VARIATION AND SELECTION

INSTRUCTIONS

Overview:

Students will conduct a natural selection simulation of predatory whitefish with different sized mouth sizes. In two different environments prey size changes over time resulting in a change in the whitefish population.

Objectives:

The student will:
- conduct a natural selection simulation; and
- will identify the causes of extinction.

Targeted Alaska Grade Level Expectations:

Science

[10] SC1.2 The student demonstrates an understanding of how science explains changes in life forms over time, including genetics, heredity, the process of natural selection, and biological evolution by explaining how the processes of natural selection can cause speciation and extinction.

Vocabulary:

evolution— change over time; In biology this encompasses small-scale changes of gene frequency in populations from one generation to the next and large scale decent of different species from a common ancestor over many generations.

extinction –when the last member of a lineage or species dies

fitness – success of reproducing relative to others of the same species

natural selection – differential survival and reproduction of particular phenotypes in a population leading to change in the gene frequencies of a population

speciation – an event that produces two or more separate species from one species; Caused by geographic isolation, reduction of gene flow or reproductive isolation

species- (biological definition) a group of individuals that actually or potentially interbreed in nature and produce fertile offspring

population- a local group of organisms of the same species

theory – in science, a theory is a broad well-tested description of a natural process or phenomenon accepted as fact such as the theory of gravity, germ theory, or the theory of evolution

Materials:

- Large Beads 0.5-inch diameter wooden beads or marbles (100)
- Medium Beads 0.25-inch diameter wooden beads or other similar-sized object (200)
- Small Beads 0.1-inch diameter wooden beads or other similar-sized object (300)
- Large binder clips, 1-inch capacity (20)
- Medium binder clips, 5/8-inch capacity (20)
- Small binder clips, 3/8-inch capacity (20)
- Plastic cup (1 per student)
- Tablecloth or bed sheet (2)
- VISUAL AID: "Broad Whitefish"
- STUDENT WORKSHEET: "KWL"
- TEACHER INFORMATION SHEET: "Prey Item Ratios"
- STUDENT INFORMATION SHEET: "Energy and Life"
- STUDENT WORKSHEET: "Whitefish Natural Selection"
- STUDENT WORKSHEET: "Prey Calculations"

VARIATION AND SELECTION

INSTRUCTIONS

Whole Picture:

Natural selection is one of the basic mechanisms of evolution, along with mutation, migration and genetic drift independently discovered by Charles Darwin and Alfred Russel Wallace in in 1858. Natural selection is not intention; individual organisms do not decide to change. Individual organisms either successfully reproduce and pass on their genes or do not. Advantageous traits that allowed the parents to survive and reproduce are thus passed on to their offspring. Organisms that have traits not well suited to their environment are less likely to survive and reproduce. Thus, over time, the population has traits well suited to their environment.

For natural selection to occur, the following three factors must take place: 1. Variation of traits, there must be differences between individuals that may be as obvious as fur color or as subtle as the type of protein produced. 2. Differential reproduction, such that all individuals do not reproduce to their full potential. Often the result of a limiting factor(s) such as food supply, predation, habitat etc. that prevents all individuals from reproducing to their full potential. 3. Heredity. Heritable traits are passed from parent to offspring. In the 1930's this mechanism was determined to be genetic material.

The environment and traits are always changing. Traits that are beneficial at one point in time may become detrimental at a later time. If a species of organisms does not survive long enough to successfully reproduce and they all die out, then that species is considered extinct. On a geologic time scale, 99% of all the species that have existed are extinct.

Broad Whitefish (Coregonus nasus) are an important substance fish for people in the Yukon and Kuskokwim river watersheds. This fish has an elongated body covered in silver scales and is broader than many other whitefish species. The broad whitefish has a downturned mouth adapted for feeding on mollusks and bottom dwelling aquatic insects. Broad whitefish are in the family Salmonidae, thus are related to salmon and are able tolerate brackish water.

Activity Preparation:

1. Review natural selection and evolution terminology and concepts including the history of our understanding of evolution from ancient Greeks to Charles Darwin and the modern synthesis.
2. Use the following chart to prepare prey items in six bags or containers (two locations for three years) before the start of the class.

