Northern Fulmars
Bycatch and Genetics

oikonos

UC SANTA CRUZ

AUK ECOLOGICAL CONSULTING

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Seabird Youth Network

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Northern Fulmars: Bycatch and Genetics

LESSON FRAMEWORK

This lesson is designed to be used as a stand-alone activity, or used in conjunction with the Seabird Youth Network's Curriculum on Seabirds. The Seabird Curriculum is available online, both in English and Russian. Chapter Four (pp 63-78) in the Seabird Curriculum focuses on seabird conservation, and briefly explains some of the key dangers or threats that seabirds face. One of these threats is commercial fishery bycatch, and Chapter Four provides information about Northern Fulmars and fishery bycatch, and some of the methods that can be used to reduce the numbers of birds caught.

This lesson is designed to reinforce and expand knowledge about fulmars and fishery bycatch, and provide a hands-on opportunity for students to investigate and integrate the information they have learned using a real research study as an example.

TARGET GRADE LEVEL

This lesson was created for grades 4-8 (ages 9-14) with activities that can be modified for lower or higher grades.

THIS CURRICULUM ACCOMPLISHES THE FOLLOWING OBJECTIVES:

- Increase the awareness of environmental and human threats to Northern Fulmars
- Introduce the students to how scientists use genetics to study seabirds

WHAT ARE ASSESSMENT METHODS?

Assessment methods vary; any of these methods can be given a point value. Methods include:

- Research summaries
- Worksheets

HOW MUCH TIME DO I NEED?

The activity can be completed in two class periods of 55 minutes each.

HYPERLINKS

Over time some hyperlinks may become obsolete. We apologize in advance for non-working links.

ACKNOWLEDGMENTS

Funding for the curriculum was provided by the North Pacific Research Board, grant 1714-1 and is based on a research project conducted by the National Oceanic and Atmospheric Administration (NOAA)/Oikonos Seabird Bycatch Necropsy Program, University of California Santa Cruz, US Geological Survey, and others to understand the impacts of fishery bycatch of Northern Fulmars in Alaska on the genetic diversity of the species in this region. More information on the research project can be found at Oikonos.org.

The lesson and activities were developed by Jesse Beck (Oikonos), Pam Goddard (Thalassa), and Ann Harding (Auk Ecological Consulting) and designed for use by elementary and middle-school students on the Pribilof Islands (Alaska) and the Commander Islands (Russia). Many thanks to Jenya Anichenko for translating the lesson into Russian.

Layout, design, and educational standard information were provided by Pam Goddard at Thalassa.

Please send any comments or inquiries to:

Jessie Beck
Oikonos
jessie@oikonos.org
oikonos.org

Ann Harding
Seabird Youth Network
a.m.a.harding@gmail.com
www.seabirdyouth.org

Pam Goddard
Thalassa
p.goddard@thalassa-education.com

LESSON OVERVIEW

Northern Fulmars: Bycatch and Genetics

Subject Area: Life Science	**Grade Levels:** Elementary/Middle School	**Teaching Time:** 2 class periods

Lesson Topics:	seabirds, feeding, breeding, conservation, seabird genetics, longline fishing
Learning Objectives:	Students will be able to list and discuss threats to seabird populations Students will have an understanding of commercial fishery bycatch Students will have an awareness of methods used to reduce the number of seabirds caught by commercial fisheries Study will have a better understanding the methods scientists use to study conservation questions

Key words:	seabirds, ecosystem, conservation, longline, offal, bait, bycatch, ganion, streamers, colony
Focus Questions:	What methods are used to reduce the number of seabirds killed by fisheries? What are the consequences of fishery bycatch for Northern Fulmar population? Do all Northern Fulmars come from the same genetic population?

LESSON	STATE STANDARDS	NEXT GENERATION SCIENCE STANDARDS		
	AK	MS-LS2 Ecosystems	Minutes	Grades
Northern Fulmars, Bycatch and Genetics	SC2;SC3.2;SE1	LS2.D: Biodiversity and Humans ETS1.B: Developing Possible Solutions	55-110	4-8

If you are using this lesson in conjunction with Lesson 4 of the seabird curriculum, the Seabird Youth Network website (http://seabirdyouth.org/seabird-activities/) has large group games and activities that reinforce the concepts presented in Lesson 4.

See Appendix II for detailed information on educational standards.

LESSON

NORTHERN FULMARS BYCATCH AND GENETICS

Seabird Youth Network

OBJECTIVES:

- Students will be able to list and discuss threats to seabird populations
- Students will have an understanding of commercial fishery bycatch
- Students will have an awareness of methods used to reduce the number of seabirds caught by commercial fisheries
- Study will have a better understanding of the methods scientists use to study conservation questions

FOCUS QUESTIONS:

- What methods are used to reduce the number of seabirds killed by fisheries?
- What are the consequences for Northern Fulmar populations?
- Do all Northern Fulmars come from the same genetic population?

