when someone inhales helium and speaks; sounds being different when you tap a class, depending on how much water you have in the glass; etc.*

Turn down the volume!
The impact of sound on Harbour Porpoise

Lesson 5 – How to Help – I have the power!

Lesson 5: Activity Description

Note to teachers: It is essential that there is emphasis on relaying a sense of empowerment to students. Too often environmental problems are relayed without the simple daily solutions that would create positive environmental change. The omission of the discussion of solutions and allowing students to enact change can lead to "ecophobia" or despondency.

1. Discussion should include:
    - Specific solutions for harbour porpoise emphasising that many solutions for the harbour porpoise are solutions for all environmental problems i.e. it is important that students recognize the big picture, and that the many environmental problems they hear of (e.g. climate change, bioaccumulation, hole in the ozone layer) have common solutions. This leads to a greater sense of hope and empowerment, and reduces the feeling of being overwhelmed.
    - Knowledge of marine mammal viewing guidelines – downloadable brochure available at http://www.whalemuseum.org/downloads/soundwatch/whaleposter-small.pdf.
    - How our daily choices can make a huge difference e.g. ensuring cleaners are biodegradable, consuming less, recycling more, saving energy. See Lesson 5: Student Handout.
    - The bigger themes include:
        - Urbanization and subsequent disconnect from nature results in our recognizing that our choices impact the other species i.e. many people in the world do not connect with Nature as British Columbians do but only see it through their television sets. This make it more difficult for them to understand why actions like recycling are so important.
        - Watershed awareness; how chemicals end up in the ground water and then in the ocean; how sewage treatment cannot remove all chemicals.
        - Humans *are* going to use the Earth's resources, all living things do. You don't have to try to be "perfect" in your environmental behaviour but – do what you can. The intent is for students to recognize the cost when we live our consumer lives without consideration of other organisms.
        - The need for precaution.
2. Provide a "Student Handout: Lesson 5" to each student.
3. Complete questions and choice of activity.

Lesson 5: Student handout
How to Help – I have the power!

1. Care! Live knowing that you are connected to the Earth's other creatures; Insist on finding out if things are dangerous before we start using them. Do what you can to help.
2. Keep habitats clean and quiet.

By Anna Hall and Jackie Hildering

3. Pick up garbage on the beach, sometimes marine mammals including harbour porpoise can accidentally eat the garbage and it can get stuck in their throats or stomachs. Plastic bags are especially dangerous because animals mistake them for food.
4. Sometimes harbour porpoise (and other marine mammals) die and wash ashore. If you find one on a beach, do not touch it, but take note of its location, and phone the Fisheries and Oceans Stranding Hotline number 1-800-455-4336. If you have a camera, take a couple of pictures, and note the date and time. These can be used by researchers who are studying BC marine mammals.
5. Sometimes cetaceans accidentally get stuck on a beach. If you find one, call the stranding number above immediately to get a rescue team to the site. If you can, stay with the animal to ensure that other people know it is there and do not let their dogs or other pets go to investigate. Being on shore is very stressful for cetaceans.
6. Make your voice count. Share what you know with others. Use your vote. When you see a cetacean you can share the information with British Columbia's Cetacean Sightings Network (www.wildwhales.org) telling them the date, time, location, how many animals and behaviour. If we share this information, we might get a better idea of how many harbour porpoise there are and how they use our ocean. The toll free number is 1-866-I SAW ONE (1-866-472-9663).
7. If you see a cetacean while you are in your boat, slow down to reduce the noise and the chance of hurting it. Make sure you follow the marine wildlife viewing guidelines which include staying 100 m away.
8. Do not contribute to contaminants in the ocean. Make sure your household products, such as laundry detergent and toilet cleaners are environmentally friendly; that they are biodegradable. Avoid pesticides. Make sure you dispose of chemicals properly.
9. Save energy! Everything from turning down the heat, to turning off lights, to using less hot water will mean fewer fossil fuels are used. The use of fossil fuels has an impact on climate change. More you can do to save energy:
    - Walk, bike, skate-board, etc more as a form of transportation,
    - Carpool and use public transportation more,
    - Use alternatives to fossil fuels when you can,
    - Use energy efficient vehicles, appliances, light bulbs, etc,
    - Unplug more and enjoy nature! E.g. unplug appliances you are not using, watch less TV spend less time playing computer games , etc.).
10. Buy smart. Do not purchase more than you need, and if you have a choice of products choose the one with the least amount of packaging, or biodegradable packaging. Buy from companies with good environmental practices. Buy local products so there is less fossil fuel pollution. Buy organic and biodegradable whenever you can.
11. Make less garbage. The more we reduce, reuse, repair and recycle, the fewer chemicals and litter go into the environment.

