Belugas out of Balance

Are there enough individuals of reproductive age in the Cook Inlet beluga whale population to promote recovery without human intervention?

Overview

Are beluga populations out of balance? Scientists from Oregon State University are studying these whales using epigenetic techniques to find out if their current population and age structure is viable and sustainable. In this lesson, students will learn about beluga ecology, how scientists analyze populations, and epigenetics, and will apply their new knowledge as they create an action plan for beluga stewardship.

Essential Questions

- *Why are some species "endangered?"*
- *Why do scientists collect life history data when studying populations?*
- *How is epigenetic analysis used to determine the ages of individuals and the reproductive health of a population?*
- *Why are conservation efforts so crucial to the survival of certain species?*

Learning Goals

Students will learn the following:

- *Endangered species are important to the genetic diversity of their specific ecosystem. Species can become endangered for a variety of reasons, including human activities.*
- *Life history data (such as age distribution in a population) is used by ecologists to assess the health of a population.*
- *Epigenetics can be used by ecologists to determine the ages of living animals and can inform action to support species.*

Learning Objectives

Students will be able to:

- *Identify factors that contribute to the endangerment of beluga whales.*
- *Analyze life history data and create pyramid graphs to model the age and sex distribution of a population and use them to predict future reproductive success.*
- *Use methylation data to determine ages of individuals.*
- *Determine conservation efforts and develop an action plan.*

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Grade Level

10-12

Time

5-7 class periods

Anchoring Phenomenon

Belugas out of Balance

Driving Question

Are there enough individuals of reproductive age in the Cook Inlet beluga whale population to promote recovery without human intervention?

Standards

Next Generation Science Standards

LS2.A – Interdependent Relationships in Ecosystems

Common Core Math Standards

HD.MP4
HS.MP.2

Photo by Saanvi Vavilala on Unsplash

Introduction

Beluga whales in Cook Inlet have been declining in population numbers as compared to other beluga populations around the world. This population is classified as endangered. A variety of resources, strategies, and activities are provided for students to explore how human activities and geographic isolation play a role in this specific population decline. Students will then utilize data (epigenetic factors) being collected by OSU researchers to determine if the Cook Inlet belugas can recover without human intervention. Finally, students will evaluate current restorative policies and then develop their own action recovery plan.

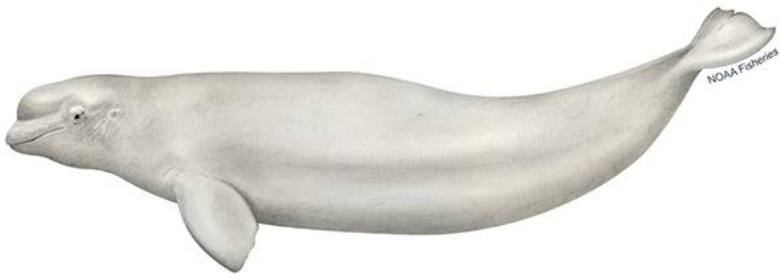
Lesson Procedure

ENGAGE

To introduce students to the anchoring phenomena, show students the NOAA video *Species in the Spotlight: Cook Inlet Beluga Whale*. This film provides background information on the decline of the specific belugas that live in Cook Inlet Alaska.

Activity: Think, Pair, Share

Have students discuss the video and introductory information about the potential reasons for population decline, then rank them in order of most likely to least likely cause.



Beluga whale. Image: NOAA Fisheries

EXPLORE

Activity #1: Exploring Geography

In this activity, students tour the geographic areas of beluga migrations as well as virtually visit different sanctuaries, aquariums, and live webcams using the Google Tour Map. Along with the virtual tour, students are provided with guided tour questions that focus on the issues surrounding the decline of this species as well as conservation efforts. The guided questions will be used as an additional assessment tool.

