Laaqudax̂: The Northern Fur Seal

GRADES 7–12 PART II: LESSONS 4-6

2018

Artwork by Thomas Stream

NOAA Fisheries Alaska Fisheries Science Center Alaska Regional Office	Pribilof School District	Thalassa	Central Bering Sea Fishermen's Association	Aleut Community of St. Paul Island Tribal Government	**National Marine Sanctuaries Foundation**
					

Laaqudaxˆ the Northern Fur Seal for grades 7-12 was developed by NOAA's National Marine Fisheries Service (NMFS)/ Alaska Fisheries Science Center and Thalassa Education, in partnership with the Pribilof School District, the Aleut Community of St. Paul Island – Tribal Government, and the NMFS Alaska Regional Office. The curriculum was developed by Lisa Hiruki-Raring (NMFS), Pam Goddard (Thalassa), Tonia Kushin (St. Paul School) , and Harriet Huber (NMFS). Graphic design and layout was provided by Rebecca White (NMFS).

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LESSON FOUR

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Subject Area(s): Life science	Grade Levels: 7-12	Presentation – 15 minutes Labs – variable

Lesson Topics:	Food chain, food web, scat analysis, food habits/diet	**Focus Questions**	• How do scientists study the fur seal's diet? • What is learned from studying food habits? • Why do scientists study food habits?
Learning Objectives:	Student will: • create a Bering Sea food web • analyze scat contents • graph and analyze scat contents	**Key words:**	diet, prey, ecosystem, scat, food habits, forage, food web, frequency of occurrence

LABS		ALASKA STANDARDS					
		Math 7	Math 8	MATH 9-12	Science	Minutes	Grades
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Lab 4.2	Microworlds: What do Marine Mammals Eat? (video)				SC2,3	30	7–12
Lab 4.3*	Scat Detective (hands on)	7.SP1-4	8.SP1	S-ID, S-IC	SA1,2, SC 2,3 SE1,2, SG2	50	7-8
Lab 4.4*	Scat Detective and Frequency of Occurrence (hands on)	7.SP1-4	8.SP1	S-ID, S-IC	SA1,2, SC 2,3 SE1,2, SG2	50	9-12
Lab 4.5*	Advanced Scat Detective (graphing and data analysis)	7.SP1-4	8.SP1	S-ID, S-IC	SA1,2, SC 2,3 SE1,2, SG2	50	9–12

Targeted Alaska Grade Level Expectations (GLEs)

Math

MD Measurement and Data
SP Statistics and Probability

Science

Science as Inquiry and Process

SA1 Students develop an understanding of the processes of science used to investigate problems, design and conduct repeatable scientific investigations, and defend scientific arguments.

SA2 Students develop an understanding that the processes of science require integrity, logical reasoning, skepticism, openness, communication, and peer review.

Concepts of Life Science

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

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Science and Technology

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History and Nature of Science

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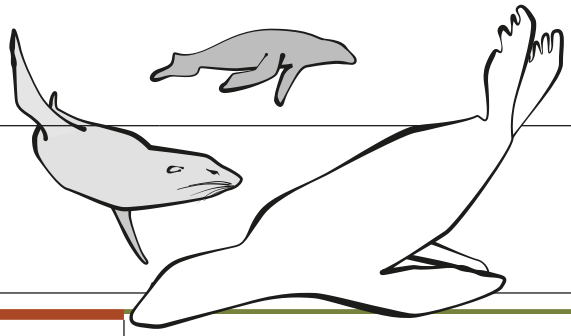
Laaqudax̂: The Northern Fur Seal

LESSON FIVE

How do fur seals dive?



Subject Area(s): Life science	**Grade Levels:** 7-12	Presentation – 15 minutes Labs – variable

Lesson Topics:	Fur seal diving and adaptations to cold environments.	**Focus Questions**	• How are pinnipeds adapted to cold water? • Why do fur seals dive? • What can be learned from studying diving behavior?
Learning Objectives:	Students will: • investigate adaptations of seals to water • collect and summarize data • interpret fur seal dive data	**Key words:**	blubber, body shape, forage, adaptation, counter-current heat exchange, thermoregulation

LABS		ALASKA STANDARDS					
		Math 7	Math 8	Math 9-12	Science	Minutes	Grades
Lab 5.1	How do Marine Mammals Stay Warm? Blubber vs. Air (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2	30	7–12
Lab 5.2	Thermoregulation: Counter Current Heat Exchange (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2 SG2	50	9-12
Lab 5.3	Waiting to Inhale! (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2 SG2	50	7–12
Lab 5.4	Interpreting Fur Seal Dive Data (data analysis)	7.SP.1-4	8.SP.1-4	S-IC.	SA1,2 SC1,2 SG2	50	9-12

Targeted Alaska Grade Level Expectations (GLEs)

Math

MD Measurement and Data
SP Statistics and Probability
Statistics: IC.1

Science

Science as Inquiry and Process

SA1; SA2

Concepts of Life Science

SC2

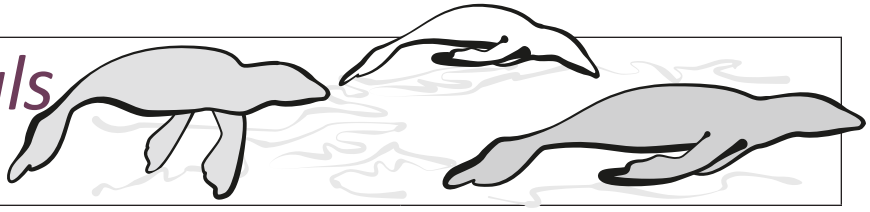
History and Nature of Science

SG2

Secondary Curriculum: Grades 7–12

LESSON SIX

Where do fur seals go in the winter?



Subject Area(s): Life science, geography, reading	**Grade Levels:** 7-12	Presentation – 15 minutes Labs – variable

Lesson Topics:	Fur seal migration, traditional knowledge of migration, and current research.	**Focus Questions**	• Why do fur seals leave the rookery? • Where do they go? • How do we know? • Why do we want to know where they go?
Learning Objectives:	Students will: • describe where northern fur seals go in the winter • plot fur seal migration tracks on a map • describe three methods scientists use to track fur seal migration routes.	**Key words:**	migrate, satellite tags, tracking instruments, latitude, longitude

Lab		ALASKA STANDARDS		
		Science	Minutes	Grades
Lab 6.1	Where are Fur Seal Rookeries? (mapping)	SA3; SC2,3; SF1,2,3	30	7-12
Lab 6.2	*Fur Seal Migrations* (video, discussion)	SA3; SC2; SF1,2,3	30	7–12
Lab 6.3	Fur Seal Migrations (mapping)	SA3; SC2,3; SF1,2,3; SG1,3,4	50	7–12

Science

Science as Inquiry and Process

SA3

Concepts of Life Science

SC2; SC3

Cultural, Social, Personal Perspectives, and Science

SF1; SF2; SF3

History

History and Nature of Science

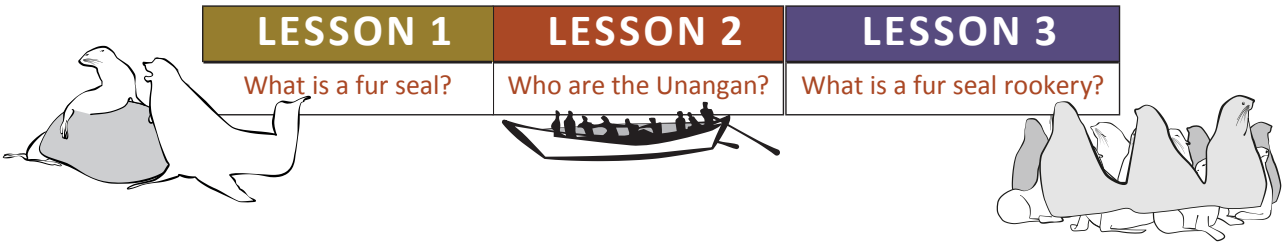
SG1; SG3; SG4

Introduction

Northern fur seals have played an important economic and biological role in the history of Alaska and the United States that is often overlooked. Historically, Alaska was home to over 90% of the world's population of northern fur seals with the majority found on the Pribilof Islands in the Bering Sea. The Unangan (Aleut people) have inhabited Alaska's Aleutian Islands for thousands of years, and their history is intertwined with that of the commercial fur harvest, as forced labor first for Russians and later for Americans. It is a little-known fact that in the twenty years following the United States' 1867 acquisition of the Alaska territory, revenues to the United States Government from the Pribilof Island fur seal harvest paid off the 7.2 million dollar purchase price.

The term **Aleut** is the Russian word used historically for the people of the Aleutian Islands. Today, people of this region use the words **Unangan** (Eastern dialect) and **Unangas** (Western dialect) to refer to the Aleut people. In this curriculum, we use the term **Unangan** when appropriate.

Part I: Marine Mammal Review



Part II: More In-Depth Biological Information

Part III: Population Estimation, Management, and Policy

LESSON 7	LESSON 8
Populations, Harvest, Management	Marine Mammal Protection Act

Goal

The goal of this integrated curriculum is to increase knowledge of northern fur seals and the Unangan through lessons and activities designed for varying grade levels and teachers with little or no background knowledge. Science, math, language arts, culture, and art have been integrated into lessons that can be adjusted for grades 7-12. Teachers with multi-grade classes have the choice to teach the same material at many levels and provide opportunities for older students to work with younger students, encouraging community teaching. The curriculum is designed as a spiral curriculum, where the same content can be revisited over several grades, each time at a higher level of difficulty and in greater depth.

Parts I, II, and III of this curriculum accomplish the following objectives:

- Review the story of the annual cycle of northern fur seals,
- Review the core concepts in fur seal biology,
- Review the relationship between northern fur seals and Unangam culture,
- Introduce methods behind population estimation,
- Understand the reasons for and consequences of the Marine Mammal Protection Act,
- Develop awareness of the science and research techniques used to study northern fur seals.

CURRICULUM FRAMEWORK

The curriculum is divided into Part I (Lessons 1-3), Part II (Lessons 4-6), and Part III (Lessons 7-8), each with a PowerPoint presentation and accompanying activities for different grade levels. A complementary curriculum is available for grades K-6. The labs are designed to reinforce and expand the lesson themes, and to provide hands-on opportunities for students to investigate and integrate the information they have learned.

Part I Lessons

1 What is a fur seal?

2 Who are the Unangan?

3 What is a fur seal rookery?

Part II Lessons

4 What do fur seals eat?

5 How do fur seals dive?

6 Where do fur seals go in the winter?

Part III Lessons

7 Populations, Harvest, and Management

8 Marine Mammal Protection Act

Lessons 1, 2, and 3 provide the foundation for the curriculum. It is strongly suggested that teachers at least review the information in these lessons before proceeding. Lesson 4-6 can be taught in any order Lessons 7 and 8 are the most advanced. They introduce population dynamics, management techniques, and the Marine Mammal Protection Act. Lessons 7 and 8 can be taught independently of the other lessons but some background information is recommended. Labs are structured to take one class period of 45-55 minutes. Some shorter labs take half a class period (30) minutes.

See Appendix III for a complete curriculum overview and Appendix IV for lesson overviews from Parts II and III.

The curriculum is designed to be flexible enough that teachers can pick and choose the order of lessons and activities within a lesson based on their students' grade level and prior knowledge.

HOW DOES THIS MATERIAL FIT THE ALASKA STATE EDUCATIONAL STANDARDS?

This curriculum has been specifically designed to meet Alaska State Standards for science, math, reading, writing, history, and cultural standards.

WHAT ARE ASSESSMENT METHODS?

Assessment methods vary with each lesson and lab; any of these methods can be given a point value and entered into a grade book. Methods include:

- Pre and Post test
- Visual representations
- Data analysis
- Geographical display (maps)
- Summary of observations using technical writing
- Verbal presentations
- Creative writing
- Visual arts

HOW MUCH TIME DO I NEED?

Each lesson can be completed in 40-60 minutes if at least one lab is selected. Labs range from 10-50 minutes with most being 50 minutes.

CULMINATING PROJECT IDEAS:

Consider choosing a culminating project that summarizes the knowledge gained from the unit, and making it a project that the class works on each week, individually or as a whole. Examples of culminating projects include:

- Teach what you have learned to someone else (family, another class).
- Create a school display.
- Create an all-school mural using the stamps created in Lab 3.4. This is a great opportunity for older students to work with younger students or earn community service hours.
- Write a song, skit or a play about a northern fur seal rookery or migration and act it out for students at your school.
- Make an educational video about something you learned.
- Record an elder telling a story. Ask for permission to share it with your class or school.
- Hold a debate on the Marine Mammal Protection Act.
- Visit the Pribilof Islands for summer camp.
- Write a letter to your Congressional representative.

Northern Fur Seal Curriculum Overview

Lesson	Topic	Components	Grade Level	Time
Labs vary by grade level allowing educators to select age appropriate activities for their class.				
	Part II Pre and Post Assessment		7-12	15 min
4	***What do fur seals eat?***	PowerPoint Overview (8 slides) Lab 4.1: Bering Sea Food Web (hands on) Lab 4.2: Microworlds: What do Marine Mammals Eat? (video) Lab 4.3: Scat Detective (hands on) Lab 4.4: Scat Detective and Frequency of Occurrence (hands on) Lab 4.5: Advanced Scat Detective (graphing and data analysis)	 7-12 7-12 7-8 9-12 9-12	 50 min 30 min 50 min 50 min 50 min
5	***How do fur seals dive?***	PowerPoint Overview (10 slides) Lab 5.1: How do marine mammals stay warm? Blubber vs. Air (hands-on) Lab 5.2: Thermoregulation: Countercurrent Heat Exchange (hands-on) Lab 5.3: Waiting to Inhale! (hands-on) Lab 5.4: Interpreting Fur Seal Dive Data (data analysis)	 7-12 9-12 7-12 9-12	 30 min 50 min 50 min 50 min
6	***Where do fur seals go in the winter?***	PowerPoint Overview (10 slides) Lab 6.1: Where are Fur Seal Rookeries? (mapping) Lab 6.2: *Fur Seal Migrations* (video) Lab 6.3: Fur Seal Migrations (mapping)	 7-12 7-12 7-12	 30 min 30 min 50 min

PART II-LESSONS 4,5, & 6: PRE/POST-ASSESSMENT

Student Name: _____ Date: _____

1. What do fur seals eat? Name at least two things. Draw a picture if you know what it looks like.
2. List three parts of the Bering Sea food web or draw a diagram of the Bering Sea food web.
3. How are pinnipeds adapted to the cold water
4. Why do fur seals dive and how are their bodies adapted to diving?
5. Where do fur seals go in the winter? Draw a map or write out the answer.
6. Why do fur seals leave the rookery in the winter?

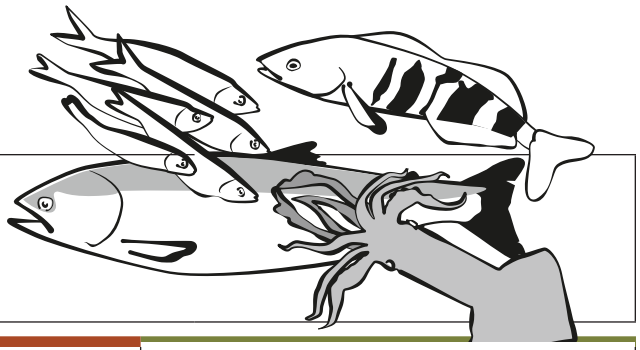
KEY PART-II LESSONS 4, 5, & 6: PRE/POST-ASSESSMENT

Lesson #	Student Name: _____ Date: _____
4	1. What do fur seals eat? Name at least two things. Draw a picture if you know what it looks like. Fish: pollock, Atka mackerel, Pacific cod, salmon Cephalopods, also know as squids
4	2. List three parts of the Bering Sea food web or draw a diagram of the Bering Sea food web. Sun, phytoplankton, zooplankton, small fish like Pacific sand lance or Pacific herring, baleen whales, salmon, squid, Pacific cod, walleye pollock, killer whales, northern fur seals, humans
5	3. How are pinnipeds adapted to the cold water? Blubber and hair keep them warm. Their flippers do not freeze due to counter-current heat exchange.
5	4. Why do fur seals dive and how are their bodies adapted to diving? To eat. Their ears close to prevent water from entering. They deflate their lungs which allows them to go down deep.
6	5. Where do fur seals go in the winter? Draw a map or write out the answer. All over the north Pacific. It depends on their age. Pups go all over the place. Adult females go south and then follow the coast back up north. Adult males often stay in the Bering Sea.
6	6. Why do fur seals leave the rookery in the winter? They need to eat. The rookery becomes covered in ice and snow.

Secondary Curriculum: Grades 7–12

LESSON FOUR

What do fur seals eat?



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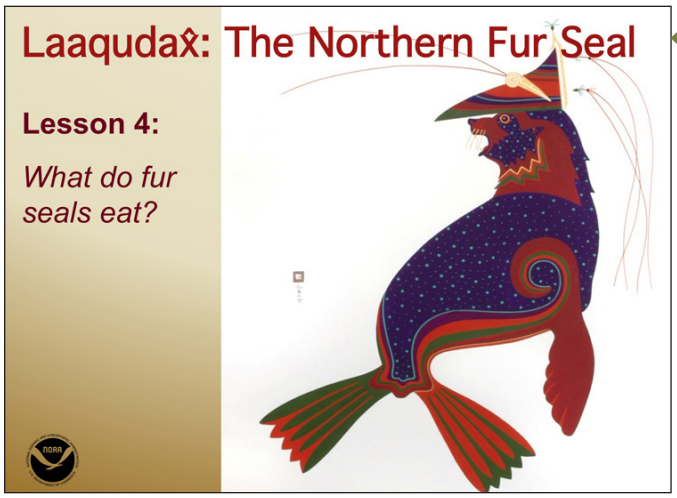


Lesson 4 gives an overview of what fur seals eat when they are at the rookery, traditional knowledge, and current scientific methods of studying fur seal food habits.

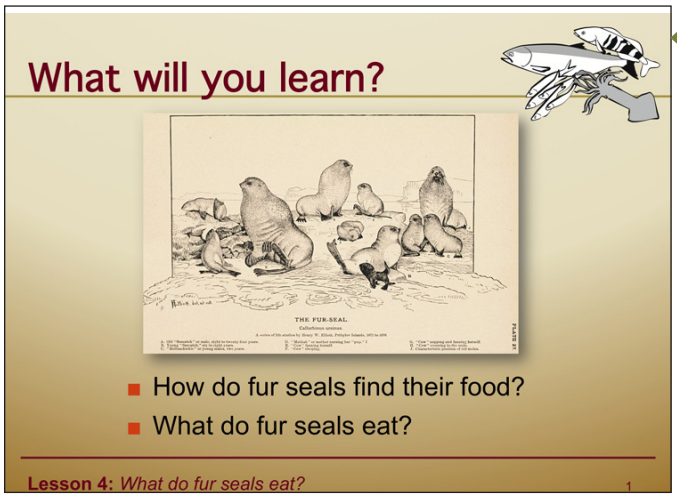


Image: Henry Wood Elliott illustration, The Fur Seal, University of Washington Library.

Fur seals find their food by foraging and diving while at sea. Most fur seals feed at night when fish and squid move closer to the surface. Fur seals large eyes are well suited for seeing underwater and in low light conditions. Their whiskers detect vibrations caused by prey moving in the water and they can hear very well.

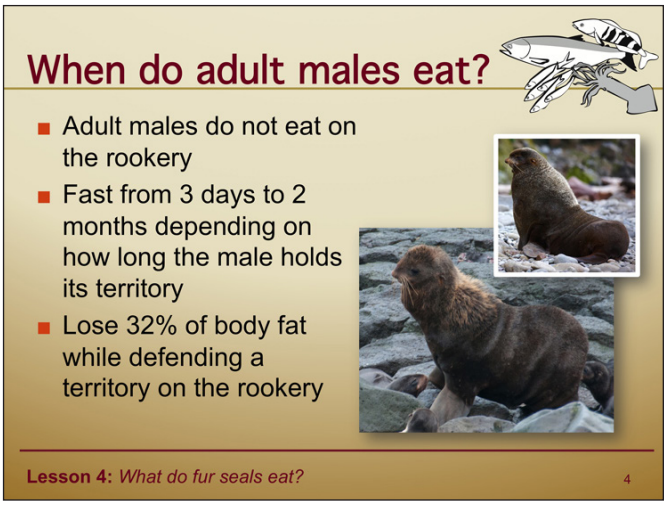
Listen to sounds created by sea creatures at Discovery of Sound in the Sea. www.dosits.org/audio/interactive

Photo: Paul Hillman, NOAA Ocean Media Center

Fur seals eat different fish in different places. The scat from St. Paul Island and St. George Island contain mostly pollock. Other prey species are squid, herring, salmon, and atka mackerel.

It is important to note that seals and humans are consuming the same species of fish and squid.

Photos: NOAA/AFSC website (http://www.afsc.noaa.gov/ABL/MSI/msi_sae_psf.htm)

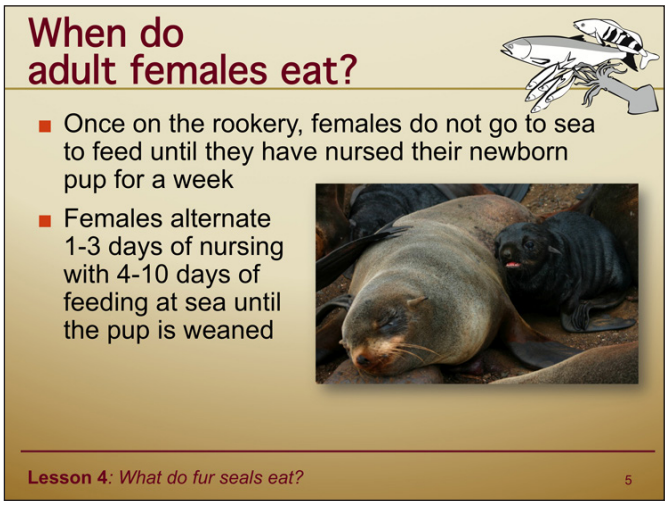


When do the different age groups eat?

Adult males on the rookery do not leave to eat; they fast for the whole time they are on the rookery. If a male left its territory to feed at sea, another male would move in and take over his territory. Males spend most of the winter feeding and gaining weight for the breeding season.

During the summer, non-territorial males and non-breeding males alternate between time on shore to rest and time at sea to feed.

Photos: thin male — Pam Goddard, Thalassa
inset — Mikhail Shlemov (Russian photographer) via Vladimir Burkanov, NOAA/AFSC/MML



The pup is nursed for about 4 months before it weans and starts feeding itself.

As the nursing pup gets older and needs more milk, the female goes out for a longer time to feed.

Females from different rookeries eat different fish and feed in different areas.

Photo: Jeremy Sterling, NOAA/AFSC/MML

What & when do pups eat?

- The pup drinks its mother's milk for the first 4 months
  - Milk is 49% fat, 37% water, 11% protein
  - Pups nurse for 1-3 days, then go without food for 4-10 days while their mothers are at sea feeding
  - Pups learn to eat fish and squid when they leave the rookery at 4 months

Lesson 4: *What do fur seals eat?* 6

Pups stay with their mom for one week after they are born, nursing every day. After the first week, the female goes out to sea to feed and to produce more milk; during that time, the pup stays in the rookery and fasts.

The female alternates feeding trips with one to three day visits ashore to nurse the pup.

After four months, the pup weans itself by leaving its mother; then it learns to hunt and feed itself.

Photo: nursing pup — Pam Goddard, Thalassa

Traditional Knowledge

- Pribilof fur seals used to eat more seal-fish (Northern smoothtongue)
- Fur seals from different rookeries eat different fish
- Fur seal meat may taste different depending on the diet of the fur seal
- Sea lions taste different than fur seals

Lesson 4: *What do fur seals eat?* 7

Northern smoothtongue (*Leuroglossus schmidti*), also known as smoothtongue, was called seal-fish by the Unangan because the seals ate these fish. Elders in the Pribilof Islands told stories that the fur seals ate more seal-fish in the past.

An elder from St. George Island who moved to St. Paul Island said that fur seals from St. George Island tasted different (better) than the fur seals from St. Paul Island. Many years later, scientists studying the diet of seals from the different islands and different rookeries found that the diet of fur seals from St. George contained more squid and salmon than the diet of fur seals from St. Paul Island.

Food habits studies of fur seals have also confirmed that fur seals from different rookeries tend to eat different food.

Source of traditional knowledge: Aquilina Lestenkof and St. Paul community members

Photo: Richard Hibpshman, NOAA/AFSC

How do we know?

- Traditional knowledge of fur seal food habits has been confirmed by scat collections
- Analysis of stomachs and intestines
- Analysis of fur, whiskers, and blood
- Observe nursing pups

Lesson 4: *What do fur seals eat?* 8

Historically, fur seals were killed for scientific purposes. Scientists collected stomachs from these seals to learn about their diets. Since the 1970s fur seals have not been killed for science.

Today fur seal diet information is collected while the seals are on the rookery.

- Scientists collect seal scat (poop), then wash it through sieves to find bones and squid beaks in the scat. These are identified to find out what fur seals eat.
- Bones and beaks are also measured to determine the size of fish and squid that the seals eat.
- Fur seal throw up (spew) large bones and squid beaks that cannot pass through the digestive tract. Scientists examine spews to identify fish and squid that are eaten.
- Stomachs and intestines from harvested animals are examined to see their contents.
- Chemical and fatty acid analyses of fur, whiskers and blood can provide information on the types of food that fur seals eat.

Photos: Paul Hillman, NOAA Ocean Media Center

Photos: Pam Goddard, Thalassa

Bering Sea Food Webs

OBJECTIVE

Students will be able to describe a marine food web and how it is different from a food chain.

TIME REQUIRED

30 minutes

BACKGROUND

Animals that eat other organisms are part of a food chain or food web. Each time an animal or plant is consumed, energy is transferred. The sun is the original source of energy in a food web or food chain.

Food chains are linear representations of energy transfers from one organism to another within an ecosystem. Food webs are many food chains linked together, modeling the complex relationships between animals in an ecosystem.

The Bering Sea is a diverse and complex ecosystem. According to The Center for Biological Diversity, the Bering Sea is home to 549 vertebrate species, of those, 418 are fish, 102 are birds, and 29 are marine mammals. All of these animals are consumers in the Bering Sea food web. The producers in this ecosystem are phytoplankton. As one animal consumes another or consumes phytoplankton, energy is transferred. Humans are the top consumers in the Bering Sea food web.

NOTE: This activity was adapted from "*Weaving the Web*" by the United States Department of Agriculture (USDA), ngss.nsta.org/Resource.aspx?ResourceID=93.

MATERIALS

- Yarn - one ball or skein, any color
- Pictures, stuffed animals or index cards with illustrations created by the students:
  - Sun
  - Phytoplankton
  - Zooplankton
  - Pacific sand lance
  - Northern smooth tongue
  - Pacific herring
  - Baleen whale
  - Salmon
  - Squid
  - Pacific cod
  - Walleye pollock
  - KIller whale
  - Northern fur seal
  - Human

PROCEDURE

- Use Worksheet 4.1.1 as a pre or post-assessment
- Ask if students know what a food web is. Describe how a food chain shows the transfer of energy from one organism to another and a feed web is multiple chains linked together in an ecosystem. Emphasize that plants make their own energy from the sun, and the sun is at the beginning of a food chain.
- Hand each student an image from the from the ones provided below or ask the students to research one of the components listed above and create their own image. If you have more students than images, you can have the students represent different types of phytoplankton or zooplankton.
- Once each student has an image, create a food chain with the yarn and images.
- **Food Chain**: Give one end of the yarn to the person who represents the sun. From the sun make the connections to primary producers (phytoplankton) and then consumers (everything else), with each person in the chain holding on to the yarn. Cut the piece of yarn when you reach the top predator. Some food chains will be shorter than others.
- Repeat these steps until everyone is holding a piece of yarn.
- Ask the students what will happen if one organism in a chain dies, e.g., walleye pollock.
- Remove an organism and everything that eats it from a food chain or cut the piece of yarn between the organism and its food source.

DISCUSSION

- What do all the food chains have in common?

  All of the food chains start with sun, phytoplankton, and zooplankton.

- What happens when one of the consumers is removed from the food web?

  Every organism that ate the consumer dies.

- What happens when the phytoplankton are removed?

  Everything dies.

Bering Sea Food Webs

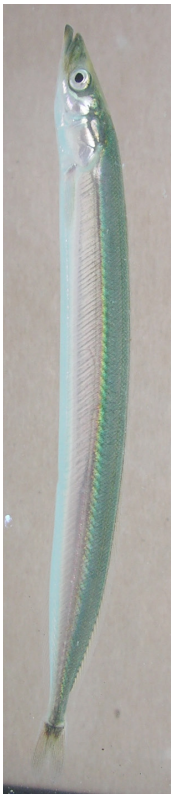
EXTENSION

- Using a different color yarn (e.g., green to represent money), add an economic chain to the food web. Include fishermen, processing plants, ports, grocery stores.
- Make a food chain or web of each student's favorite food.
  - Example: if the favorite food is macaroni and cheese, talk about what the main ingredient is in macaroni noodles (wheat) and where cheese comes from (milk, from a cow), and then draw a food chain:
    - Macaroni: Sun, wheat (which is made into pasta), STUDENT
    - Cheese: Sun, plants, cow (makes milk which is made into cheese), STUDENT

Sun

phytoplankton

zooplankton



Pacific sand lance

Pacific herring

northern smooth-tongue

squid

Pacific cod

walleye pollock

salmon

killer whales

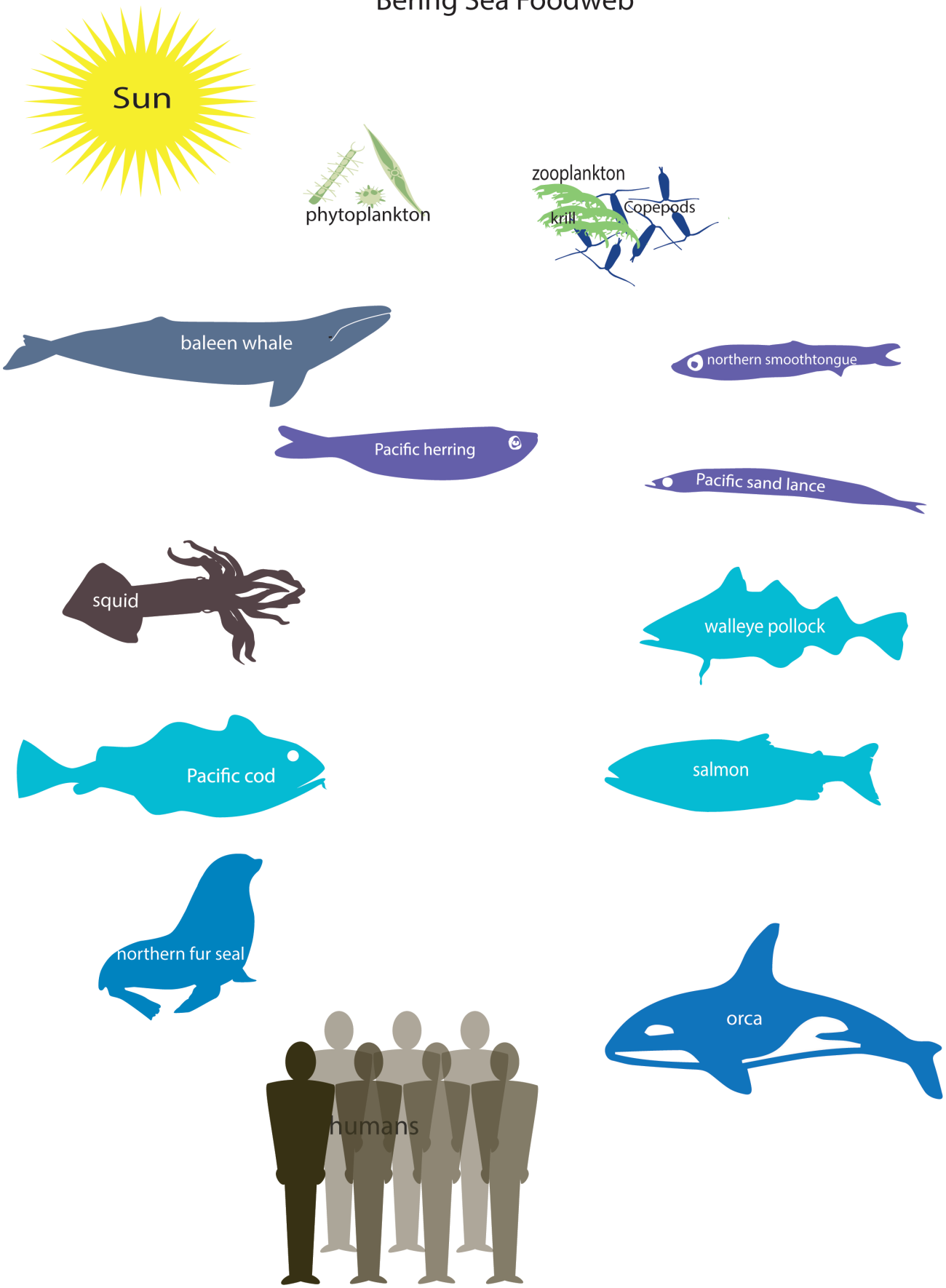
northern fur seal

humpback (baleen) whales

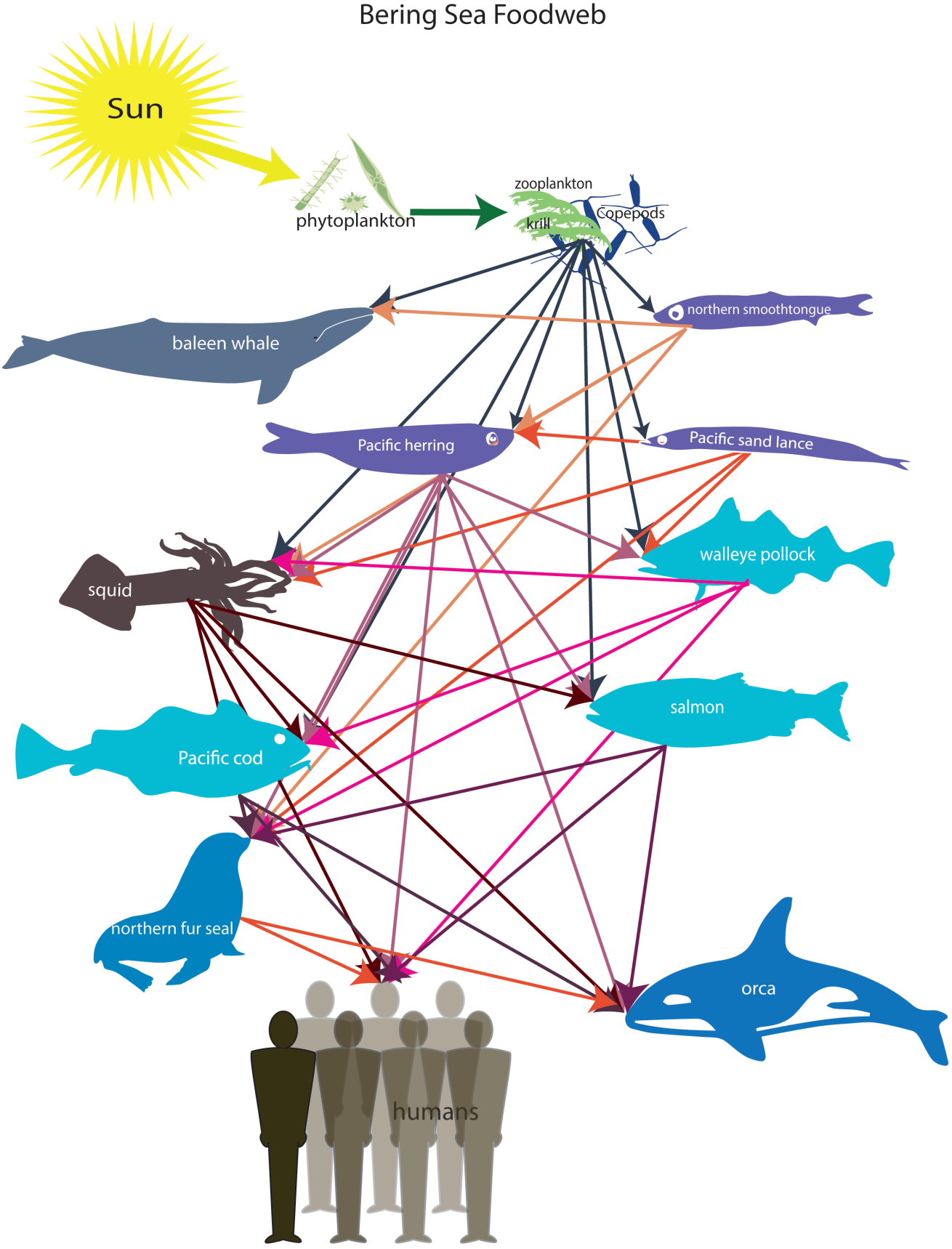
humans

LAB 4.1 WORKSHEET 4.1.1 Bering Sea Food Web

Bering Sea Foodweb



Bering Sea Foodweb



LESSON FOUR **LAB 4.2 SCIENCE/WRITING** **Grade Level 7–12**

Microworlds: What do Marine Mammals Eat?