BACKGROUND

SEABIRDS

A seabird is a bird that spends most of its life at sea. Despite a diversity of species, seabirds share similar characteristics. They are all adapted for a life at sea and they all must come to land to lay their eggs and raise their chicks. Most seabirds gather in large colonies along marine shorelines to breed and raise their young.

NORTHERN FULMARS

Latin name: *Fulmarus glacialis*

Unangan (Aleut) name: Saayux̂

Northern Fulmars are long-lived, slow reproducing seabirds that are in the Procellaridae family. They are closely related to albatross and other "tubenoses", and can live to be well into their forties. Northern Fulmars breed in the North Pacific and the North Atlantic on steep cliffs on islands. If they feel threatened at their nests, they will projectile vomit oily fishy barf on potential intruders. They

NORTHERN FULMARS: BYCATCH AND GENETICS

also have a distinctively musty odor that permeates their colonies. Northern Fulmars come in two color variations: light morphs and dark morphs. They are typically monogamous (only have one mate) and raise only one chick a year. In the non-breeding season (fall and winter), they live entirely at sea and some birds from Alaska travel as far as south as California. Northern Fulmars forage primarily on fish, squid, and large zooplankton. For this reason, Northern Fulmars can be attracted to the discards from fishing boats.

FISHERY BYCATCH

Commercial fishery bycatch is when animals that are not the target fish species are accidentally caught during fishing activities. Fishery bycatch can include other types of animals such as sharks and rays, marine mammals, sea turtles, and seabirds.

SEABIRDS FACE A RANGE OF DANGERS, AND THEY MAY BE ONE OF THE MOST THREATENED GROUPS OF BIRDS ON EARTH

Dangers include: pollution, invasive species, fishery bycatch, fishery competition, habitat destruction, seabirds as human food, and climate change. All of these dangers are described in Lesson 4 of the Seabird Curriculum (http://Seabird Curriculum/seabirds/).

This additional lesson on Northern Fulmars focuses on fishery bycatch.

COMMERCIAL FISHERY BYCATCH

Fisheries bycatch is the greatest threat to many seabird populations, especially albatrosses. In commercial fishing, bycatch is the incidental capture of marine species that the fisherman do not want or they are not allowed to keep.

Seabirds are attracted to fishing boats because of the bait and discarded offal (fish waste), and are at risk of getting tangled in the fishing gear and drowning. The tubenoses (shearwaters, albatross, fulmars) are the most common group of seabirds caught in fishing gear because their feeding grounds overlap with many fisheries and they are surface feeders/scavengers. Pursuit diving feeders (birds that swim underwater to catch their food, such as puffins) are more likely to be caught in gillnets which sit under the surface of the water.

It's been estimated that an average of 5800 seabirds were killed each year in Alaska Bering Sea long-line fisheries (between 2014-2017). The most common species killed were the Northern Fulmar, glaucous-winged gull, short-tailed shearwater, black-footed albatross, and Laysan albatross.

NORTHERN FULMARS: BYCATCH AND GENETICS

Seabird Bycatch in long-line fisheries: Longlines use a long mainline, with hundreds or thousands of hooks hanging off of it. These mainlines can stretch for miles under the water. Seabirds are at risk of getting caught on the fishing hooks between the time the hooks leave the fishing boat and the time they sink below the diving depth of the foraging seabird. Prevention methods are designed to prevent contact between the birds and the hooks during this critical period.

Longliner with seabirds. © Kim Dietrich

Seabird Bycatch in Trawl-fisheries: Trawling is a fishing technique where a large net is dragged behind the vessel. This technique is used extensively in the Bering Sea for walleye pollock, Pacific cod, and flatfishes. Seabirds can be killed by collisions with fishing cables or entangled in the net itself when the net is being set and retrieved.

WHAT CAN WE DO?

There are several simple (mitigation) methods that can reduce the number of seabirds killed in long-line and trawl fisheries.

Methods for trawl fisheries either focus on deterring birds from making contact with cables or reducing the attractiveness of the fishing boat by managing the discharge of the offal differently.

Methods for long-line fisheries can be divided into four main categories

(a) Avoid fishing in areas and at times when seabird interactions are most likely and intense (conduct commercial fishing at night).

(b) Limit bird access to baited hooks (underwater setting funnel).

NORTHERN FULMARS: BYCATCH AND GENETICS

(c) Deter birds from taking baited hooks (streamer (bird-scaring) lines).

(d) Reduce the attractiveness or visibility of the baited hooks (using colored or artificial baits).

Long liner with streamers. © Ed Melvin, WA Sea Grant.

