

# One Whale or Two or ...? The Speciation of Orca Whales

by

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## Pre-Class Assignment

Orca whales (or killer whales, as they are commonly called) are found in all of the oceans on Earth. They have awed humans for thousands of years. These whales are the largest members of the dolphin family and travel in matrilineal groups called pods. They are curious and generally non-aggressive with humans, making kayaking and boating with orcas a common sight-seeing activity in the Pacific Northwest where several types of orca whale exist. These types hunt together socially within groups, but do not interact between each other. Their social system is the most stable of any animal (Ford et al., 2000) and their culture is complex and varied.

The several types of orca whale are referred to by biologists as “ecotypes.” Each type is unique, specializing in food, language, and behavior. Because types are so different, they rarely interact in the wild. This cultural disparity between ecotypes of a species is unusual. What leads to variation in culture? What are the consequences to a species when members are culturally divided?

Before class, watch the following two videos and then answer the questions below on a separate sheet of paper.

## Videos

- *Blackfish* (Running time: 2:24 min): <<https://youtu.be/Y6ou5DqfkZ8>>
- *Modes of Selection* (Running time: 4:53 min): <<https://youtu.be/ewOAGMGI8bI>>

## Questions

1. Imagine an original population beginning to diverge genetically into two different forms. One lineage would go on to become the orca whales that we see today while the other might go on to become their closest whale relatives. At some point before this process, one might assume that the ancestral population of orca whales was more uniform in color, but had a few members with a splotchy pattern of color. *Graph the appropriate mode of selection for this process.*
2. *Provide a one-paragraph written description* of a trait in orca whales that may be the result of stabilizing selection.
3. During sympatric speciation, some experts suggest that culture played a big role in reproductive isolation. Vocalization rates and patterns in an ancestral population may have been uniformly distributed. As some families specialized in stalking mammals, vocalizing less became advantageous because prey mammals have good enough hearing to detect the approaching predators if they are vocalizing. In other families that specialized in hunting salmon, vocalizing more became advantageous for more sophisticated communication between hunting individuals working together to corral groups of fish. *Graph the appropriate mode of selection for this process.*

## Part I – Jigsaw Activity

Orca whale experts differ in their opinion on species classification (Riesch et al., 2012).

In your working groups of four to five students, assign one or two experts in the following categories that pertain to different concepts for what distinguishes different species:

- Biological Species Concept
- Ecological Species Concept
- Morphological Species Concept
- Phylogenetic Species Concept

Each expert will meet with other class members in their own expert group and prepare an answer to Question 1 below.

### *Question*

1. According to the consensus of your expert group, are orca whales one species or more than one species?

After reviewing your expert information and answering Question 1 above, return to your original working group. Together, your group has four well-informed “expert” opinions. Briefly explain the information from your expert group to your colleagues and together come to a consensus on an answer to the following question:

### *Question*

2. Do orca whale ecotypes represent a single species or more than one species? Which species definition did your group decide was most useful? Why?

## Expert Handout: Biological Species Concept

The biological species concept states that if members of two populations mate and produce viable offspring, they are considered to be members of the same species. Similarly, if members cannot mate or cannot produce viable offspring, they are considered to be of different species. Reproductive isolation can result from both prezygotic and postzygotic non-compatibility. With prezygotic isolation, individuals are unable to mate (this can be due to behavior such as courtship rituals, reproducing at different times of the year, or anatomical differences). With postzygotic isolation, offspring can be made but may not survive or be able to reproduce.

As Biological Species experts, your task as a group is to evaluate the following information and decide on an answer to the following question: *Are orca whales all one species?*

Orca whales (*Orcinus orca*) are found in all oceans. They are highly social apex predators. There are several populations and types, mostly formed from matrilineal groups. In other words, offspring stay with their mother and grandmother throughout their lives.

Members of the different types generally actively avoid each other and do not normally mate with one another. Reproductive isolation is not complete however, and gene flow is known to still occur between certain groups, although extremely rarely (Reisch, 2012, pg 9). Genetic comparison between “transient” and “resident” types, who share the same waters off the northern pacific coast, suggest that they have not interbred in the wild in over 10,000 years (Chadwick, Douglas H., April 2005, “Investigating A Killer,” *National Geographic*).

Orca whales are commonly active at the surface of the ocean, where they sometimes perform acrobatic maneuvers, such as tail-slapping and leaping. Orcas have complex social structure, and it is understood that some of these acrobatics are type-specific courtship rituals. During courtship, family groups of the same type come together as large males from one group approach females from the other group.

