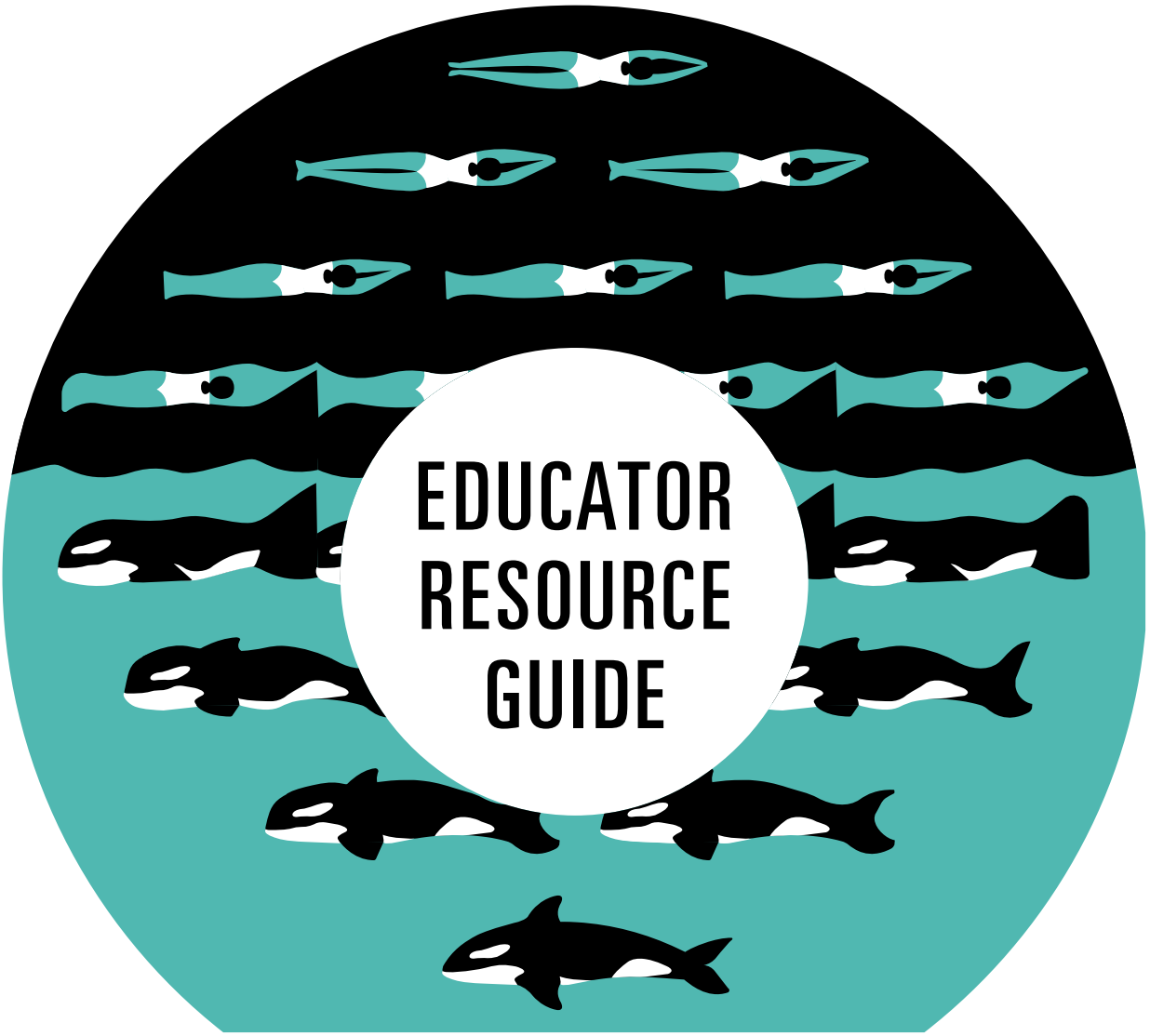

EDUCATOR RESOURCE GUIDE

orcas

Our Shared Future

ROYAL BC MUSEUM

IN PARTNERSHIP WITH

Museums Partner

Inside

Exhibition produced by the Royal BC Museum in partnership with MuseumsPartner.

WHAT'S IN STORE

INTRODUCTION

This guide is intended to be used to support educators and students as they explore the feature exhibition *Orcas: Our Shared Future*. The exhibition weaves together three ways of understanding the world that are often thought of as separate–science, popular culture and Indigenous knowledge.

To help you prepare

- Field Guide
- Gallery Overview
- Quick Orca Facts
- Discussion Prompts

Ready for some activity plans?

- Grades 1–5: Listening Like an Orca
- Grades 6–8: Microplastics Everywhere
- Grades 4–12: Gallery Visit Worksheet
- Grades 9–12: What Can We Do?

Want a little bit more?

- Glossary
- Extra Resources
- See, Think, Wonder Worksheet

Big Ideas Explored

Oceans and humans are inextricably connected (we have a shared ecology).

Orcas are animals with unique cultures and behaviours including language and memory.

For Indigenous people of the Northwest Coast, the border between human, natural and supernatural worlds is porous. People are related to the beings of land and sea.

The Royal British Columbia Museum is uniquely positioned to address both natural history and cultural connections to the orca story.

WHAT'S IN STORE

Jump In

We strongly suggest you use your time in the exhibition for experiential learning. This means spending more time look around to connect with what's inside the galleries and less time writing on a worksheet.

We aren't a classroom, we are an experience. Use this to your advantage! Give students time to explore, let them try our interactive stations, and foster discussion in places that they gravitate towards inside the gallery. This guide will offer you and your chaperones a few different ways to try this out while you are enjoying your Orcas experience.

WHAT'S IN STORE

Before Your Visit

First, give yourself a pat on the back and a high-five from us.

You've taken the time to plan and organize a field trip. That's no easy task. Why not make the most out of all your hard work? Prepare your students with a few simple activities.

You can

- Explain your goals/intentions for coming to the museum
- Start a class Know Wonder Learn chart about orcas (and finish it after your visit)
- Start a class discussion about one of the Big Ideas to get their minds activated before they arrive
- Print out a copy of the **Field Guide, Quick Orca Facts** and **Gallery Visit Activity** (if using) for your chaperones.