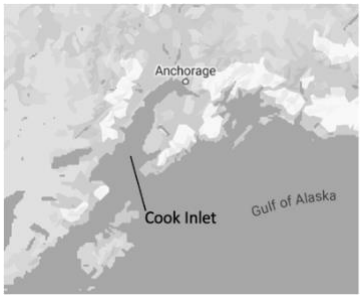
LESSON RESOURCES

NOAA Species in the Spotlight

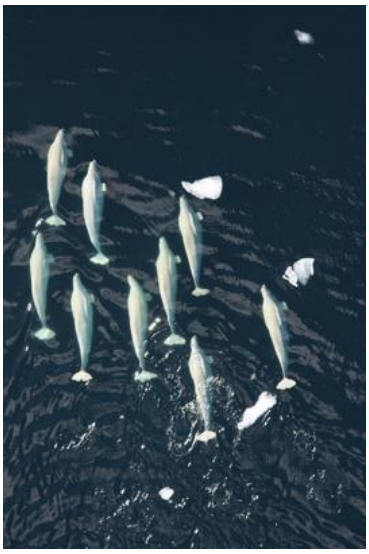
- *Cook Inlet Beluga Whale video (YouTube) (in ppt)*

Exploring Geography

- *Google Earth tour*
- *Guided Tour Questions (pdf)(doc)*



Location of Cook Inlet, Alaska



Beluga whales. Image: NOAA Fisheries

Activity #2: Population Age Structures
Next, students will learn about one way to look at analyzing age structures within a population by completing the *Power of the Pyramids* activity created by Population Education. This activity can be done on paper using the instructions and templates, and includes answer keys. Alternatively, since so many of us are operating in an online or hybrid format, there is an electronic version of the graphing activity using *Excel* or *Google Sheets*, and we adapted the introduction, instructions, and discussion questions for a *PowerPoint* or *Google Slides* formats.

Activity #3: Epigenetics
Finally, students will learn about epigenetics through the *Exploring the Epigenome* activity adapted from *Patterns Biology* (shared under a Attribution-NonCommercial-Sharealike Creative Commons License). The presentation includes embedded videos, questions, and a simulation of DNA methylation and its effect on gene expression. We suggest introducing the video using Slides 2 and 3 as a whole class and discussing the questions on slide 4, and then having students go through the *Gene Control* activity on their own and reflecting on it in small groups and then discussing with the whole class, with the teacher summarizing key concepts the students have discovered using the simulation.

Additional Resources
- Video (slide 6): *What is Epigenetics* video from TedEd
- Edpuzzle: *What is Epigenetics* with embedded questions
- Teacher background: *Epigenetic Clocks* NIH lecture

EXPLAIN

Activity: Beluga Whales and Epigenetic Clocks
Using the *How Old is that Beluga?* presentation created by researcher Kaimyn O'Neill, lead a class discussion in which students will synthesize:
- their knowledge abou the history of the Cook Inlet whale population from the ENGAGE portion of the unit;
- their understanding of the need to get accurate age structure data from the EXPLORE portion of the unit;
- their learnings about epigenetics and DNA methylation from the EXPLORE portion of the unit; and
- new information from Oregon State University scientitsts about how epigenetic analysis has been applied to studying the age structure of the Cook Inlet beluga population.

Optional Extension: Beluga Epigenetic Clock Dataset
Teachers can choose to show students the actual *Dataset* of beluga whale epigenetic clocks and age estimations. Most of our students

Power of the Pyramids
- *Population Education resource*
- *Pyramids Lesson Plan*
- *Virtual Learning Adaptations*
  - *Instruction: (ppt)(slides)*
  - *Graph: (xls)(sheets)*

Epigenetics
- *Patterns Biology resource (shared under CCL)*
- *Exploring the Epigenome (ppt) (slides)*
- *Gene Control activity*

Additional Resources
- *What is Epigenetics edpuzzle*
- *What is Epigenetics video*
- *Epigenetic Clocks lecture*

Concepts & Vocabulary
- *Epigenetics*
- *Methylation*
- *Ecology*
- *Geographic isolation*
- *Conservation*
- *Estuary*