OBJECTIVE

Students will be able to describe how scientists study northern fur seal food habits and what the seals eat.

TIME REQUIREMENT

10 minutes for video

20 minutes discussion

BACKGROUND

Fur seals spend most of their lives at sea. When they are on land they do not eat. Scientists have used many different ways to study fur seal food habits. This video of Dr.Tony Orr from the NOAA Fisheries' Alaska Fisheries Science Center explains how Tony studies the diets of northern fur seals and sea lions.

This video and discussion can be used as an introduction to the hands on labs that follow.

MATERIALS

- NOAA Microworlds: What do Marine Mammals Eat? DVD or website

PROCEDURES

Watch “What do marine mammals eat?”

DISCUSSION

Discuss or write about the following.

- Why is it so hard to study what marine mammals eat?
  - Instruments are expensive: underwater video cameras, satellite tags
  - Marine mammals move quickly: very hard to follow under water, dive to great depths
  - Marine mammals eat underwater: do not bring food to the surface, feed at night or in deep water
- In the video Tony mentions he studies northern fur seal food habits by using scats, spews, and hair. What are different ways scientists study northern fur seals diets?
  - DNA from scat
  - Animal tissue (whiskers, blood, hair, blubber)
- Why is it so important to know what they eat?
  - Fishing pressure
  - Competing with humans for food
  - Learn why population is declining
  - Changes in diet could indicate changes in ecosystem

RESOURCES

NOAA Microworlds: What do Marine Mammals Eat? DVD or website
http://www.youtube.com/watch?v=Ntu_x9JkrxI

LESSON FOUR | LAB 4.3 SCIENCE | Grade Level 7–8

Scat Detective

OBJECTIVE

Students will examine scats, tally the data, and produce frequency histograms.

TIME REQUIREMENT

50 minutes

BACKGROUND

Fur seals eat many different types of fish and sometimes they eat birds. One of the ways scientists study fur seal food habits it by examining their scat. Scat is also called feces or poop. Each summer, scat is collected from rookeries, frozen, and then shipped back to the lab for further examination. After all of the organic material has been washed away the bony parts of the fur seal's prey is left behind. Many of the bony or hard parts can be traced back to a specific species of fish, squid, or octopus. The parts that survive traveling through the digestive tract of a fur seal are:

- Otoliths (fish earbones)
- Fish bones
- Fish eye lenses
- Squid or octopus beaks (mouth parts)

By using extensive reference collections located at the Alaska Fisheries Science Center, scientists are able to identify species of fish, squid, or octopus that the bones, otoliths, lenses, or beak come from. We call the scientists Scat Detectives.

MATERIALS

- Images of prey items (Appendix VI, page 115)
- 10 small bags (plastic or cloth) or paper envelopes
- Otolith, bone, and fish reference keys (Appendix VII, page 124)
- Graph paper or spreadsheet software

PROCEDURE

Preparing the scats

This should be completed at least one day before you teach the lesson.

1. Print and cutout the images of otoliths, bones, and beaks provided in Appendix VI.
2. Label each bag with the with a unique letter or number. Keep track of how many prey items are in each bag.
3. Cut out the individual images.
4. Fill up the bags with images of prey items.
5. There are two ways to fill up the bags with prey items.

   Mix up all of the prey items and randomly assign them to the 10 bags.

   Create a table and decide how many of each species you want to assign to each bag. Keep the table for future years.
6. Before filling the bags with prey items, label each item with the bag number and Island code. This will help with organization once the students start opening the bags.
7. Distribute filled bags to students groups along with worksheet 4.3.1.

Analyze the data using a frequency histogram

1. Using the reference keys, ask the students to identify the bones, otoliths, and beaks in their bags.
2. Complete Worksheet 4.3.1
3. Have group of students graph the result for their scat bag. The x-axis should be the species and the y-axis is the frequency or total.
4. Now consolidate the data for the class and make another graph.

DISCUSSION

Did all of the scats contain the same species?

No

How were the individual scats different from the class total?

The individual scats did not contain all of the species. Some scats had more bones or otoliths than others.

Why do you think the seals would eat different prey?

Their diet depends on where they forage or eat. Seals from different rookeries feed in different areas. It also depends on what species are available when the seal was feeding.

Scat Detective

What is an otolith and why is it useful in identifying fish?

Otoliths are the inner ear bones (or ear stones) of fish. Each fish has three sets of otoliths; one otolith in each set is located on each side of the head. The largest set of otoliths is useful in identifying fish because these bones are distinctive for each fish species and they are usually not degraded too much by the digestion process.

Why is it important to figure out what marine mammals are eating?

To see how fisheries, contaminants, or the availability of prey impact marine mammal populations.

What might happen if marine mammals and humans eat the same thing?

If humans and marine mammals are competing for the same food, the marine mammals might be able to switch to another prey species. If not, humans might have to set limits on when and where they fish to ensure there is enough food for the marine mammals.

EXTEND AND EXPLORE

Research the species on the reference keys and answer some of the following questions. A good place to start is FishBase, www.fishbase.org.

1. Where is the species found?
2. How big does it get? How many would a fur seal have to eat to fill up?
3. Is the species commercially harvested in Alaska or off the West Coast? If yes, what time of the year is it harvested? What size fish are the fishermen targeting?

NOTE: It takes time to cut out all of the images and put them in bags. Start the preparation for this Lab one or two days before you plan on teaching it.

Number of Images to print	Pacific sand lance	Pacific herring	salmon	northern smooth-tongue	Atka mackerel	squid	Pacific cod	walleye pollock
Bones	5	6	2	3	3		5	42
Otoliths	3	2	1	3	4		2	28
Beaks						15		
Total	8	8	3	6	7	15	7	70

LAB 4.2 WORKSHEET 4.3.1 Scat Detective

Student Name:_____

Scat Bag #: _____

Place a tally mark for each item that is present in your bag.

Species Name	bones or beaks	otoliths	Total
walleye pollock			
Pacific cod			
Atka mackerel			
Pacific herring			
Pacific sand lance			
Northern smoothtongue			
coho salmon			
squid			

Class Total

Total # of scat bags: _____

Species Name	# bones	# otoliths or beaks	Total
walleye pollock			
Pacific cod			
Atka mackerel			
Pacific herring			
Pacific sand lance			
Northern smoothtongue			
coho salmon			
squid			

LAB 4.3 TEACHER KEY 4.3.1 Scat Detective

Student Name: EXAMPLE

Scat Bag #: 32

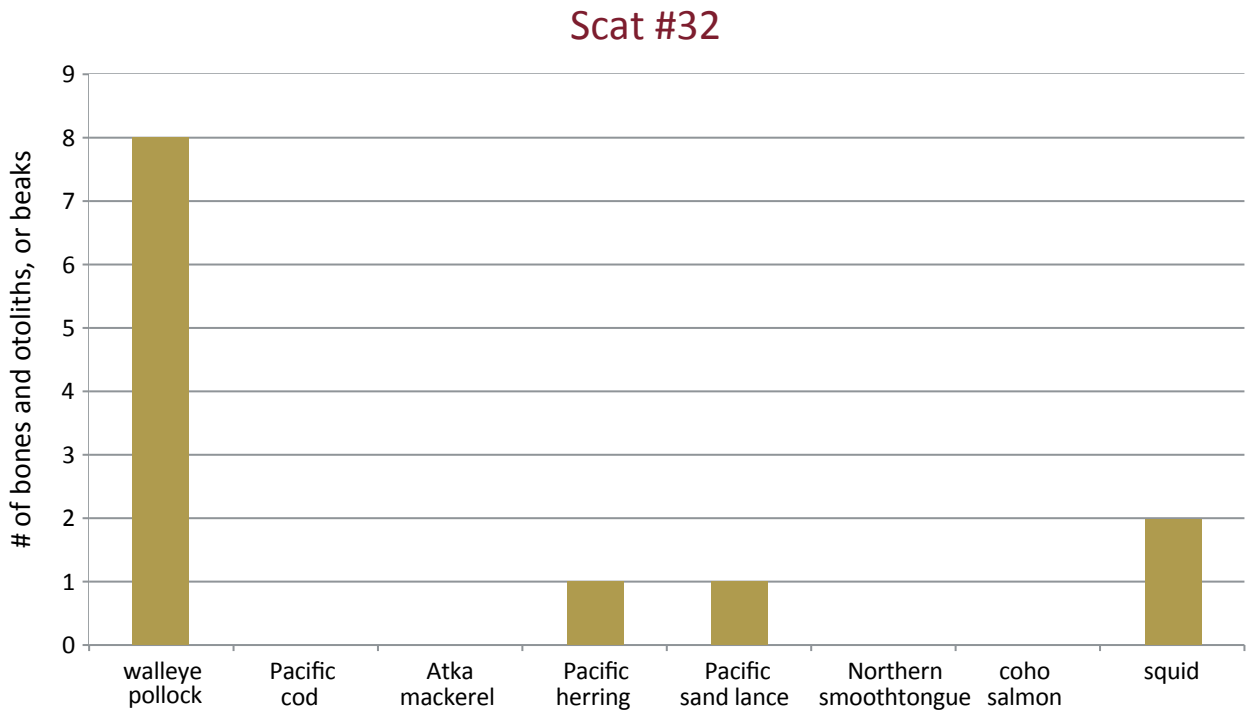
Place a tally mark for each item that is present in your bag.

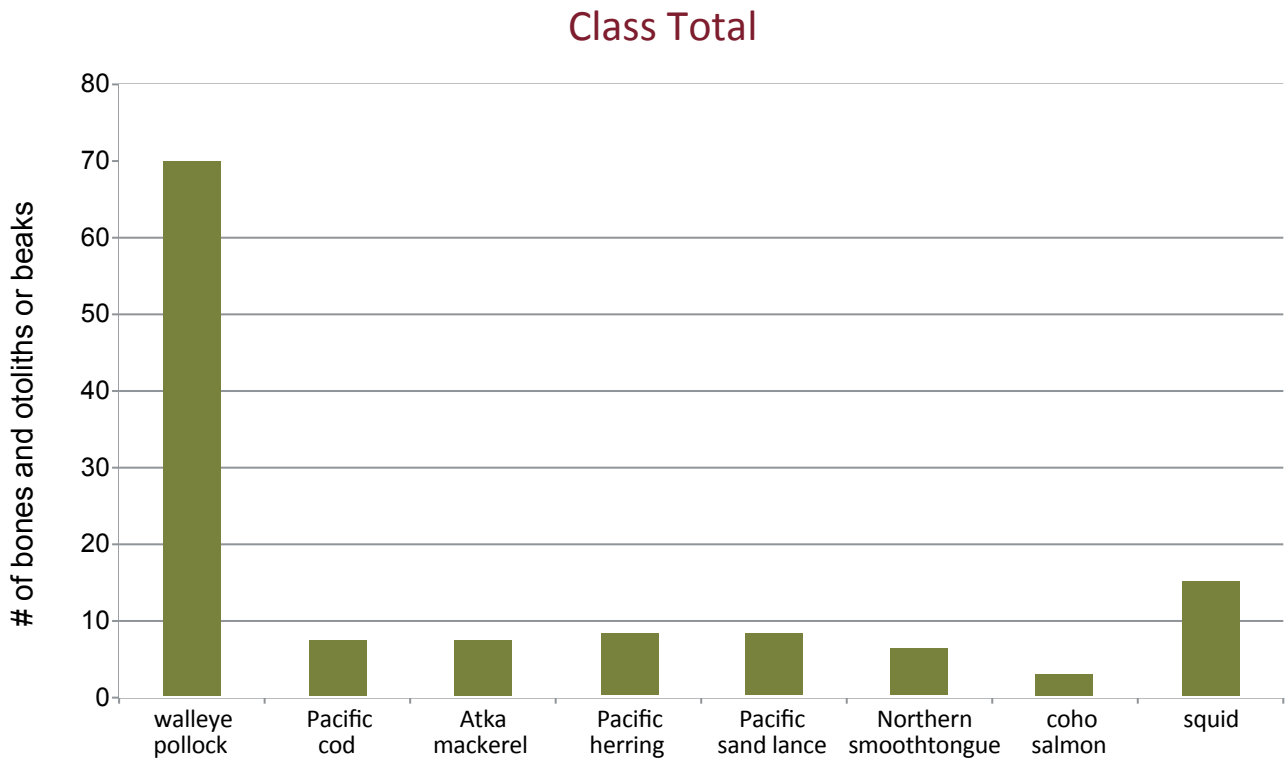
Species Name	bones	otoliths or beaks	Total
walleye pollock	𝍸 I	II	𝍸 III
Pacific cod	𝍸 I		
Atka mackerel			
Pacific herring	I		I
Pacific sand lance	I		I
Northern smoothtongue			
coho salmon			
squid		II	II

Class Total EXAMPLE

Total # of scat bags: 10

Species Name	# bones	# otoliths or beaks	Total
walleye pollock	42	28	70
Pacific cod	5	2	7
Atka mackerel	3	4	7
Pacific herring	6	2	8
Pacific sand lance	5	3	8
northern smoothtongue	3	3	6
coho salmon	2	1	3
squid		15	15


Scat #32
# of bones and otoliths, or beaks
0
1
2
3
4
5
6
7
8
9
walleye pollock
Pacific cod
Atka mackerel
Pacific herring
Pacific sand lance
Northern smoothtongue
coho salmon
squid


Class Total
# of bones and otoliths or beaks
0
10
20
30
40
50
60
70
80
walleye pollock
Pacific cod
Atka mackerel
Pacific herring
Pacific sand lance
Northern smoothtongue
coho salmon
squid

Scat Detective and Frequency of Occurrence

OBJECTIVE

Students will use data provided by the Alaska Fisheries Science Center to analyze northern fur seal scats.

Students will use frequency of occurrence to analyze the data from two different rookeries and compare the results

TIME REQUIRED

50

BACKGROUND

Fur seals eat many different types of fish and squid. One of the ways scientists study fur seal food habits is by examining their scat. Scat is also called feces or poop. Scat is collected from the rookery, frozen, and shipped back to the lab for analysis. After all of the organic material is washed away, the bony parts of the fur seal prey are left behind. Many of the bony parts can be traced back to specific species of fish, squid, or octopus. The parts that come through the digestive track of a fur seal are:

- Otoliths (fish earbones)
- Eye lens
- Fish bones
- Squid or octopus beaks (mouth parts)

Scientist use both frequency and frequency of occurrence to analyze prey consumption of marine northern fur seals.

Frequency is the number of items or individuals a specific animal or group of animals consumed.

Frequency of Occurrence (FO) is gives an estimate of how often a prey species is eaten. It does not represent the volume or weight of the prey consumed only the presence or absence of prey and the number of species consumed.

The table on page 23 contain actual food habits data from scats collected on Vostochni and Zapadni rookeries on St. Paul Island. Students will use this data to calculate and plot prey frequency and prey frequency of occurrence (FO).

MATERIALS

- Lab 4.4 Data Key on page 27
- Images of prey items (Appendix VI)
- Worksheet 4.4.1
- 20 plastic bags or envelopes
- Teacher Key (Excel File) NFS_Lab 4.4_Scat_Rookery_TeacherKey_2017.xlsx

PROCEDURES

- Photo copy and cut out the necessary number of images for each prey
- Use the table belowto determine how many images of each prey item are needed to fill enough bags for your class.
- Fill each bag with the number of prey items listed in the table. You can use a combination of otoliths and bones to fill the bags.
- Give each student a bag and a copy of Worksheet 4.4.1
- Have each student record the data from their bag in the first table.
- Tally the class data.
- Graph your results. Species is on the x-axis and frequency is on the y-axis.

DISCUSSION

- What species occurred most frequently?

  Pollock

- What species occurred the least?

  Depends on the rookery

  Vostochni - salmon

  Zapadni - Atka mackerel, sand lance

- Are there commercial fisheries for any of the fish found in the scats?

  Yes, there are commercial fisheries for pollock, Pacific cod, Atka mackerel, Pacific herring, and salmon.

- Why is it important to know what marine mammals eat?

  Knowing what marine mammals eat helps scientists manage the oceans as an ecosystem. It also allows managers to determine if fisheries, contaminants, or availability of prey impact marine mammal populations.

- Why is it important to know what fur seals from different rookeries are eating and whether their prey are also targets of commercial fisheries?

  If seals are eating species that are also being commercially fished, there may be competition between the fisheries and fur seals.

Scat Detective and Frequency of Occurrence

- What might happen if marine mammals and humans eat the same thing?

  If humans and marine mammals are competing for the same food, the marine mammals might be able to switch to another prey species. If not, humans might have to set limits on when and where they fish to ensure there is enough food for the marine

EXTEND AND EXPLORE

Research the species on the reference keys and answer some of the following questions. A good place to start is FishBase, www.fishbase.org.

- Where is the species found?
- How big does it get?
- What is the energy content of the fish? How many calories does it provide? Example: Conduct a Google search on "walleye pollock calories". Use the United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference to look up the calorie content of individual fish species (https://ndb.nal.usda.gov/ndb/search/list).

  walleye pollock 100 g = 70 Calories

  Atka mackerel 100 g = 158 Calories

  Pacific herring 100 g = 195 Calories

  Pacific sand lance 100 g =

  northern smoothtonge 100 g =

  salmon (coho) 100 g = 146

  squid 100 g = 92 Calories

- Compare the calorie contents of the different fish. Which ones provide more calories?
- Compare different species. Which species provides the most calories per gram of body weight?
- Is the species commercially harvested in Alaska or off the West Coast? If yes, what time of the year is it harvested? What size fish are the fishermen targeting?

LAB 4.4 DATA KEY Scat Detective and Frequency of Occurrence

Rookery: Vostochni	Pacific sand lance	Pacific herring	salmon	northern smooth-tongue	Atka mackerel	squid	walleye pollock	Total
Scat # 1		1					7	8
Scat #2	1	1					7	9
Scat #3	1		1				6	8
Scat #4	1	1				1	5	8
Scat #5						1	7	8
Scat #6		1					7	8
Scat #7	1	1				1	5	8
Scat #8	5	1					3	9
Scat #9		1					4	5
Scat #10	1		1			1	4	7
Total	10	7	2	0	0	4	55	78
Rookery: Zapadni	Pacific sand lance	Pacific herring	salmon	northern smooth-tongue	Atka mackerel	squid	walleye pollock	Total
Scat # 1				1		1	8	10
Scat #2		1				1	6	8
Scat #3	1		2			5	1	9
Scat #4					1	1	6	8
Scat #5			1				7	8
Scat #6				1			7	8
Scat #7			1			1	7	9
Scat #8	1	1					8	10
Scat #9						2	6	8
Scat #10				1		1	6	8
Total	2	2	4	3	1	12	62	86

Number of Images to print	Pacific sand lance	Pacific herring	salmon	northern smooth-tongue	Atka mackerel	squid	walleye pollock
Total	12	9	6	3	1	16	114

LAB 4.4 WORKSHEET 4.4.1 Scat Detective and Frequency of Occurrence

Student Name:_____

Rookery:_____

Scat Bag #: _____

Place a tally mark if the items from the prey are in your bag.

Species Name	bones, beaks, or otoliths
Pacific sand lance	
Pacific herring	
salmon	
northern smoothtongue	
Atka mackerel	
squid	
walleye pollock	
Total	

Class Total and Frequency of Occurrence

Rookery:_____

Total # of scat bags: _____

Species Name	Total Frequency for Rookery	# of scat bags with bones, beaks or otoliths	FO= (# of scats with bones or otoliths/ total # of scats) *100
Pacific sand lance			
Pacific herring			
salmon			
northern smoothtongue			
Atka mackerel			
squid			
walleye pollock			
Total			

LAB 4.4 TEACHER KEY Scat Detective and Frequency of Occurrence

Student Name:_____

Rookery: Zapadni

Scat Bag #: 8

Place a tally mark if the items from the prey are in your bag.

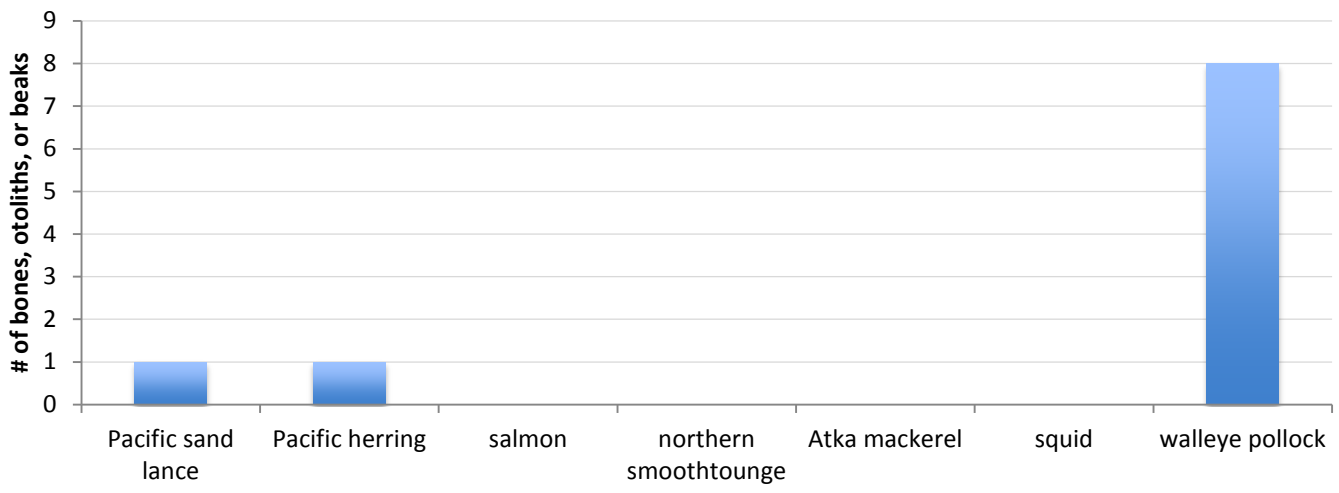
Species Name	bones, beaks, or otoliths
Pacific sand lance	1
Pacific herring	1
salmon	0
northern smoothtongue	0
Atka mackerel	0
squid	0
walleye pollock	8
Total	10

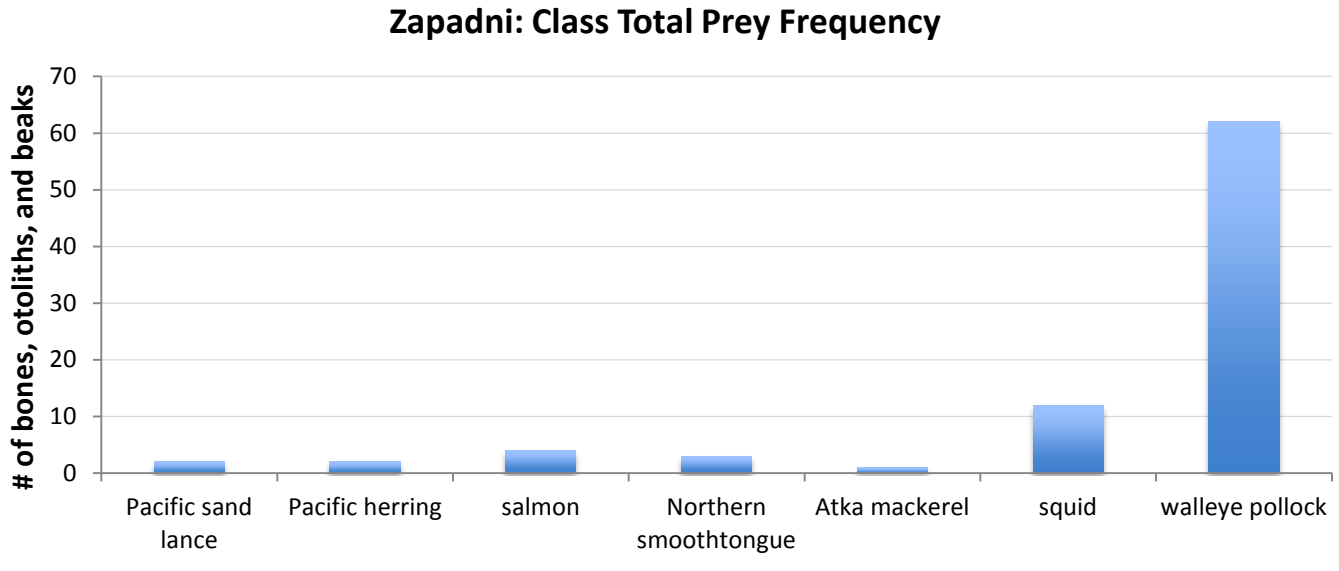
Class Total and Frequency of Occurrence

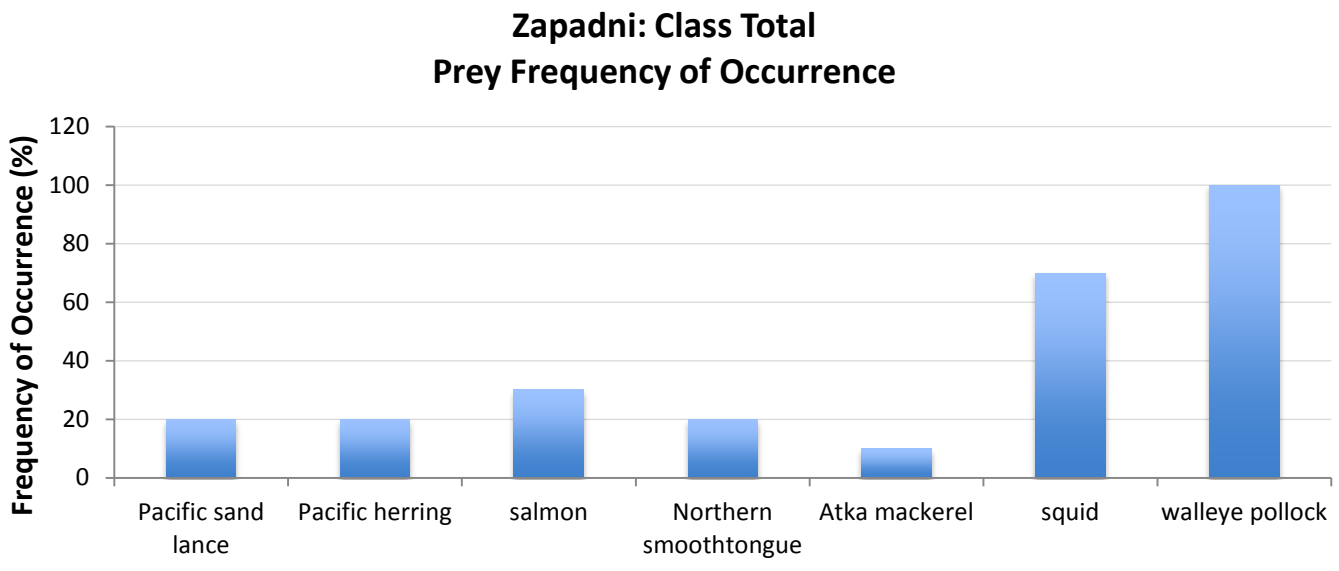
Rookery: Zapadni

Total # of scat bags: 10

Species Name	Total Frequency for Rookery	# of scat bags with prey items present	FO= (# of scats with bones or otoliths/ total # of scats) *100
Pacific sand lance	2	2	2/10*100 = 20
Pacific herring	2	2	2/10*100 = 20
salmon	4	3	3/10*100 = 30
northern smoothtongue	3	2	2/10*100 = 20
Atka mackerel	1	1	1/10*100 = 10
squid	12	7	7/10*100 = 70
walleye pollock	62	10	10/10*100 = 100
Total	78	10	


Zapadni: Prey Frequency Scat #8
# of bones, otoliths, or beaks
0
1
2
3
4
5
6
7
8
9
Pacific sand lance
Pacific herring
salmon
northern smoothtounge
Atka mackerel
squid
walleye pollock


Zapadni: Class Total Prey Frequency
# of bones, otoliths, and beaks
0
10
20
30
40
50
60
70
Pacific sand lance
Pacific herring
salmon
Northern smoothtongue
Atka mackerel
squid
walleye pollock


Zapadni: Class Total
Prey Frequency of Occurrence
Frequency of Occurrence (%)
0
20
40
60
80
100
120
Pacific sand lance
Pacific herring
salmon
Northern smoothtongue
Atka mackerel
squid
walleye pollock

LAB 4.4 TEACHER KEY Scat Detective and Frequency of Occurrence

Student Name:_____

Rookery: Vostochni

Scat Bag #: 8

Place a tally mark if the items from the prey are in your bag.