Learn more at:

http://www.birdlife.org/seabirds/bycatch/albatross.html

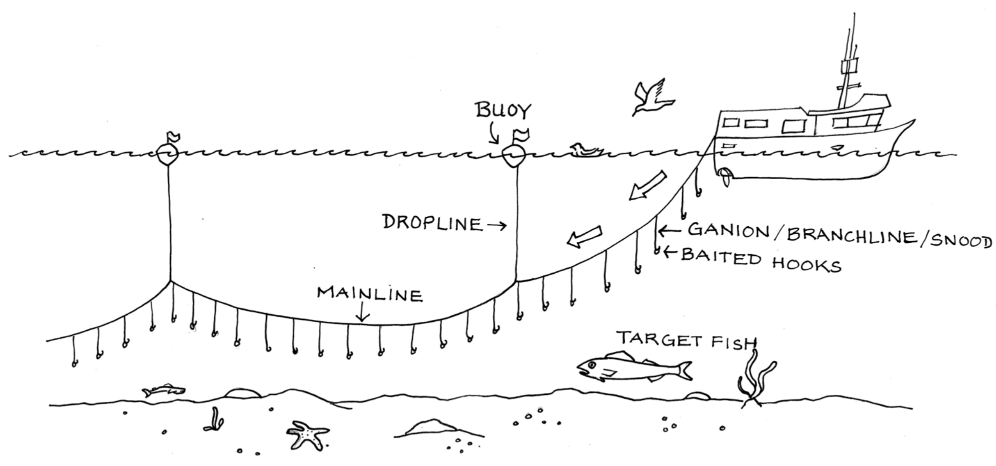
http://www.afsc.noaa.gov/refm/reem/Seabirds/Default.php

http://www.sciencedaily.com/releases/2012/02/120228123852.htm

NORTHERN FULMARS: BYCATCH AND GENETICS

NORTHERN FULMARS AND LONGLINES

Around the world, many fishermen and women use longlines to catch fish at deep depths in the ocean. In Alaska, the North Pacific groundfish fisheries often use longlines and are some of the largest and most commercially important fisheries in the United States. Longlines use a long mainline, with hundreds or thousands of hooks hanging off of it. These mainlines can stretch for miles under the water. Fishermen and women catch many different types of target fish with longlines, such as halibut and tuna. Longlines also accidently catch non-target fish, marine mammals, turtles, and seabirds. This is called bycatch. One species of seabird that is often accidently caught as bycatch in the Bering Sea is the Northern Fulmar. Northern Fulmars normally fly hundreds of miles to find fish and squid. When fishing boats offload bits of fish waste (offal) behind the boat or when the fulmars see pieces of fish (bait) on the longline hooks as they are reeled in, they try to eat the bait or offal and can get lethally hooked.

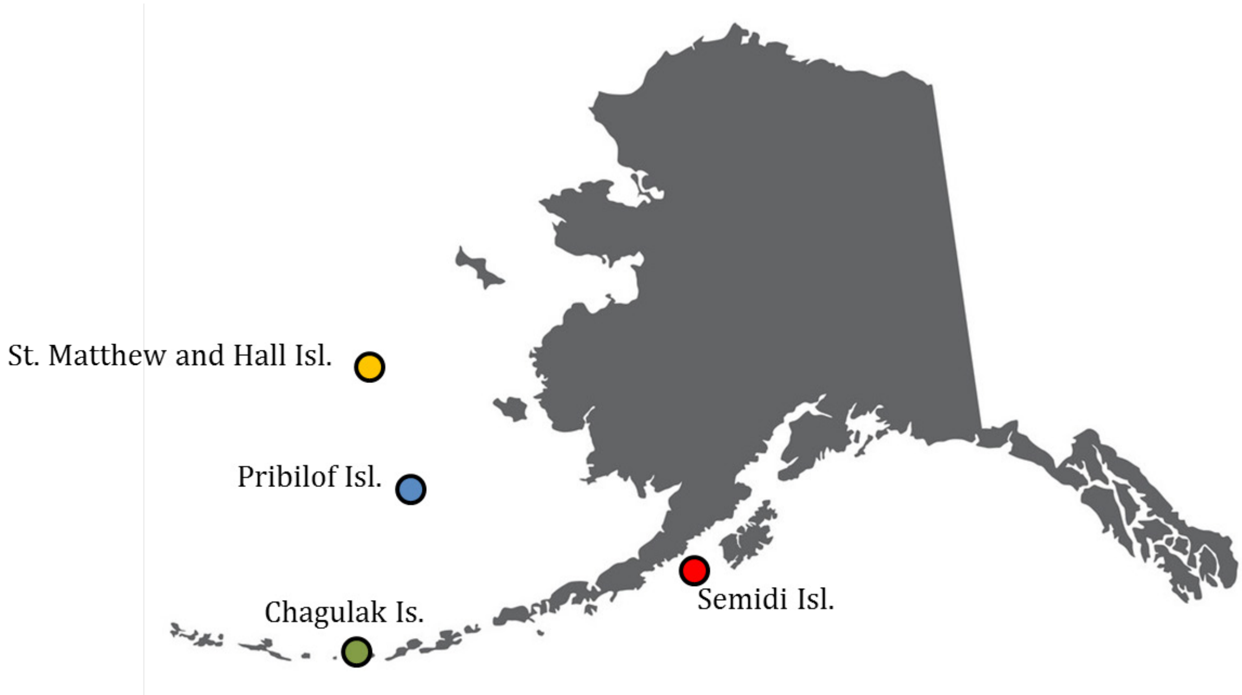


Longline vessel and fishing gear.