For information about your reservations, transportation and logistics please contact your host venue or refer to your confirmation emails.

While You're Here

- Encourage critical thinking. Ask them to think about the narrative.
  Who is giving them this information?
  What else might they want to know?
  How do the objects help to tell the story?
- Have your students travel in smaller groups through the exhibit with a chaperone. Give the chaperone some tips on how to encourage conversation.

If you do choose to do a worksheet, give them enough time to go through the whole gallery first, then save 15–20 minutes at the end to walk through again and complete/discuss the worksheet in their small chaperone groups. Alternatively, you can use the worksheets back in your classroom after your visit.

After Your Visit

The museum visit shouldn't be the end of your students' learning. We want your class to leave not only with new information, but also with questions and passion to find out more. Encourage formal or informal ways to reconnect with their experiences, and challenge them to find out more.

- Have students question and research what was left out of the gallery
- Follow up on the links found in the Resources section
- Visit the Royal BC Museum's Learning Portal for more orca content

FIELD GUIDE

Tips

- Be an active member of the group during your visit.
- Encourage discussion about what your students notice and experience.
- Give students some time to explore what is around them.
- If one area is occupied, move to another area and go back later.

Ways to encourage discussion

- What do you see?
- What do you think that is?
- What makes you think that?
- What else do you notice?

GALLERY OVERVIEW

INTRODUCTION: WELCOME TO THE WORLD OF ORCAS

Main Messages

- Orcas exist in all the world's oceans.
- The exhibition focus is the Eastern North Pacific. Research on orcas, capturing and exhibiting orcas, ecological activism to save the orcas—it all began here.
- What we have learned here is relevant globally.

GALLERY OVERVIEW

ORCA CULTURE AND SOCIETY

Main Messages

- Orcas are apex predators.
- Orcas are social animals.
- Orcas are cultural animals, passing their language, knowledge and ways of life from generation to generation.
- Shaped by the ocean, they live in a world of sound.
- Orca society is matriarchal—matriarchs are the knowledge holders and teachers within each pod.

GALLERY OVERVIEW

UNDERSTANDING ORCAS: THE SCIENTIFIC METHOD

Main Messages

- Science done off the west coast of North America has spread new scientific knowledge about orcas.
- Orcas are mammals, as humans are. Orca anatomy and life cycles reveal their similarities to us.
- The fossil record shows that orcas began their evolution on land.
- Orcas are diverse in appearance and have unique behaviours in different regions.
- Orcas use sound to communicate, navigate and hunt. Language is passed down from generation to generation.

GALLERY OVERVIEW

UNDERSTANDING ORCAS: THE INDIGENOUS POINT OF VIEW

Main Messages

- What Indigenous peoples know about orcas is increasingly important to humans' understanding and stewardship of the world's oceans and their inhabitants.
- For Indigenous societies of the Northwest Coast, boundaries between the human, natural and supernatural worlds are not fixed.
- Killer Whales are the most powerful of the Ocean People.
- Killer Whales are powerful beings in both the natural and supernatural realms and function as links between the two interconnected realms.
- Orcas may function as supernatural messengers, be represented in ceremonies and symbolize wealth and power.
- In Indigenous cultures there is respect for Killer Whales and gratitude for what they teach and what they bring.

GALLERY OVERVIEW

UNDERSTANDING ORCAS: THE AGE OF CAPTIVITY

Main Messages

- In 1964, the capture of an orca called Moby Doll changed our fear of orcas into love almost overnight
- Orcas became a phenomenon in aquariums around the world, stars of Hollywood films and commodities, as souvenirs and children's toys.
- Tragic capture events like Penn Cove, the uplifting drama film Free Willy and the documentary Blackfish about the traumatic deaths of trainers combined into a global call to end to captivity.
- The Eastern North Pacific is the origin for:
  - Orcas in marine aquariums
  - Orcas for films and documentaries
  - Release and reintroduction
  - Debates on environmental and orca rights
  - Ecotourism and first regulation of whale watching
  - Participatory public science to understand orca society

GALLERY OVERVIEW

OUR SHARED FUTURE

Main Messages

- An end to captivity is not the end of the story.
- Wild orcas face challenges beyond the aquarium industry.
- Some orca populations are increasing; some appear stable; some are declining.
- There are threats to orcas and efforts to save the endangered and our ecosystems worldwide.
- Court cases about orcas are shaping the legal debate about law and rights for wild animals.
- We are a part of nature, not apart from nature.

QUICK ORCA FACTS

Background for teachers and chaperones

GENERAL

- Orcas (Orcinus orca) are mid-sized toothed whales closely related to dolphins.
- Different cultures have different names for orcas to illustrate the awe, fear or respect that they inspire. For example, the Kwakwaka'wakw peoples, in British Columbia, Canada, call the orcas "Maxinuxwwhich" (meaning "side-by-side tribe") and the Yuin, in Australia, name the orcas "Beowas" (meaning brothers or kin). Orcas are named "Beleia assassina" (meaning assassin whale) in Portuguese and "Háhyrningur" (meaning high horn) in Icelandic.
- For the Indigenous Peoples in the Northwest coast of Canada, orcas are often spiritual ancestors or kin. There are many stories of orcas that transform into humans and impact people's lives.
- One suggestion for the origin of the common name, "killer whale," is that Basque fishermen called orcas "whale killer" when they saw them hunting large whales in packs.
- While orcas were once perceived as fearful beasts, they are now better understood as intellectual animals with a complex social structure.

PHYSICAL DESCRIPTION

- Orcas can be easily identified by their characteristic black-and-white colouring and tall dorsal fin. The dark back and light belly may provide a form of camouflage called countershading.
- The unique shapes of the white patches near their eyes, scars and saddle patches (markings behind the dorsal fin) can be used to identify individual whales, living in distinct populations. Canadian scientist Michael Bigg developed a system of cataloging orcas by identifying a pod with a letter and each whale with a number. Some well-known orcas are given names.
- The lifespan of orcas is estimated to be 50 to 60 years for males and 80 to 90 years for females, who bear one calf every 3 to 5 years.
- Adult males are larger than females and can be distinguished by their large dorsal fins. Male orcas are usually six to eight metres long (the size of a bus) and reach approximately 5,000 kilograms (the weight of four midsize cars). Females are usually five to seven metres long and approximately 4,000 kilograms.

