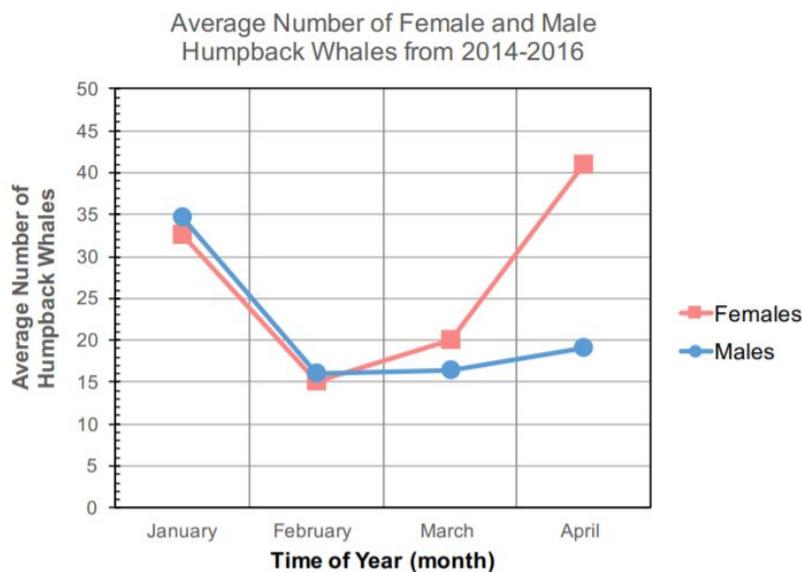


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Data Integration
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Course: Methods of STEM Education: Secondary

Data Source: When Whale I See You Again
(<http://datanuggets.org/2017/11/when-whale-i-sea-you-again/>)

Lesson Enhancement: I currently teach a unit on Polar Ice to my Marine Science students as part of their unit on Water and Its Properties. The lesson is data based and looks at the area of sea ice coverage and land ice coverage and how it is changing. These changes are correlated to past and recent changes in the Earth's climate, the impact of the albedo of the Earth's surface and the seasonality of ice coverage. The last part of the lesson is looking at how the loss of sea ice coverage, both in terms of extent and the number of days that ice is present, causes krill populations to decline. The krill feed on algae that are trapped in the ice during the end of the previous summer. The students watch a NOVA documentary called the Mystery Beneath the Ice (<https://www.youtube.com/watch?v=AdNO-kzmCwk>) which follows the scientists as they make this discovery.

The new lesson from data nuggets on humpback whale populations makes a connection between the krill population and how long the humpback whales stay to feed into the Antarctic fall (April). This introduces my students to the migratory habits of humpbacks that they will study in a later unit on cetaceans. The data set looks at differences between the amount of time males and females spend feeding in the Western Antarctic Peninsula (WAP) before migrating to their spawning grounds (see graph below). The scientist highlighted in the study hypothesizes that the sex ratio is changed due to decreased krill populations caused by decreased sea ice coverage.



(http://datanuggets.org/wp-content/uploads/2017/11/When-whale-I-see-you_studentA.pdf)

This data enhances my current unit by making connections to cross cutting concepts in the field of life science and, by adding the lens of anthropogenic climate change, it also includes human impact on the environment. The current Polar Ice unit I am teaching addresses Earth's Systems standards:

High School: Earth's Systems

HS-ESS 2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS 2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS 3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.

(<https://www.nextgenscience.org/topic-arrangement/hsearths-systems>)

The new standards that can be addressed are:

High School: Life Science

HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

(<https://www.nextgenscience.org/topic-arrangement/hsinterdependent-relationships-ecosystems>)

The Data Nuggets website also provides scaffolding for with working with the data. There are three different options for student worksheets: analyzing a graph that is provided, graphing data on pre-labeled graphs or making the graph completely independently. This allows me to include differentiated graphing skills for students with different academic levels. Marine Science is an elective and students from the AP level to the remedial level are enrolled in the class.

This data will improve the lesson by connecting to topics that we study later on such as the feeding habits of baleen whales, animal migration and food webs. Students enter class with the idea that the marine mammal most affected by loss of sea ice is the polar bear and they will realize that whales are also affected. They will broaden their understanding of the fragility of the Antarctic ecosystem because krill is a keystone species and dependent on shrinking sea ice. This case study also perfectly illustrates that ecosystem balance is determined by the interaction between biotic and abiotic factors.

Using Data: Using data to drive instruction empowers students to become scientifically literate and to understand that science is a set of practices that have established a body of knowledge. Without using data, the teacher is the source of creating meaning in the classroom. When students analyze graphs and can visualize what is happening in the real world, they become the meaning makers. Students should also get experiences using scientific practices themselves through the experience of collecting data whether through a student designed experiment or through mastering the use of scientific equipment such as a probe.

I think a bias exists amongst some science educators that data analysis is something only advanced students can do and my experience teaching many levels of students has proven otherwise. In fact, if students are able to easily create graphs through Google sheets it allows them to visualize complicated topics. Many of my students who are English Language Learners (ELLs) have excelled at interpreting graphs. I experienced this phenomenon this year when my general education students participated in the Hudson River Data Jam competition (<https://www.caryinstitute.org/students/hudson-data-jam-competition>). By incorporating technology and basic statistics in Google Sheets, all students are able to make sophisticated explanations of their data sets.

In conclusion, data is the future of science education. Students must understand how knowledge is constructed and how to construct their own knowledge.

Rationale and interdisciplinary STEM connections: If a data set is to be used in the classroom, the rationale should be based on the data showing a phenomena. Data sets that are used in education should be curated like the whale data set from data nuggets. This data set is simple to understand but can be applied to more complex topics. It is also important that students understand how the data was collected. In the case of the whale study, various technologies were used or created to amass the data:

Humpback whales only surface for air for a short period of time, making it difficult to determine their sex. In order to identify surfacing whales as female or male, scientists need to collect a biopsy, or a sample of living tissue, in order to examine the whale's DNA. Logan worked with a team of scientists at Oregon State University and Duke University to engineer a modified crossbow that could be used to collect samples. Logan uses this crossbow to collect a biopsy sample each time they spot a whale. To collect a sample, Logan aims the crossbow at the whale's back, taking care to avoid the dorsal fin, head, and fluke (tail). He mounts each arrow with a 40mm surgical stainless steel tip and a flotation device so the samples will bounce off the whale and float for collection. The samples are then frozen so they can be stored and brought back to the lab for

analysis. Logan also takes pictures of each whale's fluke because each has a pattern unique to that individual, just like the human fingerprint. Additionally, at the time of biopsy, Logan records the pod size (number of whales in the area) and GPS location. (http://datanuggets.org/wp-content/uploads/2017/11/When-whale-I-see-you_studentA.pdf)

This process of sex determination and identifying individual humpback whales includes various technologies that could be explored in the classroom:

1) The use of Karyotyping to evaluate biopsied tissue from Humpback Whales (<https://www.nrcresearchpress.com/doi/10.1139/z88-181#.XRFyRuhKhPY>)

2) The use of fluke photographs for individual humpback whale identification

3) The development of a crossbow and attached flotation device to allow scientists to collect tissue samples from whales without needing to capture them

Students could create models of these technologies, access additional data sets and complete an engineering challenge to build a prototype crossbow that can collect soft "tissue" and have a floating bobber to be retrieved. My school has a lake in front of it so we could test our crossbows on the lake with pre-placed targets.