Prey Item Ratio Chart

	1st Year	2nd Year	3rd Year	4th Year
Upstream	Don't add prey. Only record numbers of mouth types.	50 small beads 100 medium beads 50 large beads	0 small beads 20 medium beads 50 large beads	0 small beads 0 medium beads 100 large beads
Downstream	Don't add prey. Only record numbers of mouth types.	50 small beads 100 medium beads 50 large beads	100 small beads 20 medium beads 0 large beads	150 small beads 0 medium beads 0 large beads

Pre-Assessment:

KWL Activity:
Pass out the KWL chart and have students fill in the "K" and "W" for the question, "Why do some species go extinct while other species do not?" After students have had time to write down their ideas, have them share their thoughts. Direct the conversation into the lab activity (see below).

Activity Procedure:

1. Display the visual aid of the broad whitefish and ask students if they have any experience fishing for this species. If they do, ask them describe the appearance and behavior. Reinforce the idea that there is variation within the species.
2. Describe to the students a hypothetical situation where there are only a few broad whitefish left in the world and they live in one river. Recently a large dam was constructed in the river separating the species into two smaller populations. One population lives upstream of the dam, the other population lives downstream of the dam. The two fish populations cannot cross the dam and are completely cut off from each other. The whitefish are at risk for extinction and physically separated which given enough time would likely lead to speciation.

   Teacher's Note: This is a hypothetical situation and as such you can include local river names and locations.
3. Display the three sizes of binder clips (small, medium, large) and tell the students that the binder clips represent the mouth size of this species of whitefish. Note that while all the whitefish have similarities, there is variation in the population.
4. Describe how mouth size of this species of whitefish is genetically determined such that a small-mouthed fish will always produce offspring with small mouths, a medium-mouthed fish will produce offspring with medium mouths and so on.
5. Explain to students that the size of prey a fish is able to eat is limited by the size of their mouth or gape size. These fish do not chew of bite pieces of their prey but instead swallow it whole.
6. Explain fish with a large mouth require more food (energy) than a small-mouth fish. The larger mouth takes more muscle and bone to grow and maintain and takes more energy to swim with a large mouth. Hand out or display STUDENT INFORMATION SHEET: "Energy and Life" and point out different prey items have different amounts of energy and that there are minimum energy requirements for the fish to survive and to reproduce.

   Teacher's Note: Calorie count, diameter of prey species and fish calorie requirements do not reflect real world values but are assigned to facilitate learning through this natural selection exercise.
7. Separate students into two groups of six. In a larger class some students will not be selected immediately but will join the activities once the first group has determined reproductive success.
8. Assign one group to the upstream whitefish population. The second group will be assigned the downstream population. Within each group give two students large clips, two students medium clips and two students small clips. Hand out one plastic cup per student and tell students the cup represents their stomach. Instruct them that in order to "eat" their prey must be transferred from the river environment to the cup via the binder clip and they will need to pick up their prey item and place it in their cup using a clipping motion. If a prey item falls out of the clip before it makes it way into the cup the prey has escaped and is not counted as being eaten.
9. Hand out STUDENT WORKSHEET: "Whitefish Natural Selection" and tell students not scoop or push prey items into their cup, but to only use the clipping action. Have students fill out their data sheet for Year 1.
10. Lay out a tablecloth on the floor to represent the down stream habitat, and another cloth for the upstream habitat. Randomly spread out the correct ratio of prey items previously prepared using the TEACHER INFORMATION SHEET: "Prey Item Ratios."
11. Inform students they will only have 30 seconds to hunt for prey items. Use the classroom clock or other timer and give students 30 seconds to hunt for prey.
12. After hunting, students should use STUDENT WORKSHEET: "Prey Calculations" to calculate the energy value of the food they caught. If a student did not catch enough food to survive they must turn in their clip. These students will then be available to become the offspring of the more successful fish. Students who

caught enough to survive will continue with the simulation. Students who caught enough to reproduce will gain an offspring from the group of students that did not survive. Offspring will have the same mouth size as their parent. If no students are available to act as offspring have students make a note of their number of offspring in the STUDENT WORKSHEET: "Prey Calculations."