In Alaska, the majority of Northern Fulmars breed at one of four large colonies: Chagulak Island, the Pribilof Islands, the Semidi Islands, and St. Matthew and Hall Islands (see map on following page). Scientists can tell which colony a fulmar is from by looking at its genetics. Fulmars from the Pribilof Islands will have special genetic Pribilof markers that only birds from that colony have, and the same is true for the other colonies. When scientists want to know if longline fisheries could be impacting Northern Fulmar populations, they can look at these genetic markers to see which colonies the bycatch fulmars are coming from. They can then compare the number of bycatch birds from that colony to its colony's population to see if there are too many birds from that colony getting caught relative to the colony size. For example, if 50% of fulmar bycatch is from Chagulak Island but

NORTHERN FULMARS: BYCATCH AND GENETICS

Chagulak is only 20% of the overall population, the fisheries are taking a disproportionate amount of fulmars from that colony. This could result in impacts to the colony itself (for example, if there are fewer fulmars, there may be less food for their predators) and also to the greater North Pacific population of Northern Fulmars by altering the genetic diversity of the whole population.



Map of Alaska and Northern Fulmar breeding colonies.

Colony name	% of total population
Semidi	30
Pribilofs	6
St. Matthew/Hall	30
Chagulak	34

NORTHERN FULMARS: BYCATCH AND GENETICS

NORTHERN FULMARS GENETICS

Researchers around the world use genetics to understand where animals come from (in this case Northern Fulmars). By looking at specific markers in genes from each colony, scientists are able to tell if the colonies are genetically unique. Genes carry the information that determines an individual's features or characteristics and are passed down (or inherited) from parents to their offspring. Unique genes in each population can make a genetic marker – like a unique fingerprint – that researchers can look for in animals from unknown populations. This is what happens when Northern Fulmars are caught on longlines. The dead birds are collected by scientific observers on the vessels and shipped back to California where their genetic code or DNA can be studied in a lab. Researchers used this exact method to study which colonies Northern Fulmar bycatch comes from in Alaskan longline fisheries.

ACTIVITY: NOFU BYCATCH AND GENETICS

Allow two class periods for this activity. One class period for setup and making the birds, and one class period to play the game and discuss the results.

MATERIALS:

- String
- Paperclips
- Scissors
- Masking tape
- Colored paper
- Hole punch
- Bread or pieces of a sponge or cut up paper (bait)
- Glue or stapler
- Timer or stopwatch

BACKGROUND

You and your students will create longline fishing gear and then simulate deploying the gear. The first gear deployment will be without any Northern Fulmar deterrents in place. Then the students will brainstorm ways to prevent the birds from eating the fishing bait. After each simulation the students will tally the number of birds killed by eating baited hooks.

SETUP PROCEDURES:

Your classroom floor is going to represent the surface of the ocean. See diagram on page 15.

1) Create a longline
   - Measure out 5 meters of string. This is the mainline.
   - Stretch it out on the floor
2) Add ganions
   - Cut 30 pieces of string, 20 cm long each
3) Make the hooks
   - Straighten 30 paperclips and then bend the lower half up to make a hook

ACTIVITY: NOFU BYCATCH AND GENETICS

4) Attach the hooks to the ganions
   - Attach 1 hook to each ganion

5) Attach the ganions with their hooks to the mainline

6) Add the bait to 20 of the 30 hooks

7) Hang one end of the mainline from a high point in the classroom. The other end should be attached to something close to the floor. Maybe at the bottom of a bookshelf or a desk
   - Hang so that 20 hooks are touching the floor and 10 hooks are hanging in the air

8) Put offal in the water
   - Add pieces of bait in the water to represent offal

9) Use paper and tape to add the islands with the breeding colonies
   - Put Pribilof Islands closest to the longline
   - St. Matthew/Hall Island is next
   - Chagulak and Semidi are the furthest away

10) Cut out 50 Northern Fulmars
   - Using the templates provided on page 16, cut out 50 birds. Depending on how many students are in the class there will be a couple to several birds per student.
   - Pribilofs - 10
   - St. Matthew/Hall - 13
   - Chagulak - 10
   - Semidis - 17

11) Cutout the genetic codes for each colony. See Appendix IV for each colony's genetic code.