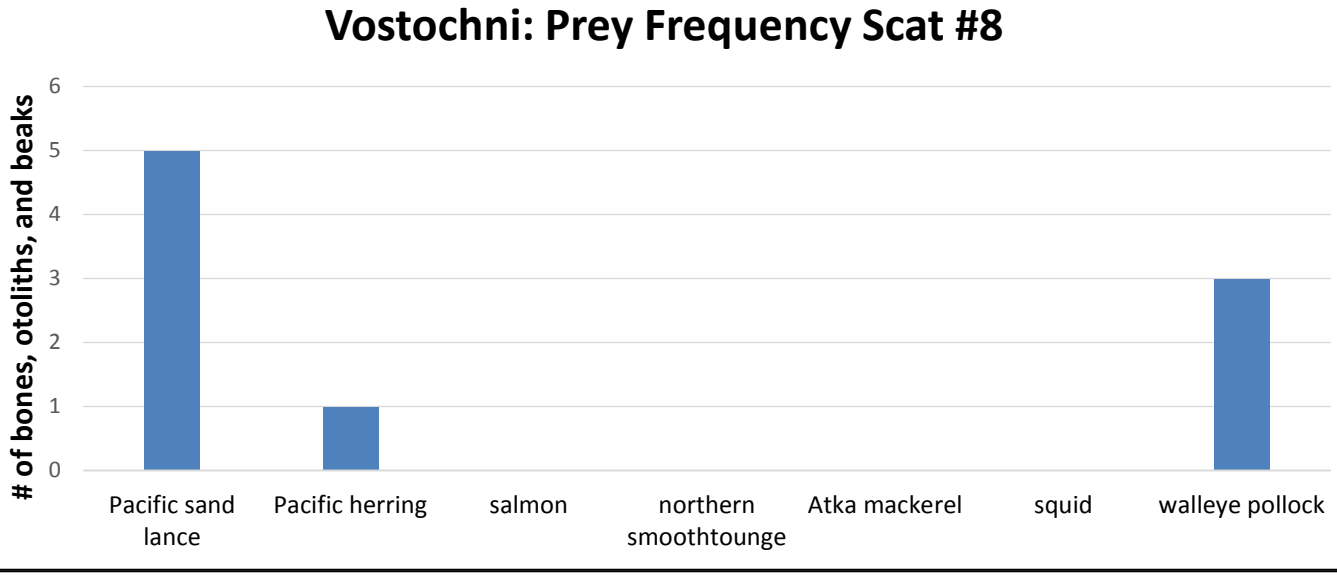
Species Name	bones, beaks, or otoliths
Pacific sand lance	5
Pacific herring	1
salmon	0
northern smoothtongue	0
Atka mackerel	0
squid	0
walleye pollock	3
Total	9

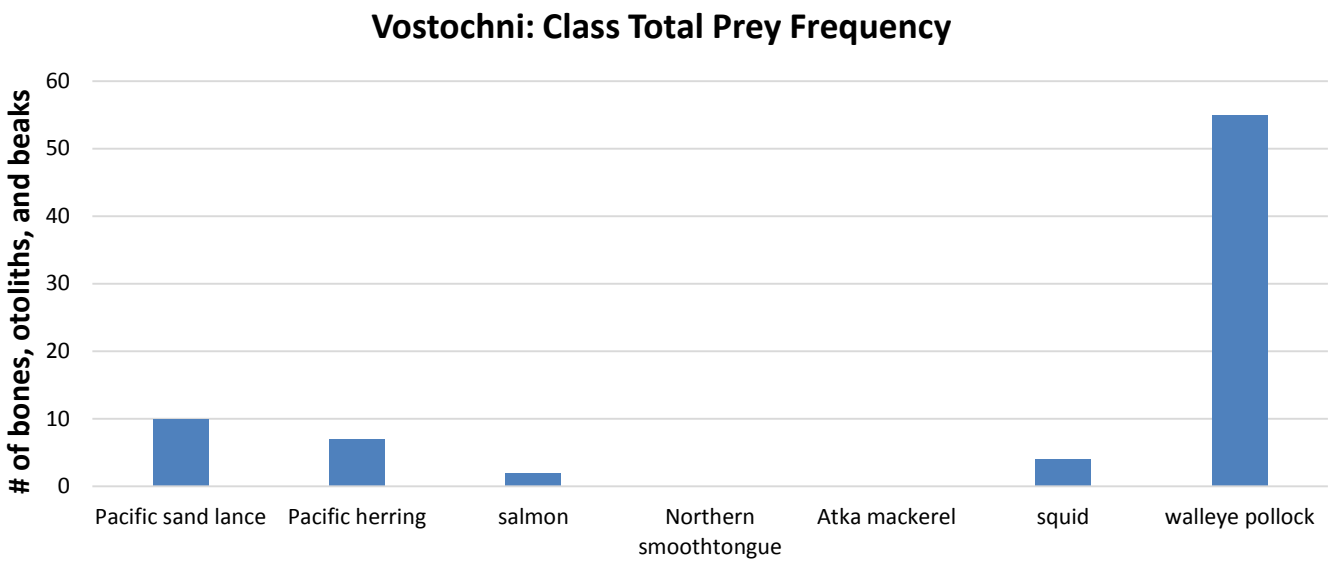
Class Total and Frequency of Occurrence

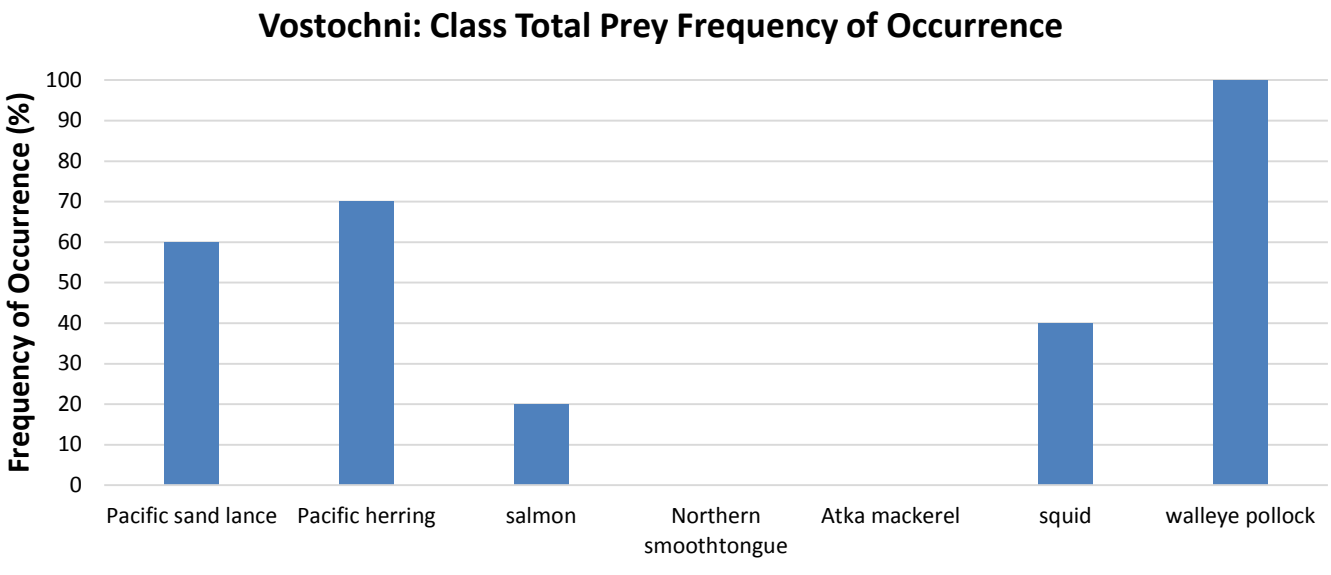
Rookery: Vostochni

Total # of scat bags: 10

Species Name	Total Frequency for Rookery	# of scat bags with prey items present	FO = (# of scats with bones or otoliths/ total # of scats) *100
Pacific sand lance	10	6	6/10*100 = 60
Pacific herring	7	7	7/10*100 = 70
salmon	2	2	2/10*100 = 20
northern smoothtongue	0	0	0
Atka mackerel	0	0	0
squid	4	4	4/10*100 = 40
walleye pollock	55	10	10/10*100 =1 00
Total	78	10	


Vostochni: Prey Frequency Scat #8
# of bones, otoliths, and beaks
0
1
2
3
4
5
6
Pacific sand lance
Pacific herring
salmon
northern smoothtounge
Atka mackerel
squid
walleye pollock


Vostochni: Class Total Prey Frequency
# of bones, otoliths, and beaks
0
10
20
30
40
50
60
Pacific sand lance
Pacific herring
salmon
Northern smoothtongue
Atka mackerel
squid
walleye pollock


Vostochni: Class Total Prey Frequency of Occurrence
Frequency of Occurrence (%)
0
10
20
30
40
50
60
70
80
90
100
Pacific sand lance
Pacific herring
salmon
Northern smoothtongue
Atka mackerel
squid
walleye pollock

Advanced Scat Detective

OBJECTIVE

Students will use pivot tables and graphing to calculate prey frequency of occurrence from multiple rookeries and compare the results.

TIME REQUIRED

50

BACKGROUND

Based on the data collected in Lab 4.4 Frequency of Occurrence (FO) is one way scientists analyze fur seal food habit data. It does not represent the volume or weight of the prey consumed only the presence or absence of prey and the number of species consumed.

Frequency vs Frequency of Occurence (FO) or Percent (%) Frequency

- Frequency of Occurrence (FO) or percent frequency – is a percentage that indicates how often the species is found in a collection of scats. Frequency of occurrence is used in food habits analysis to determine what fur seals and other marine mammals eat.

MATERIALS

- Computers with spreadsheet software installed
- Student file: NFS_Lab_4.5_Advanced_SD_Student.xlsx
- Teacher Key: NFS_Lab_4.5_Advanced_SD_TeacherKey.xlsx

PROCEDURES: GRAPHING

The data has already been put into pivot tables and converted to Frequency of Occurrence (FO).

- Open Excel file: 'Laaqudax_Lab4.5_Student.xlsx'
- The data has already been put into pivot tables. The sheet labeled '1992 data' has an example of a frequency graph and a frequency of occurrence plot.
- Using the directions on sheet 'Graphing' create new plots for each year.
- Compare frequency to frequency of occurrence (FO).

PROCEDURE: ADVANCED GRAPHING

Feeling brave! Start from scratch.

- Use the 'Save as' function to save the file with a new name
- Put the data into pivot tables, calculate FO, and graph the results.
- Group Fish, Create Pivot Tables, and Plot Data
- Copy the raw data to a new sheet named "Grouped" or something similar.
- Highlight all of the data on the worksheet.
- Go to the "Tools" menu and select "Sort."
- Select the column labeled "Classification" and then select ascending.
- Select 'Sort' to sort the data alphabetically by species name.
- Insert a new column.
- Copy the Species names into the new column.
- Using the data provided discuss what species were found. Come up with different groupings of similar species. Rename the cells in the new column to reflect your new groups.
- Now sort that data again by 'YR' or year.
- Copy and paste all of the data for each year into the sheet labeled for each year.
- Create a Pivot Table and graphs for each year using the instructions on the sheet labeled 'Graphing' in the Excel workbook.
- Once you have a graph for each year they can be copied to the sheet labeled 'Graphs' to compare and contrast the results.
- QUESTIONS
- How many different species of identifiable fish were found in the scat for 1992, 1994, 1995, and 1996?
- How many different samples were collected?
- Plot the data by rookery. Do the seals from different rookeries have the same diet?

DISCUSSION

- How many different species of identifiable fish were found in the scat for 1992, 1994, 1995, and 1996?
- How many different samples were collected?
- What species was consumed the most? Is this species commercially fished?

Advanced Scat Detective

EXPLORE AND EXTEND

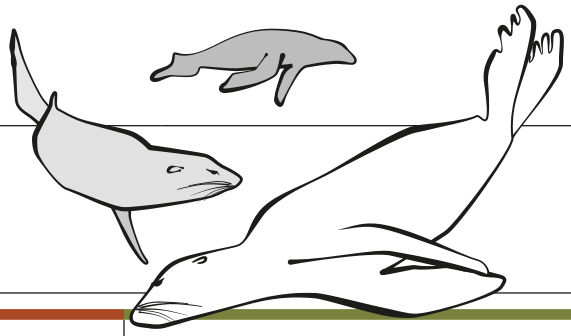
- Compare and contrast the data from year to year.
- What species or groups of fish do fur seals mostly eat?
- What is the largest fishery in the United States?

  Alaska walleye pollock
- What happens when humans and animals compete for the same resource or prey?

  Humans have to actively manage the catch limits to ensure a viable population for all consumers.

LESSON FIVE

How do fur seals dive?



Subject Area(s): Life science	**Grade Levels:** 7-12	Presentation – 15 minutes Labs – variable

Lesson Topics:	Fur seal diving and adaptations to cold environments.	**Focus Questions**	• How are pinnipeds adapted to cold water? • Why do fur seals dive? • What can be learned from studying diving behavior?
Learning Objectives:	Students will: • investigate adaptations of seals to water • collect and summarize data • interpret fur seal dive data	**Key words:**	blubber, body shape, forage, adaptation, counter-current heat exchange, thermoregulation

LABS		ALASKA STANDARDS					
		Math 7	Math 8	Math 9-12	Science	Minutes	Grades
Lab 5.1	How do Marine Mammals Stay Warm? Blubber vs. Air (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2	30	7–12
Lab 5.2	Thermoregulation: Counter Current Heat Exchange (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2 SG2	50	9-12
Lab 5.3	Waiting to Inhale! (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2 SG2	50	7–12
Lab 5.4	Interpreting Fur Seal Dive Data (data analysis)	7.SP.1-4	8.SP.1-4	S-IC.	SA1,2 SC1,2 SG2	50	9-12

Targeted Alaska Grade Level Expectations (GLEs)

Math

MD Measurement and Data
SP Statistics and Probability
Statistics: IC.1

Science

Science as Inquiry and Process

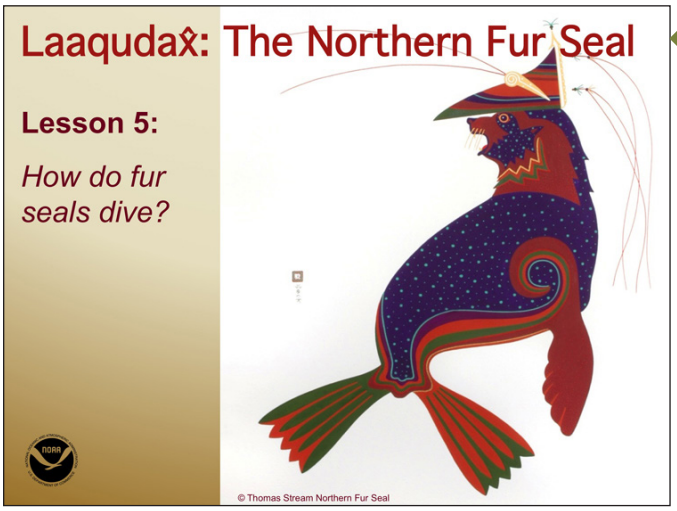
SA1; SA2

Concepts of Life Science

SC2

History and Nature of Science

SG2



Lesson 5 contains a brief overview of how seals are adapted to the water and how they are adapted to dive, how deep they dive, and what we can learn from this information.

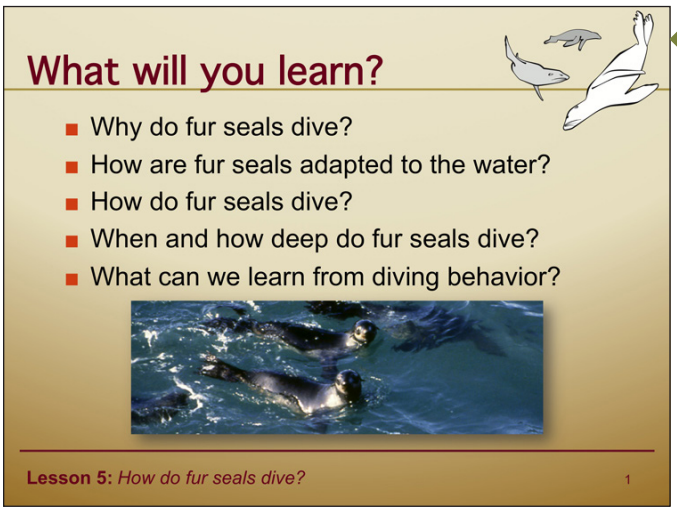
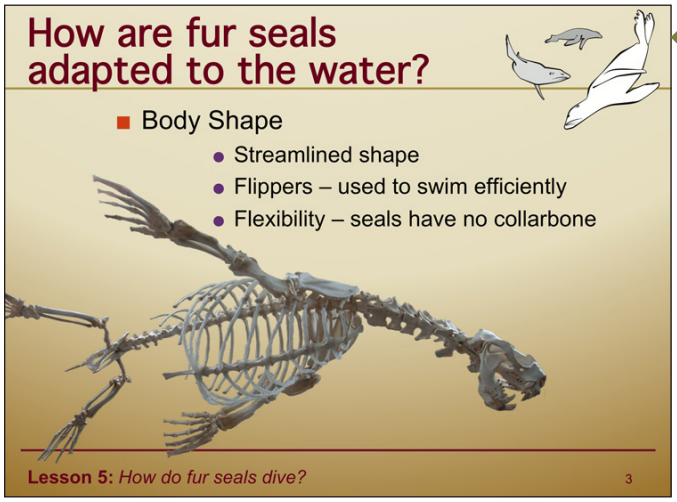


Photo: NOAA/NMFS/AFSC/MML, Observer Training PowerPoint

Fur seals dive primarily to search for food, and while traveling.

Photo: Paul Hillman, NOAA Ocean Media Center

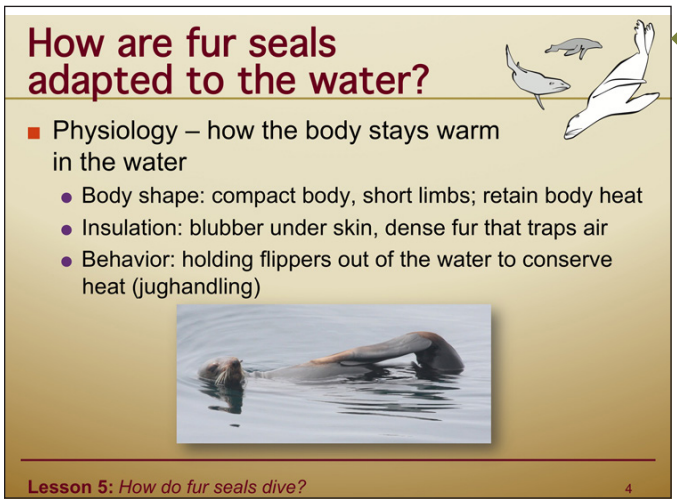


Pinnipeds spend over half their lives in the water, so their bodies are adapted to the water in many ways. The next several slides give an overview of some of the major adaptations to the water: body shape, ability to stay warm in water and cool on land, ability to see and hear underwater.

Pinnipeds have a streamlined body shape with relatively short, wide flippers (compared to the legs of a terrestrial animal like a horse). The body is also very flexible.

- Because of the sleek, streamlined body, seals can move swiftly through the water with little drag. The ears and tail are small so that they don't cause resistance in the water.
- Flippers help efficiently propel the body through water, which is denser than air (and therefore requires more effort to move through).
- Because the seal's body is extremely flexible, it can maneuver easily when swimming underwater. This flexibility also helps seals be effective underwater predators.

Source: Riedman, M. 1990. The Pinnipeds.
Photo by: Lisa Hiruki-Raring, NOAA/AFSC (edited by Rebecca White, NOAA/AFSC)

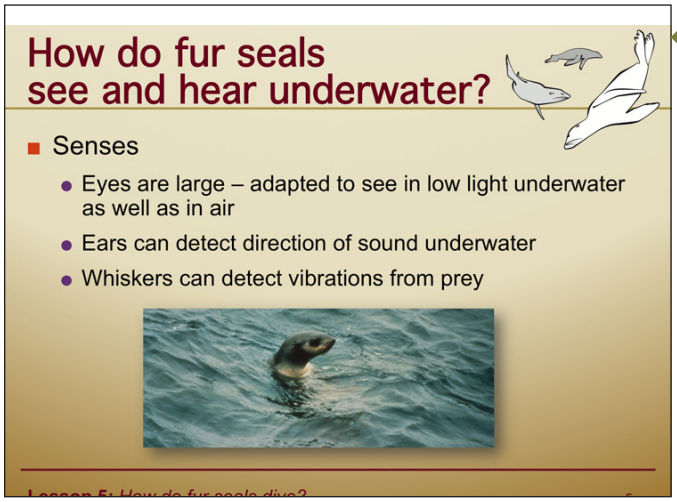


Ocean water is cold – the body loses heat 25 times faster in water than it does in air. Pinnipeds must keep their body temperature close to 100° F (38° C) in ocean water that may be only 30°-40° F (0-5° C).

To allow pinnipeds to regulate their temperature in water and to conserve heat, they have the following adaptations:

- **Compact body and short limbs** – body size is also relatively large (there are no seals as small as a mouse), as large bodied mammals chill less quickly than small ones. Less heat is lost from a compact body with short limbs.
- **Blubber and dense fur** – minimizes heat loss in the water. Fat insulates animals from cold and stores energy for when seals fast. Fur seals have two layers of fur: flattened protective outer guard hairs and thick, fine underfur to protect against cold. The underfur traps air, which insulates the body from cold.
- **Behavior** – fur seals hold their flippers out of the water (called "jughandling") to conserve heat in the cold water. Seals also have a network of small blood vessels in their flippers that allow heat to be kept close to the core of the body.

Source: Riedman, M. 1990. The Pinnipeds.
Photo: Robert Pitman, Protected Resource Division/SWFSC/NOAA



Seals can see well both underwater and in air. Their eyes are large in relation to their body size and are adapted to seeing in low light levels.

Seals have good underwater hearing. They can tell which direction a sound is coming from, the same way that people do.

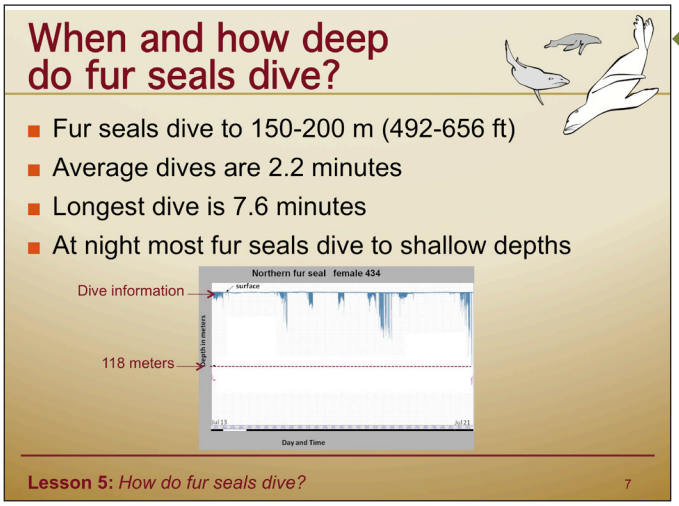
Long, sensitive whiskers appear to help pinnipeds "feel" vibrations of prey in the water, especially when visibility is poor. Whiskers may also help seals navigate underwater.

Source: Riedman, M. 1990. The Pinnipeds.
Photo: NOAA/NMFS/AFSC/MML Observer training PowerPoint

Air-breathing mammals like pinnipeds must be able to take in enough oxygen while they dive for food. Most eared seals dive to relatively shallow depths of 150-200 meters (compared with 1000-1200 meters for other seals and cetaceans). Seals have to adapt to the pressure of deep dives (as depth increases, the water pressure increases) and conserve oxygen while diving.

- A seal exhales at the beginning of a dive and holds its breath during a dive. That way, its lungs are only partially filled with air, and it can dive more easily. A seal also does not have many air spaces in the body, and its ribs are flexible and can flatten the lungs during a dive.
- The seal's nostrils automatically close.
- The seal's blood circulation becomes restricted to only essential organs and tissues: the brain, the heart, and a few other vital organs, and the heartbeat slows down.
- The seal's muscles have a large amount of myoglobin, a substance that stores oxygen.
- The seal's eyes stay open so that it can see prey underwater.
- Ears close during a dive.

Source: Riedman, M. 1990. The Pinnipeds.
Photo: Paul Hillman, NOAA Ocean Media Center



Fur seals dive to different depths depending on their prey.

This graph shows dive data from a recorder placed on a female northern fur seal. The x-axis along the bottom is date and time. The y-axis is depth in meters with the surface (0 meters) at the top. The data show that this fur seal dove mostly at night.

Source: Gentry, R. 1998. Behavior and ecology of the northern fur seal.

On land, pinnipeds have the problem of keeping cool, while still having all the adaptations that allowed them to stay warm in the water.

Fur seals cool off in several ways:

Panting - Most mammals have sweat glands which allow them to cool the body by evaporation of sweat. Panting is a form of sweating. The tongue is cooled as water evaporates off the surface. Northern fur seals are the only marine mammal that pants.

Flippers – the hindflippers are very long, and neither hind nor foreflippers have fur. A fine network of blood vessels in the flippers allows for exchange of heat; when the seal is in cold water, heat in the blood can be kept near the core of the body, but when the seal is hot, the warmth in the blood goes out to the flippers and can be released to the environment when the seal waves its flipper in the air. When the seal waves its flipper, the blood is cooled and heat is released from the body. The cooled blood then goes back into the body from the flipper.

Source: Riedman, M. 1990. The Pinnipeds., p. 19 (panting), 20 (flippers)
Photo: Rolf Ream, NOAA/NMFS/AFSC/MML

What can we learn from diving?

- When, where, how often, and how deep seals are diving
- Competition with fisheries and risk of bycatch of seals in fisheries

Lesson 5: *How do fur seals dive?* 9

By attaching instruments to seals, scientists can find out location of dives (where seals are foraging, or where they travel), time of day (when seals are diving), frequency of diving (some seals dive more often at night than during the day), depth of dives (depth can give information on the prey targeted by seals).

From dive locations and depths, scientists and managers can see if seals are feeding in areas where fisheries are active.

Photos: adult male — Jeremy Sterling, NOAA/AFSC/MML
pup – Jason Baker, NOAA/AFSC/MML

How do we know?

- Instruments on seals
  - **Time-depth recorders** (TDRs) give time and the depth of dives
    - instrument must be retrieved
    - less expensive but doesn't collect location information
  - **Satellite-linked instruments** transmit dive and location data via satellites to computers
    - no instrument retrieval
    - more expensive
  - **GPS tags** record location
    - Must be combined with TDR
  - **Cell phone tags**
    - Can be used in more populated areas (not the Bering Sea!)

Lesson 5: *How do fur seals dive?* 10

Things to think about when putting an instrument on an animal:

- Size of instrument compared to the size of the animal (scientists couldn't tag pups until the tags were small enough that they wouldn't affect the pup's ability to swim). If the tag is too big, the animal's ability to move around (swim, walk) is affected.
- Attachment method. The first instruments were attached by harnesses on the animals, which were bulky and caused a lot of drag in the water. Currently, instruments are attached with glue to the fur of the seal.

Photo: Rolf Ream, NOAA/AFSC/MML

Summary

- Fur seals dive to eat
- Fur seals can see and hear underwater
- Their bodies are adapted to being in cold water
- The average dive is 2.2 minutes

Lesson 5: *How do fur seals dive?* 11

LESSON FIVE | LAB 5.1 SCIENCE/MATH | Grade Level 7–12

How do marine mammals stay warm? Blubber vs. Air

OBJECTIVE

Students will investigate how blubber helps marine mammals stay warm in cold water by experiencing first hand the discomfort of cold water and the insulating properties of a blubber mitt. Students will also compare the abilities of blubber and air to provide insulation from cold water.

TIME REQUIRED

50 MINUTES

BACKGROUND

Like humans, marine mammals are warm-blooded animals. Although they live in some of the coldest environments on earth, they still maintain a constant body temperature.

Most marine mammals have blubber. Blubber is a thick layer of fat under the skin that acts as insulation against the cold ocean water. Almost all marine mammals need the insulating properties of blubber to stay warm. Blubber is firmer and far thicker than the fatty tissue of land mammals and is laced with connective tissue. Unlike fur, blubber does not compress when the animals dive deep to feed. Whales, dolphins, and walrus depend primarily on blubber to keep warm; sea lions and seals depend on both blubber and fur. Blubber is such an effective insulator that marine mammals must guard against overheating.

Some marine mammals, like sea otters and fur seals (and some freshwater aquatic mammals, like beavers and river otters) stay warm by trapping air in the fur close to their skin. Many birds (both seabirds and land birds) also trap air in the feathers close to their skin to stay warm.

MATERIALS

For each team of students:

- blubber bag
  - 2 one-gallon or one quart plastic freezer bags (no zipper bags)
  - 4 cups vegetable shortening (Crisco)
  - duct tape
- bubble wrap bag
  - 2 one-quart plastic freezer bag
  - bubble wrap (enough to line the one-quart bag
  - duct tape
- 3-12 oz plastic cups
- towels
- ice
- 1 digital thermometer
- 1 bucket or tub or small cooler
- hot or warm water (can use tap water or plug-in kettle water)
- 1 stopwatch, iPod, watch or clock with second hand
- graph paper
- Worksheet 5.1.1

PROCEDURES

Introductory Discussion

- Ask students how marine mammals stay warm in the water.
- Talk about how humans stay warm in cold water.
  - Divers wear wet suits or dry suits.
- Introduce the concept of blubber and fur that marine mammals use to keep warm.

Either you or your students will need to make blubber bags. If you can stand the mess, consider having your students make the bags. Once a set of bags is constructed, you can use them year after year.

Students should work in groups of 3 or more.

Make the blubber bag and bubble bag

Blubber bag

1. Fill 1 one-quart plastic with enough shortening to coat all of the surfaces.
2. Turn the second bag inside-out and insert it into the first bag. Try to keep the seals free of shortening to allow for a better grip. Seal the tops together.
3. Use duct tape on the seals to prevent water from entering the blubber bags.

Bubble bag

1. Cut bubble wrap so that it lines the inside of a one-quart plastic bag. You want to have a layer of bubble wrap around the outside surface of the bag.
2. Turn the second bag inside-out and insert it into the first bag. Seal the tops together.
3. Use duct tape on the seals to prevent water from entering the blubber bags.

Testing Procedure

1. Have the students write down their prediction of which method (blubber or air) will keep the water

How do marine mammals stay warm? Blubber vs. Air

warm for longer, or whether they both will perform the same. This is their hypothesis.

2. Fill the cooler about 2" deep with ice and water (enough to go about 2/3 high on the cups).

3. Set the three cups (one cup in the blubber bag, one cup in the bubble wrap bag, and the third cup with no insulation – this is the control cup) on a table. Pour an equal amount of warm/hot water into each of the three cups – fill them ½ to 2/3 full.

4. Start the clock, and take the temperature in each of the cups (time=0).

5. Place the cups into the ice water

6. Assign tasks or allow students to volunteer for a task.

   Tester — holds the blubber cup, bubble cup, and control cup so that the temperature can be measured in each. Make sure that the cups are held in a line so that each cup is surrounded by cold water.

   Temperature measurer — uses the digital thermometer to record the temperature 4 times (at zero, 2 minutes, 4 minutes, 6 minutes). Make sure that the cups are measured in the same order each time (e.g. control, blubber, bubble wrap).

   Data recorder — records the time and temperature on the data sheet.

   Timer — watches the clock to let the temperature measurer know when to record the temperature.

7. Repeat the procedure two more times with a fresh batch of warm water each time. Each group should have three sets of measurements.

8. Rotate roles among students.

9. Compare the results from the blubber, bubble, and control cups in table form (calculate the average of the three trials). Draw a line graph showing the results of the three trials. Write a conclusion about which bag provides the most insulation.

DISCUSSION

- Discuss the results. Which material provided the best insulation and why?
- Were there any surprises?
- What are other materials that could be used? How do other animals stay warm? ?

  In land environments, animals have thick hair or wool during the winter; fluffy feathers.

- Are there examples that students can think of where these methods are used in sports or in their own clothes?

  wetsuits, drysuits, wool socks, down jackets

- Was there anything that affected the outcome?

  If cold water got into the blubber bag, it would affect the temperature recorded in the cup.

- How this could happen in an animal with blubber

  The animal gets an injury and cold water gets past the blubber.

- What were other variables which could have affected the outcome of the data?

  Whether the temperature was taken at the top of the cup or down at the bottom; whether the cups were bunched up or in a line; the thickness of the blubber in the blubber bag; the size of the air bubbles in the bubble wrap).

EXTEND AND EXPLORE

- Have students create their own 'survival bag' by substituting other materials for the shortening and the bubble wrap in the mitt, such as Styrofoam packing peanuts, feathers, or wool, retry the experiment, and compare results.
- Research how northern fur seals stay cool on land. See also Lesson 5 PowerPoint slide #8.

ACKNOWLEDGEMENTS

The Blubber Mitt Lab is a lesson adapted with permission, from the award-winning FOR SEA family of curriculum guides for grades 1–2, available from FOR SEA Institute of Marine Science, Indianola, Washington 98342 (http://www.forsea.org)

LAB 5.1 WORKSHEET 5.1.1 Blubber vs. Air

Names:

Date:

Question: Does blubber or air provide more insulation from the cold water?

Prediction:

Data Table: Temperature inside cup and bags: Trial 1

	Temperature (°C)		
Time (minutes)	Control Cup	Blubber Bag & Cup	Bubble Bag & Cup
0			
2			
4			
6			

Data Table: Temperature inside cup and bags: Trial 2

	Temperature (°C)		
Time (minutes)	Control Cup	Blubber Bag & Cup	Bubble Bag & Cup
0			
2			
4			
6			

Data Table: Temperature inside cup and bags: Trial 1

	Temperature (°C)		
Time (minutes)	Control Cup	Blubber Bag& Cup	Bubble Bag& Cup
0			
2			
4			
6			

Average			

LAB 5.1 | WORKSHEET 5.1.1

Blubber vs. Air

Conclusion:

Additional observations (What affected the outcome?)

LAB 5.1 TEACHER KEY 5.1.1 Blubber vs. Air

Names: Student A

Date:

Question: Does blubber or air provide more insulation from the cold water?

Prediction: I predict the blubber will provide more insulation.

Data Table: Temperature inside cup and bags: Trial 1

	Temperature (°C)		
Time (minutes)	Control Cup	Blubber Bag & Cup	Bubble Bag & Cup
0	0	18	17
2	0	18	16
4	2	16	16
6	2	16	16

Data Table: Temperature inside and bags: Trial 2

	Temperature (°C)		
Time (minutes)	Control Cup	Blubber Bag & Cup	Bubble Bag & Cup
0	0	16	17
2	2	16	17
4	1	16	16
6	2	16	16

Data Table: Temperature inside cup and bags: Trial 1

	Temperature (°C)		
Time (minutes)	Control Cup	Blubber Bag & Cup	Bubble Bag & Cup
0	0	18	18
2	0	18	16
4	2	18	15
6	2	17	15

Average	1.1	16.9	16.3

LAB 5.1 TEACHER KEY 5.1.1 Blubber vs. Air

Conclusion:

Both blubber and air provided good insulation.

Air provided a little better insulation.

Additional observations (What affected the outcome?)

We started off measuring temperature at the top of the cup and found it was different from the temperature at the bottom of the cup.

The thickness of the blubber was not consistent. It was thinner at the bottom.

LESSON FIVE LAB 5.2 SCIENCE/MATH Grade Level 7-12

Thermoregulation: Countercurrent Heat Exchange

OBJECTIVE

Students will design a countercurrent heat exchanger based on the same system in marine mammals that helps them stay warm in the winter and prevent overheating in the summer. Students will develop an understanding of body temperature regulation of northern fur seals by comparing different models of heat exchange.

TIME REQUIRED

40 minutes

BACKGROUND

Almost all marine mammals utilize the insulating properties of blubber to stay warm. Blubber is firmer and far thicker than the fatty tissue of land mammals and is laced with connective tissue.

Pinnipeds (seals, eared seals, and walrus) face a challenge, as they must conserve heat while they are in cold water, but they must also regulate their temperature when they are resting on land or ice. Blubber is such an effective insulator that pinnipeds and other marine mammals must guard against overheating as the external temperature rises.

