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Making a Splash: A Population Study of Orcas and Its Application for Student Inquiry in Iowa

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A Population Study of Orcas and Its Application for Student Inquiry in Iowa

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ABSTRACT: The author participated in an Earthwatch Institute sponsored population survey of the Southern Resident Orca (killer whales). The two main aspects of this survey were to study the Orca population and to monitor the effects of humans on them. Orcas are listed as a "threatened" species and their population is currently declining. Results of the study linked the presence of the pollutant Polychlorinated-biphenyls (PCBs) in the ocean to this decline. Students will use the procedures outlined by this research to conduct their own population study on their local community. They will go to the cemetery to collect the mortality (death rates) of their community over several years. Furthermore, they will examine the effect of humans on local waterways. The students will collect data, such as pH, and make a community outreach plan to educate the public about what they are doing on a local and global level. *This article promotes National Science Education Content Standards A, C, and F, and Iowa Teaching Standards 2, 3, 4, and 5.*

The Study of Orcas

Off the coast of San Juan Islands, Washington, a group of truly amazing organisms known as the Southern Resident Orca (killer whales) travels up and down Haro Strait from June through August. These Orca have been monitored and studied by Ken Balcomb and the Center for Whale Research since 1976, and a dramatic population decline has been observed. In the late seventies the Orca population declined precipitously because of efforts to capture them for display in aquariums. In the early 1980's the United States passed a law that limited and eventually outlawed the capture of whales.

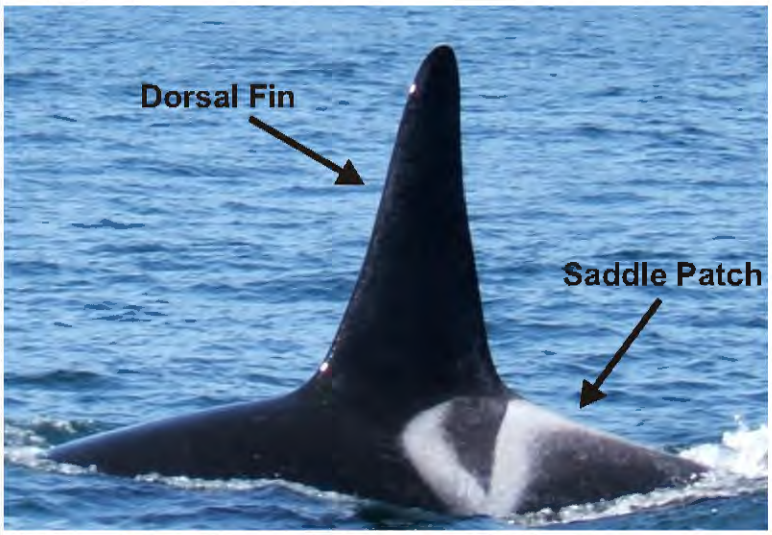
For a short time afterwards, the Orca population slightly increased. However, a severe decline in the early 1990's initiated a study of the Southern Resident Orcas. The investigation team at the Center for Whale Research has concluded that the severe decline resulted from levels of polychlorinatedbiphenyls (PCB's) in the water. PCB's are found in common lubricants and oils commonly used by, but not limited to, logging industries. When introduced into the Orcas habitat they eventually show up in the whales' blubber.

PCBs are known to destroy Orcas' immune system when the whales metabolize their fat. Due to the small size of the population and its recent decline, the Southern Residents qualify as being listed as "endangered" based on the criteria established by the International Union for the Conservation of Nature. There were also declared "threatened" by the British Columbian government in 1999, but not by the United States.

The Center's research, sponsored by Earthwatch Institute, is ongoing and keeps the local community and world informed about what human activities are doing to the world's waters and, in particular, the Southern Resident Orca population.

This population study collects data necessary to identify the Orcas and understand their behavior. The staff members and volunteers at the Center for Whale Research identify their subjects by the size and shape of the dorsal fin, shape and coloration of their saddle patch, and in difficult cases, the shape of the eye patch. Approximately seven hours each day are spent photographing the whales to obtain shots (Figures 1, 2) to determine which whales have returned. Since the project's inception in 1976, a photographic log has been maintained showing both sides of the saddle patch for each known Orca, as well as their family lineage. These Orcas have tight family relationships, staying with their mothers for the duration of their life and always traveling together. If one hasn't been spotted within the season (June through August) at the time when salmon return to the Haro strait, then the missing individual is assumed to have died.