12) Glue or tape the genetic code to the inside of each bird and glue the bird together. Leave a hole to pull out the genetic code at the end of the game.

13) Punch a hole in the nose of each bird and a hole on its back.

ACTIVITY: NOFU BYCATCH AND GENETICS

PLAY THE GAME

1) Put the birds on their islands. This is done by the teacher, since only the teacher knows the genetic code for each bird.

2) Assign the students to the islands and have them pick up the birds.

3) All of the birds must be picked up by a student.

4) Give the students 1 minute to walk over to the longline and pick bait off the hooks or from the ground.

5) If the hook is empty, the bird does not get caught.

6) If the hook has bait on it then the bird gets caught. The student hangs the bird on the hook.

7) If the bird eats offal, a hook catches it in the back.

8) Once the time is up put the free birds back on their breeding colony.

9) Count the number of birds caught on hooks. (There should be 20.)

10) Open the belly of each bird and figure out which colony it came from.

11) Calculate the percentage of birds caught from each colony.

    E.g. if there are 20 birds caught and 5 are from the Pribilof Islands

    5/20 = X/100, 500/20 = X, X = 25% are from the Pribilofs

    Or because 20 x 5 = 100, just multiply each number of birds caught by island by 5

    5 x 5 = 25% are from the Pribilofs

Fill out a table similar to the one below to compare percentages of bycatch birds to colony sizes.

Colony Name	% of Total population	% of bycatch
Semidis	30	35
Pribilofs	6	20
St. Matthew/Hall	30	25
Chagulak	34	20

ACTIVITY: NOFU BYCATCH AND GENETICS

FOLLOW UP QUESTIONS:

1) How can fishermen and women prevent birds from getting caught on the hooks? Have students brainstorm ideas.

   Fisherman strategies

   - Streamers
   - Don't release offal when setting hooks
   - Deploy the mainline through a chute directly into the water
   - Deploy at night (lowers bycatch of many species but not all)

2) Does it matter if Northern Fulmar bycatch comes more from one colony than the other? What impacts might that have?

   Ecosystem Impacts

   - Less fulmars depositing nutrients onto islands
   - Less fulmar eggs, chicks and adults for their predators to eat, like gulls and eagles
   - Fulmar prey (fish, macroplankton) eaten less often by fulmars around the colonies