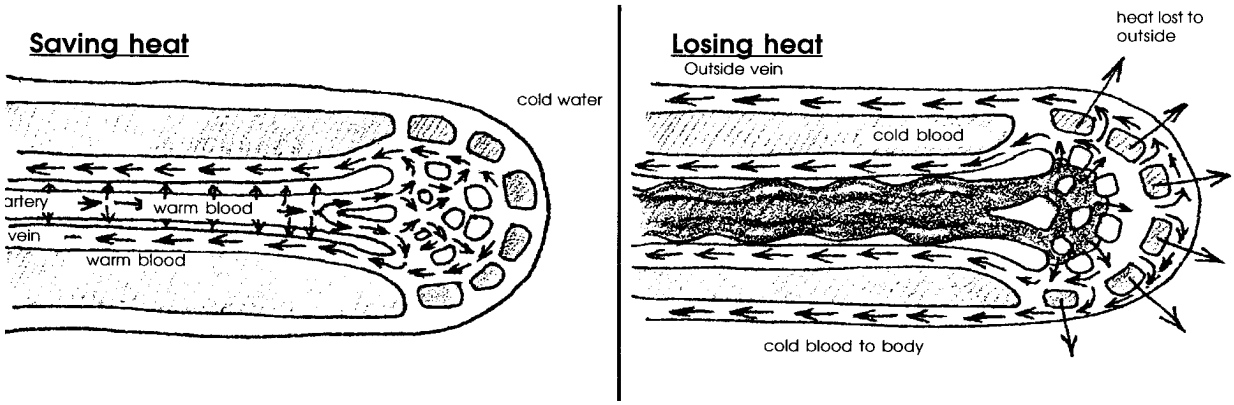
Blubber and fur are adaptations that enable marine mammals to maintain a constant body temperature even in very cold environments. But, all marine mammals that have fur also have parts of their bodies that are not covered in fur and don't have blubber; a good example of this is flippers. Flippers don't have fur or blubber but they also don't freeze or suffer from frost bite thanks to an amazing biological system known as countercurrent heat exchange. Marine mammals use countercurrent heat exchange, an internal regulatory system that prevents them from overheating in the summer and freezing in the winter or in cold water. A countercurrent heat exchanger is a transfer of thermal energy from high energy (hot) fluid to a low energy (cold) fluid.

Whales and seals have blood vessels close to the skin surface in their appendages (e.g., flippers) and they can regulate blood flow to these extremities to dissipate or conserve heat. A system known as countercurrent heat exchange helps to conserve energy so that the animal can thermoregulate (regulate its body temperature). In this countercurrent circulation system, vessels carrying warm blood moving away from the heart toward the extremities pass near vessels carrying cooled blood back to the heart. The warm blood loses its heat to the returning blood instead of losing it to the cool water that surrounds the extremities. The returning blood is now slightly warmer and, therefore, will require less reheating when it returns to the body core.

Countercurrent exchangers can also be used to cool the animal. To prevent overheating, blood is shunted away from the core to the extremities or surface of the flippers. Heat is lost to the outside cooling the blood before it returns to the body core. By gently fanning their flippers, fur seal can transfer heat from the flipper to the surrounding environment, effectively cooling the blood and preventing overheating.

MATERIALS: PER GROUP OR STATION

- Worksheet 5.3.1



Counter-current blood flow in flipper

LESSON FIVE LAB 5.2 SCIENCE/MATH Grade Level 7-12

Thermoregulation: Countercurrent Heat Exchange

- 1 section of 1 meter latex or thin walled tubing
- 1 large funnel
- 1 large pitcher
- cold/ice water (0-5° C)
- warm/hot water (40-50° C)
- 1 digital thermometers
- Tape
- 2 large bowls all of the same material and size
- paper towels or cloth towels

PROCEDURES

This lab can be set up as stations or individual groups depending on the size of your class and the availability of materials.

During this lab, students will create and test the following systems:

- Controls - warm water flows through tubing
- Heat exchanger - warm water flows through tubing placed in ice water
- Countercurrent heat exchanger - water flows a tubing with a loop placed in ice water

NOTES:

1. Results will vary greatly depending on whether the temperature is recorded just as the water exits the tube or once the water has touched the bowl. We found that the warm water cools rapidly once it touches the bowl. This is something you can discuss with your students or allow them to discover on their own.
2. The temperature of the tubes affects the results. We recommend pre-warming or taking 4 temperature readings and discarding the first reading.
3. Emptying the water from the tubing after each trial will alter your results. Decide before starting this experiment whether you will empty the tubing between trials.

Control

1. Put the funnel in one end of the tubing and hold it at shoulder height or higher. Place the other end of the tubing in the empty bowl.
2. Fill the pitcher with warm water.
3. Record the temperature of the warm water.
4. Pour the warm water into the funnel.
5. Measure and record the temperature of the water just as it leaves the tubing and collects in the empty bowl.
6. Repeat Steps 2-5 two more times.
7. Record the data on Worksheet 5.2.1
8. Discuss your results.

Heat exchanger

1. Place a bowl of ice water on a table or counter.
2. Place an empty bowl near the ice water but at a slightly lower level.
3. Place one piece of tubing in the ice water.
4. Hold one end up in the air and attach the funnel.
5. Put the middle of the tubing in the bowl of ice water.
6. Place the remaining end of the tubing in the empty bowl.
7. Measure and record the temperature of the ice water.
8. Collect a pitcher of warm to hot water.
9. Measure and record the temperature of the hot water.
10. Pour the warm water into the funnel.
11. Measure and record the temperature of the water leaving the tube.
12. Calculate and record the difference in temperature.

Thermoregulation: Countercurrent Heat Exchange

Countercurrent loop

1. Take one piece of rubber tubing approximately one meter long and make a loop in the tubing. Tape the ends together. It should look like a tennis racket. For improved results, put insulation over the tape.
2. Leave 20-30 cm of tubing at each end.
3. Put one end of the tubing in an empty bowl to collect the water as it comes out.
4. Place a bowl of ice water on a table or counter.
5. Measure and record the temperature of the ice water.
6. Put the loop of the tubing in the ice water.
7. Collect a bowl of warm to hot water or attach the dialysis tubing to a hot water faucet.
8. Measure and record the temperature of the hot water in the bowl or the water coming from the faucet.
9. Using a syringe, inject warm water into the tubing. If using a water faucet, turn on the warm water.
10. Measure and record the temperature of the water leaving the tube.
11. Calculate and record the difference in temperature.

EXTEND AND EXPLORE

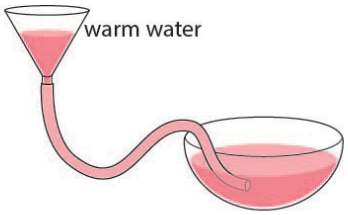
- Add insulation to the heat exchanger where the tubes touch each other and repeat the experiments.
- Try different types of fluids.
- Design and create your own countercurrent heat exchanger.
- Draw a diagram of a countercurrent heat exchanger and explain how it works.
- Research countercurrent exchangers in other animals such as humans and birds.
- Look at the computer illustration created by Lorna Ash and Greg Goss (2000) at using Bio-DiTRL software (http://www.bio-ditrl.org/) http://www.biology.ualberta.ca/facilities/multime

RESOURCES

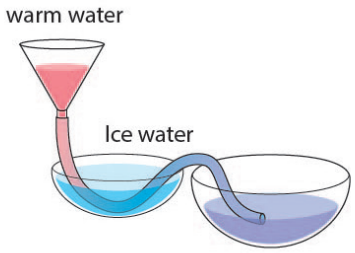
- Latex tubing or rubber tubing, and large funnels can be purchased online.
- University of Alberta, Countercurrent Heat Exchange: http://www.biology.ualberta.ca/facilities/multimedia/uploads/zoology/counter%20current.html
- Gustav Adolhus College; Howard Hughes Medical Institute Outreach Program https://gustavus.edu/events/nobelconference/2012/teachers/files/Heatexchangelesson_000.pdf

Examples

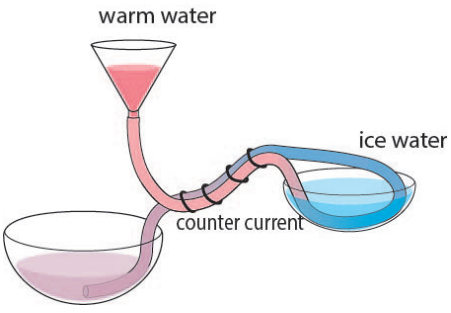
1. Control



2. Heat Exchange (no countercurrent loop)



3. Countercurrent loop



LESSON FIVE LAB 5.2 SCIENCE/MATH Grade Level 7-12

Thermoregulation: Countercurrent Heat Exchange

Temperature Comparison Chart °C to °F

Celsius	Fahrenheit	Hints
-40	-40	
-30	-22	
-22.2	-8	coldest temperature on St. Paul Island (1996-2008)*
-20	-4	
-10	14	
-1.4	24.8	average temperature on St. Paul Island in January (1996-2008)*
-1.9	28.3	**saltwater freezes**
0	32	**freshwater freezes**
2.8	37	average refrigerator temperature
10	50	
18.3	65	warmest temperature on St. Paul Island (1996-2008)*
20	68	room temperature
30	86	
37	98.6	normal human body temperature
40	104	
100	212	water boils

*Data provided by Western Regional Climate Summary, http://www.wrcc.dri.edu/summary/snp.ak.html

To convert from degrees Celsius to degrees Fahrenheit use the following equation.

[°F] = [°C] x 9/5 + 32

Example: convert 25 °C to °F

°F = 25 x 9/5 + 32

°F = 45 + 32

°F = 77

LAB 5.2 WORKSHEET 5.2.1 Countercurrent Heat Exchange

Student Name: _____ Date: _____

Question: Will the warm water running through the countercurrent system lose less heat than the warm water running through the tubing without the loop?

Hypothesis:

Control 1 - Single tube with warm water

CONTROL	Start temperature (°C)	End temperature (°C)	Difference (°C)
Trial 1			
Trial 2			
Trial 3			
Mean			

Heat Exchanger - No Countercurrent - Tube in ice bath, no loop.

NO COUNTERCURRENT	Start temperature (°C)	End temperature (°C)	Difference (°C)
Trial 1			
Trial 2			
Trial 3			
Mean			

Countercurrent Heat Exchanger - Loop of single tubing in ice bath.

COUNTERCURRENT	Start temperature (°C)	End temperature (°C)	Difference (°C)
Trial 1			
Trial 2			
Trial 3			
Mean			

Material

Control

No Countercurrent loop

Countercurrent loop

LAB 5.2 WORKSHEET 5.2.1 Countercurrent Heat Exchange

Student Name: _____ Date: _____

Hypothesis:

_____

1. How much heat was lost (drop in temperature) from the warm water passing through the control tubing? Explain what happened. If heat was lost, where did it go. If heat was not lost, explain why.

2. How much heat was lost from the warm water when the tubing was placed in an ice bath? Explain your answer. If heat was lost, explain what happened. If heat was not lost, explain why.

3. Based upon your results, which heat exchange system is most similar to the system in a northern fur seal's flipper? Explain why.

4. EXPLORE: What are other examples of countercurrent exchange that happen inside living organisms? (Hint: Penguins)

5. EXPLORE: Research and describe an example of a countercurrent heat exchange in a non-biological system.

LAB 5.2 TEACHER KEY 5.2.1 Countercurrent Heat Exchange

Student Name: _____ Date: _____

Hypothesis:

_____

1. How much heat was lost (drop in temperature) from the warm water passing through the control tubing? Explain what happened. If heat was lost, where did it go? If heat was not lost, explain why.

   Heat is lost to the air or to the tubing material.

   If heat was not lost, insulating properties of the tubing material might high. Thinner tubes might be needed.

2. How much heat was lost from the warm water when the tubing was placed in an ice bath? Explain your answer. If heat was lost, explain what happened. If heat was not lost, explain why.

   Heat is lost to cold water.

   If heat was not lost, insulating properties of the tubing material might high. Thinner tubes might be needed.

3. Based upon your results, which heat exchange system is most similar to the system in a northern fur seal's flipper? Explain why.

   Trial #3, Countercurrent is most similar to fur seal flippers, as the warm water is going into or cold medium (like sea water) and needs to be warmed before going back to the body.

4. EXPLORE: What are other examples of countercurrent exchange that happen inside living organisms? (Hint: Penguins)

   Penguin and seabird feet - they stand in freezing water

   whale's tongue

   NOTE: countercurrent exchange doesn't just have to involve heat.

   - kidneys (conserve water)
   - nasal tuurnates in elephant seal, penguin, reindeer, camel, kangaroo rat (minimizes water loss)
   - gills in fish

5. EXPLORE: Research and describe an example of a countercurrent heat exchange in a non-biological system.

   Conserving heat when heating buildings with warmer water pipes.

   Water cooled engines

   Power stations

   Steam power stations

   Heat pumps

   Air conditioners

LESSON FIVE LAB 5.3 SCIENCE/MATH Grade Level 7-12

Waiting to Inhale!

OBJECTIVE

Students will learn how long fur seals hold their breath when they dive.

TIME REQUIRED

40 minutes

BACKGROUND

INSTRUCTOR: This is an activity that should not be done at home or unsupervised. Instructors should take precautions to warn students that this activity should be done only at school.

Air-breathing mammals like pinnipeds (seals, eared seals and walruses) must be able to take in enough oxygen to survive while they are underwater diving for food. Most eared seals (fur seals and sea lions) dive to depths of 150-200 meters while other seals can dive to 1,000-1,200 meters. Fur seal dives are short for pinnipeds, averaging 2 to 9 minutes. Because they have larger bodies, males can dive longer than females.

MATERIALS

- Worksheet 5.2.1
- Timer (clock with second hand)
- Calculator

PROCEDURES

Collect your own data.

1. Talk about adaptations that pinnipeds have for diving (after viewing Lesson 5 PowerPoint).
2. Hand out Worksheet 5.2.1. Have the students make a prediction: how long can they hold their breath? Have students write down their prediction.
3. Have students work in pairs. One student will hold his or her breath; the other student will record the length of time that the first student can hold his or her breath. Repeat three times, then switch.
4. Graph results as a class.
5. Compare predictions to their actual results
6. Discuss and write a conclusion sentence. "I conclude that I held my breath 10 seconds longer than I predicted…"
7. Show the students Table 1 (average and maximum dive duration of male northern fur seals) and talk about whether the students were able to hold their breath as long as fur seals hold their breath to dive.

Compare your data to fur seal data.

8. Once all students have compared their predictions to their results, hand out Lab Worksheet 5.2.2. Have students write down their average and maximum breath-hold durations and make a prediction about whether they can hold their breath longer than a fur seal.
9. Hand out Table 5.2.2 or show it on the overhead projector. Have students compare their individual breath-hold duration with male fur seal dive durations and write a conclusion based on their prediction. Have students calculate mean and median dive durations.
10. The class will fill out Worksheet 5.2.3 as a group, either on the whiteboard or as an overhead projection. Students will have to convert their times to decimal minutes if they recorded them as minutes and seconds.
    - For times recorded as MM:SS, take the seconds (SS) and divide by 60, then add to the minutes (MM).
    - Example:
        - 89 seconds = 1 minute 29 seconds
        - Divide seconds by 60: 29÷60=0.48
        - The amount would be written 1.48 minutes
11. Calculate a class average breath-holding duration (average of all the students) and maximum

DISCUSSION

- What was the class average for breath-holding?
- How did it compare to the average northern fur seal breath-holding?
- Why can fur seals hold their breath so much longer than humans?

LESSON FIVE | LAB 5.3 SCIENCE/MATH | Grade Level 7-12

Waiting to Inhale!

Most mammals have hemoglobin, a molecule in red blood cells that carries oxygen. Seals and cetaceans also store oxygen in a molecule called myglobin which is in the muscles. Seals also have a lot of blood compared to other mammals (about 12% of their body weight; a person has about 7% of their body weight composed of blood). So, seals have lots of hemoglobin and myoglobin to carry oxygen, which they use when they are diving.

EXTEND AND EXPLORE

- Research the dive durations of other marine mamals.
- Compare the dive durations of the students in the class.
- Compare the "dive durations" of males versus females or adults versus students.

  Male fur seals can dive longer than females because they are 4 times larger than females.

LAB 5.3 WORKSHEET 5.3.1 Waiting to inhale!

Student #1 Name:

Student #2 Name:

Prediction: How long can you hold your breath?

Student #1 Prediction:

Student #2 Prediction:

Data Table: Length of time holding breath (in seconds)

	Student # 1 Name:	Student # 2 Name:
Trial 1		
Trial 2		
Trial 3		
Average		

Conclusion:

Student #1:

Student #2:

LAB 5.3 EXAMPLE 5.3.1 Waiting to inhale!

Student #1 Name: Joe

Student #2 Name: Mary

Prediction: How long can you hold your breath?

Student #1 Prediction : Joe 60 seconds

Student #2 Prediction : Mary 90 seconds

Data Table: Length of time holding breath (in seconds)

	Student #1 Name: Joe	Student #2 Name: Mary
Trial 1	49	79
Trial 2	56	85
Trial 3	58	89
Average	54 seconds	84 seconds

Conclusion:

Student #1: I conclude that my prediction was very close to how long I could actually hold my breath.

Student #2: I conclude that I could hold my breath longer than I predicted.

LAB 5.3 **TABLE 5.3.2** Waiting to inhale!

HOW LONG DO MALE NORTHERN FUR SEALS DIVE?

Average and maximum dive durations for male northern fur seals. Dive durations are shown in two units: in minutes and seconds, and in decimal minutes. Decimal minutes are used for calculating mean and median durations. Divide the seconds by 60 to convert minutes:seconds to decimal minutes.

Male #	Average dive duration (minutes:seconds)	Maximum dive duration (minutes:seconds)	Average dive duration (decimal minutes)	Maximum dive duration (decimal minutes)
1	3:40	6:17	3.67	6.28
2	5:25	8:14	5.42	8.23
3	5:39	8:59	5.65	8.99
4	3:34	5:10	3.56	5.17
5	2:56	5:16	2.94	5.26

LAB 5.3 WORKSHEET 5.3.3 Waiting to inhale!

Student Name: _____ Date: _____

COMPARING YOUR RESULTS TO NORTHERN FUR SEAL DIVE DURATIONS.

What was your average breath-holding duration? _____

What was your maximum breath-holding duration? _____

Prediction 1: Do you think you can hold your breath longer than a fur seal? _____

Look at Table 5.2.2
Calculate the mean and the median duration for the following:

	Mean duration (decimal minutes)	Median duration (decimal minutes)
Male fur seals — Average dive duration		
Male fur seals — Maximum dive duration		

Conclusion: _____

LAB 5.3 **EXAMPLE 5.3.3** Waiting to inhale!

COMPARING YOUR RESULTS TO NORTHERN FUR SEAL DIVE DURATIONS.

What was your average breath-holding duration? 54 seconds (0:54) or .9 decimal minutes (54/60)

What was your maximum breath-holding duration? 58 seconds (0:58) or .97 decimal minutes (58/60)

Prediction 1: Do you think you can hold your breath longer than a fur seal? NO

SHOW THIS TABLE TO STUDENTS – available on page 60

TABLE 5.2.2. HOW LONG DO MALE NORTHERN FUR SEALS DIVE?

Average and maximum dive durations for male northern fur seals. Dive durations are shown in two units: in minutes and seconds, and in decimal minutes. Decimal minutes are used for calculating mean and median durations.

Male #	Average dive duration (minutes:seconds)	Maximum dive duration (minutes:seconds)	Average dive duration (decimal minutes)	Maximum dive duration (decimal minutes)
1	3:40	6:17	3.67	6.28
2	5:25	8:14	5.42	8.23
3	5:39	8:59	5.65	8.99
4	3:34	5:10	3.56	5.17
5	2:56	5:16	2.94	5.26

CALCULATE THE MEAN AND THE MEDIAN DURATION FOR THE FOLLOWING:

	Mean duration (decimal minutes)	Median duration (decimal minutes)
Male fur seals — Average dive duration	4.25	3.67
Male fur seals — Maximum dive duration	6.79	6.28

Conclusion: My prediction that I could not hold my breath longer than a fur seal was correct. My maximum breath- hold duration was 58 seconds and some male fur seals can hold their breath over 8 minutes.

LAB 5.3 WORKSHEET 5.3.4 Waiting to inhale!

Comparing students' breath-holding duration with fur seals' dive duration.

Fill out the following table as a class. For fur seal dive durations, use data from Table 5.2.2.

Male #	Average dive duration (decimal minutes)	Maximum dive duration (decimal minutes)	Student Name	Average breath-holding duration (decimal minutes)	Maximum breath-holding duration (decimal minutes)
1					
2					
3					
4					
5					
Average:			**Average:**		

LAB 5.3 EXAMPLE 5.3.4 Waiting to inhale!

Comparing students' breath-holding duration with fur seals' dive duration.

Fill out the following table as a class. For fur seal dive durations, use data from Table 5.2.2.

Male #	Average dive duration (decimal minutes)	Maximum dive duration (decimal minutes)	Student Name	Average breath-holding duration (minutes:seconds converted to decimal minutes*)		Maximum breath-holding duration (minutes:seconds converted to decimal minutes*)	
1	**3.67**	**6.28**	Student 1	0:54	**0.95**	0:58	**0.97**
2	**5.42**	**8.23**	Student 2	1:24	**1.40**	1:29	**1.48**
3	**5.65**	**8.99**	Student 3	1:05	**1.08**	1:10	**1.17**
4	**3.56**	**5.17**	Student 4	1:00	**1.00**	1:10	**1.17**
5	**2.94**	**5.26**	Student 5	1:15	**1.25**	1:30	**1.50**
Average:	**4.25**	**6.79**	**Average:**		**1.14**		**1.26**

**** decimal minutes are in bold***

LESSON FIVE | LAB 5.4 SCIENCE/MATH | Grade Level 7-12

Fur Seal Dive Data

OBJECTIVE

Interpret dive records of a northern fur seal female in relation to light levels and temperature.

BACKGROUND

The data in these graphs were collected by satellite tags attached to a female northern fur seal during the breeding season. Satellite tags are instruments that send data from a tagged animal to a satellite, which then sends the data to the scientist's computer. Satellite tags are a great improvement over previous instruments used by scientists because they do not have to be retrieved from the animal to get the data. Satellite tags are attached with epoxy (glue) to the backs of female fur seals at beginning of the pupping season.

Below are five graphs displaying data from a satellite tag placed on a female northern fur seal. All graphs show data collected by the satellite tag between July 13th and July 21st. The data have been separated out so they can be considered separately.

- Graph 1: temperature in ^{o}C (purple line)
- Graph 2: temperature (purple line) and dive depth (blue line)
- Graph 3: light (green line)
- Graph 4: light (green line) and dive depth (blue line)
- Graph 5: all variables - temperature, dive, depth, and light

The recorded temperature is the temperature of the satellite tag on the seal's back, not the internal temperature of the seal. The time here is recorded as 24 hr clock or military time.

With a complicated graphs like these, we need to spend some time looking at them before they can be understood.

- What is being measured? (relationship of depth of dive, light and temperature)
- What are the units of measurement for all three things being measured? (depth in meters, intensity of light scale between 0 and 225, temperature in degrees Celsius)
- What is constant for all three scales? (date and time)

Note that the x-axis is Day and Time. The time is recorded in Greenwich Mean Time (24 hours) and temperature is recorded in degrees Celsius (°C). Most Americans use the 12-hour clock in their current time zone for recording time and degrees Fahrenheit (°F) for recording temperature. To understand the data better you can convert the time to Alaska Standard time and temperature to degrees Fahrenheit in Worksheet 5.4.1

MATERIALS

- Graphs of data collected from female 434
- Worksheet 5.4.1 Time Conversions
- Worksheet 5.4.2 Temperature Conversions
- Worksheet 5.4.3 Fur seal dive data

PROCEDURES

Time conversion

Complete Worksheet 5.4.1

- Converting GMT to 24 hour or Military time and then to Alaska Standard Time (AST).
- The time scale on graphs is Greenwich Mean Time (GMT)
- Time on the Pribilofs is GMT-8 during Daylight Savings Time (April-October) and GMT-9 the rest of the year.
- Convert GMT 21:57, 17:52, 04:47, and 0:26 to Pribilof time (13:57 or 1:57 p.m.; 09:52 or 9:52 am; 2047 or 8:47 p.m.; and 16:26 or 4:26 p.m.

Scientific data is often collected in Greenwich Mean Time or GMT. The Greenwich Meridian or Prime Meridian (0 degrees longitude) marks the beginning of every time zone around the world. This is a standardized time recorded in the 24 hr clock, 0 to 12 is midnight to noon and 1201 to 2359 is I minute after noon to 1 minute before midnight. Scientists use it to prevent confusion between 6 am (0600) and 6 p.m. (1800). An easy way to convert GMT to is to add 12 to all times between noon and midnight so 1:30 p.m. becomes 1330.

Temperature conversion

Complete Worksheet 5.4.2 by converting temperature in degrees Celsius to degrees Fahrenheit

Example: convert 25 °C to °F by using the following equation

$[°F] = [°C] \times 9/5 + 32$

$°F = 25 \times 9/5 + 32$

$°F = 45 + 32$

$°F = 77$

Fahrenheit to degrees Celsius

Example: convert 50 °F to °C by using the following equation

[°C] = ([°F] - 32) × 5/9

°C= (50-32) x 5/9

°C= 18 x 5/9

°C= 10

DISCUSSION

- What are the general daily patterned you see in the female fur seals behavior?

  The seal dives the most at night (when light levels are low) but when it does dive during the day, it dives deeper. This can indicate that the prey the seal is feeding on are deeper during the day.

EXTEND AND EXPLORE

- For a more in-depth exploration of diving behavior and other factors that can be measured by a satellite tag, see "Shedding Light on the Unknown with Marine Mammal Tags," Appendix VI.

LAB 5.4 WORKSHEET 5.4.1 Time Conversion

Student Name: _____ Date: _____

Time Conversion - Convert Greenwich Mean Time to Alaska Standard Time

GMT (satellite tag time)	Alaska Standard Time 24hr Clock GMT-8 (Mar. 13-Nov. 6) GMT-9 (Nov.7-Mar. 12)	Alaska Standard Time 12 hr clock (Daylight Saving)	Hints
0000 midnight			
0100			
0200			
0300			
0400			
0500			
0600			
0700			
0800			midnight Alaska
0900			
1000			
1100			
1200			
1300			
1400			
1500			
1600			
1700			
1800			
1900			
2000			noon Alaska
2100			
2200			
2300			

LAB 5.4 TEACHER KEY 5.4.1 Time Conversion

Student Name: _____ Date: _____

Time Conversion - Convert Greenwich Mean Time to Alaska Standard Time

GMT (satellite tag time)	Alaska Standard Time 24hr Clock GMT-8 (Mar. 13-Nov. 6) GMT-9 (Nov.7-Mar. 12)	Alaska Standard Time 12 hr clock (Daylight Saving)	Hints
0000 midnight	1600	4 p.m.	
0100	1700	5 p.m.	
0200	1800	6 p.m.	
0300	1900	7 p.m.	
0400	2000	8 p.m.	
0500	2100	9 p.m.	
0600	2200	10 p.m.	
0700	2300	11 p.m.	
0800	0000	12 a.m.	midnight in Alaska
0900	0100	1 a.m.	
1000	0200	2 a.m.	
1100	0300	3 a.m.	
1200	0400	4 a.m.	
1300	0500	5 a.m.	
1400	0600	6 a.m.	
1500	0700	7 a.m.	
1600	0800	8 a.m.	
1700	0900	9 a.m.	
1800	1000	10 a.m.	
1900	1100	11 a.m.	
2000	1200	12 a.m.	noon in Alaska
2100	1300	1 p.m.	
2200	1400	2 p.m.	
2300	1500	3 p.m.	

LAB 5.4 WORKSHEET 5.4.2 Temperature Conversion

Student Name: _____ Date: _____

Convert temperatures from °C to °F

Celsius	Fahrenheit	Hints
-40°		
-30°		
-20°		
-10°		
-1.9°		**saltwater freezes**
0°		**freshwater freezes**
10°		
20°		room temperature
25°		
30°		
37°		normal body temperature
40°		
100°		water boils

To convert from degrees Celsius to degrees Fahrenheit use the following equation.

[°F] = [°C] x 9/5 + 32

Example: convert 25 °C to °F

°F = 25 x 9/5 + 32

°F = 45 + 32

°F = 77

LAB 5.4 TEACHER KEY 5.4.2 Temperature Conversion

Student Name: _____ Date: _____

Convert temperatures from °C to °F

Celsius	Fahrenheit	Hints
-40°	-40°	
-30°	-22°	
-20°	-4°	
-10°	14°	
-1.9°	28.3°	**saltwater freezes**
0°	32°	**freshwater freezes**
10°	50°	
20°	68°	room temperature
25°	77°	
30°	86°	
37°	98.6°	normal body temperature
40°	104°	
100°	212°	water boils

To convert from degrees Celsius to degrees Fahrenheit use the following equation.