FIGURE 1



K21, an immature male (summer 2005)

FIGURE 2

L Pod at rest (summer 2005)

Investigating Orca Behaviors

In addition to collecting data necessary to identify returning Orcas, their behaviors are logged and photographed. The main behaviors noted are the group's formation and speed of travel. These are used as indicators of the Orca's food supply location, and indicate the extent they are being affected by nearby boats. Over the past thirty years, the whales are traveling in increasingly loose formations, which means they have to cover more ground to find prey. In other words, their food supply, primarily salmon, is diminishing. During the summer of 2005 the Orcas often traveled in loose formations, and it appeared that the only time they traveled tightly was while resting. Orcas never completely sleep, rather they send out repeating sonar clicks to follow the breathing pattern of the lead whale.

Much has been learned from other behaviors of the Orca. One of the most significant discoveries is that Orca whales are social animals. When two pods meet there is a greeting ceremony between the whales involving a great deal of play. Playing behaviors include breaching (Figure 3), cartwheels, tail lobs, and pec waves (Table 1). On one occasion when two pods labeled J and K came together, twenty-two such behaviors were recorded in one minute. Furthermore, the Southern Resident and Antarctic Orca are the only Orca in the world that do "spyhops," where they lift their eyes and pectoral fins out of the water. The Antarctic Orca do this to observe prey (primarily

FIGURE 3

J40, baby girl breaching (summer 2005)

seals) on icebergs. However, the Southern Resident Orca eat primarily salmon and don't need to see what's above the water. Scientists speculate that the Orcas spy-hop to examine the boats that are observing them.

Overall, the research gathered from this Earthwatch population study has resulted in several governmental responses. Initially, the decline in their number due to efforts to capture them resulted in banning the capture of Orca unless a permit has been obtained (very few permits are given). Furthermore, the study concluded that the number of boats in the area has not yet significantly impacted Orca or their behavior. However, if boats with running motors come too close, the Orca could be in danger of being hit and killed by the propellers, which happened to Luna (L-98) in March of 2006. As a result of Orca behaviors recorded by the Center for Whale Research, regulations regarding boat activity have been enacted in Haro Straight. These regulations permit boaters to "leap frog" the whales, meaning the boats must have no motor running within 100-yards of the whales. Boaters must turn off their engines before they get within that distance of the Orca and let the whales come to them.

In other studies, the amount of PCB's was measured from deceased Orcas and linked to their deaths. Because of these and other reports, based on health concerns for humans, the American and Canadian government have banned the manufacture and importation of PCB's. Unfortunately, old industrial equipment still contains PCB's and are still in use. However, lack of similar regulations among many Asian countries illustrates how nature has no political boundaries. Pollution in their waters travels through ocean currents reaching the western United States within twenty-four hours and enters the ecosystem. This is just one reason why the Center for Whale Research continues Asian data collection and public education efforts.

From Open Waters into the Classroom

While Orcas are not found in Iowa, students can learn much from this research and apply it to population studies conducted in their local habitat. For instance, two readily applicable aspects of an ecological population study were illustrated in the Orca Survey. First, it is a basic population study that looks at birth and death rates. Students have access to limitless information about how human populations in their area have changed based on birth and death rates. Second, the Orca study collected data on the whales' behavior. Students, through firsthand observation or through secondary sources, can also collect this sort of information. Finally, the Orca survey models how research may be used to explain factors, including human influences, that may affect the environment locally and/or globally.

One example for having students conduct a population study is to have them collect data from a local cemetery. Such a study can be initiated by asking students how life expectancy in their local area prior to 1950 compares to that after 1950. Any year can be used, but 1950 has significance because it is shortly after World War II and prior to several important medical advances, including the discovery of the polio vaccination. Do not tell students what makes the chosen year significant, as what accounts for the life-

TABLE 1

Orca Socializing Glossary

Breaching: whale jumps out of the water on its side

Cartwheel: lower half of the body goes over the top half while out of the water

Tail Lobs: hitting the water with its tail

Pec Waves: one of the pectoral fins emerges out of the water as if waving

expectancy prior to and after the year chosen is something students should investigate.

Whatever year chosen, the question itself raises other questions such as "What is meant by life-expectancy?" "How is life-expectancy determined?" "How might data relevant to the question be collected?" and "How far prior to and after the date selected should data be collected?" These questions should be directed at students rather than making the decisions for them. While telling students exactly what they are to do will save time and effort, cookbook activities rarely mentally engage students and promote ends consistent with the National Science Education Standards. Key to this activity's success is asking key questions that help students understand complexities in research and make decisions they are capable of making alone or with the help of a more knowledgeable individual. This exemplifies teaching within students' zone of proximal development (Vygotsky, 1968).

With this information, and the general knowledge that they have about the history of their area, have students speculate about what groups will have the highest life expectancy and why. Most students will say that the people who died after 1950 will have the highest life expectancy because living conditions had improved. After they make their predictions, decide to what extent students are capable of forming groups appropriate for the task. Use questioning to help students think through this and other tasks necessary to successfully complete the data collection. This includes, but is not limited to, how many cemeteries should be visited, how any necessary permission will be acquired, for how many individuals birth and death data should be collected, how data will be written so that others will easily understand the information, and appropriate behavior when visiting cemeteries and collecting information from tombstones. Having several classes collaborate not only reduces the time required to collect needed data, it also reflects the collaboration characteristic of science research. Again, asking questions and playing off students' ideas are crucial in helping students make these important decisions. Too often teachers do most of the decision-making in science activities, but doing so does not prepare children to become capable and mature individuals.