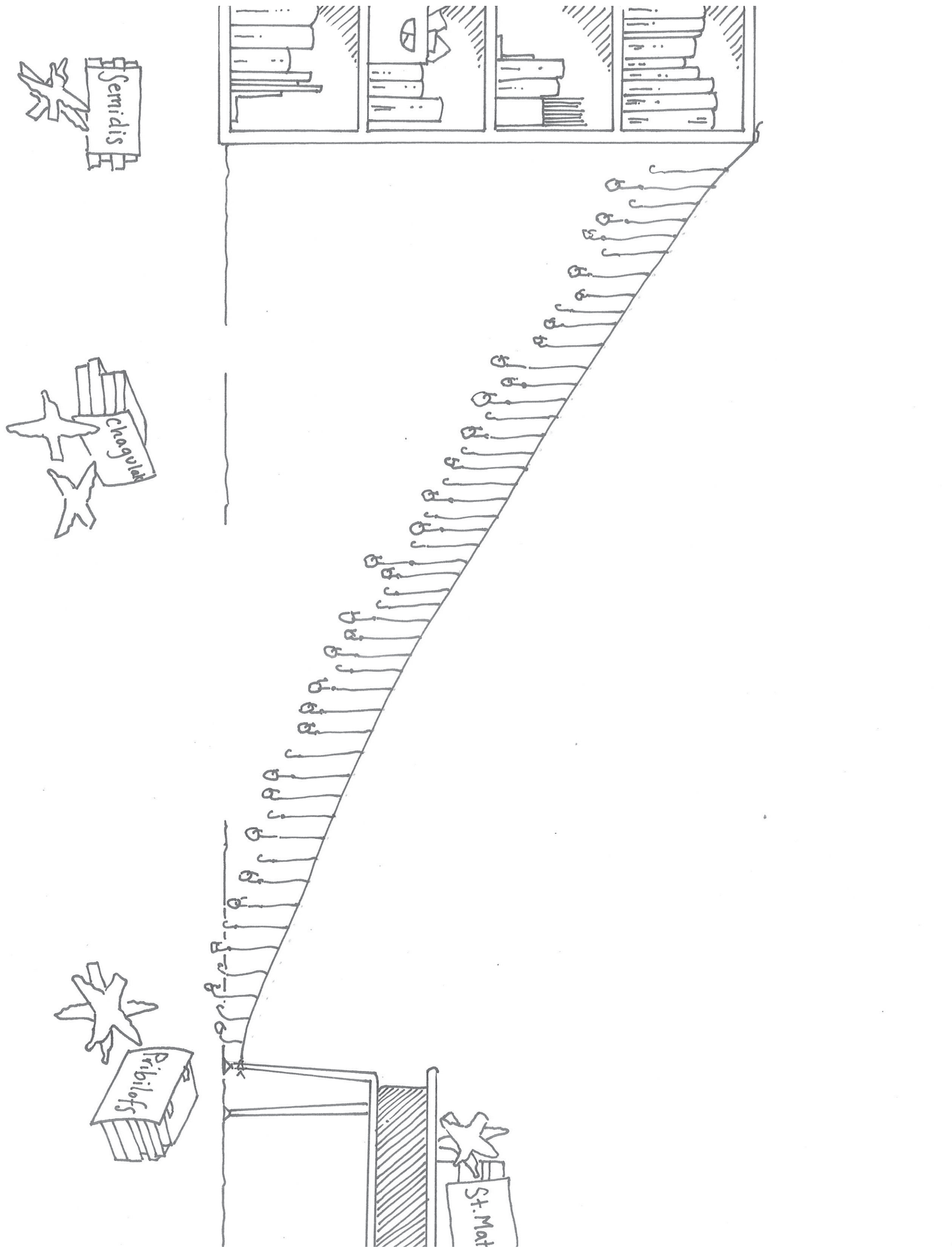
   Genetic Impacts

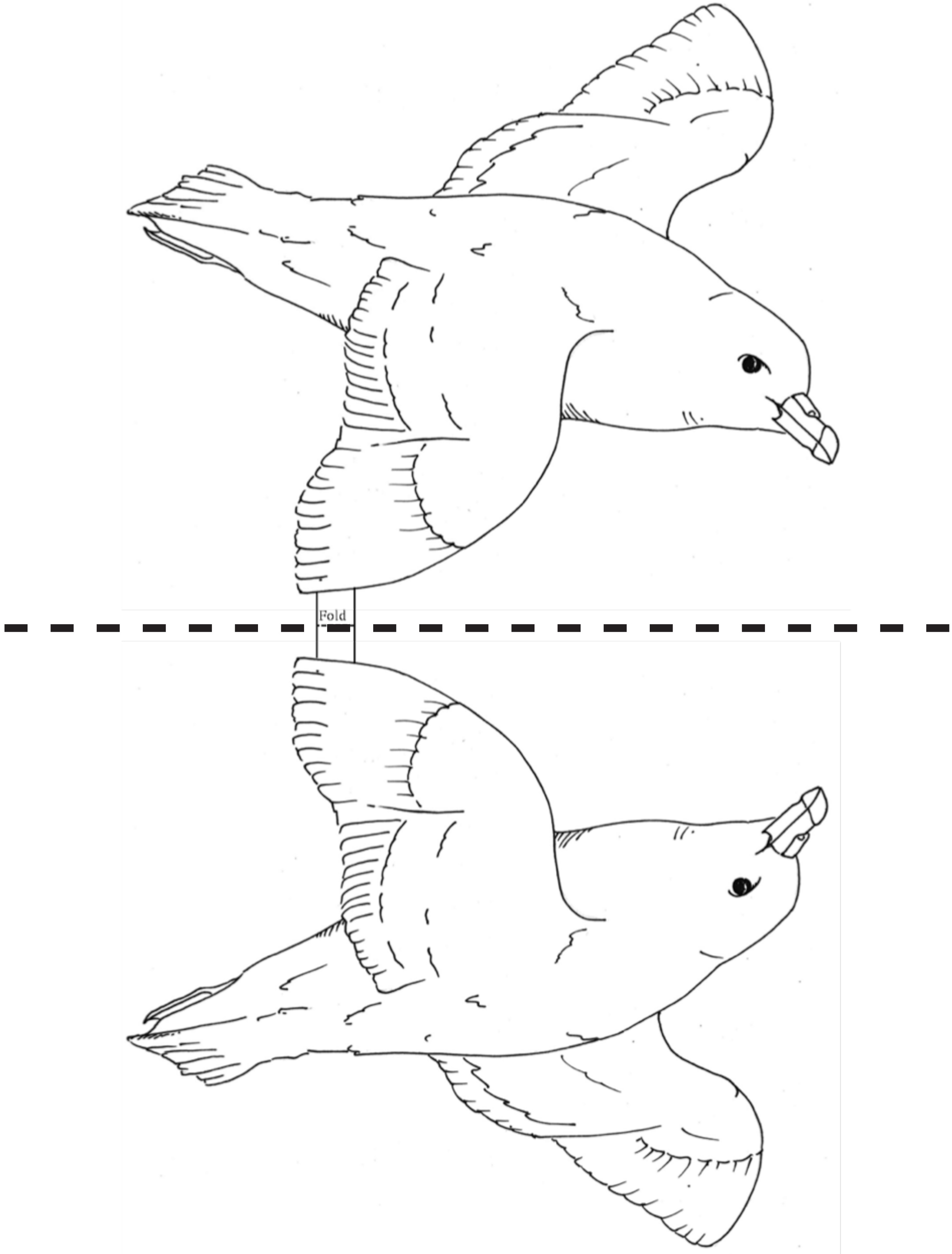
   - If each island is genetically different from other islands, then there could be less genetic diversity overall
   - Populations are stronger when they're more genetically diverse because they have a wide variety of traits that help them respond to environmental and human pressures

3. How are these data are going to help fisherman and women, scientists, and communities on these islands learn about the impacts and solutions to Northern Fulmar bycatch?