QUICK ORCA FACTS

Background for teachers and chaperones

DISTRIBUTION

- Around 50,000 orcas live throughout the world's five oceans.
- Orcas frequent cold waters, such as those off Alaska, Antarctica and Norway, although they sometimes stray into warmer tropical and subtropical areas. The most studied killer whales are the Resident, Bigg's (formerly known as Transient) and Offshore populations in the North Pacific Ocean.
- Orcas do not follow a seasonal migration pattern. Instead, they follow their food sources, making it difficult to track their movements across the world.

CULTURE

- Unique groups of orcas called ecotypes differ in appearance, prey preference, dialects and behaviours. For example, Resident killer whales in the Pacific Northwest eat Chinook salmon, whereas Bigg's killer whales eat larger mammals such as seals, sea lions, dolphins, porpoises or larger whales. Orcas off the coast of New Zealand hunt stingrays and sharks, whereas orcas near Norway feed on schooling fish such as herring.
- Orcas have complex social structures. Within each ecotype, there are social groups called pods made up of up to 20 individuals. Each pod has its own unique dialect including various clicks, whistles and calls that are used for communication, hunting and navigation.
- Orcas have a matrilineal social structure, meaning that descent is traced through the female line. Most individuals stay in their original pods for their whole life. Orcas have strong maternal instincts, as shown in 2018 by an orca named Tahlequah who carried around her dead calf for 17 days.
- The need for social interaction likely led an orca named Tsux'iit (Luna, L98) in Nootka Sound, British Columbia, to seek contact with humans after being separated from his family.

QUICK ORCA FACTS

Background for teachers and chaperones

THREATS

- In Canada and the United States, orcas are designated threatened or endangered. The International Union for Conservation of Nature (IUCN), however, lists the conservation status of orcas as "data deficient," given the unpredictability of orca movements around the world.
- Some ecotypes, such as the Resident killer whales, feed primarily on Chinook salmon. Chinook salmon populations are threatened or endangered due to overfishing, habitat loss and hatchery influences.
- There are many contaminants released from wastewater treatment plants, sewer outfalls and pesticide applications. For example, the persistence of toxic pollutants called PCBs (polychlorinated biphenyls) cause reproductive and immune system damage to orcas.
- Plastics can break apart into smaller pieces in the ocean (called microplastics), and can be ingested by marine organisms. Plastics adsorb contaminants while floating in the sea, and these chemicals accumulate higher up in the food chain. As orcas are apex predators (at the top of the food chain), they are among the most toxic animals in the world. One orca that died in South Africa had large plastic items as well as wrappers and bags from junk food in its stomach.
- Orcas navigate, communicate and hunt using echolocation. Noise interference from various vessels such as commercial cargo ships, military ships, whale watching boats and leisure boats could affect orcas' abilities to use sound.
- The first orca caught and studied in captivity was an orca named Moby Doll in 1964. Since then, a better understanding of the physical and mental health of orcas in captivity has led some institutions to return orcas to the wild. However, there are still some orcas that are kept in aquariums around the world.
- Ship strikes are a significant threat to orcas globally. Scars on some orcas are evidence of near misses where ships strayed too close and failed to turn off motors. Regulations can help to keep boats away from orcas (for example, vessels are required to keep 400 metres away from orca pods in the Eastern North Pacific).

DISCUSSION PROMPTS

Use the questions below to probe prior knowledge and encourage critical thinking during and after your gallery visit.

PRE-VISIT

Prior Knowledge/Inferences

- What do you know about orcas?
- Brainstorm a list of 10 questions that you would like to ask about orcas. Use sentence starters such as: What . . . ? How . . . ? Why . . . ? What if . . . ?
- What connections do Indigenous groups in your local area have with orcas (or animals in general)?
- How are orcas important to our society and environment?
- In what ways do humans impact orcas?

POST-VISIT

- Fill out the **See-Think-Wonder** chart. What did you see in the exhibit? What did it make you think about? What do you wonder further about?
- Have your thoughts, ideas or opinions about orcas changed after seeing the exhibition? Complete the sentence: I used to think. . . , but now I think . . .
- The main theme of the exhibition was "we are a part of nature, not apart from nature." In what ways did you see this in the exhibition?
- What action can you take to make a difference for threats posed to orcas?

GALLERY VISIT ACTIVITY

AN EYE TO THE OCEAN

As you travel through the exhibition, think critically about the positive and negative ways that people have impacted the ocean.

Look for information everywhere as you travel through the exhibition. Don't just read the text—look at the objects, interactives and videos as well.

After you have explored the whole gallery, fill in the following table in partners or as a group:

POSITIVE IMPACTS	NEGATIVE IMPACTS

POST-VISIT ACTIVITIES

LESSON 1: LISTENING LIKE AN ORCA

Overview

In this activity, students will create a sound map to imagine what it is like to rely on sound for communication, navigation and hunting. Students will then look at images of orcas exposed to various sounds from vessel traffic such as commercial tankers or whale-watching boats. They will then be invited to create art or music that illustrates what it is like to be an orca living in noisy waters.

Target audience: Grades 1–5 Estimated time: 2 hours

Objectives

- To develop auditory awareness of one's surroundings.
- To understand how sound pollution affects orcas' abilities to communicate, navigate or hunt.
- To develop empathy for orcas that live in noisy waters due to increased marine vessel traffic.