13. Students should sort and clean up the remaining prey items on the tablecloth.
14. Use Season 3 prey items and repeat directions from 11 to13.
15. Use Season 4 prey items and repeat directions from 11 to13.
16. Have students sort and clean up the prey items for the final time.
17. Have students post upstream and downstream mouth size population on the board and use this information to fill out STUDENT WORKSHEET: "Whitefish Natural Selection" and answer the questions.
18. Ask students to describe their observations of mouth sizes in the upstream and downstream populations.
19. Have students use their answers from STUDENT WORKSHEET: "Whitefish Natural Selection" to drive class discussion.
20. Point out to students that the mouth size of whitefish changed over time. This was due to differential reproductive success, some whitefish had traits that fit their environment better than others and were able to reproduce while other were not as successful and either just survived without reproducing or died. In this exercise prey size was the limiting factor influencing reproductive success. For example, the large mouth traits were beneficial in the upstream population while the small mouth fish died out. Make sure that students understand that individual fish didn't change from small to large mouth but the fish that were better adapted to the environment simply were able to survive and pass on their traits more often than the small mouth fish.
21. Explain to students this is how natural selection works. Individual organisms that have traits beneficial in the environment are able to survive and reproduce more than other individuals. Over time the population changes and, given enough time, a new species may develop. Species that do not pass on their genes go extinct.

Teacher's Note: If one or more of the mouth sizes died-out use this as an example of how species go extinct. Review that the fish did not choose to become extinct. Additionally individual organisms do not mutate in order to fit their environment. Simply, the ones that were better suited to their particular environment survived long enough to reproduce and passed on their genes more often than other individuals.

22. Ask students what would happen to the whitefish species if the only food source were the size of a basketball. (Students should suggest that the species would become extinct as the whitefish would not be able to eat such large prey items and would all die out.)
23. Have students complete their KWL chart by filling in what they learned about extinction.

Teacher's Note: If one or more of the mouth sizes died-out use this as an example of how species go extinct. Review that the fish did not choose to become extinct. Additionally individual organisms do not mutate in order to fit their environment. Simply, the ones that were better suited to their particular environment survived long enough to reproduce and passed on their genes more often than other individuals.

Extension Idea:

Conduct simple virtual natural selection experiments by selecting for dominant and recessive traits, limiting factors and environment differences for a population of rabbits.
http://phet.colorado.edu/en/simulation/natural-selection

Resources:

Student and teacher resource for evolution and natural selection:
http://evolution.berkeley.edu/

The complete works of Charles Darwin, which includes his publications, manuscripts, illustrations and private correspondences:
http://darwin-online.org.uk/

This PBS site hosts videos, animations and activities detailing natural selection and evolution:
http://www.pbs.org/wgbh/evolution/library/01/index.html

Easy to read 1-page summaries of 15 papers published in Nature that illustrates recent research regarding evolution and natural selection:
http://www.nature.com/nature/newspdf/evolutiongems.pdf

Common terminology and concepts for teaching evolution and natural selection:
http://evolution.berkeley.edu/evolibrary/teach/912pitfalls.php

Evolutionary biology and disease:
http://www.lsa.umich.edu/psych/courses/darmed/links.htm

BROAD WHITEFISH

VISUAL AID

Broad whitefish (Coregonus nasus)
Image curtsey of Alaska Fish and Game: http://www.adfg.alaska.gov/index.cfm?adfg=broadwhitefish.photogallery

NAME: _____ STUDENT WORKSHEET

KWL

	K = Know	**W = Want to know**	**L = Learned**
Why do some species go extinct while other species do not?			