   - The data from this type of project can help fishery managers and fisherman reduce impacts on Northern Fulmar populations by helping them decide if, where, and when they should avoid fishing in certain areas near colonies. It can also help human communities that live on islands with Northern Fulmar colonies understand the threats to their fulmars and inform management and harvest of Northern Fulmars in their areas.

CLASSROOM SETUP

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WORKSHEET: NOFU BYCATCH AND GENETICS

Names:____ Date:___________

Play the game 3 times and calculate how many birds from each island died from eating bait or offal from the longline vessel. Use the genetic code inside each bird to determine which island it came from. For rounds 2 and 3 come up with ways to prevent the birds from eating bait and offal.

Colony Name	% of Total population	Round 1 no deterrents % of bycatch	Round 2 deterrent #1 % of bycatch	Round deterrent #2 % of bycatch
Semidis	30			
Pribilofs	6			
St. Matthew/Hall	30			
Chagulak	34			

What is the best way to prevent Northern Fulmars from eating bait and offal produced by longline vessels?

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APPENDIX I GLOSSARY

abundance The number of individuals in a population.

AMNWR Alaska Maritime National Wildlife Refuge

bait A marginal sea of the North Pacific located north of the Aleutian Islands, west of Alaska, and east of Russia.

Bering Sea A marginal sea of the North Pacific located north of the Aleutian Islands, west of Alaska, and east of Russia.

biome A distinct region occupied by plants and animals suited for its climate and vegetation.

bycatch Marine animals caught while fishing that fishermen do not want, cannot sell, or are not allowed to keep.

colony A place where seabirds gather to breed, nest, and raise their chicks.

colonial nesting seabirds (seabird colony) A seabird colony is a large congregation of individuals of one or more species of bird that nest or roost in proximity at a particular location (on an island). Many kinds of birds are known to congregate in groups of varying size; a congregation of nesting birds is called a breeding colony.

commercial fishing Fishing in which harvested fish are sold, bartered, or traded.

competition A contest between organisms, animals, individuals, and/or groups, for territory, a niche, resources (food, shelter, etc.), mates, or group or social status. Each side of the contest is a competitor.

conservation The act of protecting or preserving natural resources in order to prevent depletion or loss.

DNA Deoxyribonucleic acid is the hereditary material found in all humans and almost all other organisms. It carries the genetic information and hereditary characteristics.

ecological community An assemblage or associations of populations of two or more different species occupying the same geographical area and in a particular time.

ecosystem A community of living organisms and their environment, and the interactions between the two. Humans are an integral part of an ecosystem.

forage fish Generally a small schooling fish that feeds on plankton and is preyed upon by larger fish, marine mammals, and seabirds.

foraging The act of searching for food.

ganion Line on longline vessel containing the hook.

gene A region or segment of DNA that stores the code for determining inherited traits.

gillnet A net suspended vertically in the water with meshes that allow a fishes head to pass through but entangle the gills when withdrawn.

habitat An ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism. It is the natural environment in which an organism lives, or the physical environment that surrounds a species population.

invasive species A plant or animal that is not native to a specific location (an introduced species); and has a tendency to spread, which is believed to cause damage to the environment, human economy and/or human health.

long line fishing A method of fishing involving a large number of short lines with hooks, which are attached to a longer main line at regular intervals.

monitoring Counting and measuring organisms or their features that are of interest (abundance of seabirds on a colony).

mortality The state of being mortal, or susceptible to death.

natural range The geographical area within which a particular species is commonly found.

APPENDIX I GLOSSARY

natural resources Raw materials obtained from nature that humans cannot make, such as light, water, air, plants, animals, or soil.
NOAA National Oceanic and Atmospheric Administration
offal Waste or by-product from a process such as commercial fishing.
pelagic Inhabiting the water column as opposed to being associated with the sea floor; generally occurring anywhere from the surface to 1,000 meters. Also, relating to or living in the open sea.
pollution The presence or introduction into the environment of something that has a harmful or poisonous effect.
population trends Changes over time in a population's abundance, distribution, or life-history.
predator (predation) An organism that eats another organism.
prey The organism which the predator eats.
salt gland A gland in marine birds that concentrates salt from the blood. Salt is collected near the nostrils and "sneezed" out.
species A group of organisms sharing similar traits that produce viable offspring.
trawl fishing A method of fishing that involves dragging or pulling a net through the water.
USFWS United States Fish and Wildlife Service
wing span The distance between the wing tips of a bird.