Materials

- Clipboard for each student
- Paper with an X-mark in the middle of the paper
- Images of orcas with a commercial ship, whale watching boat and fishing boat
  - **https://www.shutterstock.com/image-photo/orca-killer-whale-near-container-ship-1825155614**
  - **https://www.shutterstock.com/image-photo/whale-boat-tourists-1510305842**
  - **https://www.shutterstock.com/image-photo/orca-killer-whale-orcinus-feeding-on-563613688**
- Various art supplies (e.g. coloured pencils, paints, etc.) as needed
- Various musical instruments (e.g. tambourine, triangle, maracas, etc.) as needed

POST-VISIT ACTIVITIES

LESSON 1: LISTENING LIKE AN ORCA

Activity

1. Create a Sound Map

Select a location near the school to visit with your class. Places with overlapping habitats (e.g. forests and streams) or places with potential animal sounds (e.g. birds) could generate interesting sound maps.

- Instruct students to select a spot to quietly sit down, close their eyes and listen to the sounds that are around them. Provide some time for students to simply enjoy the sounds and calm their minds prior to beginning the activity.
- Provide a clipboard for each student with a paper that has an X marked in the centre. The X indicates where the student is sitting. Instruct students to draw pictures/ write a few words around the X to indicate the sounds that they hear from various directions. Note that the focus should be on listening rather than making detailed notes, so rough sketches/few words are recommended. (See Resources for a video on how to conduct this activity.)
- Depending on the age group of the students, the activity can be done in 5 to 15 minutes.
- When students are finished, they can share their sound maps with one another back in the class. Some questions to prompt the discussion:
  - What sounds did you recognize? What sounds did you not recognize?
  - What sounds did you like? What sounds did you not like?
  - How did the activity make you feel? What do you think it would be like to be an animal that relies mostly on sound for communication/navigation?
  - Now imagine a large truck that drives close to your listening place. What would that sound like? How would that affect your ability to hear the sounds that you identified on the sound map?

POST-VISIT ACTIVITIES

LESSON 1:
LISTENING LIKE AN ORCA

2. Introduction to Orcas

Back in the class, engage students in an introduction about how orcas hunt, navigate and communicate in the ocean. Sound waves travel 4.5 times faster in the water than the air. Orcas emit clicks that bounce off of nearby objects, allowing them to determine the location of objects in dark waters (echolocation). Orcas also use whistles and calls to communicate with members in their pods. Each ecotype has evolved a series of unique sounds to communicate with each other, similar to how dialects are used in languages. Listen to hydrophone data to explore what these sound like:
https://soundcloud.com/oceannetworkscanada/sets/biggs

3. Step Inside

Show students three pictures of orcas exposed to various noises in the ocean. Using a thinking routine from Harvard's Project Zero called "Step Inside":

- Invite students to select one picture that they are most drawn towards. Provide time for students to look at the picture and to step inside the perspective of the orcas in the images.
- Then invite students to write/draw based on the prompt: What sounds does this orca hear? What does it feel like to be this orca? What does this orca think/care about?
- Instruct students to gather in small groups to discuss what they wrote. Despite having chosen different images, students will likely discuss how different vessel sounds could affect orcas' abilities to transmit and receive acoustic signals, and how orcas would prefer to live in quieter waters. Remind students about their earlier experience drawing the sound map and how urban sounds could disrupt nature sounds.
- Play vessel sounds found here: **nps.gov/teachers/classrooms/echolocation-in-action.htm**. You can also overlap these vessel sounds with the orca calls above.

POST-VISIT ACTIVITIES

LESSON 1: LISTENING LIKE AN ORCA

4. Taking Action Through Art

Invite students to create an artwork/some music to illustrate what it is like to be an orca living in noisy waters. Encourage students to be creative! For example, students might think about what kind of recreational activity on the water is friendlier to orcas: Jet Skis or kayaks? Students might draw an image of a human on a kayak with happier orca pods swimming beneath the surface.

Further Activities

- Play a game to simulate what it is like to communicate with sound: **scienceworld.ca/resource/echolocation-hunt/**
- Invite students to take action on sound pollution. What can students do to minimize sound pollution? (Lesson 3).
- Explore more lesson plans on orcas and sound pollution from Ocean Networks Canada & Open School BC: **openschool.bc.ca/shouting_whales/**
- Explore more lesson plans on ocean sounds from Orca Web: **orcaweb.org.uk/images/education/3-communication/lesson3/ORCA_Teachers_Pack_3_--_Oceans_of_Noise.pdf**
- Watch a video on how to create a sound map: **sharingnature.com/sound-map.html**
- Watch OceanWise explain how echolocation works: **youtube.com/watch?v=5GuaNA-5qWw**
- Listen to more hydrophone data from Orca Research Trust: **orcaresearch.org/index.php/audio-2**
- Watch *Sonic Sea,* a documentary about ocean noise: **sonicsea.org/film**
- Watch Ted Ed explain how different orca pods have different dialects: **youtube.com/watch?v=sQpGT1BgdX4**
- Read Seattle Times' article on *The Roar Below: How our noise is hurting orcas:* **projects.seattletimes.com/2019/hostile-waters-orcas-noise/**

POST-VISIT ACTIVITIES

LESSON 2: MICROPLASTICS EVERYWHERE

Overview

In this interactive game, students will play the role of different species in a marine ecosystem to simulate how energy is transferred in a food chain. Students will explore how microplastics travel through the food chain and accumulate in top predators such as orcas.

Target audience: Grades 6–8
(with extension options for secondary students)

Estimated time: 2 hours

Objectives

- To explore how species are related to each other in a marine ecosystem.
- To understand how energy transfers in a food chain.
- To understand the processes of bioaccumulation and biomagnification of microplastics.

Materials (For A Class Of 30 Students)

- 150 blue marbles
  (could be substituted with any other coloured token, such as paper clips, buttons, etc.)
- 50 red marbles
- 30 paper bags
- 30 species labels on index cards (could be substituted with an arm band or face paint to represent different species)

POST-VISIT ACTIVITIES

LESSON 2:
MICROPLASTICS EVERYWHERE

Teacher Prepration

1. Research the diet of a local orca ecotype. For example, Resident killer whales found off the west coast of Canada and the northwest United States primarily eat Chinook salmon, whereas Bigg's (formerly known as Transient) killer whales eat larger mammals such as seals, sea lions, dolphins, porpoises or larger whales. Killer whales off the coast of New Zealand eat stingrays and sharks, whereas killer whales near Norway feed on schooling fish such as herring.