Data collection can be completed as a field trip experience, or it may be assigned as an out-of-school experience. Regardless of how the individual experiment is set up it is important to emphasize the fact that they will need to collect information based on the number of deaths before and after the designated year in order to compensate for the fact that many people born after that year are still living. Upon their return the class will calculate the average survivorship for each age group and cohort.

A class discussion should ensue regarding how the data should be presented (types of data tables and graphs) and the pros and cons of suggested ideas. The teacher's role is to ask questions that have students expressing their initial ideas (e.g. How might we express our data?), use wait-time I and II (Rowe, 1984) to ensure all students are encouraged to share their ideas, and play off those ideas by asking questions that have students consider the merits of suggested ideas (e.g. What are the pros and cons of each suggested idea? What will best help the reader understand our data and what it means?). While the data table suggested in Figure 5 is one way to express the data, it is not the only way and students should be engaged in making such decisions. When these and other decisions are always made for students, they may never learn to make these decisions on their own.

After class consensus is reached, ask students to consider the data in light of their prior speculations. Students should then seek explanations to account for their data. Looking to historical events, students will understand that epidemics, wars, advances in medicine, and perhaps other factors contributed to the changes in life expectancy. This activity lends itself well to collaboration with history teachers and illustrates the profound effect of science, the technology that flows from science, and its impact on human health and longevity.

Going forward, this activity may be extended to illustrate another aspect of the Orca study: how humans affect the environment at both local and global levels. For instance, you might connect increased life expectancy to population growth. This, in turn, could be connected to prior or future studies of the water cycle. For instance, students might examine a nearby water system and determine the influence of human population growth on water needs and water pollution. This project should

begin by having students brainstorm all the ways they directly and indirectly use water in their daily lives. While students readily provide examples of direct water use, they may struggle to understand the immense amount of water consumed indirectly (e.g. growing and processing food, creating and shipping products). Once students come to understand the amount of water consumed per capita, the following question should be posed: "What happens to the quality of water when it is used for the purposes we have listed?" This introductory activity helps students understand that humans pollute water on a daily basis, and as life expectancy has increased, so has the population, demands on water consumption, and pollution.

FIGURE 4

Age (years)	Females who died □1950	Males who died □1950	Females who died □1950	Males who died □1950
0 - 9				
10 - 19				
20 - 29				
30 - 39				
40 - 49				

Sample Data sheet to show teacher one way students may choose to organize their data.

To emphasize this, you might have students investigate a local waterway, such as a nearby creek, and collect basic information about the health of the waterway. Several tests could be conducted to determine the waterway's overall health. These tests are outlined by IOWATER and are available from their website, http://www.iowater.net, or local volunteers. Generally a measure of the pH, phosphates, dissolved oxygen, and nitrates are good determinants of pollution. The students should also record the aquatic organisms in that habitat, as several species serve as bioindicators of the relative health of the water habitat. This raises questions regarding how water is cleaned and how it was cleaned by nature prior to human technological processes.

All of the preceding activities and learning may be effectively drawn together by having students create a public outreach project in which they present their findings to the local community. For examples, my Advanced Placement Biology students teamed up with the Talented and Gifted students and examined a local creek one month after it had been cleared of debris. The creek was again full of debris, however not as severely, and the nitrate levels were found to be extremely high. The students analyzed this data to try to determine why the levels were so high. Each group of students then made a community outreach plan. Students wrote letters to the local officials, submitted a newspaper article to the school and local paper, sent a video to Oprah, displayed posters, and distributed pamphlets to residents in their neighborhoods.

This sequence of events helps students develop a far deeper understanding of relevant science content, science research, and the connection of both to society. The activities also help students develop a sense of community that includes the natural world, their place in the natural world, and their responsibility to protect it.

The Orca Survey trip was provided by Earthwatch Educator Fellowship and was made possible with the help of the Davenport Community School District. For more information on how you can become part of an Earthwatch experience, visit their website at www.earthwatch.org. Special thanks to Ken Balcomb and his team of researchers at the Center of Whale Research, who assisted with background information on Orca whales. Their latest research is available at http://www.whaleresearch.com.

Laura Howell has taught for three years at Davenport North High School. In addition to teaching AP Biology, Molecular Biology, and Genetics, Laura is also the cheerleading coach. For additional information on the Orca survey or the student portion of the activity, contact Laura at howelll@davenportschools.org.