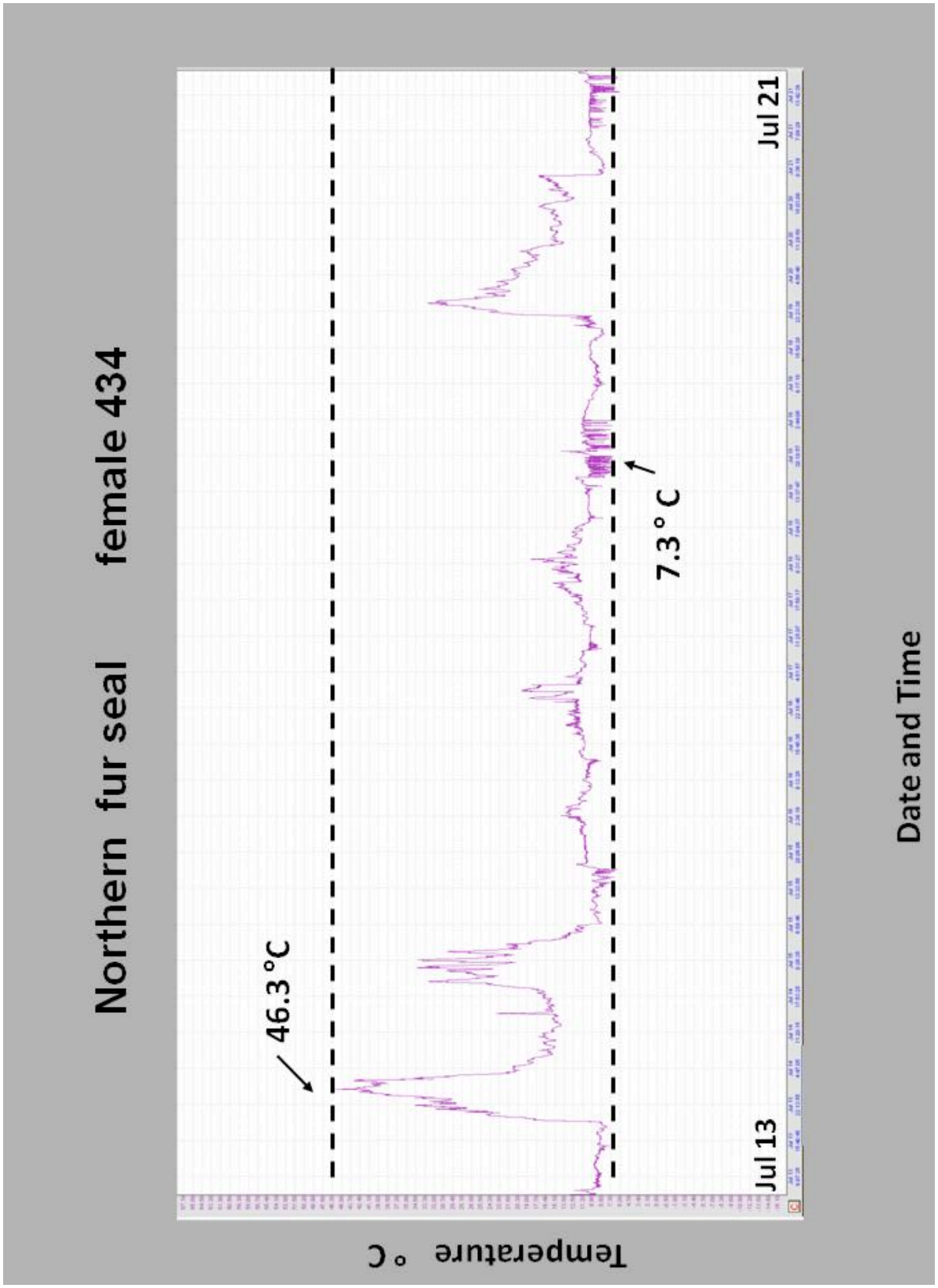
[°F] = [°C] x 9/5 + 32

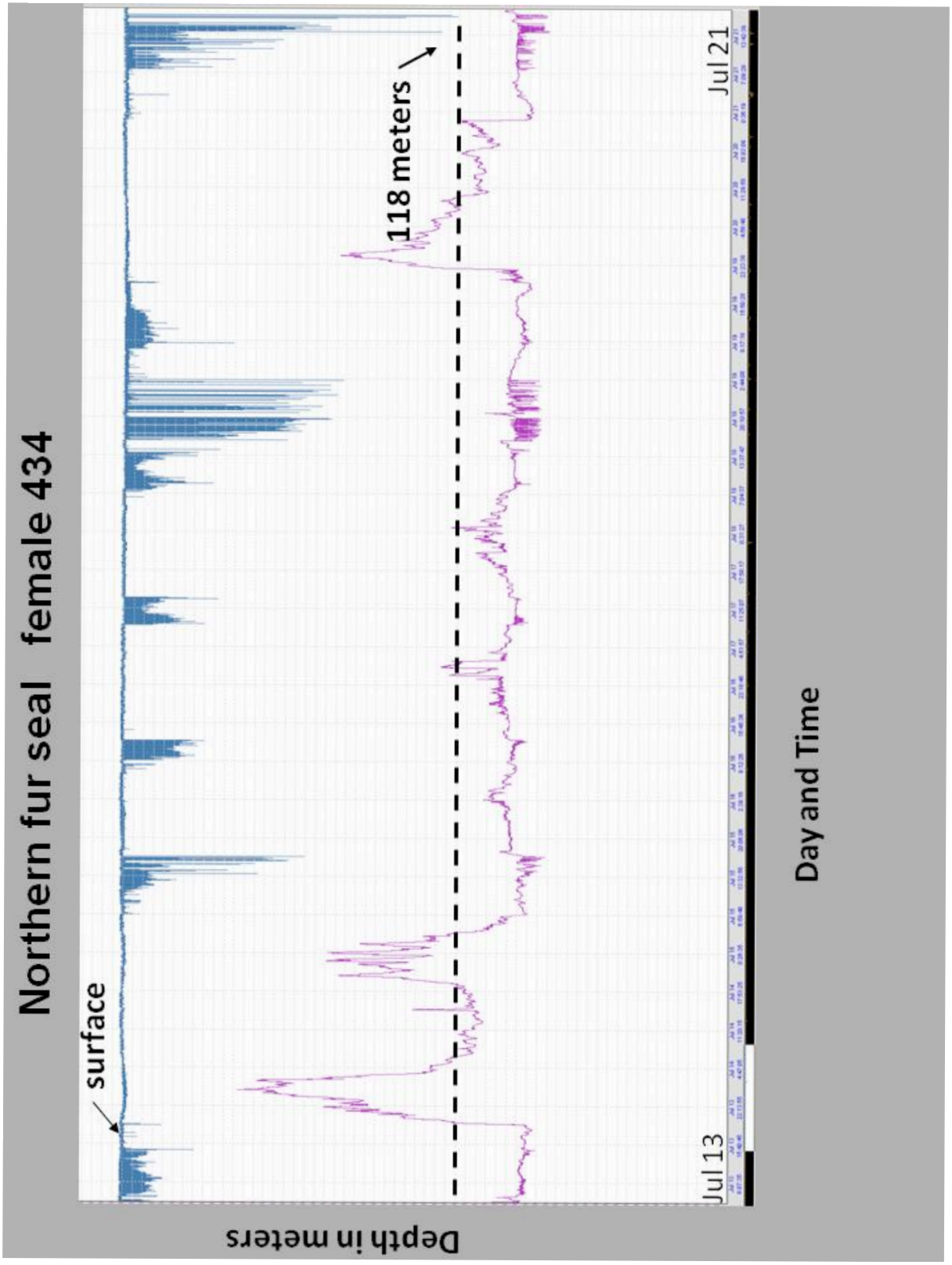
Example: convert 25 °C to °F

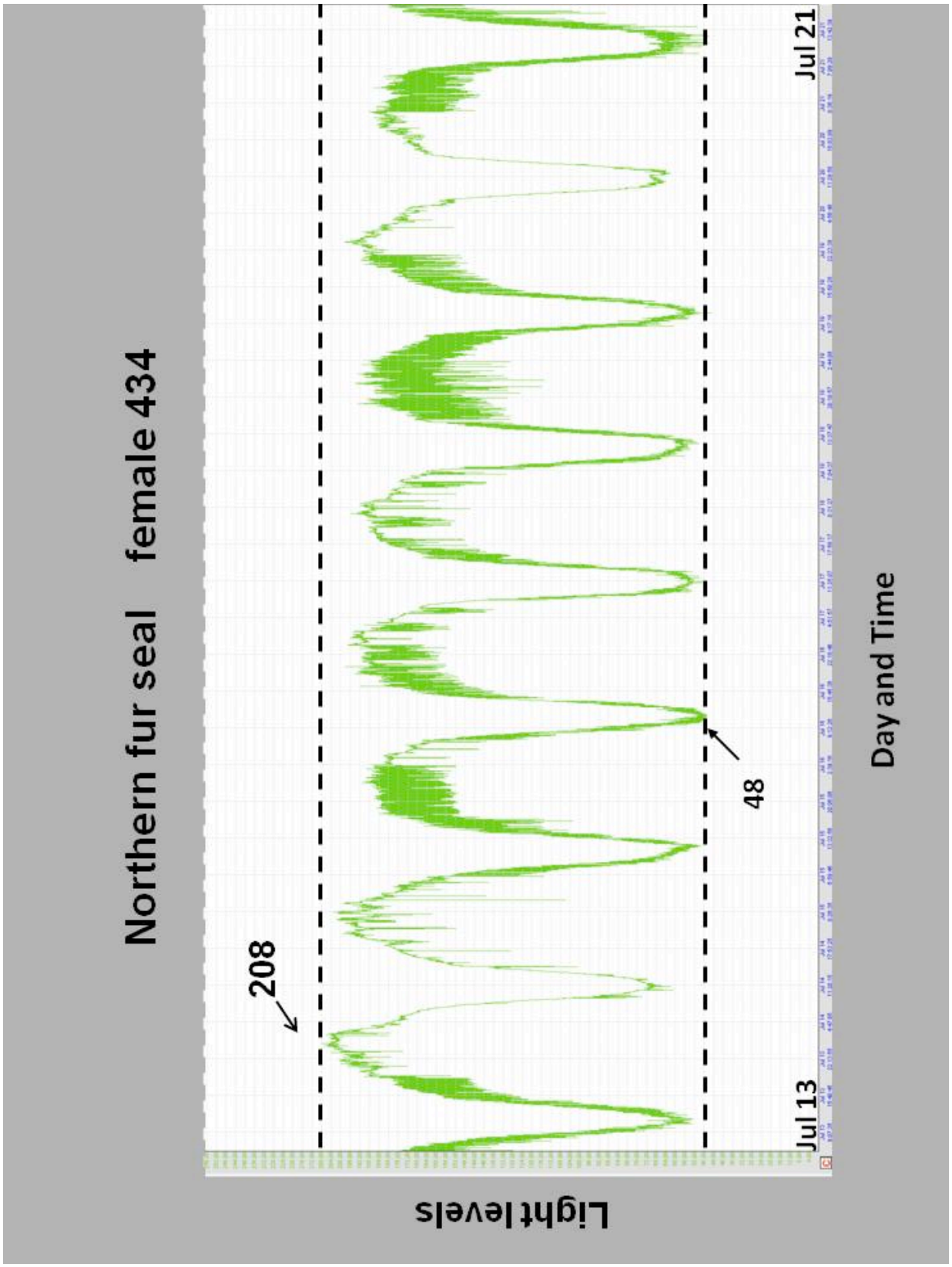
°F = 25 x 9/5 + 32

°F = 45 + 32

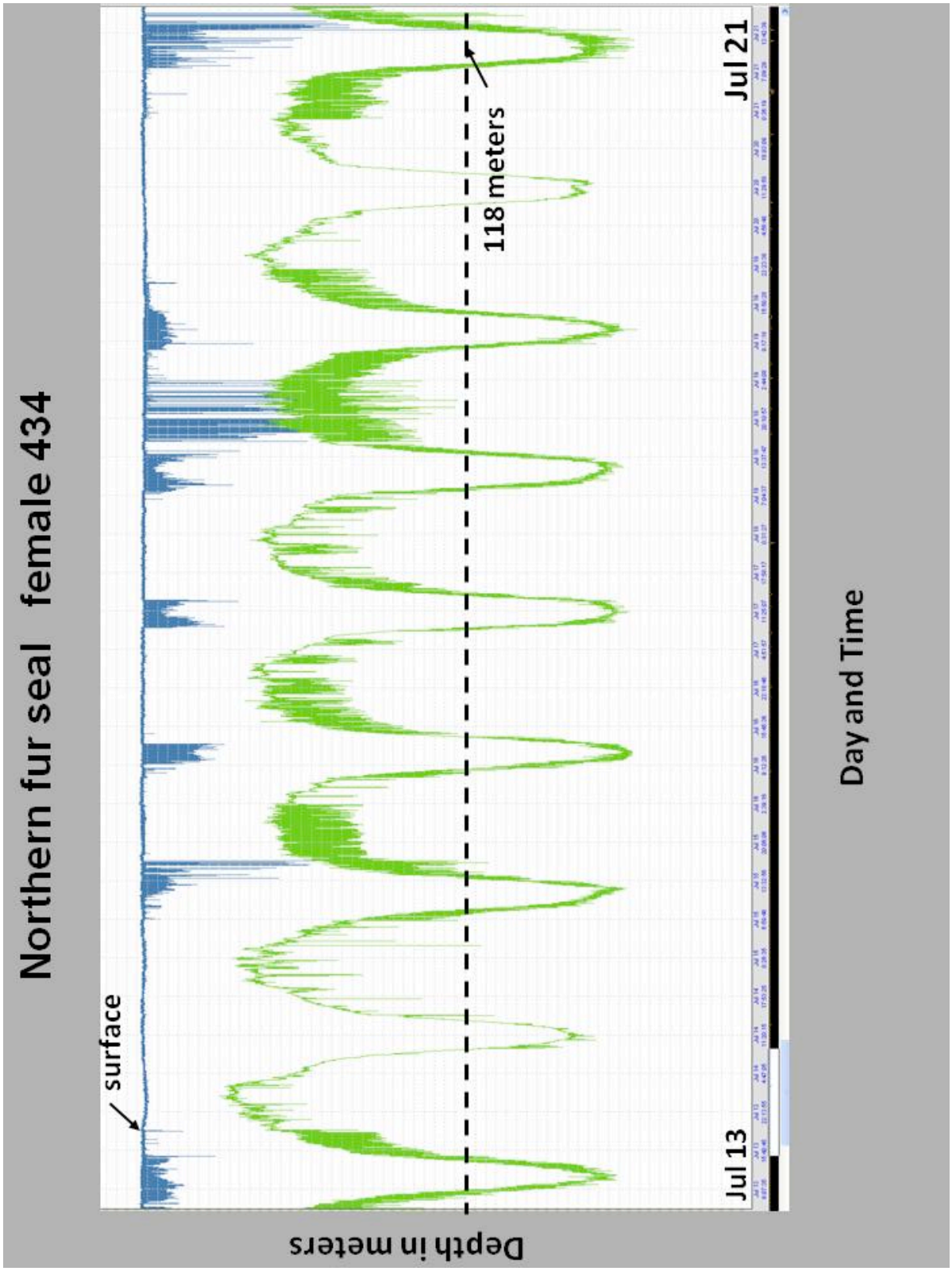
°F = 77

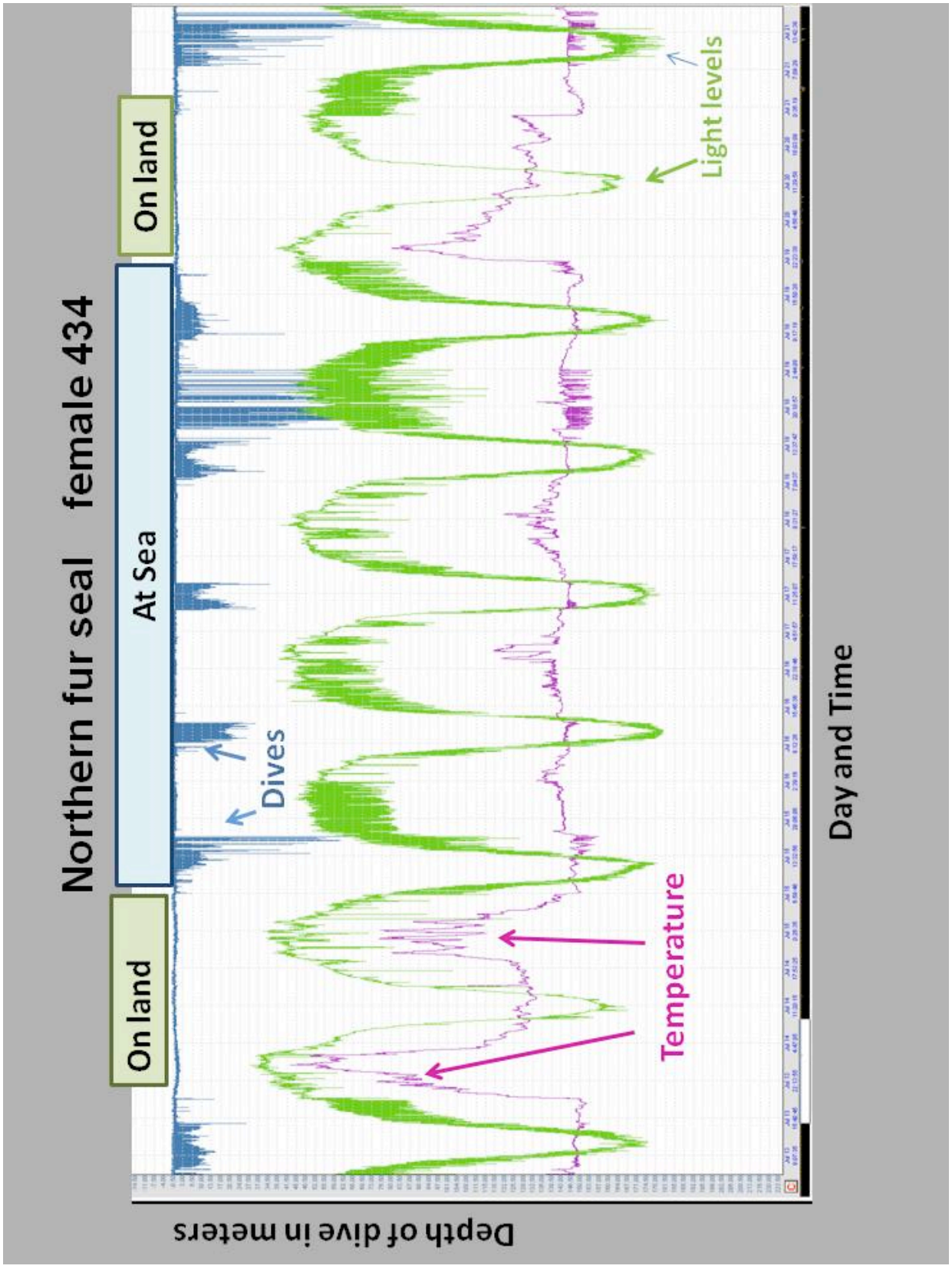

Northern fur seal female 434
46.3 °C
7.3 °C
Jul 13
Jul 21
Temperature °C
Date and Time


Northern fur seal female 434
surface
118 meters
Jul 13
Jul 21
Depth in meters
Day and Time


Northern fur seal female 434
208
48
Jul 13
Jul 21
Light levels
Day and Time

LAB 5.4 5.4.3 GRAPH 4: LIGHT AND DEPTH Fur Seal Dive Data




Northern fur seal female 434
On land
At Sea
On land
Dives
Temperature
Light levels
Depth of dive in meters
Day and Time

LAB 5.4 **5.4.3 WORKSHEET** Fur Seal Dive Data

Student Name: _____ Date: _____

Graphs 1 and 2: Temperature and Depth

1. Why is the temperature changing?

2. Where do you think the seal is when the temperature is the highest/lowest?

3. Draw on the graph when you think the seal was in the water and when she was on land.

Graphs 3 and 4 : Light and Depth

4. Draw on the graph when you think the seal is in the water and when she is on land.

5. Look for the light cycle or a repeating pattern. Why do you think there is a cycle?

6. How are depth and light related?

Graph 5: Temperature, Light, and Depth

7. Describe what you think the seal is doing. Is she travelling, feeding, resting, etc. How do you know?

LAB 5.4 WORKSHEET 5.4.3 TEACHER KEY Fur Seal Dive Data

Student Name: _____ Date:_____

Graphs 1 and 2: Temperature and Depth

1. Why is the temperature changing?
   The temperature on land is warmer than in the water.

2. Where do you think the seal is when the temperature is the highest/lowest?
   Highest: on land

   Lowest: diving in the water

3. Draw on the graph when you think the seal was in the water and when she was on land.

Graphs 3 and 4 : Light and Depth

4. Draw on the graph when you think the seal is in the water and when she is on land.

5. Look for the light cycle or a repeating pattern. Why do you think there is a cycle?
   Cycle is for day and night.

6. How are depth and light related?
   Inverse: no light when the seal dives. Light is brightest when the seal is on land.

Graph 5: Temperature, Light, and Depth

7. Describe what you think the seal is doing. Is she travelling, feeding, resting, etc. How do you know?
   You can tell when the seal is on land from the temperature (high). She is probably feeding when she is diving, and resting or travelling when she is not diving at sea.

   Days 1-2: Seal on land

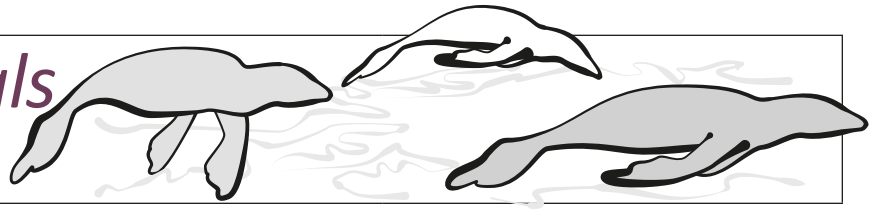
   Days 3-5: Seal at sea, diving at night and during the day. She is probably close to the rookery because she is on land the next day.

   Days 7-8: on land

   Day 9: at sea

LESSON SIX

Where do fur seals go in the winter?



Subject Area(s): Life science, geography, reading	**Grade Levels:** 7-12	Presentation – 15 minutes Labs – variable

Lesson Topics:	Fur seal migration, traditional knowledge of migration, and current research.	**Focus Questions**	• Why do fur seals leave the rookery? • Where do they go? • How do we know? • Why do we want to know where they go?
Learning Objectives:	Students will: • describe where northern fur seals go in the winter • plot fur seal migration tracks on a map • describe three methods scientists use to track fur seal migration routes.	**Key words:**	migrate, satellite tags, tracking instruments, latitude, longitude

Lab		ALASKA STANDARDS		
		Science	Minutes	Grades
Lab 6.1	Where are Fur Seal Rookeries? (mapping)	SA3; SC2,3; SF1,2,3	30	7-12
Lab 6.2	*Fur Seal Migrations* (video, discussion)	SA3; SC2; SF1,2,3	30	7–12
Lab 6.3	Fur Seal Migrations (mapping)	SA3; SC2,3; SF1,2,3; SG1,3,4	50	7–12

Science

Science as Inquiry and Process

SA3

Concepts of Life Science

SC2; SC3

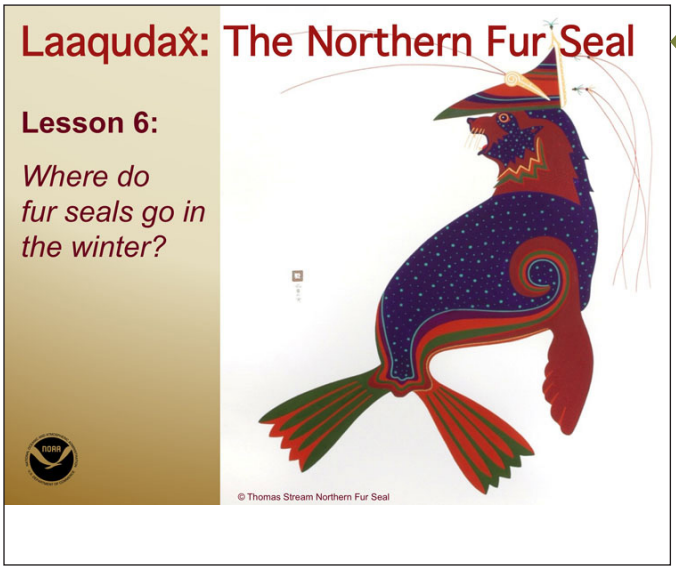
Cultural, Social, Personal Perspectives, and Science

SF1; SF2; SF3

History

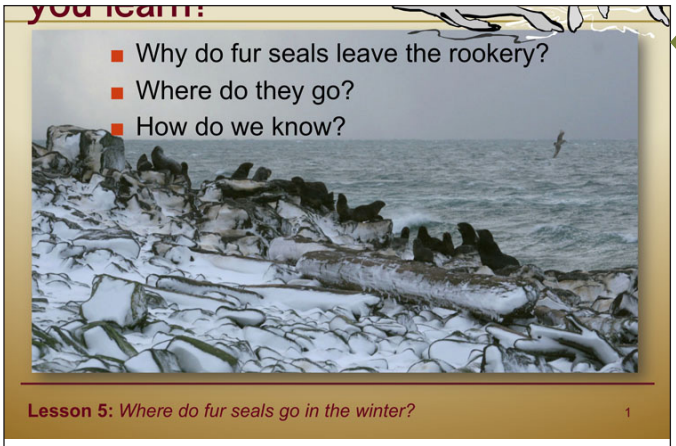
History and Nature of Science

SG1; SG3; SG4



Lesson 6 provides an overview of the winter migration of fur seals, where different age groups of seals go, what traditional knowledge, archaeology and current science can tell us about fur seal migration, and what we can learn from the information.

Photo: Jeremy Sterling, NOAA/AFSC/MML



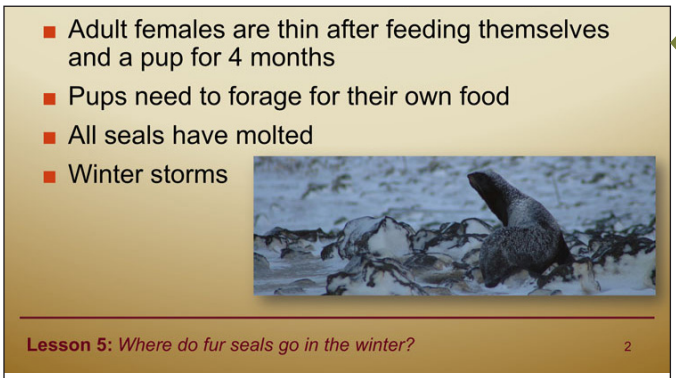
Northern fur seals use the winter months to feed and gain energy reserves for the following summer and the next year's breeding season.

- Adult males do not feed while they are on the rookery defending their territory. Once the males have mated with the last female, they head to sea for the winter.
- Adult females have been feeding themselves and their pups for about 4 months.
- Pups actually wean themselves. They stop nursing just before heading out to sea. Once at sea pups have to learn how to forage for food on their own. The pups that learn how to forage quickly will survive the best. Most pups are at sea for 18-20 months before returning to the Pribilofs.

All fur seals must come to land to molt (shed old fur and grow new fur).

The Pribilof Islands are often surrounded by ice in the winter and spring, making the rookeries inaccessible to the seals.

Photo: Jeremy Sterling, NOAA/AFSC/MML

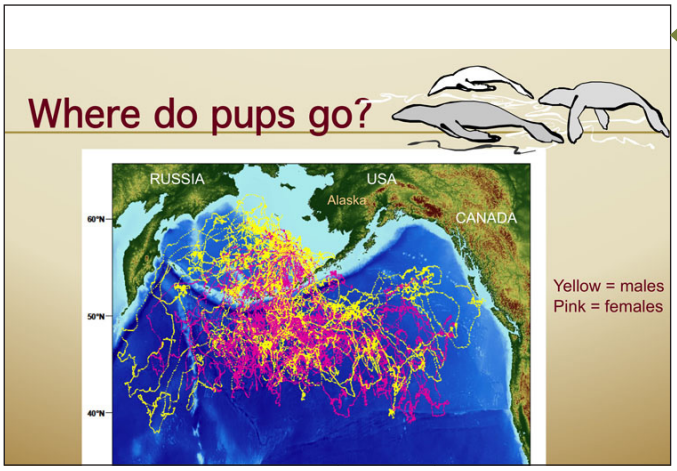


The pups who have just weaned and are headed to sea for the first time will stay at sea for 18-20 months, and return to the rookery as a 2-year-old.

Some of these juveniles will come to shore during that time but not many.

All other fur seals stay at sea for eight to ten months until the following spring/summer when they return to the rookery.

Photo: northern fur seals playing in the surf at Reef Rookery, St. Paul Island, Alaska; Lisa Hiruki-Raring, NOAA/AFSC/MML



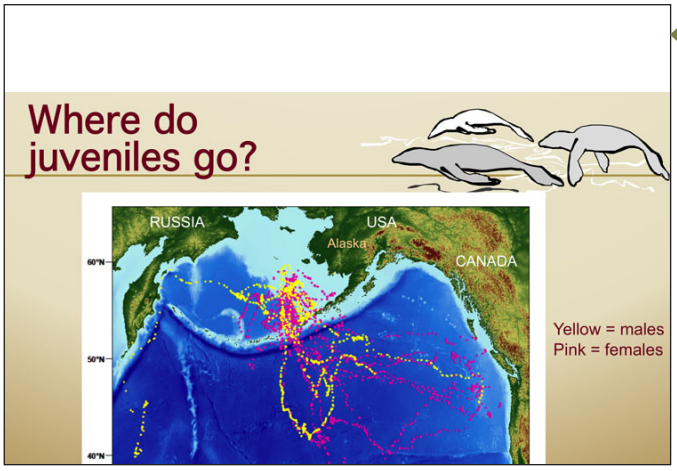
Scientists at NOAA have been tagging pups for years trying to figure out where they go in the winter. The next four slides display geographical data collected by satellite tags placed on northern fur seals by NOAA scientists. Almost all of the animals headed south of the Aleutian Islands.

Slide 1: Pups

Pups leave the rookery when they are 4 months old. In their first year, pups' tracks are not very directed. They are at the mercy of the weather much of the time. As the seals get older and stronger, their tracks are more directed. Less than half of the pups who leave the Pribilofs will return. The mortality (death) rate for pups is very high.

See the next three images for tracks of juveniles, adult females, and adult males.

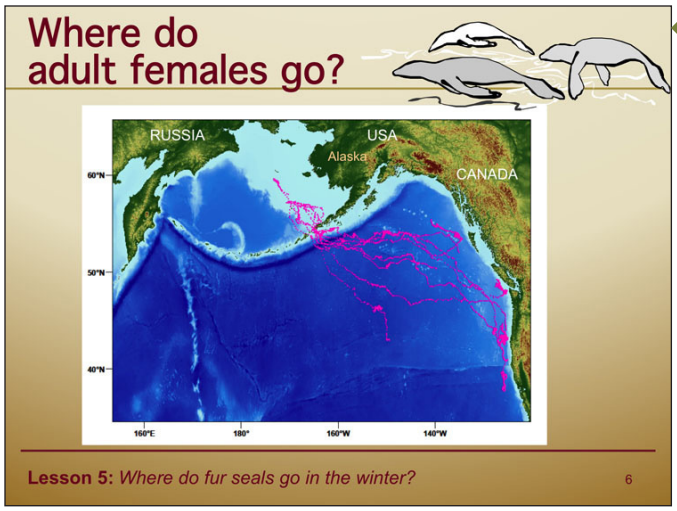
Source: NOAA/NMFS/AFSC/MML Alaska Ecosystem Program



Slide 2

Juvenile males and females start to become more directed in their winter migrations. Compared to the pups' tracks, the majority of juvenile tracks are headed toward the eastern North Pacific and the west coast of the U.S. (only a selection of tagged seals are displayed on this chart).

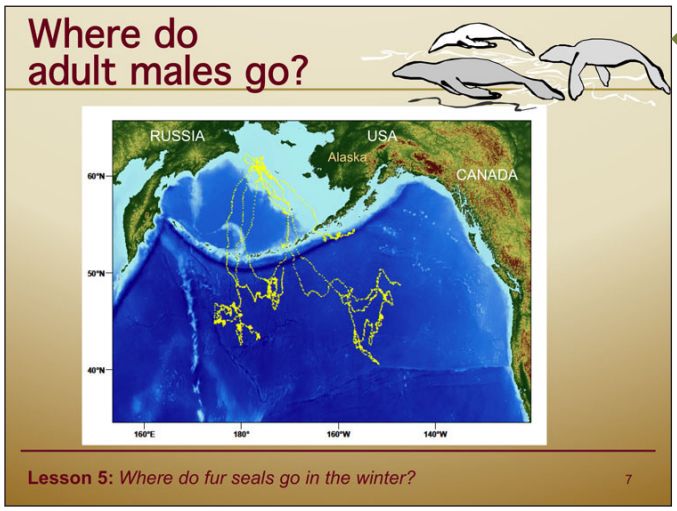
Source: NOAA/NMFS/AFSC/MML Alaska Ecosystem Program



Slide 3

Adult female fur seals' tracks are very consistent in their movements toward the west coast of North America.

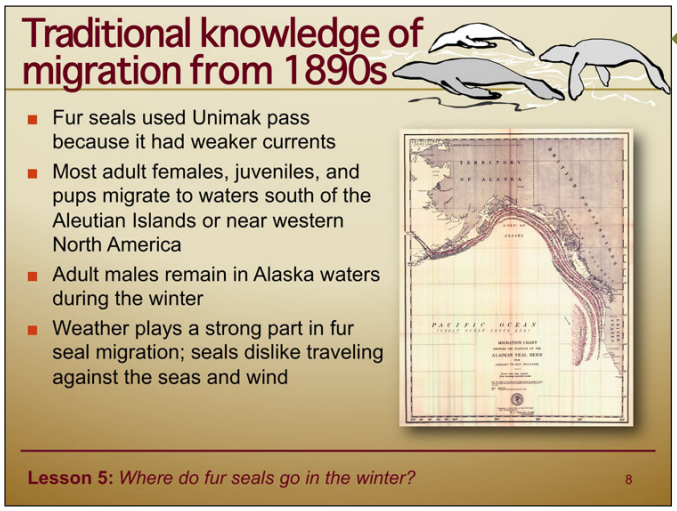
Source: NOAA/NMFS/AFSC/MML Alaska Ecosystem Program



Slide 4

Adult male winter migrations go more toward the middle of the north Pacific Ocean. Note that the males' migration areas are generally separate from the females' migration areas.

Source: NOAA/NMFS/AFSC/MML Alaska Ecosystem Program

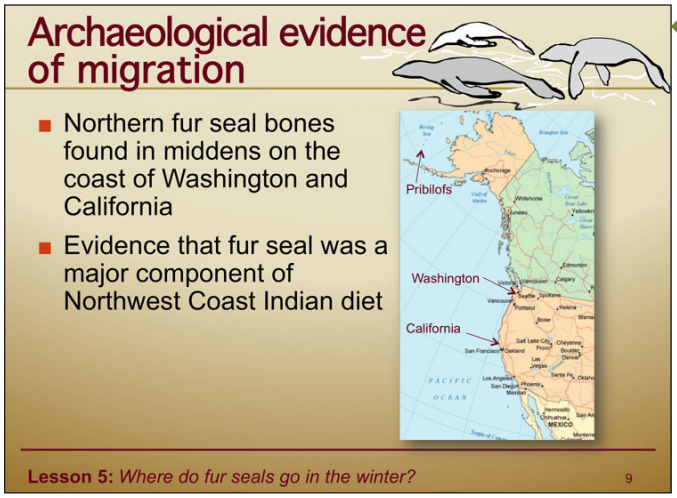


In the 1890s, Unangam hunters and northwest tribal hunters were interviewed to document their knowledge of the migration routes of northern fur seals. Several patterns emerged from these interviews that have been confirmed by current scientific research.

The term "Alaska waters" in the interviews may simply mean waters that are not coastal to North America.

Sterling AFSC Quarterly Report, July 2011 (http://www.afsc.noaa.gov/Quarterly/jas2011/divrptsMML1.htm)

Map: Henry Wood Elliott, 1884



Northern fur seal remains have been found in Native American settlements in Washington and California, indicating there has been a reliance on northern fur seals by native people over a wider geographic area than the Aleutian Islands, where Unangan have been hunting fur seals for thousands of years.

Northern fur seal bones were found in middens from the Makah village of Ozette on the coast of Washington when the village was excavated in the 1970s.

A midden is a mound or deposit containing shells, animals bones and other trash that indicate the presence of humans.

Northern fur seal bones have also been found on the Farallon Islands off the California coast.

Many First Nations Tribes of Canada hunted fur seals during the seals' winter migration off the coast of North America.

Source: http://www.washington.edu/news/archive/2044

Michael Etnier, PhD Thesis: http://www.calacademy.org/science_now/archive/academy_research/doug_long.php

Current scientific research has confirmed much of the information documented in the 1890s from Unangam hunters.

For many years, the information gathered from Unangam hunters was ignored. Current satellite data has confirmed the Unangam traditional knowledge. Today scientists often work closely with native communities to gather information about traditionally hunted animals.

Photo: NOAA/NMFS/AFSC/MML

Photo: resting northern fur seals, St. Paul Island; Pam Goddard: Thalassa

LESSON SIX | LAB 6.1 SCIENCE/GEOGRAPHY | Grade Level 7-12

Where Are Fur Seal Rookeries?

TIME REQUIRED

20 minutes

OBJECTIVE

Students will learn where northern fur seal rookeries are located on a map.

BACKGROUND

Northern fur seals breed at specific locations (rookeries) during the summer. Students will label a map showing the locations of fur seal rookeries in Russia and Alaska, and a map showing locations of fur seal rookeries in the United States.

MATERIALS

- Map A (Russia and Alaska) with fur seal rookeries
- Map B (North America) with Pribilof Islands and San Miguel Island labeled

PROCEDURES

- Hand out Map 6.1.1; have the students label the map with the indicated countries, bodies of water, state and city, and rookeries. Students can color the map if desired.
- Hand out Map 6.1.2; have the students label the map with the indicated countries, bodies of water, state and city, and rookeries. Students can color the map if desired.

DISCUSSION

- Are there any rookeries on the mainland?

  No, they are on islands.

- What might influence the location of a rookery?

  Food availability during the summer, protection from storms and predators.

  Why do you think that seals are so far south at San Miguel Island?

  The San Miguel Island fur seal rookery was originally started in the late 1950s or early 1960s by pregnant females from the Pribilof Islands who had their pups there instead of returning to the Pribilofs. Scientists discovered the rookery in 1968.

LAB 6.1 MAP 6.1.1 Where are fur seal rookeries?