2. A food chain shows the feeding relationships of organisms. Research one producer and three consumers in a food chain including orcas. For example, the Southern Resident orcas are supported by plankton, herring and salmon (see Figure 1; note that for the purposes of this activity, zooplankton and phytoplankton will be collectively called "plankton"). Research some basic facts and information about each species, such as their size, habitat, life cycle, appearance and distribution. The Animal Diversity Web (**animaldiversity.org/**) is an excellent source of background information.

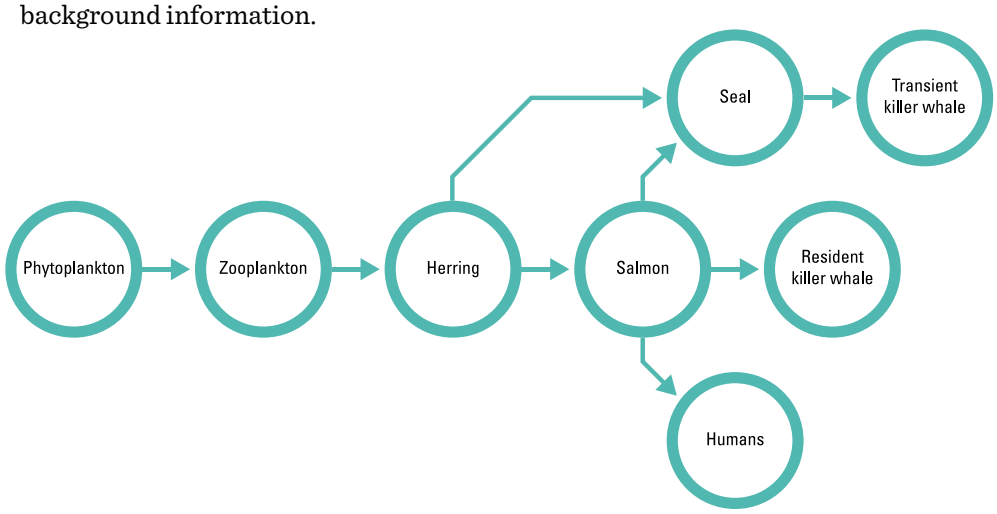

Figure 1.
Simplified food web for Resident and Bigg's (or Transient) orcas.
Source: **pac.dfo-mpo.gc.ca/education/lessonplans-lecons/whale-epaulard-eng.html**

3. Create species labels using index cards. For a class of 30 students, the ratio of species should be approximately as follows: 14 plankton, 9 herring, 5 salmon, 2 orcas. This is to represent the approximate number of producers and consumers in the ecosystem.

4. Prepare one paper bag with four blue marbles for each student in the class.

POST-VISIT ACTIVITIES

LESSON 2: MICROPLASTICS EVERYWHERE

Activity

Adapted from Fisheries and Oceans Canada's lesson on bioaccumulation (**pac.dfo-mpo.gc.ca/education/lessonplans-lecons/whale-epaulard-eng.html**).

1. Introduction:
Introduce the species that are found in your local marine ecosystem, including orcas. Briefly describe the species profile researched above and the position of this species in the food chain. Extension: Depending on the grade level of your students, you may wish to further discuss the following terms: producer, consumer (primary/secondary/tertiary), trophic level, energy pyramid, food chain and food web (see Glossary).

2. Game set-up and rules:
Explain that the students will play several rounds of the game to model how energy passes through the food chain.

- Distribute one species card and one paper bag (with four blue marbles in each bag) to each student. Students should attach the species card to themselves. Tell them that they have now become this organism!
- Identify an area in your classroom where the feeding area will be.
- Tell students that they will pass marbles to each other in the feeding area as they eat prey/are eaten by predators. When students are in the feeding area, they will find one prey or predator to interact with. Remind students which position they are on the food chain, as there are specific species that they can eat (e.g., an orca eats a salmon, a salmon eats a herring, a herring eats a plankton, but an orca does not eat a plankton). Species must interact with both predator and prey (except for producers and top consumers) throughout the game. For example, a herring must sometimes challenge a salmon instead of always feeding on plankton. A good rule of thumb is to alternate the species that they interact with.
- When a prey meets a predator, they will play a game of rock-paper-scissors to decide whether the prey will be eaten. If the predator wins, the prey must give 2 marbles to the predator. If the predator loses, the prey can escape the predator.
- When producers run out of marbles, they can get another set of 4 marbles from the main supply bin. When consumers run out of marbles, they can sit outside of the feeding area.

POST-VISIT ACTIVITIES

LESSON 2: MICROPLASTICS EVERYWHERE

3. Game Round 1:
Modelling how energy transfers in a food chain (without disturbance).

- Introduce producers (e.g., plankton) and primary consumers (e.g., herring) into the feeding area and let the game begin! After the primary consumer has had some time to eat, introduce the secondary consumers (e.g. salmon), then finally the tertiary consumers (e.g. Resident killer whales). Throughout the activity, students will see that marbles transfer from the producers to the top consumers through feeding.
- Extension option: You may wish to ask secondary students to count the number of marbles that they have at the introduction of each species. This could be graphed later to show how energy transfers in a food chain.

Post-activity discussion questions

- What did you observe in this game? How is energy passed from one species to another in a food chain?
  - Energy is transferred from producers to consumers via feeding in a food chain. Producers convert light energy into chemical energy through photosynthesis, and the chemical energy is transferred through the food chain.
- Why were the producers allowed to have unlimited access to marbles?
  - The bucket of marbles represents the constant supply of solar energy that fuels the food chain.
- Extension question: Why were not all marbles transferred when the organism was eaten?
  - Some of the energy that the organism has is lost through respiration or excretion. The 10 per cent rule suggests that only 10 per cent of the energy from one trophic level will be transferred to the next trophic level.
- Extension question: Why are there few top predators in the ecosystem?
  - Because only 10 per cent of the energy is passed from one trophic level to the next, there is not enough energy to support a large number of top predators. As a result, top predators such as orcas are vulnerable to changes in the food chain.