- Do not litter.
- Buy fewer things you don't need.
- Avoid using disposable items e.g. non-rechargeable batteries; Styrofoam cups; plastic bags!
- Share instead of throwing things away e.g. donate to second hand store.
- Fix things rather than throwing them out.
- Recycle more.
- Compost more.
- Create less food waste.

12. Save water. Using less water means it does not need to be treated which saves energy and chemicals.
13. Volunteer with organizations that work to protect the environment. There are several organizations in British Columbia that work on salmon enhancement (which helps harbour porpoise since salmon smolts are their prey), stream restoration and beach clean ups.

Questions:

1. What does “biodegradable” mean?
2. How can turning off your lights help harbour porpoise?
3. How can recycling your batteries or using rechargeable batteries make a huge difference (hint – there are some really bad chemicals in batteries).
4. How can the spilled oil from someone’s paved driveway end up in the ocean?
5. What is a pesticide? How can non-biodegradable pesticides end up in the ocean?

Answer Key Lesson 5

A1. Biodegradable means that something can be completely broken down in nature by organisms like fungus and bacteria. That it can rot.

A2. By turning off your lights when you don’t need them, you are saving energy that most often comes from using fossil fuels like oil and gas at power plants to make electricity. When fossil fuels are burnt, they create polluting gases that are bad for the environment. Discussion: For example, carbon dioxide contributes to Climate Change. If it gets hotter on earth, this changes the harbour porpoise’s habitat by maybe making it harder for small fish to survive. This would mean that the harbour porpoise may have less to eat.

A3. Batteries have chemicals in them that are really bad for the environment, if you use less by recharging or if you make sure they get recycled properly, these bad chemicals will not just end up in the landfill. If they are in the landfill, the chemicals get in the soil and could end up in the groundwater and go to the ocean.

A4. The spilled oil gets washed away with the rain, goes down the storm drain and goes directly to the ocean.

A5. A pesticide is a chemical used to kill unwanted organisms e.g. weeds, insects, fungus etc. If the pesticide cannot biodegrade, it will go into the soil and down to the groundwater. From the groundwater it goes to the ocean. Discussion: Because it does not break down, it enters the food chain and builds up with every level in the food chain (bioaccumulation).

Lesson 5: Supplementary Activities

1. Write a poem showing how much you learned about harbour porpoise and how to help them. Use the title “Plea for a porpoise”.
2. Make a poster to help people understand how we can help harbour porpoise. Guidelines for the poster.

- It must include a realistic drawing of harbour porpoise.
- Poster must clearly show what your conservation concern is.
- Your drawing must be supported by clear written message indicating what the concern(s) are. Slogans are effective here.
- Poster’s main message and drawing should be clearly visible from a minimum of 2 metres away.
- Poster should be neat and clean. That means that all lines should be solid with no evidence of eraser marks, text should be straight, poster should not be wrinkled.

3. Be an environmental detective! Identify an environmental problem at the school and solve it! (e.g. teach younger students how important it is to recycle; reduce the use of disposable items by using Tupperware containers rather than baggies in their lunches; improve recycling; reduce the amount of paper that is used; start using recycled paper).
4. Make a skit that contrasts behaviour good for harbour porpoises with behaviour bad for harbour porpoises e.g. harbour porpoise hero verses harbour porpoise villain.
5. Take part in the Great Canadian Shoreline Clean-up! See http://www.vanaqua.org/cleanup/.