Thirty-two orca whales currently residing in theme parks were born in captivity. The first captive born whale to survive was Kalina (born 1985, died 2010). Her mother and father were of two different orca types. She was fertile and gave birth to four calves during her lifetime. Since that time, several whales have been conceived in captivity via artificial insemination (<[https://en.wikipedia.org/wiki/Captive\\_killer\\_whales](https://en.wikipedia.org/wiki/Captive_killer_whales)>). These “hybrid” whales are considered to have no “conservation value,” meaning they are not considered important for preserving the species (Dave Duffus, 20<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 2013, <<https://weforg.files.wordpress.com/2014/01/panelkwenglish.pdf>>).

## Expert Handout: Ecological Species Concept

This species concept defines a species as a set of organisms adapted to a similar set of resources, or niche. The idea is that the more similar two organisms are, the more likely their needs will overlap, to the point of overlap being so similar that the organisms are, in fact, the same species.

As Ecological Species Concept experts, your job is to evaluate the following information to answer the question: *Are orca whales all one species?*

Orca whales (*Orcinus orca*) are found in all oceans. They are highly social apex predators. There are several populations and types, mostly formed from matrilineal groups. In other words, offspring stay with their mother and grandmother throughout their lives.

Orca whales are not limited in distribution by habitat considerations such as depth, water temperature, or salinity. They have been documented in water temperatures ranging from below freezing to tropical waters. They will spend considerable time in brackish water and will enter fresh water rivers and tributaries (<[http://www.sararegistry.gc.ca/species/speciesDetails\\_e.cfm?sid=699](http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=699)>).

Types of whales differ in their diet. In general, they will eat birds, fish, mammals, and sharks, but populations differ in their preferred diet. Some North Atlantic individuals feed at different trophic levels, suggesting a greater niche width in some populations. Other populations exhibit extreme dietary specificity. In the waters off the Pacific Northwest, for example, some populations specialize in hunting marine mammals, requiring the whales to travel long distances throughout the year. Other populations of orca whales in these same waters specialize in eating salmon. They tend to remain close to their food source year round. In over 40 years of intense research on these Pacific Northwest populations, no individual has ever been found to kill and eat prey outside of their group preference (either mammal or fish) (Riesch, 2012). Researchers follow tagged whales and have discovered that ranges of mammal and fish eating whales greatly overlap (see <[http://www.nwafc.noaa.gov/research/divisions/cb/ecosystem/marinemammal/satellite\\_tagging/blog2016.cfm](http://www.nwafc.noaa.gov/research/divisions/cb/ecosystem/marinemammal/satellite_tagging/blog2016.cfm)>).

In the 1970s, three mammal-eating whales were captured and fed only fish. One of the three died from self-induced starvation. Only after the first died, did the other two begin eating fish. They reverted back to eating mammals when they were released from captivity. A different capture of two mammal eating whales resulted in a 24-hour self-starvation. After 24 hours, the two were put into a pool with a fish-eating whale. Both were feeding on fish within a few hours, after being passed fish by the fish eater (Reisch, 2012, pg 11).

Whales communicate vocally underwater. Each type of whale has their own language. Some types vocalize rarely, and others vocalize frequently and for different behaviors. Structure and frequency of sounds differ between types, but there are some universal acoustic signals. Salmon cannot detect whale sounds, so fish-eating whales have likely evolved to vocalize more frequently. Marine mammals have good hearing underwater, and whales specializing in hunting these animals have an obvious advantage to not vocalizing while hunting. There are even dialect differences between social groups within the same populations (Ford, 1991).

Pods are typically from two to five animals, but occasionally larger groups will temporarily form within a type. These larger groupings may occur for mating, prey capture, or socialization. Interaction between ecotypes of whale is very rarely observed. In fact, they actively avoid each other.

## Expert Handout: Morphological Species Concept

Organisms are classified in the same species if they appear identical by morphological criteria. The extent to which individuals appear “identical” varies by species and can be quite subtle.

*As Morphological Species Concept experts, your job is to evaluate the following information and come to a consensus on the following question: Are orca whales all one species?*