POST-VISIT ACTIVITIES

LESSON 2: MICROPLASTICS EVERYWHERE

4. Game Round 2:
Modelling how energy transfers in a food chain (with microplastics)

- Repeat the game as above, but this time, mix red marbles in the main supply bin to represent microplastics (Suggestion: Do not tell students what this means until later). As producers runs out of marbles, they will collect more from the main supply bin and thus the red marbles will move through the food chain. Once the round is over, reveal to the students that the different coloured marbles are microplastics.
- Extension option: You may wish to ask secondary students to count the number of marbles that they have at the introduction of each species. This could be graphed later to show how bioaccumulation and biomagnification occurs in a food chain.

Post-activity discussion questions

- What happened to the red marbles throughout the game? What did the marbles represent?
  - The red marbles moved through the food chain and accumulated with the top predator. The marbles represent microplastics.
- What are microplastics?
  - Microplastics are small fragments of plastic that are less than 5 mm. There are different types of microplastics, such as hard plastics, Styrofoam and nurdles (pre-production pellets). These microplastics originate from larger pieces of plastics that break down into smaller pieces over time through light and wave action.
- Where are plastics found in your day to day life?
  - Plastics are found in a wide variety of products including plastic bags, toothbrushes, straws, sanitary pads, tea bags, clothes made from polyester, rayon, or acrylic, and more. Microbeads, a type of microplastic, can sometimes be found in cosmetics and health care products.

POST-VISIT ACTIVITIES

LESSON 2: MICROPLASTICS EVERYWHERE

- Extension: What is bioaccumulation and biomagnification?
  - Bioaccumulation is a process where contaminants accumulate in an organism, and biomagnification refers to how these contaminants accumulate in greater concentrations in organisms at higher trophic levels.
- Extension: How do microplastics affect orcas?
  - Various persistent organic pollutants such as PCBs can attach to microplastics and hitch-hike their way through the food chain. These accumulate in the apex predators like orcas (see Figure 2), and can interfere with orca health in areas such as hormone production. While this is still an emerging field of study, scientists have found orcas with microplastics in their feces (see Resources).

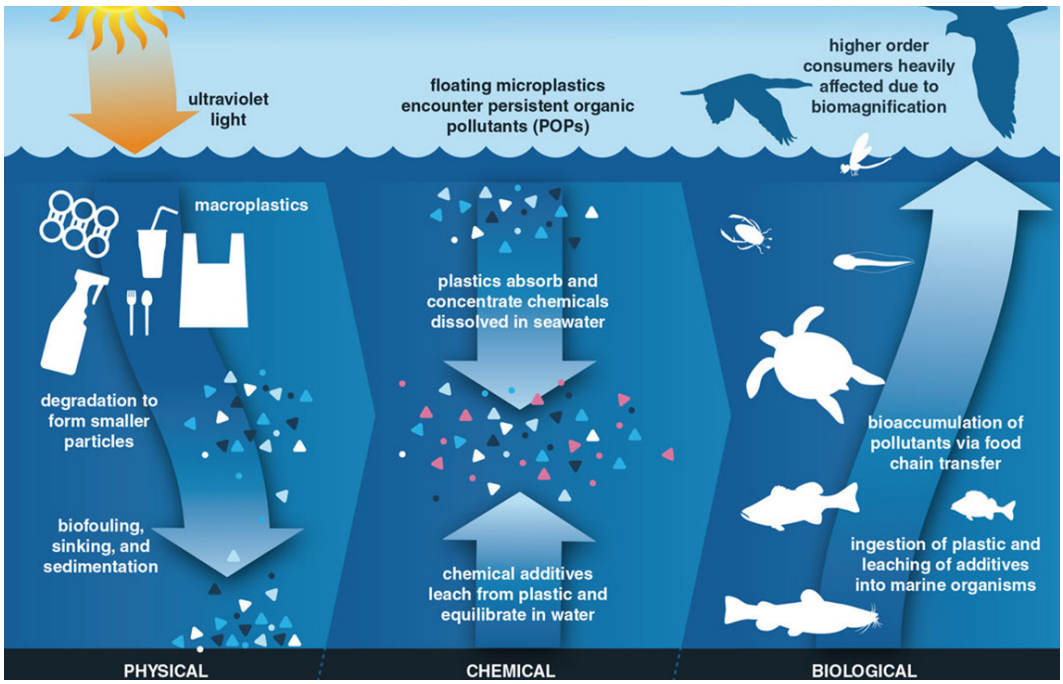

Figure 2. Microplastic accumulation in marine ecosystems.
Source: https://www.americanscientist.org/article/plastics-plastics-everywhere

POST-VISIT ACTIVITIES

LESSON 2: MICROPLASTICS EVERYWHERE

5. Game Round 3:
Modelling how energy transfers in a food chain (with microplastics and humans).

- Repeat the game as above, but this time, assign two or three students to represent humans. Since humans eat herring and salmon in large quantities, these students can take four marbles instead of two for every interaction.
- Extension option: You may wish to ask secondary students to count the number of marbles that they have at the introduction of each species. This could be graphed later to show how bioaccumulation and biomagnification occurs in humans as well.

Post-activity discussion questions

- How did humans affect the simulation? The introduction of humans in the food web drastically impacted the herring and salmon populations. Without the primary and secondary consumers, the top predators (e.g., orcas) did not have enough food. In fact, a decline in the salmon population is one of the primary threats to the Southern Resident killer whales, as their primary source of food is Chinook salmon. Chinook salmon populations are threatened or endangered due habitat destruction, increased harvest rates and hatchery influences.
- Are microplastics found in humans? How do microplastics affect human health?
  - Yes, microplastics can be found in humans! Recently, microplastics were found in human feces (see Resources). As this is an emerging field of study, the extent to which they pose a risk to human health is less understood.

Further Activities

- Graph the data collected in the simulation above and see how bioaccumulation and biomagnification occurs.
- Discuss the strengths and limitations of these simulations. How do the games simulate what happens in the real world? What is left out in the simulation?
- Take students on a beach walk to see if they can find microplastics. They are most commonly found on sandy beaches. For a further in depth study, try microplastics sampling using sieves (see Resources).
- Encourage students to take action on plastic pollution (Lesson 3).