Student Name: _____ Date: _____

MAP A: RUSSIA AND ALASKA

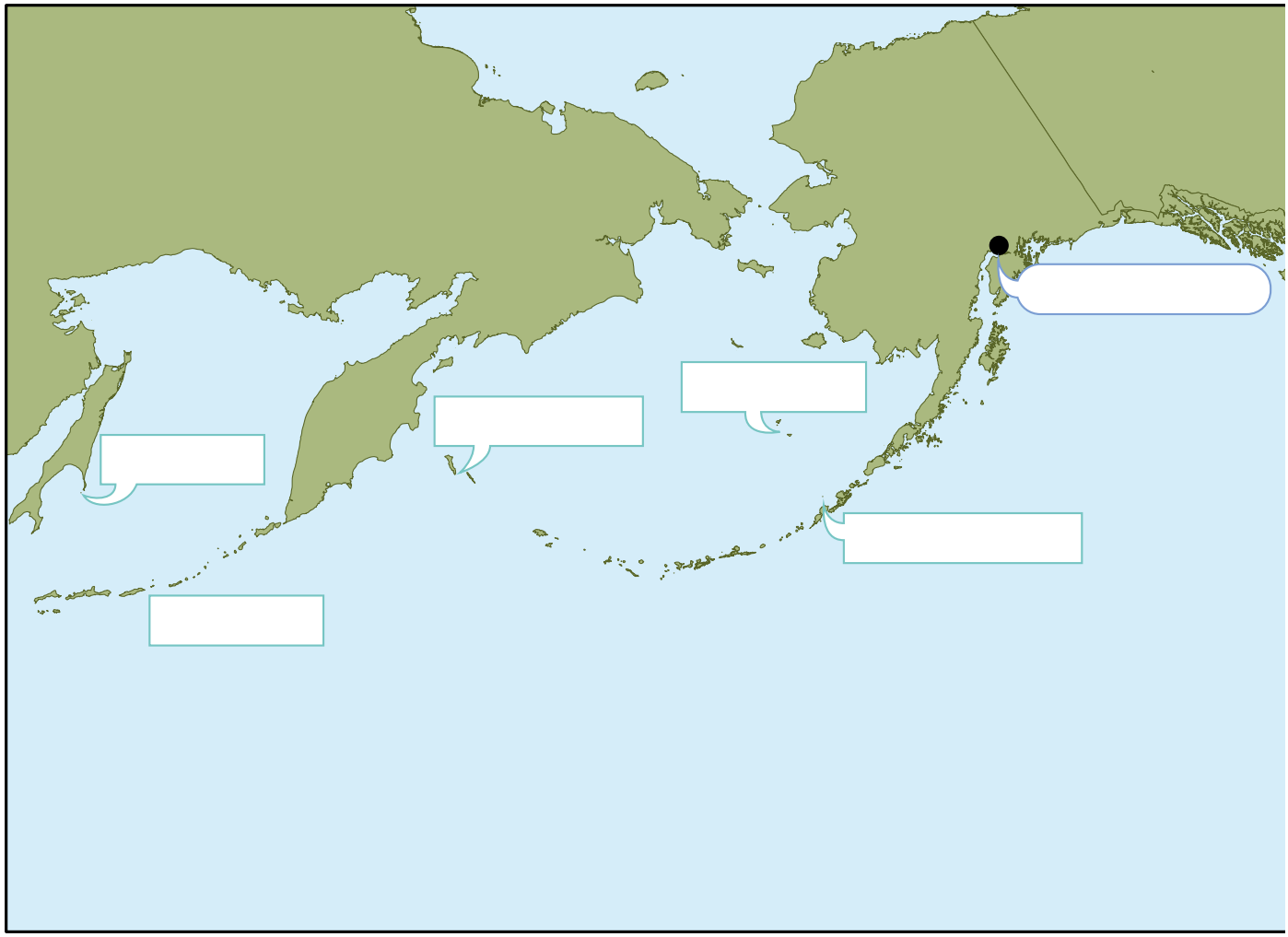
Label the countries:
- Russia
- USA
- Canada

Label the state:
- Alaska

Label the bodies of water:
- Bering Sea
- Pacific Ocean

Label this city as a reference point:
- Anchorage

Label the rookeries (look up the locations in an atlas if you are not sure where the location is):
- Robben Island
- Commander Islands
- Kuril Islands
- Pribilof Islands
- Bogoslof Island



LAB 6.1 TEACHER KEY 6.1.1 Where are fur seal rookeries?

Student Name: _____ Date: _____

MAP A: RUSSIA AND ALASKA

Label the countries:
- Russia
- USA
- Canada

Label the state:
- Alaska

Label the bodies of water:
- Bering Sea
- Pacific Ocean

Label this city as a reference point:
- Anchorage

Label the rookeries (look up the locations in an atlas if you are not sure where the location is)**:**
- Robben Island
- Commander Islands
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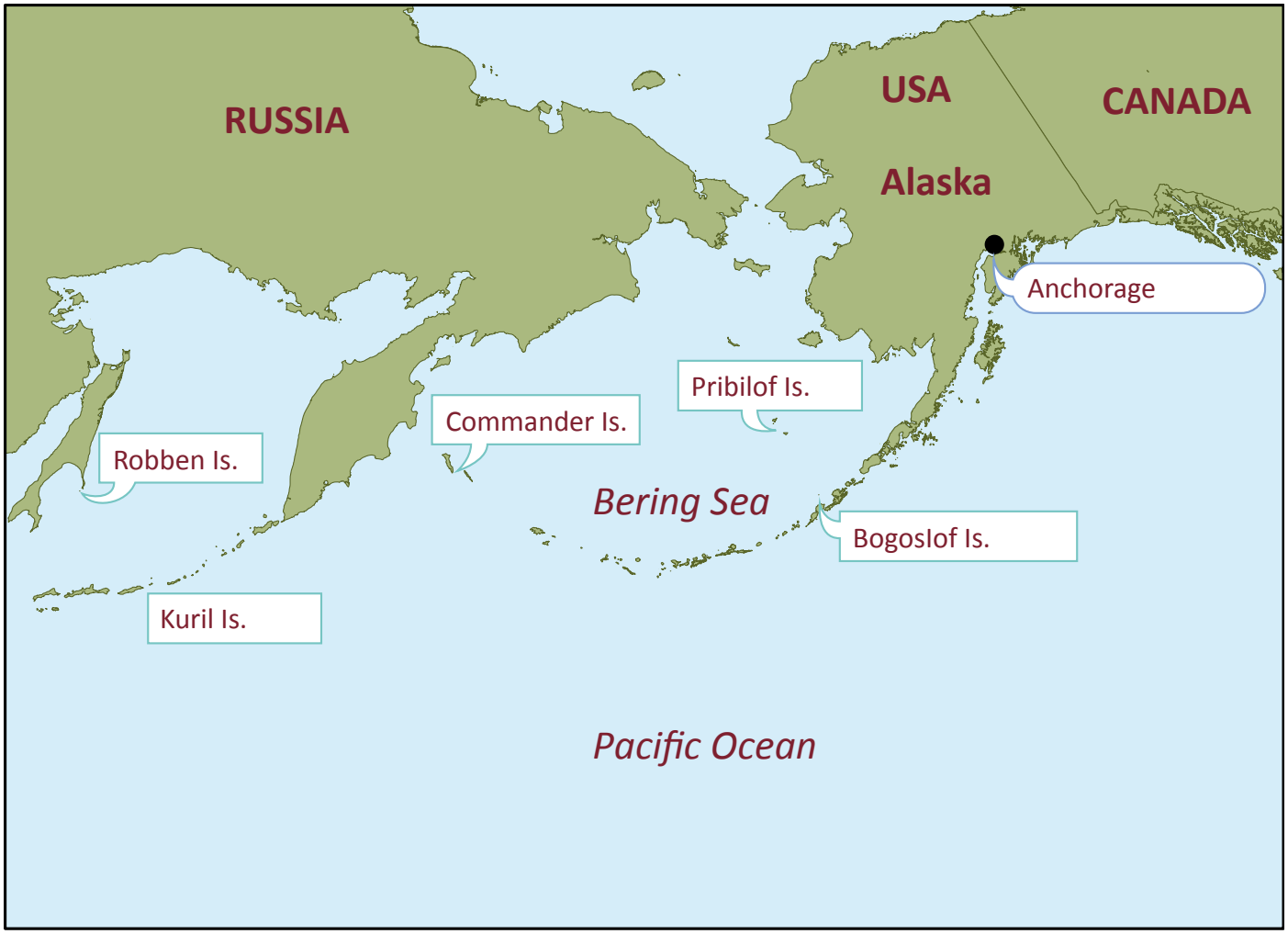
- Bogoslof Island



LAB 6.1 MAP 6.1.2 Where are fur seal rookeries?

Student Name: _____ Date: _____

MAP 6.1.2: USA

Using a globe or map as a reference, place the labels listed below on Map B.

The boxes indicate rookeries. Students will use the information presented in this Lab determine the location of the three northern fur seal rookeries located in the United States.

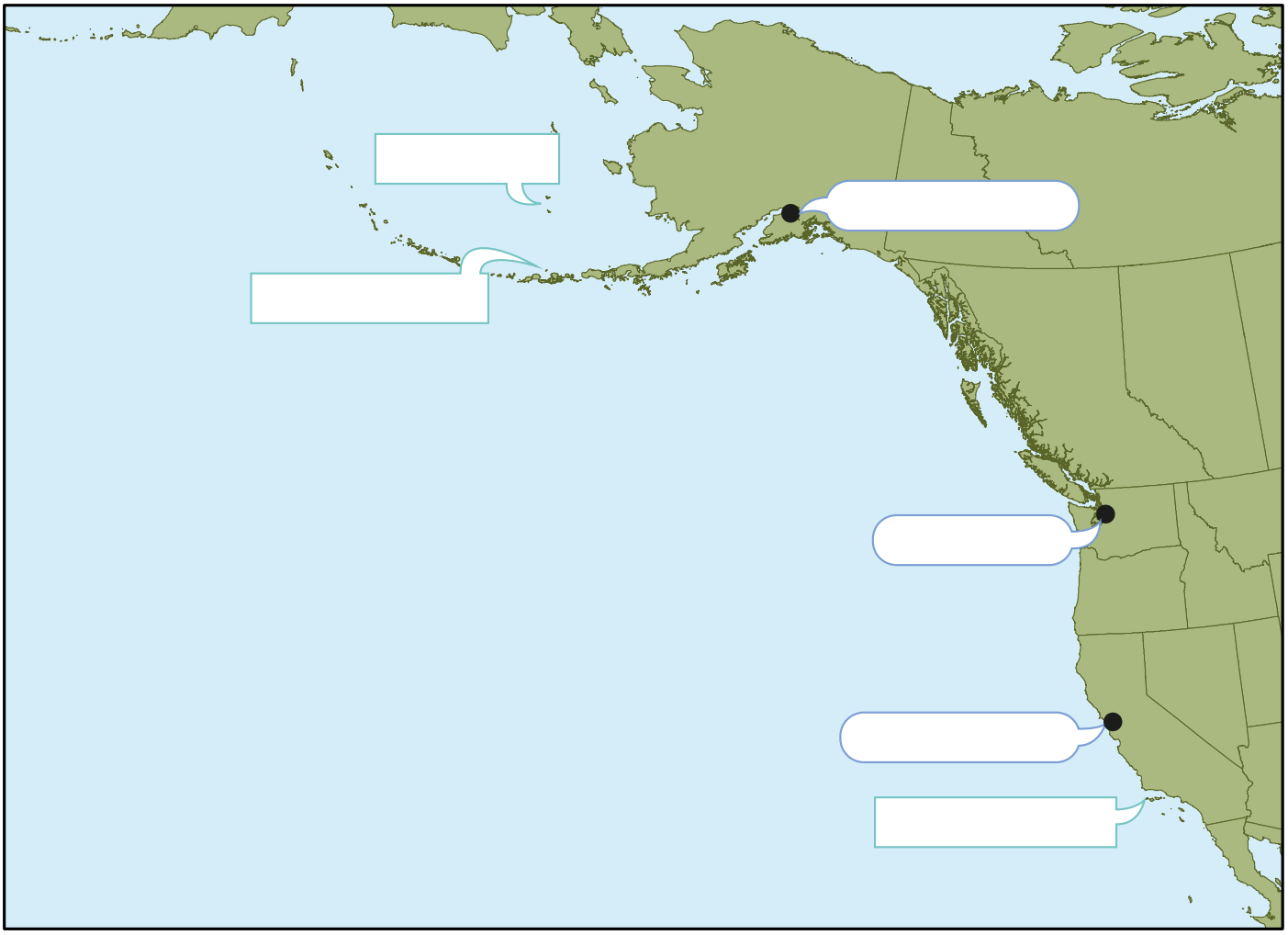
Label the countries:
- USA
- Canada

Label the bodies of water:
- Bering Sea
- Pacific Ocean

Label these states as reference points:
- Alaska
- Washington
- Oregon
- California

Label these cities as reference points:
- Anchorage
- Seattle
- San Francisco

Label the rookeries (look up the locations in an atlas if you are not sure where the location is):
- Pribilof Islands
- Bogoslof Island
- San Miguel Island



LAB 6.1 TEACHER KEY 6.1.2 Where are fur seal rookeries?

Student Name: _____ Date: _____

MAP 6.1.2: USA

Using a globe or map as a reference, place the labels listed below on Map B.

The boxes indicate rookeries. Students will use the information presented in this Lab determine the location of the three northern fur seal rookeries located in the United States.

Label the countries:
- USA
- Canada

Label the bodies of water:
- Bering Sea
- Pacific Ocean

Label these states as reference points:
- Alaska
- Washington
- Oregon
- California

Label these cities as reference points:
- Anchorage
- Seattle
- San Francisco

Label the rookeries (look up the locations in an atlas if you are not sure where the location is):
- Pribilof Islands
- Bogoslof Island
- San Miguel Island

LESSON SIX | LAB 6.2 SCIENCE/WRITING | Grade Level 7–12

Fur Seal Migrations

TIME REQUIRED

10-30 minutes

OBJECTIVE

Students will observe a visual presentation of fur seal migrations and discuss, as a class, information gained by watching the 3 minute video.

BACKGROUND

The Pribilof Islands are often surrounded by ice in the winter and spring, making the rookeries inaccessible to the seals. Every year, northern fur seals migrate thousands of miles round-trip from their summer breeding grounds on the Pribilof Islands in the Bering Sea to other parts of the Pacific Ocean. The seals use the winter months to feed and gain energy reserves for the following summer and the next year's breeding season.

Learn how NOAA scientists track these seals on their incredible migrations, and where the seals go during the winter months.

MATERIALS

Fur Seal Migrations video -

http://www.youtube.com/watch?v=qI0yzIrEJ4M

(approximately 3 minutes)

PROCEDURE

Watch "Fur Seal Migrations" two times. The first time, allow the students to just watch the video. The second time, ask the students to think about the following questions.

DISCUSSION

- How do scientists find out where fur seals are going?
- What time of year does the fur seal stay at sea?
- How far does the fur seal travel when it is at sea?
- When does the fur seal return to the Pribilof Islands?
- Why might the fur seal population be declining?

Replay the video if necessary to find the answers.

Ask student to write down 3 things that they learned from the video.

EXPLORE AND EXTEND

Using Google Earth

- Calculate how many miles it is from St. Paul or St. George Island to San Miguel Island.
- Calculate the distance to Ozette, WA, where fur seal bones were found in Native American middens.
- Research other species from the Pribilof Islands that also have a seasonal migration.

LAB 6.2 WORKSHEET 6.2.1 Fur Seal Migrations

Student Name: _____ Date:_____

1. How do scientists find out where fur seals are going?

2. What time of year do the scientists tag the fur seal? When do they expect the seal to return?

3. Where does the seal go? How fast does she travel?

4. What does she do when she is not traveling?

5. Does she return to the Pribilof Islands?

6. How old are the pups when they start migrating? How long are they gone?

7. Why might the fur seal population be declining?

LAB 6.2 TEACHER KEY 6.2.1 Fur Seal Migrations

Student Name: _____ Date:_____

1. How do scientists find out where fur seals are going?

   NOAA scientists use satellite transmitters to track northern fur seal movements at sea.

2. What time of year do the scientists tag the fur seal? When do they expect the seal to return?

   The female seal is tagged in early November. They expect her to return the next July for the breeding season.

3. Where does the seal go? How fast does she travel?

   She travels south, passes through the Aleutian Islands into the north Pacific Ocean to California.

   She travels about 70 miles each day.

   She travel a total of 6,000 miles round-trip

4. What does she do when she is not traveling?

   She eats and sleeps.

5. Does she return to the Pribilof Islands?

   Yes, she is spotted at Polovina Cliffs rookery on July 4th.

6. How olds are the pups when they start migrating? How long are they gone?

   Pups are 4 months old when they start their first migration.

   They are gone just as long as the adults and travel just as far.

7. Why might the fur seal population be declining?

   It might be marine debris and climate change but it is not fully understood.

LESSON SIX | LAB 6.3 GEOGRAPHY | Grade Level 7–12

Mapping and Fur Seal Migration Track

OBJECTIVE

Students will become familiar with basic concepts of geography. Students will use latitude and longitude data to plot northern fur seal migration tracks.

BACKGROUND

Geography

Every place on the earth can be described using two numbers, latitude and longitude. In order to accurately pinpoint locations on the surface of the earth, humans created a geographical grid system using lines of latitude and lines of longitude. This grid is attached to two fixed points, the North Pole and the South Pole.

Latitude lines run around the globe parallel to the equator. They measure the distance north and south of the equator.

Longitude lines (or meridians) are arcs running from the North Pole to the South Pole. They measure distances east and west from a base line or prime meridian.

For this lesson, latitude and longitude will be presented in Decimal Degrees.

Place	Latitude	Longitude
St Paul	57.18° N	170.3° W
St George	56.61° N	169.56° W
San Francisco	37.78° N	122.42° W
Equator	0°	
Greenwich, England		0° (prime meridian)

Migration

All northern fur seals migrate during the winter months. Seals depart the rookeries between August and December (males first, then pups, then females). Fur seals travel to different locations in the winter depending on their age and sex (see PowerPoint Lesson 6, slides 4-7 for maps). Pups must find their own way; neither parent teaches them how to feed or where to feed. Pups that do not find food will die of starvation. Storms, winds, currents and fish abundance all affect where seals go in the winter. Fur seals follow the food, so they seldom move in a straight line. If food is hard to find they will move out of the area. If food is abundant, they will stay in the area.

MATERIALS

- World globe (teacher provided)
- Diagram of Prime Meridian, Arctic Circle, Tropic of Cancer
- Yarn or string (teacher provided)
- Map of adult female fur seal migration track

PROCEDURES – GEOGRAPHY REVIEW

Orientation

1. On the globe, show students latitude and longitude lines.

1. Have them find the North Pole, South Pole, and Pribilof Islands.

1. Have students find the Arctic Circle and the Tropic of Cancer. What latitude are they?

1. Arctic Circle (66.5° N)
   Tropic of Cancer (23.5° N)

1. Have students find the equator, Tropic of Capricorn, and Antarctic Circle and determine their latitudes.

Lines of Latitude

1. Cut six pieces of yarn long enough to go around your globe at least once.

2. Assign six students or six groups of students to measure a line of latitude from the list below.

   a. Arctic Circle
   b. Tropic of Cancer
   c. Equator
   d. Tropic of Capricorn
   e. Antarctic Circle
   f. Latitude 57° N (latitude of St Paul Island)

3. Before measuring, predict which line of latitude is the shortest and which is the longest.

4. Compare the lengths of yarn.

Based on the lengths of yarn, answer the following questions.

- Which line of latitude is the longest?

  Equator

- Which line of latitude is the shortest?

Arctic and Antarctic Circles

- Which lines of latitude are the same?

  Arctic and Antarctic Circles are the same.

  Tropic of Cancer and Tropic of Capricorn are the same.

Lines of Longitude

Using new pieces of yarn measure the lines of longitude listed below. Lines of longitude are measured from pole to pole. Measure the distance between the North Pole and South Pole for each set of numbers.

Before measuring ask each student to predict which line of longitude they think will be the shortest and which will be the longest.

1. 0° and 180°
2. 169° West and 169° East,
3. 100° East, 100° West

   HINT: They should all be the same.

Label Map

- Have the students work individually or in groups to label Map 6.3.1 based on what they learned from the globe.
- Ask students to label the continents:
  - North America
  - South America
  - Europe
  - Antarctica
  - Asia
  - Africa
  - Australia
- Ask students to label the following geographic features:
  - Arctic Circle
  - Tropic of Cancer
  - Equator
  - Tropic of Capricorn
  - Antarctic Circle
  - Prime Meridian

DISCUSSION

What was the difference between the lengths of yarn used to measure latitude and longitude?

The latitude lines were shorter as they neared the poles whereas longitude lines were all the same length. This is because longitude lines are tied to fixed points at the north pole and south pole.

PROCEDURES – MAPPING

1. Using the data provided in Labs 6.3 - 6.4 use either Google Maps, Google earth, or the blank maps provided to plot the tracks of the female, male, and pup northern furs seals.
2. Connect the dots on the map in order of date to see the migration tracks.
3. Add arrows to show the direction of their movements.

DISCUSSION

- How many days were the seals at sea?

  Female = 139 days

  Male = days

  Pup = days

- Where did the female seal end up?

  Use latitude and longitude to determine her endpoint. Check other maps from Lab 6.1.

  The seal's approximate location is 37° N 126° W, just west of Monterey Bay, California (37° N 122° W).

- Do you see any patterns in the fur seal's movements?

  The seal slows down and stays in the same area between January 29 and March 4.

- How many miles do you think the fur seal travelled? Use the Internet to determine the distance between St. Paul Island and Monterey Bay, California.

  Female - roughly 2,600 miles.

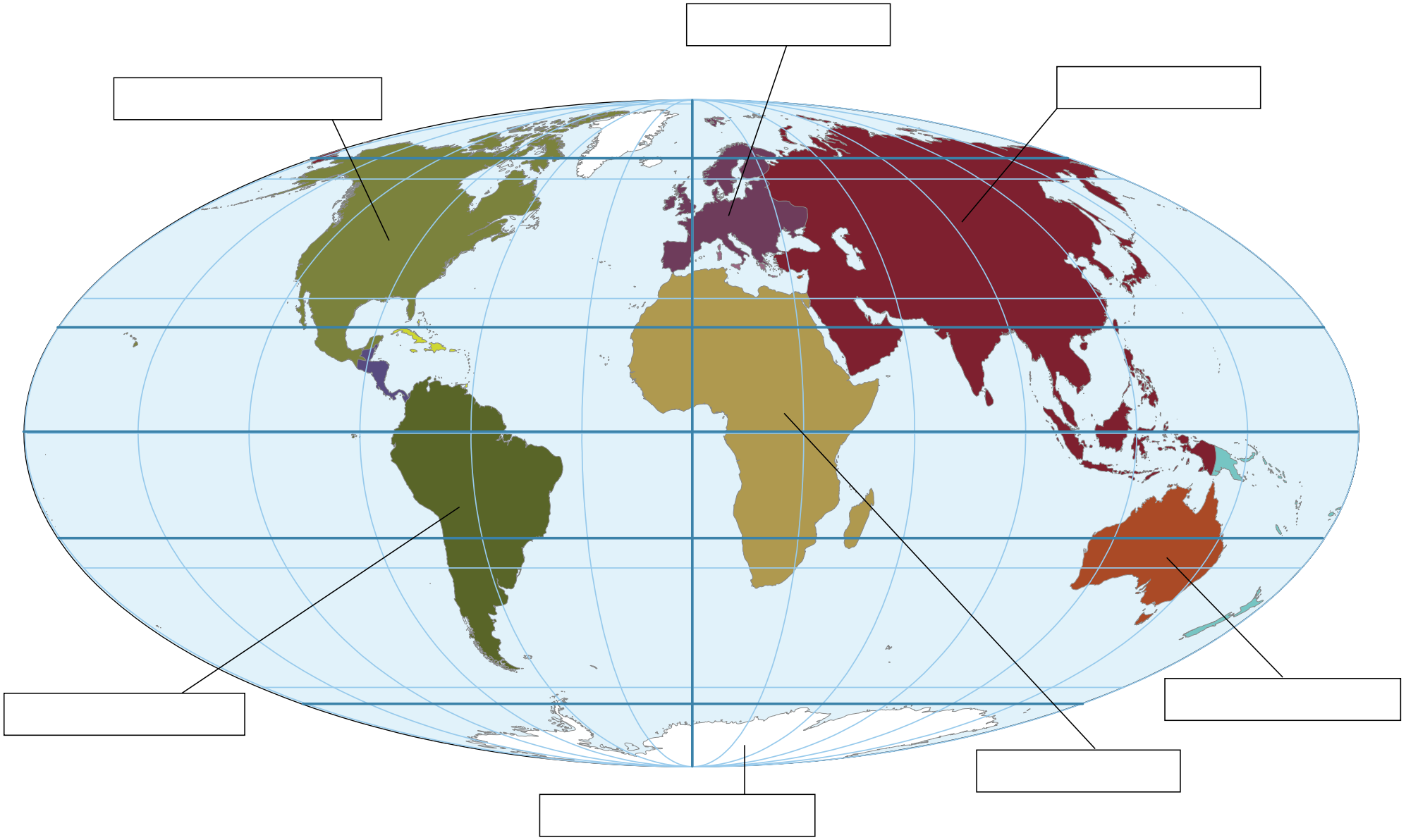
- Describe the difference in winter movements between the male and female fur sea.

  Adult female goes south toward the North Pacific, then over to the west coast of North America and north up the coast back to the Pribilofs.

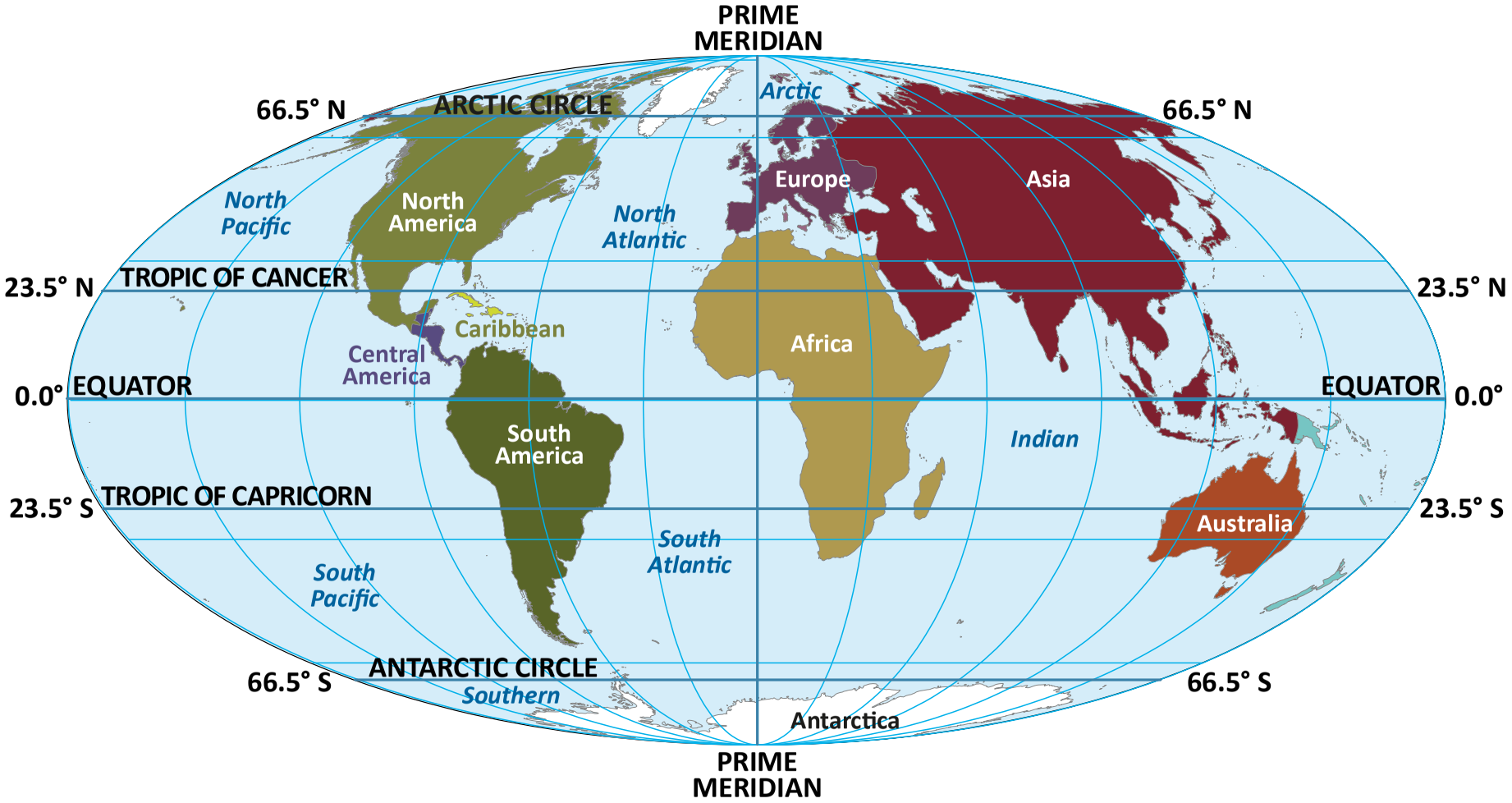
  Adult male stays in the Northern Bering Sea.

  Pups go everywhere.

LAB 6.3 **MAP 6.3.1** Student Name: Date:



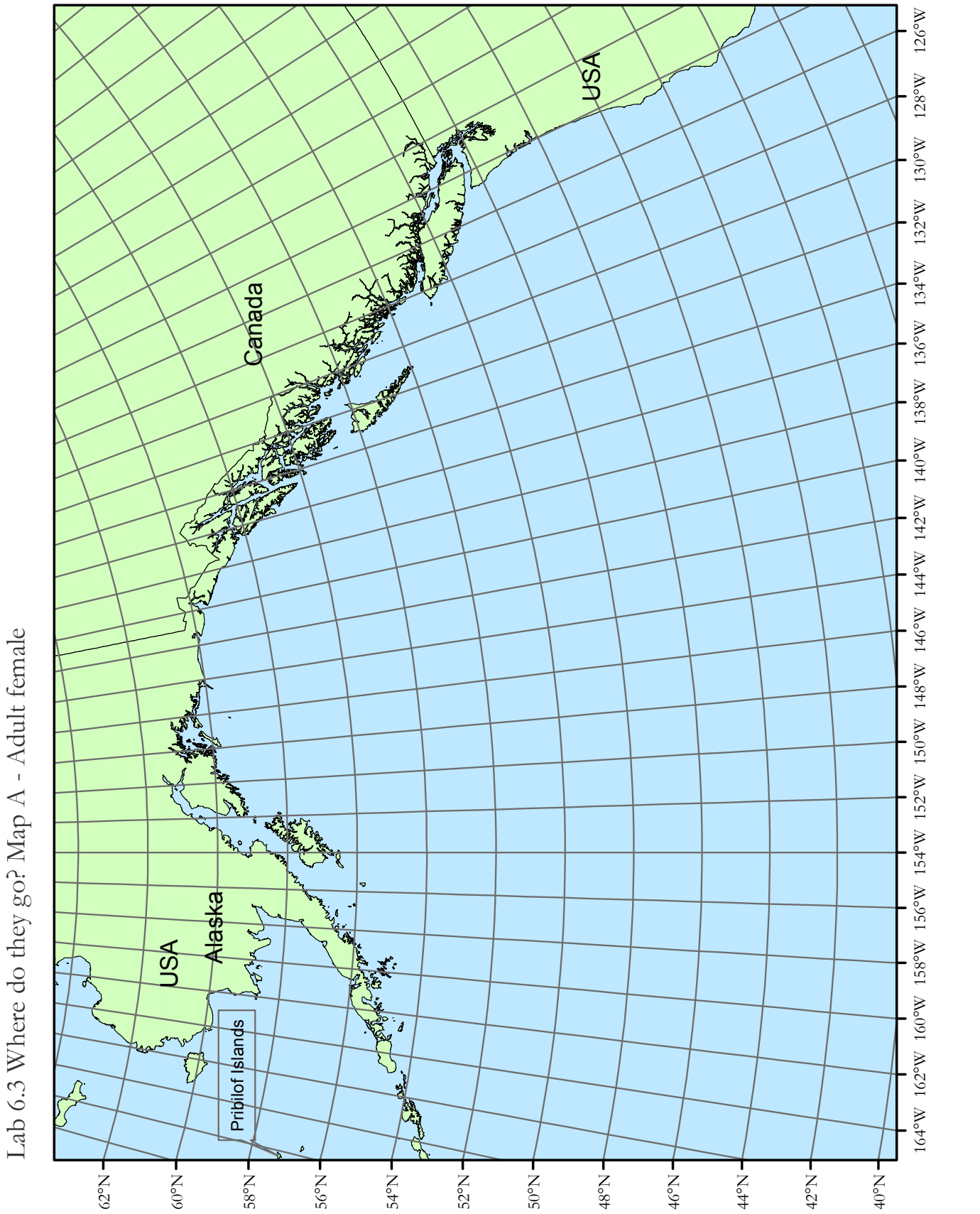
LAB 6.3 **TEACHER KEY 6.3.1** Student Name: Date:



LAB 6.3 **MAP 6.3.2**

Adult female fur seal migration

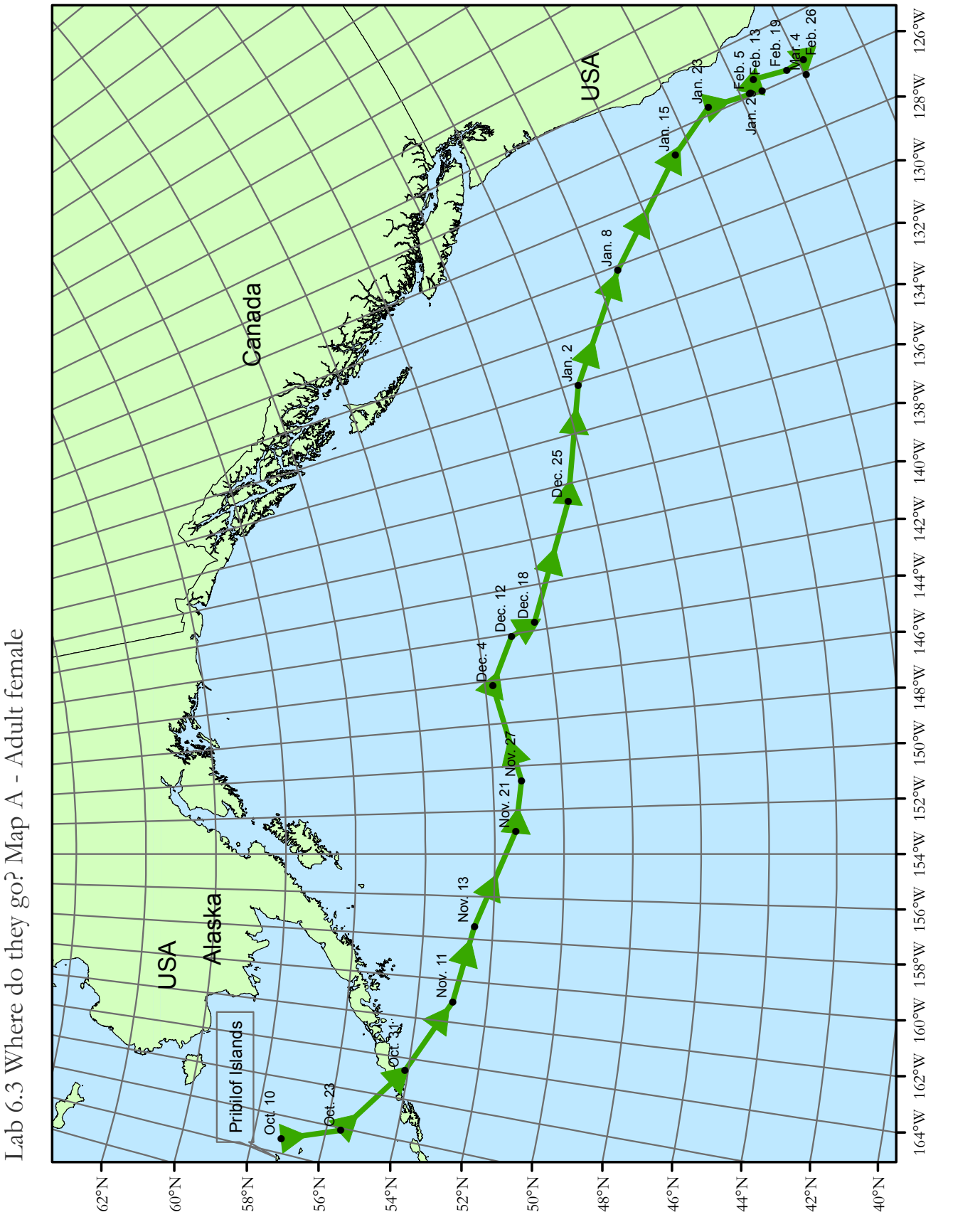
Student Name: _____ Date: _____



Lab 6.3 Where do they go? Map A - Adult female

LAB 6.3 TEACHER KEY 6.3.2 Adult female fur seal migration

Student Name: _____ Date: _____



LAB 6.3 TABLE 6.3.2 Adult female fur seal migration

Adult Female Northern Fur Seal Migration Data

Date	age	sex	weight kg	latitude	latitude	longitude	longitude
10/16/2010	Adult	F	37.6	57.2	N	-169.23	W
10/23/2010	Adult	F	37.6	55.59	N	-168.13	W
10/31/2010	Adult	F	37.6	54.1	N	-164.63	W
11/6/2010	Adult	F	37.6	52.99	N	-161.03	W
11/13/2010	Adult	F	37.6	52.54	N	-157.4	W
11/21/2010	Adult	F	37.6	51.39	N	-152.97	W
11/27/2010	Adult	F	37.6	51.18	N	-150.67	W
12/4/2010	Adult	F	37.6	51.77	N	-146.22	W
12/12/2010	Adult	F	37.6	51.05	N	-144.11	W
12/18/2010	Adult	F	37.6	50.33	N	-143.66	W
12/25/2010	Adult	F	37.6	48.7	N	-138.73	W
1/2/2011	Adult	F	37.6	47.53	N	-134.12	W
1/8/2011	Adult	F	37.6	45.34	N	-130.18	W
1/15/2011	Adult	F	37.6	42.49	N	-126.86	W
1/23/2011	Adult	F	37.6	41.03	N	-125.74	W
1/29/2011	Adult	F	37.6	39.36	N	-125.98	W
2/5/2011	Adult	F	37.6	39.7	N	-125.9	W
2/13/2011	Adult	F	37.6	39.45	N	-125.49	W
2/19/2011	Adult	F	37.6	38.43	N	-125.68	W
2/26/2011	Adult	F	37.6	37.83	N	-125.58	W
3/4/2011	Adult	F	37.6	37.94	N	-126.1	W

LAB 6.3 TABLE 6.3.3 Adult male fur seal migration

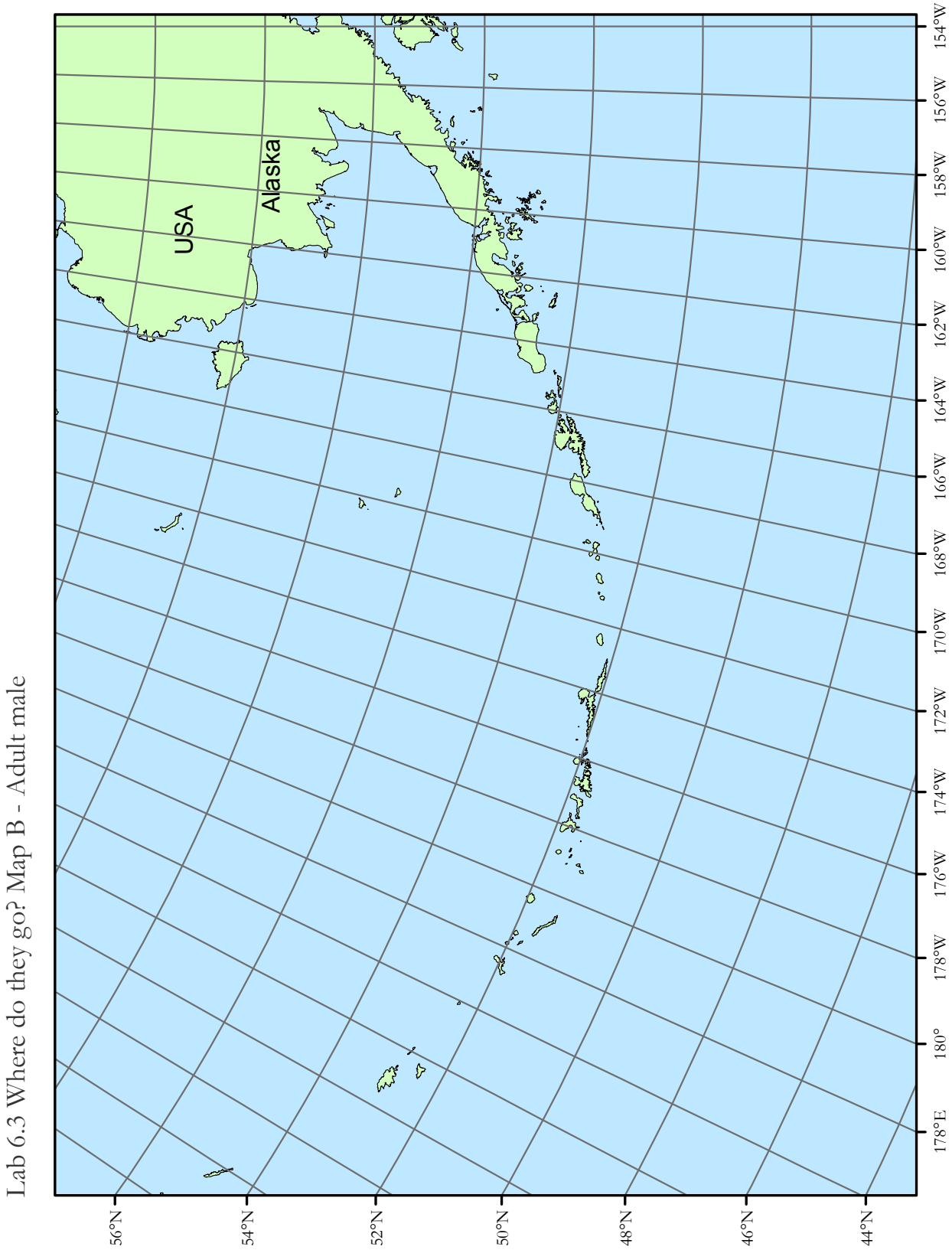
Adult Male Fur Seal Migration Data

Date	age	sex	weight kg	latitude		longitude	
10/21/2009	adult	M	152.9	57.12	N	-170.272999	W
10/28/2009	adult	M	152.9	57.09	N	-170.42356	W
11/5/2009	adult	M	152.9	57.15	N	-170.327448	W
11/12/2009	adult	M	152.9	59.34	N	-172.584637	W
11/19/2009	adult	M	152.9	60.25	N	-174.909245	W
11/26/2009	adult	M	152.9	56.34	N	-179.698767	W
12/2/2009	adult	M	152.9	51.09	N	-178.309796	W
12/9/2009	adult	M	152.9	50.19	N	-173.035653	W
12/16/2009	adult	M	152.9	53.59	N	-170.629016	W
12/23/2009	adult	M	152.9	56.37	N	-171.194472	W
12/30/2009	adult	M	152.9	58.54	N	-174.513738	W
1/6/2010	adult	M	152.9	60.36	N	-176.10978	W
1/13/2010	adult	M	152.9	61.08	N	-177.570581	W
2/10/2010	adult	M	152.9	48.26	N	-178.350296	W
2/17/2010	adult	M	152.9	47.64	N	-176.943076	W
2/24/2010	adult	M	152.9	47.97	N	-176.180085	W
3/2/2010	adult	M	152.9	47.64	N	-174.797957	W
3/9/2010	adult	M	152.9	46.26	N	-173.160103	W
3/16/2010	adult	M	152.9	47.83	N	-173.577444	W
3/23/2010	adult	M	152.9	47.87	N	-172.965194	W
3/30/2010	adult	M	152.9	48.94	N	-173.216234	W
4/6/2010	adult	M	152.9	49.29	N	-172.897557	W
4/13/2010	adult	M	152.9	49.30	N	-173.774444	W
4/20/2010	adult	M	152.9	48.09	N	-174.515481	W
4/27/2010	adult	M	152.9	48.14	N	-174.1137	W
5/4/2010	adult	M	152.9	49.16	N	-174.456898	W
5/11/2010	adult	M	152.9	47.48	N	-173.545334	W
5/18/2010	adult	M	152.9	48.73	N	-171.687422	W
5/22/2010	adult	M	152.9	50.34	N	-171.358997	W

LAB 6.3 **MAP 6.3.3**

Adult male fur seal migration

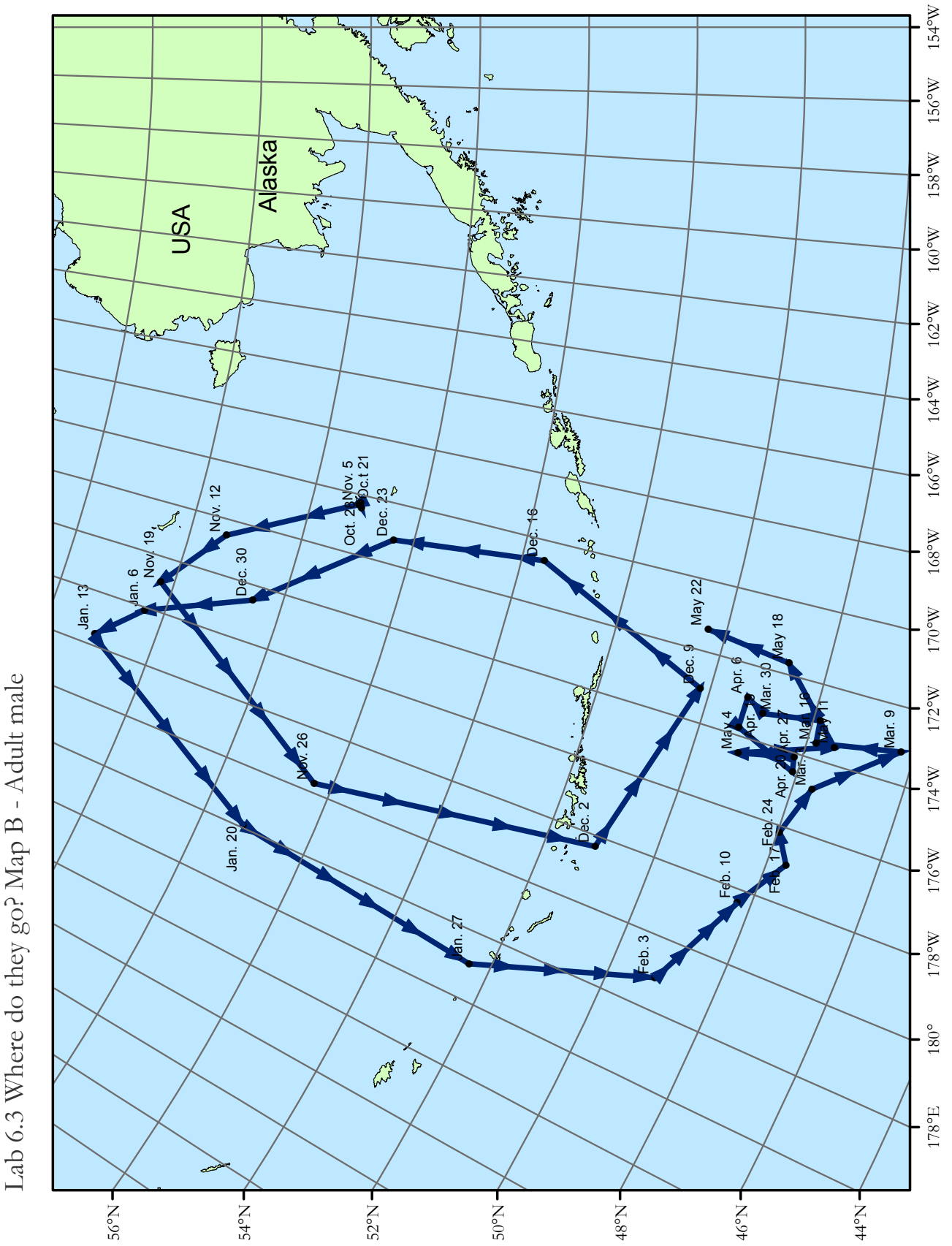
Student Name: _____ Date: _____



Lab 6.3 Where do they go? Map B - Adult male

LAB 6.3 TEACHER KEY 6.3.3 Adult male fur seal migration

Student Name: _____ Date: _____



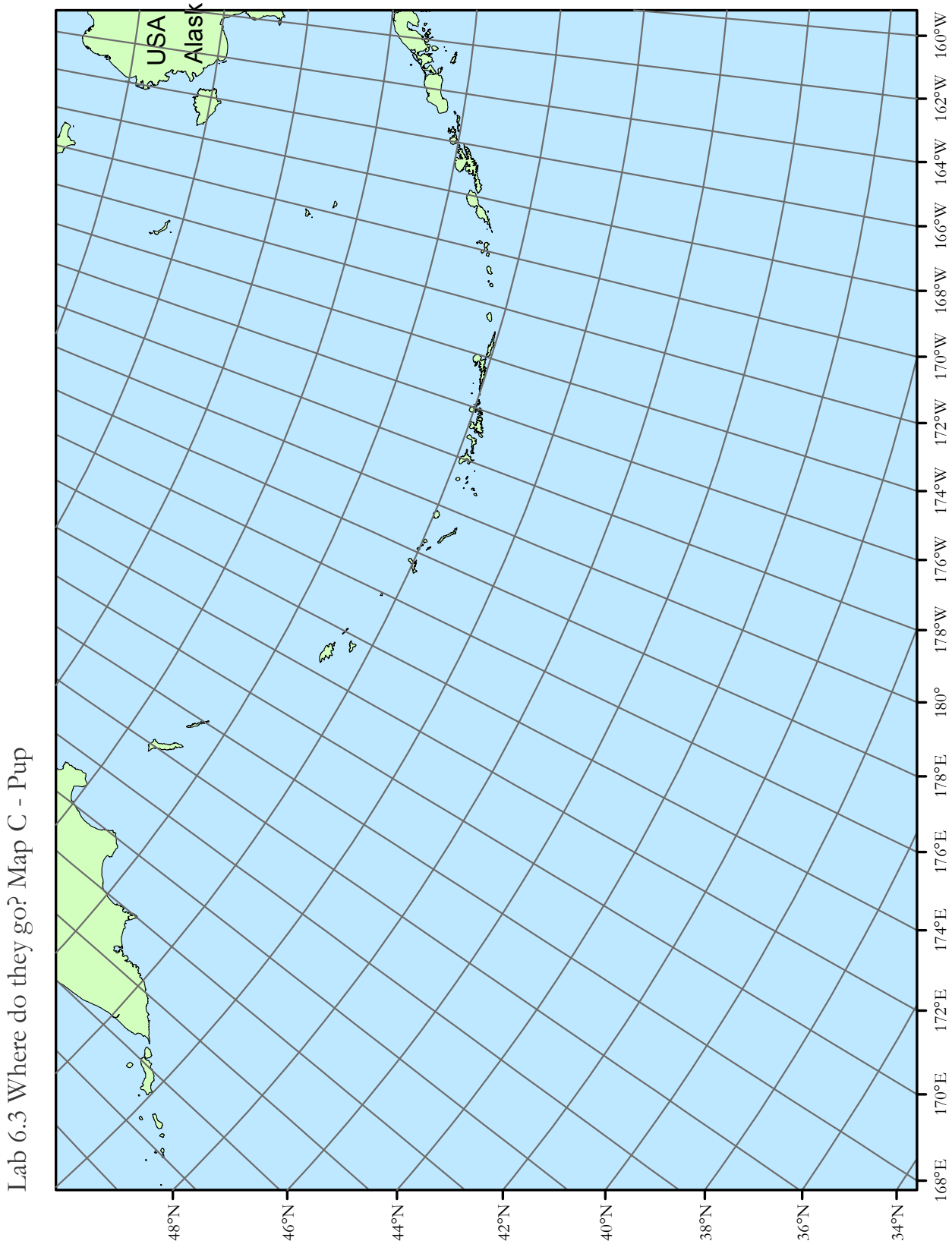
LAB 6.3 TABLE 6.3.4 Pup fur seal migration

Pup Northern Fur Seal Migration Data

Date	age	sex	latitude	latitude	longitude	longitude
11/15/2005	pup	M	57.2948	N	-170.091752	W
11/22/2005	pup	M	53.858181	N	-173.498419	W
11/29/2005	pup	M	53.164995	N	-172.763224	W
12/7/2005	pup	M	53.264667	N	-176.286678	W
12/14/2005	pup	M	53.384925	N	-177.601637	W
12/22/2005	pup	M	52.792756	N	-179.784222	W
12/27/2005	pup	M	53.254865	N	179.290937	E
1/4/2006	pup	M	53.124632	N	179.354705	E
1/10/2006	pup	M	52.276863	N	178.231327	E
1/17/2006	pup	M	52.510232	N	178.9586	E
1/25/2006	pup	M	53.233107	N	-179.165492	W
1/31/2006	pup	M	52.212752	N	178.500673	E
2/7/2006	pup	M	53.015293	N	179.812403	E
2/14/2006	pup	M	52.626541	N	176.231415	E
2/21/2006	pup	M	52.350866	N	177.471198	E
2/28/2006	pup	M	52.620947	N	177.785248	E
3/6/2006	pup	M	52.515271	N	177.198458	E
3/13/2006	pup	M	52.591536	N	179.523507	E
3/20/2006	pup	M	52.698302	N	179.255049	E
3/27/2006	pup	M	50.011152	N	179.3984	E
4/4/2006	pup	M	46.922167	N	-178.29188	W
4/10/2006	pup	M	44.477685	N	-179.530605	W
4/17/2006	pup	M	42.4611	N	178.875399	E
4/24/2006	pup	M	46.75259	N	178.1934	E
5/3/2006	pup	M	48.49282	N	179.293593	E
5/8/2006	pup	M	48.266793	N	179.595869	E
5/15/2006	pup	M	48.662363	N	176.128345	E
5/22/2006	pup	M	47.041551	N	171.815525	E
5/29/2006	pup	M	44.913063	N	166.153223	E
6/5/2006	pup	M	40.721638	N	164.714724	E
6/12/2006	pup	M	39.747556	N	163.404012	E
6/19/2006	pup	M	40.031238	N	165.036759	E
6/27/2006	pup	M	40.479202	N	166.996934	E

LAB 6.3 MAP 6.3.4 Pup fur seal migration

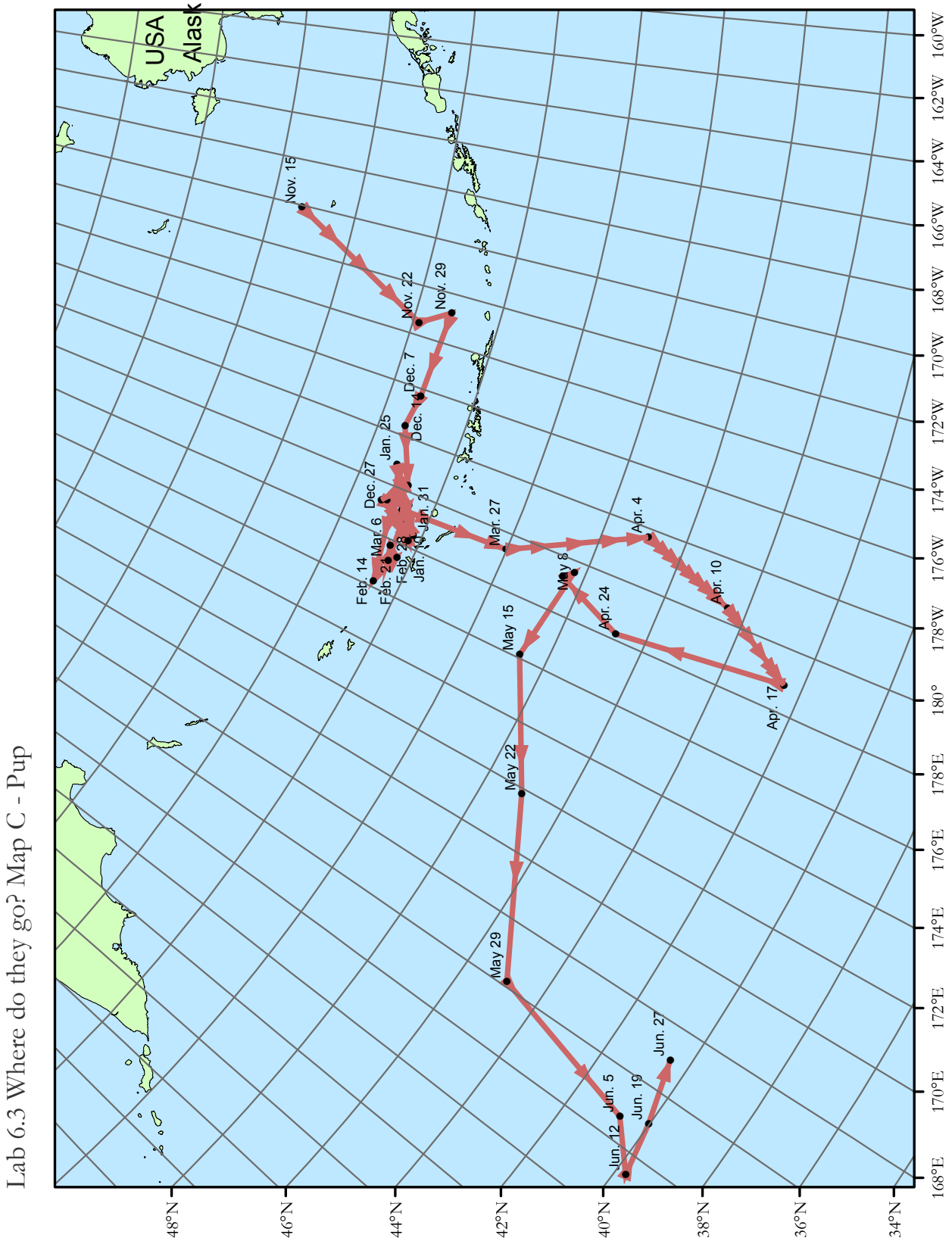
Student Name: _____ Date: _____



Lab 6.3 Where do they go? Map C - Pup

LAB 6.3 TEACHER KEY 6.3.4 Pup fur seal migration

Student Name: _____ Date: _____



Lab 6.3 Where do they go? Map C - Pup

APPENDIX I GLOSSARY

adaptation Any change in the structure or functioning of an organism that makes it better suited to its environment. (Oxford Dictionary of Science)

Aleut Name used by Russian fur traders in the 1700s when referring to people who inhabited the islands now known as the Aleutian Islands.

Antarctic Circle The line of latitude 66.5° south of the equator. Along this line in the southern hemisphere the sun does not set on the day of the summer solstice (usually 21 December) and does not rise on the winter solstice usually 21 June).

archipelago An extensive group of islands.

Arctic Circle The line of latitude 66.5° north of the equator. Along this line in the northern hemisphere the sun does not set on the summer solstice (usually 21 June) and does not rise the winter solstice (usually 21 December).

baleen A fibrous structure made of keratin found in the mouths of filter-feeding whales such as humpback and gray whales. In humans, keratin can be found in fingernails and toenails.

baleen whale A whale with baleen in its mouth instead of teeth. There are 11 species of baleen whales; three examples are blue whale, humpback whale, and gray whale. Also called a mysticete.

blind A shelter used for observing or hunting animals.

blubber A thick layer of fat underneath the skin of marine mammals that provides insulation from the cold and a source of energy when food supplies are low.

breeding philopatry or breeding-site fidelity returning to the same location to breed, year after year.

cetacean A marine mammal of the order Cetacea, which includes whales, dolphins, and porpoises.

chromosome A threadlike strands found in the nucleus of most living cells consisting of a single DNA molecule bonded to proteins and that carries genetic information in the form of genes.

cold-blooded Having a body temperature that is dependent on the surrounding environment. A cold-blooded animal is hot when its environment is hot and cold when its environment is cold.

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

countercurrent heat exchange A process that occurs in nature preventing large amounts of heat from being lost to the environment by causing the transfer of heat from warm blood to cool blood reentering the core of the body.

DNA (deoxyribonucleic acid) is the material present in all living organisms that carries all the information about how a living thing will look and function.

eared seal A pinniped of the family Otariidae, which includes sea lions and fur seals. Unique characteristics include an external ear flap and flexible hindflippers that can be rotated forward under the body allowing the animal to walk on all four when on land.

ecosystem A community of living organisms and their environment, and the interactions between the two.

equator The line of latitude that is an equal distance from the North Pole and the South Pole, designated as 0° latitude.

Eskimo A name commonly used in Alaska to refer to Inuit and Yupik people.

eye lens A transparent structure in the eye used to focus light.

feces Bodily waste discharged from animals; also called stool or scat.

fecundity Fecundity is derived from the word fecund which means 'fruitful'. In biology, fecundity refers to fertility or the rate of reproduction of an individual or population.

fissiped Carnivores with toes that are separated from each other. Fissiped is Latin for "split-foot." Weasels (sea otters, mink, badgers), bears (polar, brown, black), dogs and cats are fissipeds.

food chain A food pathway that links different plants and animals within a community or ecosystem. Nutrients and energy are passed from creature to creature through the food chain.

food web A network of food chains in an ecosystem

foraging The act of searching and hunting for food.

gene Genes are made of DNA and are the basic physical unit of heredity.

APPENDIX I GLOSSARY

harbor seal A true seal with spotted coat, commonly found in coastal waters of the northern hemisphere. See true seal definition for characteristics.

haulout Areas on land or ice where pinnipeds (seals, sea lions and walruses) can temporarily leave the water to rest.

hemoglobin The protein in red blood cells that carries oxygen. Similar to myoglobin in muscles.

insulate To prevent the transfer of heat.

Laaqudax̂ Unangam word for northern fur seal.

Laaqudaax̂ Unangam word for northern fur seal pup. Note that the last syllable is longer than the word for northern fur seal.

latitude or line of latitude Imaginary line that runs east to west around the globe parallel to the equator. A latitude line measures the distance north or south of the equator.

locus the location of a gene on a chromosome.

longitude or line of latitude Imaginary line that runs from the North Pole to the South Pole. It measures distances east and west from a base longitude line or prime meridian.

mammal Warm-blooded vertebrate that has hair or fur, gives birth to live offspring, and produces milk to nurse its offspring.

Marine Mammal Protection Act of 1972 An Act to protect marine mammals and their environment, passed by Congress and signed by President Richard Nixon in 1972. Animals protected under this Act include whales, dolphins, seals, sea lions, and walruses.

MMPA: Depletion a population below its optimum sustainable population.

MMAP: Harassment causing a marine mammal to change its behavior in any way.

MMPA: Moratorium a complete ban on taking or importing marine mammal/marine mammal products.

MMPA: Optimum Sustainable Population (OSP) the number of animals that will maintain a healthy population in their ecosystem.

MMPA: Population stock a group of marine mammals of the same species that interbreed.

MMAP: Take the "hunt, harass, capture, or kill" a marine mammal or attempt to do so.

MMPA: Secretary the Secretary of Commerce of the Secretary of the Interior, or both.

midden A mound or deposit containing shells, animal bones and other trash that indicates the presence of humans.

migration The long distance movement of animals on a seasonal basis.

molt To shed old fur and grow new fur.

mortality Death.

myoglobin The protein in muscle that carries oxygen. Similar to hemoglobin in blood.

natal philopatry When an animal returns to the site where it was born, to breed or give birth.

NOAA An abbreviation for the National Oceanic and Atmospheric Administration, a federal government agency in the Department of Commerce, created in 1970. NOAA scientists conduct research on the world's oceans and atmosphere.

northern fur seal A pinniped with ear flaps (an "eared seal"), long front flippers, the ability to walk on all four flippers on land, and with dense underfur. Northern fur seals are found in the North Pacific Ocean, the Bering Sea and the Sea of Okhotsk.

northern fur seal: adult female A female northern fur seal that is old enough to have pups. Usually three years or older.

northern fur seal: adult male A male northern fur seal that is old enough to mate. Usually 7 years or older.

northern fur seal: breeding male An adult male who defends a territory on the rookery containing females. Usually 9 years or older.

northern fur seal: idle male An adult male who may hold a territory on the rookery but does not hold females on the territory.

northern fur seal: juvenile A northern fur seal from December of its birth year until it is old enough to mate.

northern fur seal: pup A northern fur seal from birth to December of its birth year.

odobenid Scientific name for walrus.

otariid (Otariidae) Scientific name for an eared seal such as a northern fur seal or Steller's sea lion.

APPENDIX I GLOSSARY

otolith Otoliths or "earstones" are found in the heads of all fishes except sharks, rays, and lampreys. The otolith of each fish species has a distinctive shape. Scientists use otolith shape to identify the species of fish eaten by seals and sea lions.

pelage Fur, hair, or wool of a mammal.

pelagic Relating to, or living in, the open ocean or seas.

phocid (Phocidae) Scientific name for a true seal such as a harbor seal.

phytoplankton Tiny plants that form the beginning of the food chain for aquatic animals.

pinniped Semi-aquatic marine mammals; pinnipeds leave the water to rest, molt, and reproduce. Pinniped is Latin for "fin-foot." Seals, sea lions and walruses are all pinnipeds.

plankton Tiny plants and animals that live in the water and float with currents. Most plankton can only be seen with a magnifying glass or microscope.

population A group of organisms that live in the same place at the same time.

prey An animal hunted and eaten for food.

Pribilof Islands A group of four volcanic islands in the Bering Sea. The Pribilof Islands are home to the largest population of northern fur seals in the world, as well as large seabird rookeries.

prime meridian A line of longitude defined to be 0°.

pup wad A group of northern fur seal pups on a rookery.

rookery A colony of breeding animals. A rookery can be a nesting place for birds (especially birds that nest in large groups), or breeding grounds for pinnipeds (seals, sea lions and walruses).

satellite tag Scientific instrument used to track the location of an animal in real time. The instrument sends location data through a satellite to a personal computer.

scat Bodily waste discharged from animals; also called stool, feces, or poop.

sea lion A pinniped with external ear flaps, long front flippers, the ability to walk on all four flippers on land, and with no dense underfur. Sea lions and fur seals make up the "eared seal" group of pinnipeds.

seal see definition for true seal

sirenian Manatees and dugongs. Marine mammals found in warm water that only eat seagrass and aquatic vegetation.

site fidelity Returning to the same area each year.

snout The part of an animal's face that projects forward and includes nose, mouth and jaws.

subsistence hunt Harvesting of wildlife by indigenous people for consumption and traditional or cultural requirements.

thermoregulate regulate temperature, especially one's own body temperature

toothed whale A whale with teeth, instead of baleen. Also called odontocete.

topography The physical or natural features of an area.

Tropic of Cancer An imaginary latitude line that lies approximately 23.5° north of the equator. It is the circle of latitude on the earth that marks the most northerly position at which the sun may appear directly overhead.

Tropic of Capricorn An imaginary line that lies approximately 23.5° south of the equator. It marks the most southerly latitude on the earth at which the sun can be directly overhead.

true seal A pinniped of the family Phocidae, which includes harbor seals and spotted seals. Unique characteristics include no external ear flaps and a sleek, streamlined, sausage-shaped body. A true seal cannot walk on all four flippers, but moves on its stomach when on land or ice. Other names include seal, hair seal or phocid seal.

Unangam (adjective) Proper adjective, for example "the Unangam People" or "Unangam culture." http://alaska.si.edu/culture_unangan.asp?continue=1

Unangan (noun) Name the people of the Aleutian and Commander Islands use for themselves. Eastern dialect. http://alaska.si.edu/culture_unangan.asp?continue=1

Unangas Name the people of the Aleutian and Commander Islands use for themselves in the western Aleutian dialect.

vertebra (plural: vertebrae) An individual bone in the backbone or vertebral column. If you run your finger down your backbone, you will feel bumps. Each of these bumps is from one vertebra

APPENDIX I GLOSSARY

vocalizations The sounds that an animal makes fur seals use calls to communicate with other fur seals.
walrus (*Odobenus rosemarus*) A pinniped of the family Odobenidae. Unique characteristics include no external ear flaps, large tusks, thick leathery hide, and hindflippers that rotate forward underneath the body allowing the animal to walk on all fours when on land. Its scientific name translates to "tooth-walking sea horse."
warm-blooded Having a high constant body temperature independent of the surrounding temperature.
zooplankton Animal plankton (tiny animals) that live in the water. Zooplankton are microscopic animals that eat other plankton (both plant and animal plankton).

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Laaqux: The Northern Fur Seal of the Pribilof Islands. 1988. Canmore, Alberta Canada: Flying Tomato Productions, 57 minutes, DVD.