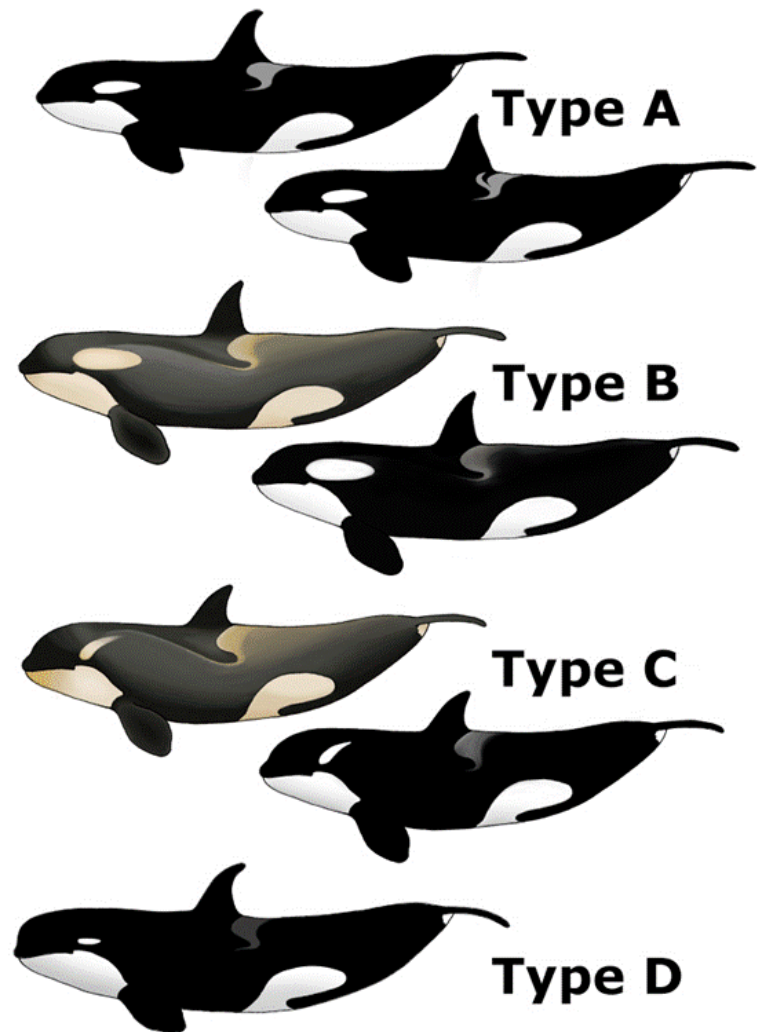
Orca whales (*Orcinus orca*) are found in all oceans. They are highly social apex predators. There are several populations, mostly formed from matrilineal groups. In other words, offspring stay with their mother and grandmother throughout their lives. Some groups look vastly different than other groups, as shown in the figure.

Type A is large, black and white, with a medium-sized white eye patch. It lives in open water and feeds mostly on minke whales. Its jaws are relatively large because it is adapted to eating other whales.

Type B is smaller than type A. It has a large white eye patch. Most of the dark parts of its body are medium gray instead of black, although it has a dark gray patch called a “dorsal cape” stretching back from its forehead to just behind its dorsal fin. The white areas are stained slightly yellow. It feeds mostly on seals and has relatively large jaws.

Type C is the smallest type and lives in larger groups than the others. Its eye patch is distinctively slanted forwards, rather than parallel to the body axis. Like Type B, it is primarily white and medium gray, with a dark gray dorsal cape and yellow-tinged patches. Its only observed prey is the Antarctic cod. It has relatively small jaws adapted to eating fish.

Type D was identified based on photographs of a 1955 mass stranding in New Zealand and six at-sea sightings since 2004. The first video record of this type happened between the Kerguelen and Crozet Islands in 2014. It is recognizable by its extremely small white eye patch, narrower and shorter dorsal fin, bulbous head (similar to a pilot whale), and smaller teeth. Although nothing is known about the Type D diet, it is suspected to include fish because groups have been photographed around longline vessels where they reportedly prey on Patagonian toothfish (*Dissostichus eleginoides*). (From Riesch, 2012)



*Note:* For Types A, B, and C, males on left, females on right; too little is known about Type D to distinguish male vs. female morphology. *Credit:* Albino.orca, CC BY-SA 3.0, <[https://commons.wikimedia.org/wiki/File:Killer\\_Whale\\_Types.jpg](https://commons.wikimedia.org/wiki/File:Killer_Whale_Types.jpg)>.