POST-VISIT ACTIVITIES

LESSON 2:
MICROPLASTICS EVERYWHERE

Further Resources

- Read National Geographic's special edition on plastic pollution: **nationalgeographic.com/environment/topic/planetorplastic**
- Watch the award-winning documentary on how plastics affect the marine environment: **plasticoceans.org/about-a-plastic-ocean/**
- Watch National Geographic's video on microbeads in beauty products: **youtube.com/watch?v=PNh-f7NpA-A**
- Watch National Geographic's "Plastic 101": **youtube.com/watch?v=ggh0Ptk3VGE**
- Look at the BBC's images on plastic pollution: **bbc.com/news/science-environment-44215881**
- Read about a young whale that died from plastic in its stomach: **https://www.nationalgeographic.com/environment/article/whale-dies-88-pounds-plastic-philippines**
- Read about microplastics found in orca feces: **https://www.fisheries.noaa.gov/feature-story/researchers-probe-orca-poop-microplastics-part-1**
- Read about microplastics found in human feces: **https://www.nationalgeographic.com/environment/article/news-plastics-microplastics-human-feces**
- Read about the Atlantic's article on how PCBs are killing killer whales: **https://www.theatlantic.com/science/archive/2018/09/pcbs-are-killing-killer-whales/571474/**
- Read the WWF's article on how Norwegian killer whales are the most toxic mammals in the Arctic: **https://wwf.panda.org/?unewsid=53520**
- Explore Mississippi State University's microplastics sampling techniques: **http://extension.msstate.edu/sites/default/files/publications/p3243.pdf**

POST-VISIT ACTIVITIES

LESSON 3: WHAT CAN WE DO?

Overview

This lesson invites students to investigate various threats to orcas, such as sound pollution, chemical pollution, orca captivity, vessel traffic and more. Through an activity called the Circle of Viewpoints, students will explore the perspectives of various stakeholders involved in the issue. Then, they will be invited to take a research-informed action on the issue.

Target audience: Grades 9–12 Estimated time: One week (Project-based)

Objectives

- To understand that complex issues involve various people/organizations with different perspectives.
- To empower students to take a research-informed action on an issue that affects their local orca population.
- Materials
- Device with internet access

Activity

1. Introduction

Introduce various threats to the orcas found in the Background Information. Some common threats include lack of food, chemical pollution, plastic pollution, sound pollution, captivity and vessel strikes. You can also encourage students to look into issues that affect the ecotype of orcas in their local area. If this activity is done as a post-exhibit activity, invite students to dig deep into issues that they felt most drawn to while visiting the exhibit.

2. Background Research

Ask each student to select one issue that they are passionate about exploring further. Ask students to begin background research on the issue of their choice, such as

- What is the issue about?
- What is the cause and effect of the issue? Who/what affects or is affected by the issue?
- How does this issue affect the society and/or the environment?

POST-VISIT ACTIVITIES

LESSON 3: WHAT CAN WE DO?

3. Circle of Viewpoints

Once students have done background research, invite them to dig deep by looking at various perspectives of the issue. Many of the threats to orcas can be identified as "wicked problems" as they are very difficult to solve (see Resources). Using a thinking routine from Harvard's Project Zero called "Circle of Viewpoints":

- Brainstorm a list of perspectives/stakeholders on an issue. For example, for the issue on orca captivity, some main stakeholders might be orcas in captivity, animal conservationists, marine scientists, orca trainers, business management at aquariums and aquarium visitors.
- Choose two or three perspectives to dig deeper into the issue. For each perspective, use the sentence starters to explain:
  - I am thinking about (the topic) from the viewpoint of (the viewpoint you've chosen)
  - I think . . . (describe the topic from your viewpoint)
  - A question I have from this viewpoint is . . . (ask a question from this viewpoint).
- For example, animal conservationists may see orcas as victims of captivity for human entertainment. As explored through the documentary Blackfish, many orcas have suffered tremendous mental and physical health issues as a result of captivity. At the same time, closer interaction with these celebrity orcas (e.g. Moby Doll, Namu, Shamu, Keiko and Tilikum) changed our worldview of orcas. For example, the accidental capture of Moby Doll changed our understanding of orcas from "monster" killer whales to loveable animals that inspired scientists to better understand their magical world (see Resources).

POST-VISIT ACTIVITIES

LESSON 3: WHAT CAN WE DO?

4. Action

Once students have looked at various perspectives related to the issue, ask them to take a position on the issue. For example, do they agree with orca captivity or not? Why or why not? Based on this, identify a form of action that they can take to address the issue. The action should involve some kind of tangible product. For example:

- Organize a petition for change through **https://www.change.org/**.
- Create an animation/video.
  For example, this student created a video on what it is like to be an orca in captivity: **petakids.com/videos/actor-august-maturo-shows-what-its-like-to-be-an-orca-at-seaworld/**.
- Educate others by creating a poster or a presentation to share during assembly time.
- Create an artwork that illustrates how you feel about your issue.
- Create music. For example, here is Spatial Sound Institute's audiovisual experience of what it's like to be an orca in captivity: **vimeo.com/440699345** .
- Use social media to inform others about your work (e.g. Instagram, Facebook, Twitter).
- Participate in a community environmental group/aquarium group that is taking action on your issue.
- Blog about your findings and current news related to your issue.
- Create a model/experiment to make a better product related to your issue.
- Help your students brainstorm ideas specific to their chosen issue.
  For example, for issues related to
  - Overfishing: Encourage others to eat sustainable food: **seafood.ocean.org/sustainable-seafood/**
  - Vessel traffic: Practice being WhaleWise by keeping a distance: **wildwhales.org/bewhalewise/**
  - Plastic pollution: Participate in a shoreline clean up: **shorelinecleanup.ca/**
  - Chemical pollution: Build a raingarden to collect polluted runoff: **12000raingardens.org**/

POST-VISIT ACTIVITIES

LESSON 3: WHAT CAN WE DO?