APPENDIX II EDUCATIONAL STANDARDS

ALASKA STATE SCIENCE STANDARDS

Science as Inquiry and Process

SC2 Students develop an understanding of the structure, function, behavior, development, life cycles, and diversity of living organisms.

SC3.2 The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by analyzing the potential impacts of changes within an ecosystem.

SE1 Students develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations, and responses to problems and everyday events.

ALASKA STATE SCIENCE STANDARDS

Statistics and Probability Standards

- Interpreting Categorical and Quantitative Data

NEXT GENERATION SCIENCE STANDARDS: DISCIPLINARY CORE IDEAS

LS2.A: Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)
- Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2)

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

APPENDIX II EDUCATIONAL STANDARDS

NEXT GENERATION SCIENCE STANDARDS: DISCIPLINARY CORE IDEAS

LS4.D: Biodiversity and Humans

- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—e.g., water purification and recycling. (secondary to MS-LS2-5)

ETS1.B: Developing Possible Solutions

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-LS2-5)

APPENDIX III LESSON RESOURCES

LESSON 4 SEABIRD CONSERVATION

WEBSITES

Oil Pollution

http://response.restoration.noaa.gov/about/media/why-are-seabirds-so-vulnerable-oil-spills.html

https://academy.allaboutbirds.org/what-oil-spills-do-to-birds/

https://www.education.com/science-fair/article/effect-of-oil-on-birds/

Ingested plastic

http://news.nationalgeographic.com/2015/09/15092-plastic-seabirds-albatross-australia/

http://www.sciencemag.org/news/2016/11/why-do-seabirds-eat-plastic-they-think-it-smells-tasty

http://oikonos.org/education/

https://ocean.si.edu/slideshow/laysan-albatrosses'-plastic-problem

Invasive species

http://en.wikipedia.org/wiki/Introduced_mammals_on_seabird_breeding_islands

http://seabirdyouth.org/invasive-species-and-seabird-curriculum/

https://www.islandconservation.org/first-global-assessment-of-seabirds-threatened-by-invasive-alien-species-on-islands-released/

http://coastalconservation.ca/invasive-species/

Commercial fishery bycatch

http://www.birdlife.org/seabirds/bycatch/albatross.html

http://www.afsc.noaa.gov/refm/reem/Seabirds/Default.php

http://www.bbc.co.uk/news/science-environment-35778655

Commercial fishery competition

http://www.sciencedaily.com/releases/2012/02/120228123852.htm

Habitat destruction

http://oikonos.org/current-projects/seabird-nests/

Seabirds as human food

https://en.wikipedia.org/wiki/Great_auk

http://www.smithsonianmag.com/science-nature/uncertain-future-puffin-dinner-180961829/

Climate change

http://www.bbc.co.uk/nature/20498368

General Seabird Conservation

http://www.audubon.org/conservation/project/saving-seabirds

http://oikonos.org/what-we-do/

http://wwf.panda.org/what_we_do/endangered_species/albatross/

BOOKS

Seabird Islands: Ecology, Invasion, and Restoration (2011), edited by Christa Mulder, Wendy Anderson, David Towns, and Peter Bellingham.

Project Puffin: The Improbable Quest to Bring a Beloved Seabird Back to Egg Rock (2010) by Stephen W. Kress and Derrick Z. Jackson

APPENDIX IV GENETIC CODES

Pribilof Colony	Pribilof Colony	Pribilof Colony	Pribilof Colony	Pribilof Colony
Pribilof Colony	Pribilof Colony	Pribilof Colony	Pribilof Colony	Pribilof Colony
St. Matthew/Hall Colony	St. Matthew/Hall Colony	St. Matthew/Hall Colony	St. Matthew/Hall Colony	St. Matthew/Hall Colony
St. Matthew/Hall Colony	St. Matthew/Hall Colony	St. Matthew/Hall Colony	St. Matthew/Hall Colony	St. Matthew/Hall Colony
St. Matthew/Hall Colony	St. Matthew/Hall Colony	St. Matthew/Hall Colony	Semidis Colony	Semidis Colony
Semidis Colony	Semidis Colony	Semidis Colony	Semidis Colony	Semidis Colony
Semidis Colony	Semidis Colony	Semidis Colony	Semidis Colony	Semidis Colony
Semidis Colony	Semidis Colony	Semidis Colony	Semidis Colony	Semidis Colony
Chagulak Colony	Chagulak Colony	Chagulak Colony	Chagulak Colony	Chagulak Colony
Chagulak Colony	Chagulak Colony	Chagulak Colony	Chagulak Colony	Chagulak Colony