## Expert Handout: Phylogenetic Species Concept

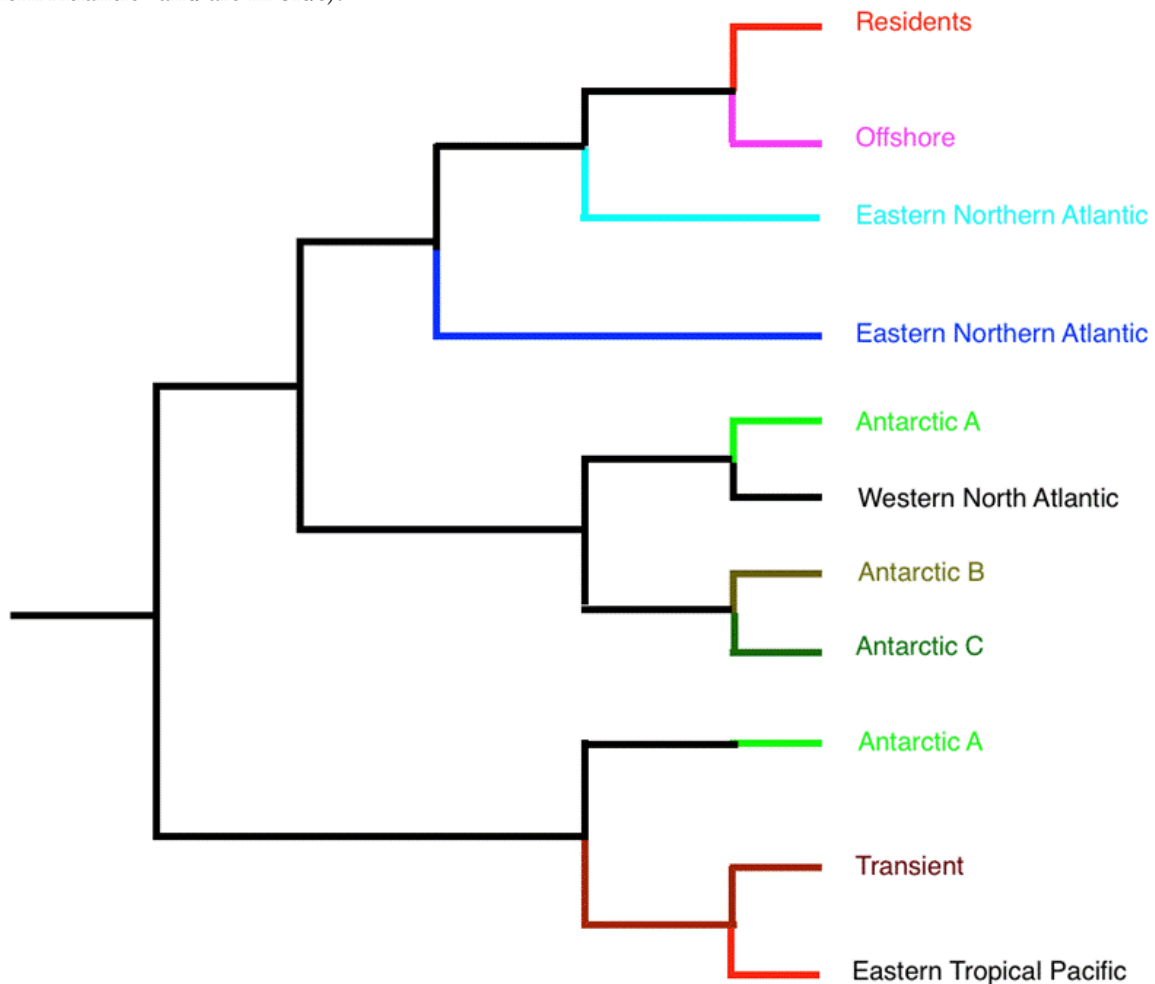
This concept uses phylogenetic data to decide on species delineations. A species is a group whose members are descended from a common ancestor and who all possess a combination of certain defining traits.

As Phylogenetic Species Concept Experts, your job is to evaluate the following information and come to a consensus on the following question: *Are orca whales all one species?*

Orca whales (*Orcinus orca*) are found in all oceans. They are highly social apex predators. There are several populations, mostly formed from matrilineal groups. In other words, offspring stay with their mother and grandmother throughout their lives.

In 2010, Phillip Morin, a cetacean biologist at the Southwest Fisheries Science Center in San Diego, California, led a group of scientists on a project to determine if isolated groups of orca whales were distinct species (Morin et al., 2010). Their findings are shown in the figure and summarized below.

Each color represents a location or type of whale (for example, green represents Antarctic whales, blue/black represents Atlantic whales, and red represents Pacific Northwest whales). Names at the end of terminal branches identify individual whales (for example, there were two individual Eastern Northern Atlantic whales represented in this study; these are named “Eastern Northern Atlantic” and are in blue).



Modified from Foote, 2011.

## Part II – Town Hall Meeting

After participating in the town hall meeting, discuss the question below in your group and then formulate a one-paragraph written group response.

### *Question*

3. Given the ruling that “captive animals such as Lolita cannot be assigned separate legal status from their wild counterparts,” is there conservation justification to consider all orca whales as a single species?