5. Share

When students have conducted their action, provide an opportunity in the class to share their successes and challenges. For assessment purposes, you may wish to ask students to submit their evidence of research (based on background research and circle of viewpoints) and evidence of action above.

Further Activities

Invite students to continue to work on their action item throughout the school year. Change can be slow, but small changes throughout the year can make a difference.
Invite guest speakers to speak on issues that students have researched.
Select an issue that students are passionate about and conduct a socratic seminar to explore multiple perspectives.
Explore the impacts of sound pollution in Lesson 1 and the impacts of plastic pollution in Lesson 2.

Further Resources

Read Stanford's Social Innovation Review about what a wicked problem is: **ssir.org/books/excerpts/entry/wicked_problems_problems_worth_solving**
Read BC Cetacean Sightings Network's threats to orcas: **wildwhales.org/threats/**
Watch Blackfish, a documentary about orca captivity: **blackfishmovie.com/**
Explore Free Morgan, a campaign about an orca in captivity in Spain: **freemorgan.org/**
Watch Whale and Dolphin Conservation's video on the fate of orcas in captivity: **youtube.com/watch?v=2-dEC3p4xDw&feature=emb_logo**
Read CBC's article on how Moby Doll changed the worldview of orcas: **cbc.ca/radio/thecurrent/the-current-for-september-19-2016-1.3768458/how-moby-doll-changed-the-worldview-of-monster-orca-whales-1.3768461**
Read PBS's interviews on pro-captivity and anti-captivity views: **pbs.org/wgbh/pages/frontline/shows/whales/debate/**
Explore Project Zero's Circle of Viewpoints: **pz.harvard.edu/resources/circle-of-viewpoints**
Explore how the Circle of Viewpoints can be used in your class: **thinkingpathwayz.weebly.com/circle-of-viewpoints.html**
More ideas for Youth Action: **dosomething.org/us**

GLOSSARY/DEFINITIONS

Bioaccumulation: A process where contaminants accumulate in an organism.

Biomagnification: A process where contaminants accumulate in greater concentrations in organisms at higher trophic levels.

Consumer: An organism that relies on others to meet its nutritional needs. A primary consumer is an organism that feeds on producers. A secondary consumer is an organism that feeds on primary consumers. A tertiary consumer is an organism that feeds on secondary consumers.

Echolocation: A process of identifying the location of a distant object by interpreting the sound waves that bounce off of an object.

Ecosystem: A community of organisms that interact with each other and the physical environment.

Ecotype: A unique group of plants or animals in a certain habitat. Orca ecotypes differ in appearance, prey preference, dialects and behaviours. For example, there are three ecotypes of orcas in the North Pacific: Resident, Bigg's (formerly known as Transient) and Offshore orcas.

Energy pyramid: A graphical representation of how energy flows from producers to top consumers.

Food chain: A linear representation that shows what species eat or what they are eaten by.

Food web: A graphical representation of all food chains in an ecosystem that shows what different organisms eat in an ecosystem.

Hydrophone: A microphone that is used to record sound waves underwater.

Matriarchy: A form of social organization in which a woman is the head.

Matrilineal: A family structure where descent is based on the female line.

Microplastic: Small fragments of plastic that are less than 5 mm. Microplastics originate from large pieces of plastics that break down into smaller pieces through light and wave action.

Producer: An organism that produces its own food (e.g. plants or algae).

Trophic level: The feeding level of an organism in a food chain.

RESOURCES

General

- Report a sighting to BC Cetacean Sighting Network: **https://wildwhales.org/sightings/**
- Download the orca identification app from Centre for Whale Research: **https://www.whaleresearch.com/appid**
- Watch TED Ed explain orca matriarchy: **https://www.youtube.com/watch?v=sQpGT1BgdX4**
- Look at various orca ecotypes from NOAA Fisheries: **https://archive.fisheries.noaa.gov/wcr/publications/protected_species/marine_mammals/killer_whales/killer_whale_ecotypes-forms.pdf**
- Meet J, K and L pods at The Whale Museum: **https://whalemuseum.org/collections/meet-the-whales**
- Meet Norwegian orcas at Norwegian Orcas Survey: **https://www.norwegianorca-id.no/**
- Explore Icelandic orca identification catalogues from Orca Guardians: **https://orcaguardians.org/orca-id-catalogues/**
- Read about orcas in Antarctica **https://www.antarctica.gov.au/about-antarctica/animals/whales/killer-whale/**
- Read about Befriending Luna from the Smithsonian Magazine: **https://www.smithsonianmag.com/science-nature/befriending-luna-the-killer-whale-40360280/**
- Watch orcas at Orca Live: **http://www.orca-live.net/community/index.html**

RESOURCES

Lesson Plans

- Explore Fisheries and Oceans Canada's lesson on bioaccumulation: **https://www.pac.dfo-mpo.gc.ca/education/lessonplans-lecons/whale-epaulard-eng.html**
- Explore Fisheries and Ocean Canada's lessons on salmonids in the classroom for primary and intermediate levels: **https://www.pac.dfo-mpo.gc.ca/education/resources-ressources-eng.html**
- Explore Ocean Networks Canada and Open Schools BC's lessons on noise pollution for grades 6–8: **https://www.openschool.bc.ca/shouting_whales/**
- Explore Orca Network's lesson plans for K–5: **http://www.orcanetwork.org/Main/index.php?categories_file=BISD%20K5%20Orca%20Curriculum**
- Watch lessons about whales and dolphins from the UK's ORCA: **https://www.orcaweb.org.uk/orcalessons**
- Explore orca mapping with Puget Soundkeepers: **https://orcamonth.files.wordpress.com/2020/08/orca-mapping-activity-description-worksheets.pdf**
- Download activity sheets for primary students from Killer Whale Tales: **https://killerwhaletales.org/resources/**

And more resources at the end of each lesson plan!

SEE- THINK- WONDER ABOUT

Orcas: Our Shared Future

See What did you see in the exhibit?	**Think** What did it make you think about?	**Wonder** What do you wonder further about?