	1st Year	2nd Year	3rd Year	4th Year
Upstream	Don't add prey. Only record numbers of mouth types.	2 cups popcorn 1 cup beans 50 beads	0.5 cups popcorn 20 beans 50 beads	100 beads 0 beans 0 beads
Downstream	Don't add prey. Only record numbers of mouth types.	2 cups popcorn 1 cup beans 50 beads	2.5 cups popcorn 20 beans 5 beads	3 cups popcorn 0 beans 0 beads

Prey Item Calorie Content

Prey Item	Approximate Diameter	Calories
Clam	0.5 inches	20
Snail	0.25 inches	10
Stone fly larva	0.1 inches	4

Calories needed to survive and to reproduce

	Calories to Survive	Calories to Reproduce
Large-mouth size whitefish	160	360
Medium-mouth size whitefish	100	200
Small-mouth size whitefish	50	100

NAME: _____

WHITEFISH NATURAL SELECTION

Class Data Upstream River				
	Year 1	**Year 2**	**Year 3**	**Year 4**
Large Mouth				
Medium Mouth				
Small Mouth				

Class Data Downstream River				
	Year 1	**Year 2**	**Year 3**	**Year 4**
Large Mouth				
Medium Mouth				
Small Mouth				

1. Use the provided chart outline or use your own to make a graph from the class data for upstream and downstream whitefish. Make sure to clearly label the graph axis and values.