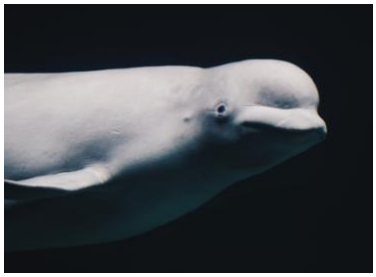


Photo by Mendar Bouchali on Unsplash

Beluga Whales and Epigenetic Clocks
- *How Old is That Beluga? (ppt)(slides)*
- *Beluga Epigenetic Clock dataset (xls)(sheets)*

have practiced making predictions about novel situations based on trendlines, and this is a great example of that type of analysis. The teacher may want to explain that, as shown in the graph on Slide 7 of the *How Old is that Beluga?* presentation, there is a linear relationship between the chronological age of a whale as determined by tooth structure (post mortem) and the methylation levels in that whale's DNA. That line represents a mathematical relationship between age and methylation that can then be used to make predictions about the ages of whales that are still alive. The predicted ages of the Cook Inlet belugas are shown on the "Living Belugas Summary" tab.
This transformed data is the source of the age estimates that will be provided for students in the *Beluga Population Pyramids* activity coming up in the ELABORATE section.

Photo: NMFS ESA/MMPA Permit #20465

ELABORATE

In this section, students use and extend what they have learned about epigenetics.

Activity: Beluga Population Pyramids
Students will apply their understanding of population pyramids and attempt to use beluga whale ages determined by OSU epigenetic clock data to analyze the structure of the Cook Inlet beluga population. If doing this work by hand, student can use the templates from the *Power of the Pyramids* activity in the Explore section. They will need to adjust the scale on the X-axis.

If they are graphing electronically, students can use the *Beluga Population Pyramids Template*. Background and instructions are included on the sheet. Additionally, a *Teacher Key* for the Beluga Population Pyramid is provided at right. One thing the students will soon realize is that the data for beluga juveniles is missing, since the researchers only took tissue samples from adult whales. They will also discover another mystery - there appear to be no whales older than 29 years old in the Cook Inlet population, even though belugas in other populations can often live to 60 years or older. Once students have created their graphs, the teacher will facilitate a student-centered brainstorm/discussion around the *Guided Discussion* questions.

Activity: Career Connections
Share the career and educational pathway of epigenetic clock researcher Kaimyn O'Neill.

Beluga Population Pyramids

- *Population Pyramids Template (xls)*
- *Population Pyramids Key (xls)*

Guided Discussion Questions

- *Does the Cook Inlet beluga population have a normal and healthy age structure?*
- *What conditions or events may have brought this situation about?*
- *What might this mean for the future of the Cook Inlet belugas?*
- *What do these data suggest about the need for continuing research on the Cook Inlet belugas and other populations at risk?*
- *What specific questions need to be explored through further research on the Cook Inlet belugas?*

Researcher Bio

- *Kaimyn O'Neill (pdf)*

Photo: Kaimyn O'Neill

EVALUATE

Students will be performing activities that include their own evaluation piece along the way. The final piece of evaluation will be student driven. Students will create an *Action Plan* that acknowledges the issues of this population, researches what practices are currently in place, how to potentially improve these practices, and what else can be done to ensure the survival and long-term success of the Cook Inlet beluga whale population. This may be a poster, slideshow, community stewardship, "Adopt a Beluga", etc. Final evaluation of objectives met will be scored via *rubric*.

Next Generation Science Standards

Performance Expectations:

HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS2-2: Plan and conduct an investigation that uses mathematical representations to support explanations about factors affecting biodiversity and populations in ecosystems of different scales.

Science & Engineering Practices:

Using Mathematics and Computational Thinking

- *Use mathematical representations of phenomena or design solutions to support and revise explanations.*

Disciplinary Core Ideas:

LS2.A – Interdependent Relationships in Ecosystems

Crosscutting Concepts:

Scale, Proportion and Quantity

Common Core Math Standards

Math Standards:

HD.MP4 – Model with mathematics

HS.MP.2 – Reason abstractly and quantitatively

Math Practices:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Save the Cook Inlet Belugas

- *Student Action Plan (pdf)(doc)*
- *Action Plan Rubric (pdf)(doc)*

Acknowledgments

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See more lessons on the ORSEA webpage:oregoncoaststem.oregonstate.edu