2. Briefly state three changes you observed in the upstream and downstream whitefish populations.

   a._____

   b._____

   c._____

3. How do the two river locations differ in respect to whitefish mouth-size in year 4?

   _____

   _____

   _____

   _____

   _____

4. Briefly explain how, through natural selection, the population of whitefish changed from year 1 to year 4.

   a. Upstream_____

   _____

   b. Downstream_____

   _____

5. Looking at both up and down stream locations, did any of the mouth-size die out?

   _____

   _____

   _____

   _____

   _____

6. What would happen to this whitefish species if the only prey item was larger than their mouth?

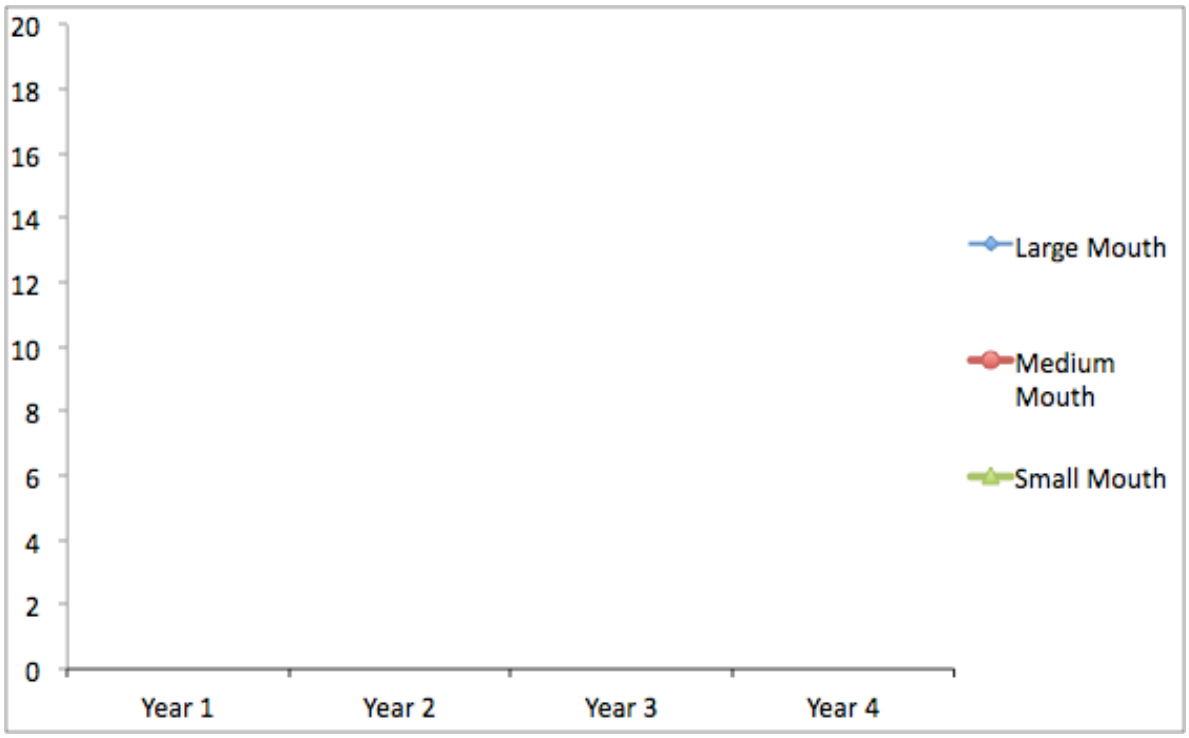
   _____

   _____

   _____

   _____

   _____


20
18
16
14
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8
6
4
2
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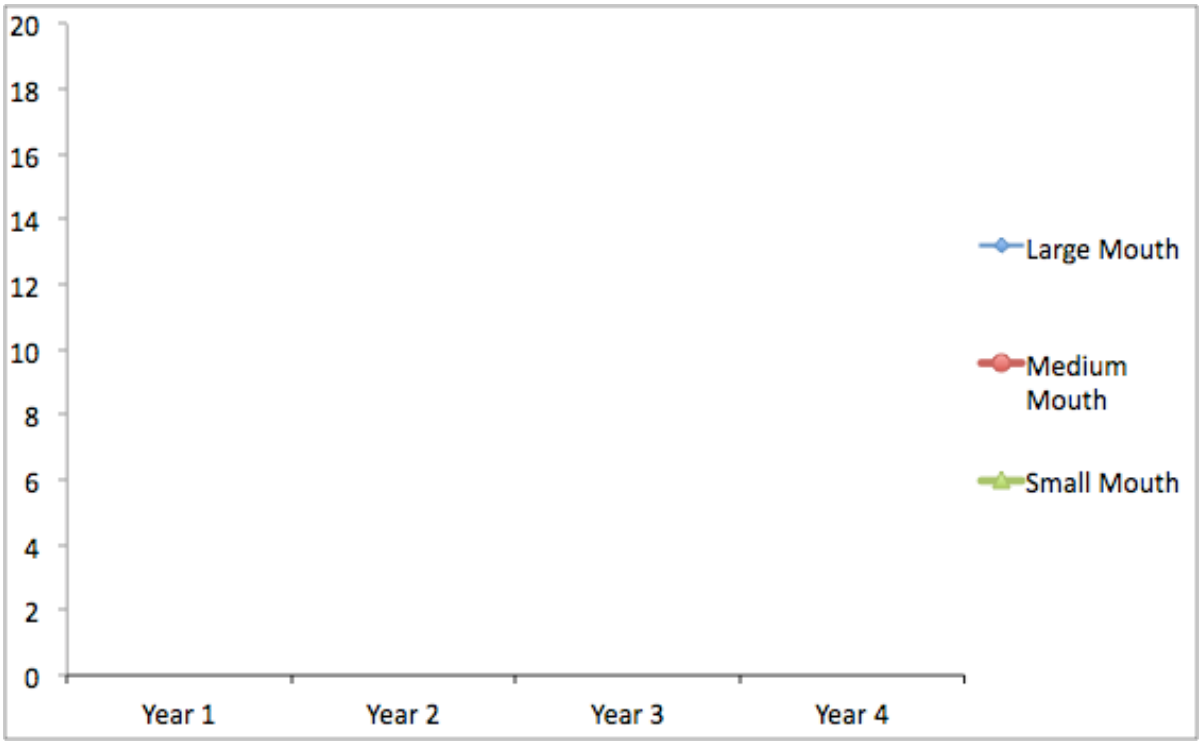
Year 1
Year 2
Year 3
Year 4
Large Mouth
Medium Mouth
Small Mouth


20
18
16
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12
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8
6
4
2
0
Year 1
Year 2
Year 3
Year 4
Large Mouth
Medium Mouth
Small Mouth

NAME: _____ STUDENT WORKSHEET

PREY CALCULATIONS

Whitefish Mouth Size	Up or Down Stream

Year 2	# of Prey Caught	Prey Calories	Total Calories Year 1	Survive Y/N	Reproduce Y/N
Clam					
Snail					
Stone Fly					

Whitefish Mouth Size	Up or Down Stream

Year 3	# of Prey Caught	Prey Calories	Total Calories Year 1	Survive Y/N	Reproduce Y/N
Clams					
Snails					
Stone Fly					

Whitefish Mouth Size	Up or Down Stream

Year 4	# of Prey Caught	Prey Calories	Total Calories Year 1	Survive Y/N	Reproduce Y/N
Clams					
Snails					
Stone Fly					