Microworlds. 2011. Seattle, WA: NOAA Alaska Fisheries Science Center, http://www.afsc.noaa.gov/education/Activities/micro_worlds.htm.

Peter Picked a Seal Stick: The Fur Seal Harvest of the Pribilof Islands. 1981. Canmore, Alberta Canada: Flying Tomato Productions, 28 minutes, DVD.

People of the Seal. 2009. Directed by Kate Raisz. Seattle, WA: NOAA Ocean Media Center, 72 minutes, http://www.youtube.com/watch?v=3TuC2erWFlI DVD,.

San: The Birds of the Pribilof Islands. 1980. Canmore, Alberta Canada: Flying Tomato Productions, 58 minutes, DVD.

Usual and Accustomed Places. Directed by Sandra Sunrising Osawa. 2000. Seattle, WA: Upstream Productions, 48 minutes, DVD.

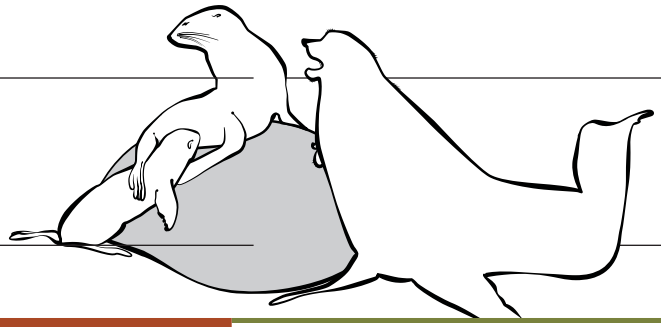
APPENDIX III CURRICULUM OVERVIEW

Lesson	Topic	Components	Grade Level	Time
		Labs vary by grade level allowing educators to select age appropriate activities for their class.		
	Curriculum Pre and Post Assessment		7-12	15 min
1	***What is a fur seal?***	PowerPoint Overview (7 slides) Lab 1.1: Review: Mammals, Marine Mammals, and Pinniped	 7-12	 30 min
2	***Who are the Unangan?***	PowerPoint Overview (10 slides) Lab 2.1: Where are the Aleutian and Pribilof Islands? (mapping) Lab 2.2: Who are the Unangan? (read and discuss) Lab 2.3: *People of the Seal* (watch and discuss) Lab 2.4: *Aleut Story* (watch and discuss) Lab 2.5: *Aleutian Sparrow*, *The White Seal*, and *Libby* (read and discuss)	 7-12 7-12 7-12 7-12 7-12	 50 min 50 min 2x50 min 3x50 min 30-50 min
3	***What is a fur seal rookery?***	PowerPoint Overview (13 slides) Lab 3.1: What is a Rookery? (review, assess, worksheet, discussion) Lab 3.2: Fecundity: The Next Generation (hands-on) Lab 3.2: Rookery Timeline (hands-on) Lab 3.4: Paternity and Maternity on the Rookery (hands-on) Lab 3.5: Create a Rookery – Rubber Stamp Making (hands on, art)	 7-12 7-12 7-12 9-12 7-12	 50 min 50 min 50 min 50 min 2x50 min
4	***What do fur seals eat?***	PowerPoint Overview (8 slides) Lab 4.1: Bering Sea Food Web (hands on) Lab 4.2: Microworlds: What do Marine Mammals Eat? (video) Lab 4.3: Scat Detective (hands on) Lab 4.4: Scat Detective and Frequency of Occurrence (hands on) Lab 4.5: Advanced Scat Detective (graphing and data analysis	 7-12 7-12 7-8 9-12 9-12	 50 min 30 min 50 min 50 min 50 min
5	***How do fur seals dive?***	PowerPoint Overview (10 slides) Lab 5.1: Blubber vs. Air (hands-on) Lab 5.2: Thermoregulation: Countercurrent Heat Exchange (hands-on) Lab 5.3: Waiting to Inhale! (hands-on) Lab 5.4: Interpreting Fur Seal Dive Data (data analysis)	 7-12 9-12 7-12 9-12	 30 min 50 min 50 min 50 min
6	***Where do fur seals go in the winter?***	PowerPoint Overview (10 slides) Lab 6.1: Where are Fur Seal Rookeries? (mapping) Lab 6.2: *Fur Seal Migrations* (video) Lab 6.3: Fur Seal Migrations (mapping)	 7-12 7-12 7-12	 30 min 30 min 50 min
7	***Populations, Harvest, Management***s	PowerPoint Overview (13 slides) Lab 7.1: Estimating a Population (math) Lab 7.2: Mark-Recapture: How Many Pups? (math) Lab 7.3: Analyzing Pup Population Data: 1961-2016 (math) Lab 7.4: Compare Historical Timelines (history, writing, discussion) Lab 7.5: Interpret Historical Images (history, writing, discussion) Lab 7.6: Analyzing Fur Seal Harvest Data: 1817-2016 (math)	 7-12 7-12 9-12 7-12 7-12 9-12	 50 min 50 min 50 min 50 min 50 min 50 min
8	***Marine Mammal Protection Act***	PowerPoint Overview (22 slides) Lab 8.1 Marine Mammal Protection Act Summary (research, writing, interpretation) Lab 8.2 MMPA: Unintended Consequences of a Law (research, writing, interpretation) Lab 8.3 MMPA Case Study: Gray Whales (research, writing, interpretation) Lab 8.4 MMPA Case Study: Northern Fur Seals (research, writing, interpretation) Lab 8.5 MMPA Comparative Analysis: Makah/Pribilof Islanders (research, writing, interpretation)	 9-12 9-12 9-12 9-12	 50 min 50 min 50 min 50 min

APPENDIX IV LESSON OVERVIEWS

LESSON ONE

What is a fur seal?



Subject Area(s): Life Science	Grade Levels: 7-12	Presentation – 10 minutes Labs – variable

Lesson Topics:	Review characteristics of mammals, marine mammals, and pinnipeds.	**Focus Questions**	• What is a mammal? • What is a marine mammal? • What is a pinniped?
Learning Objectives:	Students will: • review the characteristics of mammals, marine mammals, and pinnipeds.	**Key words:**	mammal, pinniped, true seal, eared seal, walrus, phocid, otariid, odobenid, northern fur seal, harbor seal, sea lion, pelage

LABS		ALASKA STANDARDS		
		Science	Minutes	Grades
Lab 1.1	Review Mammals, Marine Mammals, and Pinnipeds (worksheets)	SC2	30	7-12

Targeted Alaska Grade Level Expectations (GLEs)

Science

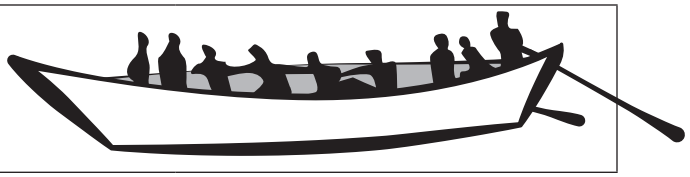
Concepts of Life Science

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

APPENDIX IV LESSON OVERVIEWS

LESSON TWO

Who Are The Unangan?



Subject Area(s): Life science, history, cultural	**Grade Levels:** 7-12	Presentation – 15 minutes Labs – variable

Lesson Topics:	Geography, Unangam culture and history, Unangan relationship to northern fur seals	**Focus Questions**	• Where are the Aleutian and Pribilof Islands? • Who are the Unangan? • How have historical events affected Unangam history?
Learning Objectives:	Students will: • investigate the geography of the Aleutian and Pribilof Islands • interpret the Unangam culture through film and literature	**Key words:**	Unangan (noun), Unangam (adjective), Aleutian Islands, Pribilof Islands, culture, history, internment

LABS		ALASKA STANDARDS			
		Science	History	Minutes	Grades
Lab 2.1	Where are the Aleutian Islands and the Pribilof Islands? (mapping)	SF1-3	PPE1	50	7–12
Lab 2.2	Who Are the Unangan? (read and discuss)		IGCP2	50	7–12
Lab 2.3	*People of the Seal* (watch and discuss)		ICGP2,9, CC1-4	2x50	7-12
Lab 2.4	*Aleut Story* (watch and discuss)		ICGP2,5,9, CC1-4	3x50	7-12
Lab 2.5	*Aleutian Sparrow, The White Seal, Libby* (read and discuss)		ICGP2,5,9, CC1-4	30-50	7-12

Targeted Alaska Grade Level Expectations (GLEs)

Cultural, Social, Personal Perspectives, and Science

SF1 Students develop an understanding of the interrelationships among individuals, cultures, societies, science, and technology.

SF2 Students develop an understanding that some individuals, cultures, and societies use other beliefs and methods in addition to scientific methods to describe and understand the world.

SF3 Students develop an understanding of the importance of recording and validating cultural knowledge.

American History-People, Places, Environment (PPE)

The student demonstrates an understanding of the interaction between people and their physical environment by:

PPE 1 comparing and contrasting geographic regions of Alaska.

Individual, Citizenship, Governance, Power (ICGP)

The student demonstrates an understanding of the historical rights and responsibilities of Alaskans by:

ICGP 2 using texts/sources to analyze the impacts of the relationships between Alaska Natives and Russians (i.e., Russian Orthodox Church, early fur traders, Russian American Companies, enslavement, and Creoles).

ICGP 5 explaining the impacts of military actions relative to Native communities (e.g., Naval bombardment of Angoon, Aleut internment, military expeditions.)

ICGP 9 exploring the federal government's influence on settlements in Alaska (e.g., Matanuska Colony, Anchorage, Adak, Tok, Hydaburg) by establishment of post offices, military facilities, schools, courts, and railroads.

Continuity and Change (CC)

The student demonstrates an understanding of the chronology of Alaska history by:

CC 1 using texts/sources to recognize and explain the interrelationships among Alaska, national, and international events and developments (e.g., international interest, trade, commerce).

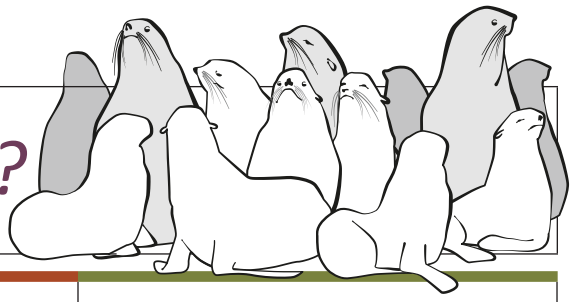
CC 2 describing how policies and practices of non-natives (e.g., missionaries, miners, Alaska Commercial Company merchants) influenced Alaska Natives.

CC 3 describing how the roles and responsibilities in Alaska Native societies have been continuously influenced by changes in technology, economic practices, and social interactions.

CC 4 giving correct and incorrect examples to explain subsistence as a way of life.

LESSON THREE

What is a fur seal rookery?



Subject Area(s): Life science, genetics, reading	**Grade Levels:** 7-12	Presentation – 15 minutes Labs – variable

Lesson Topics:	Fur seal rookery structure, location, and seasonal changes	**Focus Questions**	• What is a fur seal rookery? • What information can scientist gather from a rookery? • How does the structure of the fur seal population change on the rookery?
Learning Objectives:	Students will: • describe the seasonal structure of a fur seal rookery • investigate fecundity • examine genetic relationships • summarize their knowledge with art	**Key words:**	rookery, haulout, fecundity, paternity, maternity, seasonal, age class, genetics

LABS		ALASKA STANDARDS		
		Science	Minutes	Grades
Lab 3.1	What is a Rookery? (review, worksheet, discussion)	SC2	30	7–12
Lab 3.2	Fecundity: The Next Generation (worksheet, hands-on)	SC2	50	7-12
Lab 3.3	Rookery Timeline (hands-on)	SC2	50	7–12
Lab 3.4	Paternity and Maternity on the Rookery (worksheet)	SC2	50	9–12
Lab 3.5	Create a Rookery – Rubber Stamp Making (hands-on, art)	SC2	2x50	7-12

Targeted Alaska Grade Level Expectations (GLEs)

Science

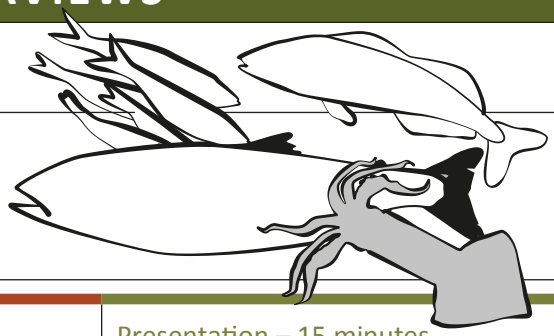
Concepts of Life Science

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

APPENDIX IV LESSON OVERVIEWS

LAB FOUR

What do fur seals eat?



Subject Area(s): Life science	Grade Levels: 7-12	Presentation – 15 minutes Labs – variable

Lesson Topics:	Food chain, food web, scat analysis, food habits/diet	**Focus Questions**	• How do scientists study the fur seal's diet? • What is learned from studying food habits? • Why do scientists study food habits?
Learning Objectives:	Student will: • create a Bering Sea food web • analyze scat contents • graph and analyze scat contents	**Key words:**	diet, prey, ecosystem, scat, food habits, forage, food web, frequency of occurrence

LABS		ALASKA STANDARDS					
		Math 7	Math 8	MATH 9-12	Science	Minutes	Grades
Lab 4.1	Bering Sea Food Web (hands on)				SC2,3	30	7-12
Lab 4.2	Microworlds: What do Marine Mammals Eat? (video)				SC2,3	30	7–12
Lab 4.3*	Scat Detective (hands on)	7.SP1-4	8.SP1	S-ID, S-IC	SA1,2, SC 2,3 SE1,2, SG2	50	7-8
Lab 4.4*	Scat Detective and Frequency of Occurrence (hands on)	7.SP1-4	8.SP1	S-ID, S-IC	SA1,2, SC 2,3 SE1,2, SG2	50	9-12
Lab 4.5*	Advanced Scat Detective (graphing and data analysis)	7.SP1-4	8.SP1	S-ID, S-IC	SA1,2, SC 2,3 SE1,2, SG2	50	9–12

Targeted Alaska Grade Level Expectations (GLEs)

Math

MD Measurement and Data
SP Statistics and Probability

Science

Science as Inquiry and Process

SA1 Students develop an understanding of the processes of science used to investigate problems, design and conduct repeatable scientific investigations, and defend scientific arguments.

SA2 Students develop an understanding that the processes of science require integrity, logical reasoning, skepticism, openness, communication, and peer review.

Concepts of Life Science

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

SC3 Students develop an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy.

Science and Technology

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.

SE2 Students develop an understanding that solving problems involves different ways of thinking, perspectives, and curiosity that lead to the exploration of multiple paths that are analyzed using scientific, technological, and social merits.

History and Nature of Science

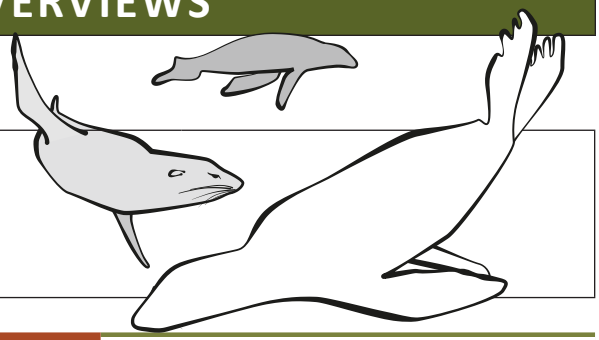
SG2 Students develop an understanding that the advancement of scientific knowledge embraces innovation and requires empirical evidence, repeatable investigations, logical arguments, and critical review in striving for the best possible explanations of the natural world.

*Labs 4.3, 4.4, and 4.5 involve investigating the diets of northern fur seals through scat analysis.
*Lab 4.3 is the most basic and involves plotting the frequency of items found in scats prepared by the instructor.
*Lab 4.4 takes the process one step further by calculating the Frequency of Occurrence of prey items found in scats created by the instructor. The data provided for this lab are very similar to real data collected in the field.
*Lab 4.5 uses a set of actual data collected from the Pribilof Islands for the students to manipulate, graph, and analyze.

APPENDIX IV LESSON OVERVIEWS

LESSON FIVE

How do fur seals dive?



Subject Area(s): Life science	**Grade Levels:** 7-12	Presentation – 15 minutes Labs– variable

Lab Topics:	Fur seal diving and adaptations to cold environments.	**Focus Questions**	• How are pinnipeds adapted to the cold water? • Why do fur seals dive? • What can be learned from studying diving behavior?
Learning Objectives:	Students will: • investigate adaptations of seals to water • collect and summarize data • interpret fur seal dive data	**Key words:**	blubber, body shape, forage, adpatation, counter-current heat exchange, thermoregulation

LABS		ALASKA STANDARDS					
		Math 7	Math 8	Math 9-12	Science	Minutes	Grades
Lab 5.1	How do Marine Mammals Stay Warm? Blubber vs. Air (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2	30	7–12
Lab 5.2	Thermoregulation: Counter Current Heat Exchange (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2 SG2	50	9-12
Lab 5.3	Waiting to Inhale! (hands-on)	7.SP.1-4	8.SP.1-4		SA1,2 SC1,2 SG2	50	7–12
Lab 5.4	Interpreting fur seal dive data (data analysis)	7.SP.1-4	8.SP.1-4	S-IC.	SA1,2 SC1,2 SG2	50	9-12

Targeted Alaska Grade Level Expectations (GLEs)

Math

MD Measurement and Data
SP Statistics and Probability
Statistics: IC.1

Science

Science as Inquiry and Process
SA1; SA2

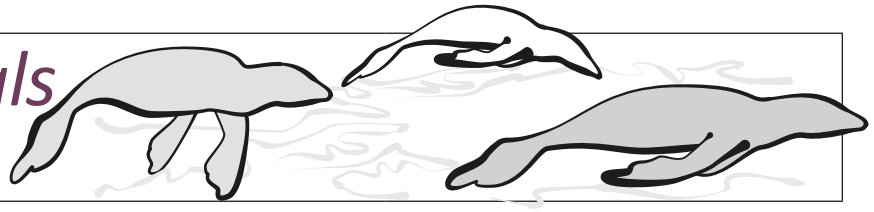
Concepts of Life Science
SC2

History and Nature of Science
SG2

APPENDIX IV LESSON OVERVIEWS

LESSON SIX

Where do fur seals go in the winter?



Subject Area(s): Life science, geography, reading	**Grade Levels:** 7-12	Presentation – 15 minutes Labs– variable

Lab Topics:	Fur seal migration, traditional knowledge of migration, and current research.	**Focus Questions**	• Why do fur seals leave the rookery? • Where do they go? • How do we know? • Why do we want to know where they go?
Learning Objectives:	Students will: • describe where northern fur seals go in the winter • plot fur seal migration tracks on a map • describe three methods scientists use to track fur seal migration routes.	**Key words:**	migrate, satellite tags, tracking instruments, latitude, longitude

LABS		ALASKA STANDARDS		
		Science	Minutes	Grades
Lab 6.1	Where are Fur Seal Rookeries? (mapping)	SA3; SC2,3; SF1,2,3	30	7-12
Lab 6.2	*Fur Seal Migrations* (video, discussion)	SA3; SC2; SF1,2,3	30	7–12
Lab 6.3	Fur Seal Migrations (mapping).	SA3; SC2,3; SF1,2,3; SG1,3,4.	50	7–12

~~Targeted Alaska Grade Level Expectations~~ (GLEs)

Science

Science as Inquiry and Process
SA3

Concepts of Life Science
SC2; SC3

Cultural, Social, Personal Perspectives, and Science
SF1; SF2; SF3

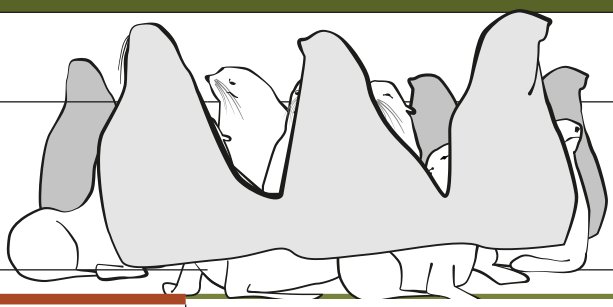
History

History and Nature of Science
SG1; SG3; SG4

APPENDIX IV LESSON OVERVIEWS

LESSON SEVEN

Populations, Harvest, and Management



Subject Area(s): Life science	Grade Levels: 7-12	Presentation – 20 minutes Labs – variable

Lab Topics:	Population estimation, harvest, and management, historical timelines	**Focus Questions**	• How do scientists estimate fur seal populations? • What are the relationships between Pribilof Island historical events, fur seal population, and world history?
Learning Objectives:	Students will: • estimate populations • interpret historical events • analyze harvest and population data.	**Key words:**	population estimation, population, harvest, stakeholder, rate of decline

LABS		ALASKA STANDARDS						
		Math 7	Math 8	Math 7-12	Science	History	Minutes	Grades
Lab 7.1	Estimating a Population (math)	7.RP.1-3 7.SP1-2	8.SP.1	S-ID,S-IC A-CED.2	SA3,SE1,2 SF1,SG1-4		50	7-12
Lab 7.2	Mark-Recapture: How many pups? (math)	7.RP.1-3 7.SP1-2	8.SP.1	S-ID,S-IC A-CED.2			50	7-12
Lab 7.3	Analyze Pup Population Data: 1961-2016 (math)	7.RP.1-3 7.SP1-2	8.SP.1	A-CED.2 S-ID,S-IC			50	9-12
Lab 7.4	Compare Historical Timelines (history, writing, discussion)					PPE2,5,7 IGCP2,5,8,8 CC1-4,7	50	7-12
Lab 7.5	Interpret Historical Images (history, writing, discussion)					PPE2,5,7 IGCP2,5,8,8 CC1-4,7	50	7-12
Lab 7.6	Analyze Fur Seal Harvest Data: 1817-2016 (math)	7.RP.1-3 7.SP1-2	8.SP.1	A-CED.2 S-ID,S-IC	SA3,SE1,2 SF1,SG1-4		20	9-12

Targeted Alaska Grade Level Expectations (GLEs)

Math

RP Ratios and Proportional Relationships
SP Statistics and Probability
A-CED Algebra-Creating Equations that Describe
S-IC Statistics-Inferences and Conclusions
S-ID Statistics-Interpreting Data

Science

Science as Inquiry and Process
SA3

Science and Technology
SE1; SE2

Cultural, Social, Personal Perspectives, and Science
SF1

History and Nature of Science
SG1; SG2; SG3; SG4

History

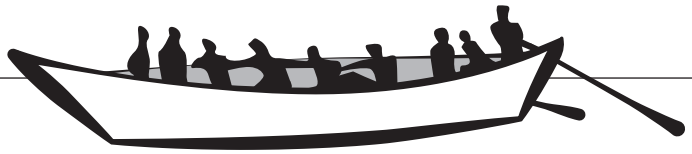
People, Places, and Environment
PPE2,5,7

Consumption, Production, Distribution
CC1-4,7

Individual, Citizenshp, Governance, Power
IGCP2,5,8,8

APPENDIX IV LESSON OVERVIEWS

LESSON EIGHT



Marine Mammal Protection Act

Subject Area(s): Life science, history, cultural	**Grade Levels:** 7-12	Presentation – 20 minutes Labs – variable

Lab Topics:	Marine Mammal ProtectionAct. subsistence hunting, treaty rights	**Focus Questions**	• What is the Marine Mammal Protection Act? • What were the unintended consequences of the MMPA? • How were the Makah and the Pribilof Islanders affected by the MMPA?
Learning Objectives:	Students will: • summarize the Marine Mammal Protection Act • compare and contrast the rights of Native American tribes in states other than Alaska and Alaska Natives.	**Key words:**	Marine Mammal Protection Act, permit, waiver, treaty, subsistence

LABS		ALASKA STANDARDS			
		Science	History	Minutes	Grades
Lab 8.1	Marine Mammal Protection Act, Summary (research, writing, interpretation)		CC1-4,7	50	9–12
Lab 8.2	MMPA: Unintended Consequences (research, writing, interpretation)		CC1-4,7	50	9–12
Lab 8.3	MMPA Case Study: Gray Whales (research, writing, interpretation)		CC1-4,7	50	9–12
Lab 8.4	MMPA Case Study Northern Fur Seals (research, writing, interpretation)		CC1-4,7	50	9-12
Lab 8.5	MMPA Comparative Analysis: Makah and Pribilof Islanders (research, writing, interpretation)		CC1-4,7	50	9-12

Targeted Alaska Grade Level Expectations (GLEs)

American History

Individual, Citizenship, Governance, Power Continuity and Change (CC)
The student demonstrates an understanding of the chronology of Alaska history by:
CC 1; **CC 2**; **CC 3**; **CC 4**; **CC 7**

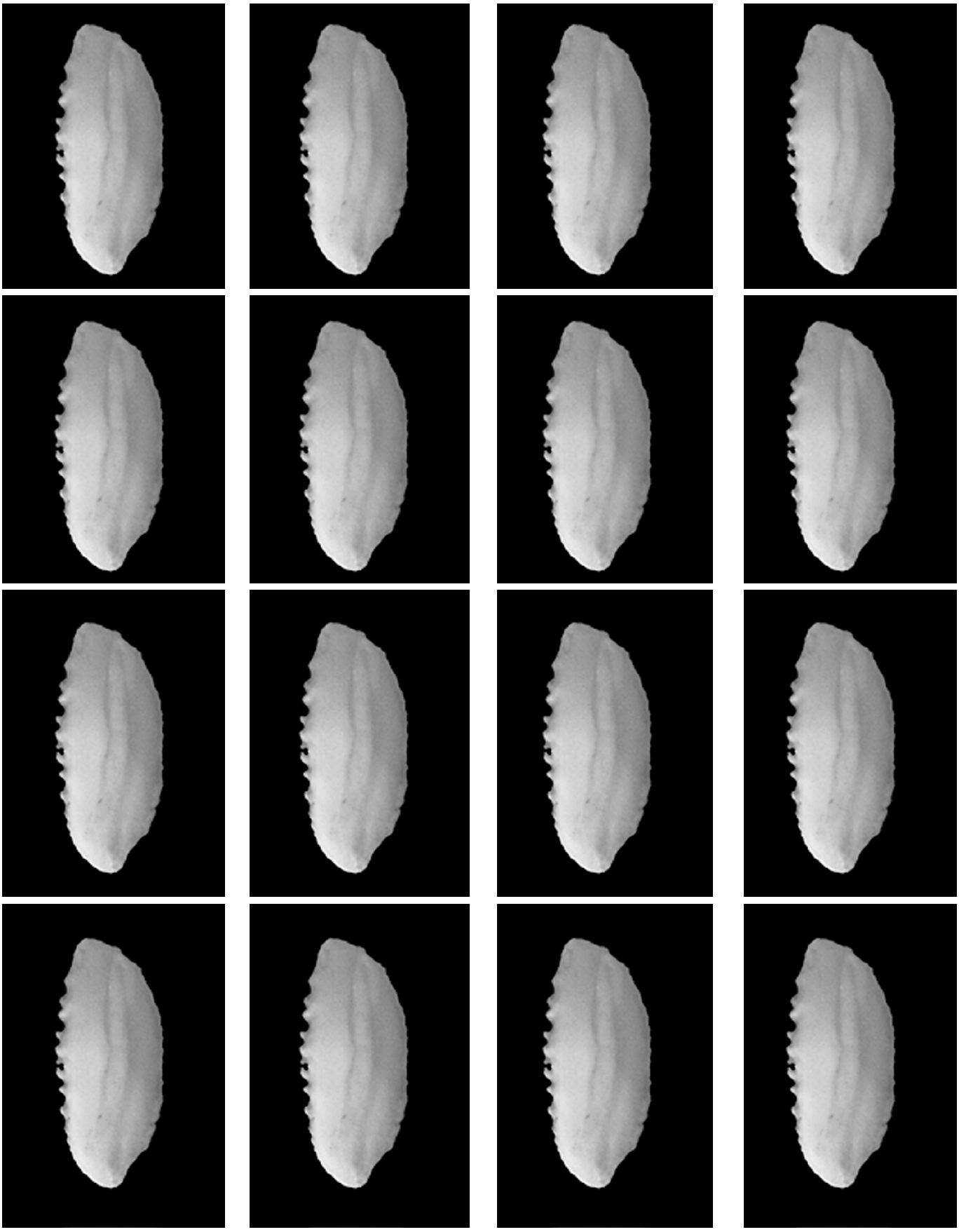
APPENDIX V CURRICULUM PRE/POST ASSESSMENT

Lesson	Student Name: _____ Date: _____
1	Name four characteristics of a mammal. List up to four mammals.
1	How is a marine mammal different from a mammal? List up to four marine mammals. (Hint: A penguin is not a marine mammal.)
3	What is a rookery? Name two animals that use rookeries.
4	Describe an ocean food web. Where do northern fur seals fit into the ocean food web?
5	What is blubber? Why do some animals need it?
6	Where are northern fur seal rookeries? Where do northern fur seals go when they are at sea?
7	How do scientists estimate the population of northern fur seals?
2	Who are the Unangan?
8	What is the Marine Mammal Protection Act?

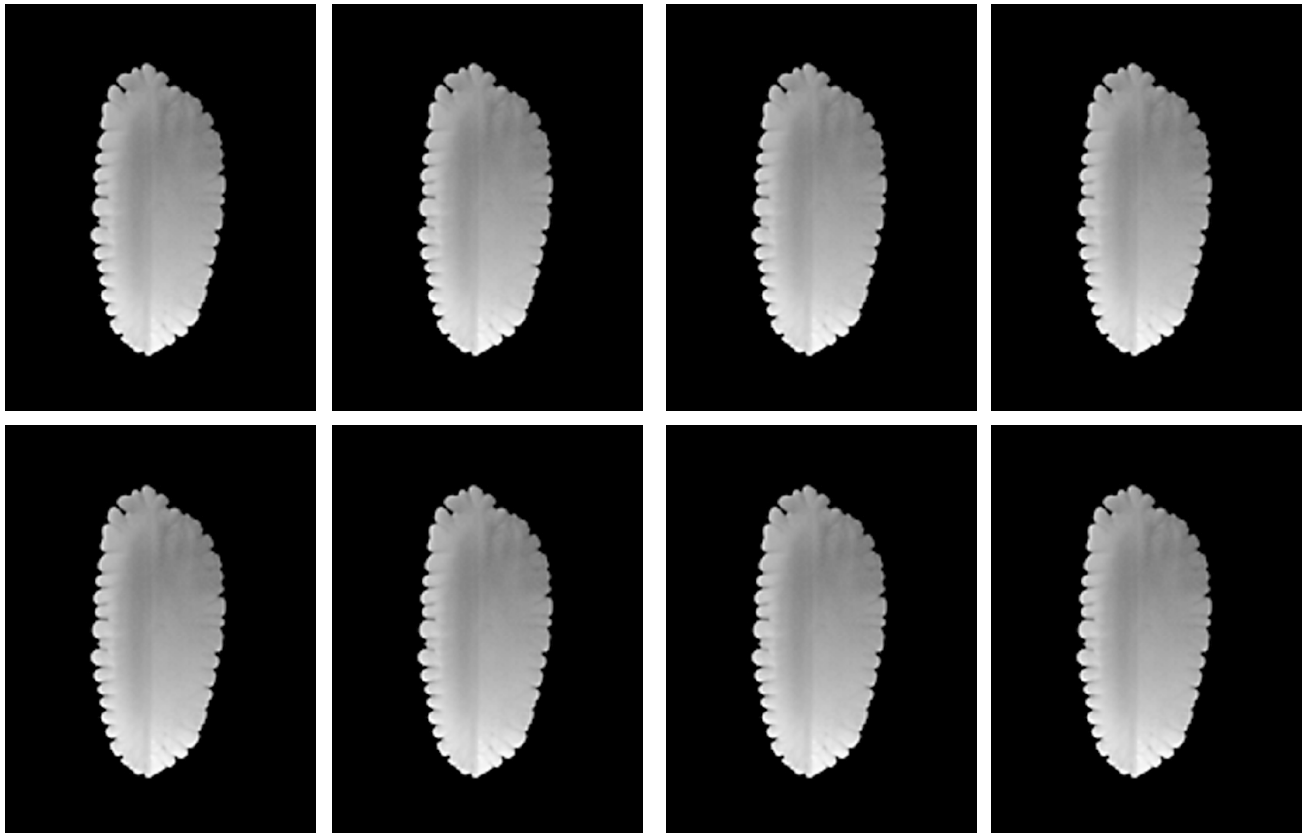
APPENDIX V TEACHER KEY: CURRICULUM PRE/POST-ASSESSMENT

Lesson	Student Name: _____ Date: _____
1	Name four characteristics of a mammal. List up to four mammals. hair or fur gives birth to live young mouse, dog, cat, mammary glands/nurses young warm blooded/endothermic human, seal, whale
1	How is a marine mammal different from a mammal? List up to four marine mammals. (Hint: A penguin is not a marine mammal.) A marine mammal lives in or depend on the ocean. fur seal, harbor seal, walrus, sea lion, elephant seal, orca, blue whale, humpback whale, manatee...(many more)
3	What is a rookery? Name two animals that use rookeries. A rookery is a colony of breeding animals. A specific area where animals gather each year to mate and raise their young. Answers will vary. E.g., northern fur seal, Steller sea lions, Puffins, Kittiwakes, and many other birds
4	Describe an ocean food web. Where do northern fur seals fit into the ocean food web? Sun - Phytoplankton - Zooplankton - Forage Fish - Fish - Marine Mammals - Humans
5	What is blubber? Why do some animals need it? Blubber is a thick layer of fat underneath the skin of marine mammals. Blubber provides insulation from the cold and is a source of energy when food supplies are low.
6	Where are northern fur seal rookeries? Where do northern fur seals go when they are at sea? > 80% of northern fur seals come to land in the Bering Sea (Pribilof Islands, Commander Islands, Bogoslof Island) a small number come to land on San Miguel Island At sea they travel south from the Bering Sea to the coast of the U.S. and then back north to the Bering Sea again.
7	How do scientists estimate the population of northern fur seals? Mark recapture
2	Who are the Unangan? The people who live in the Aleutian, Pribilof, and Commander Islands.
8	What is the Marine Mammal Protection Act? A law that protects marine mammals from being killed or harassed.

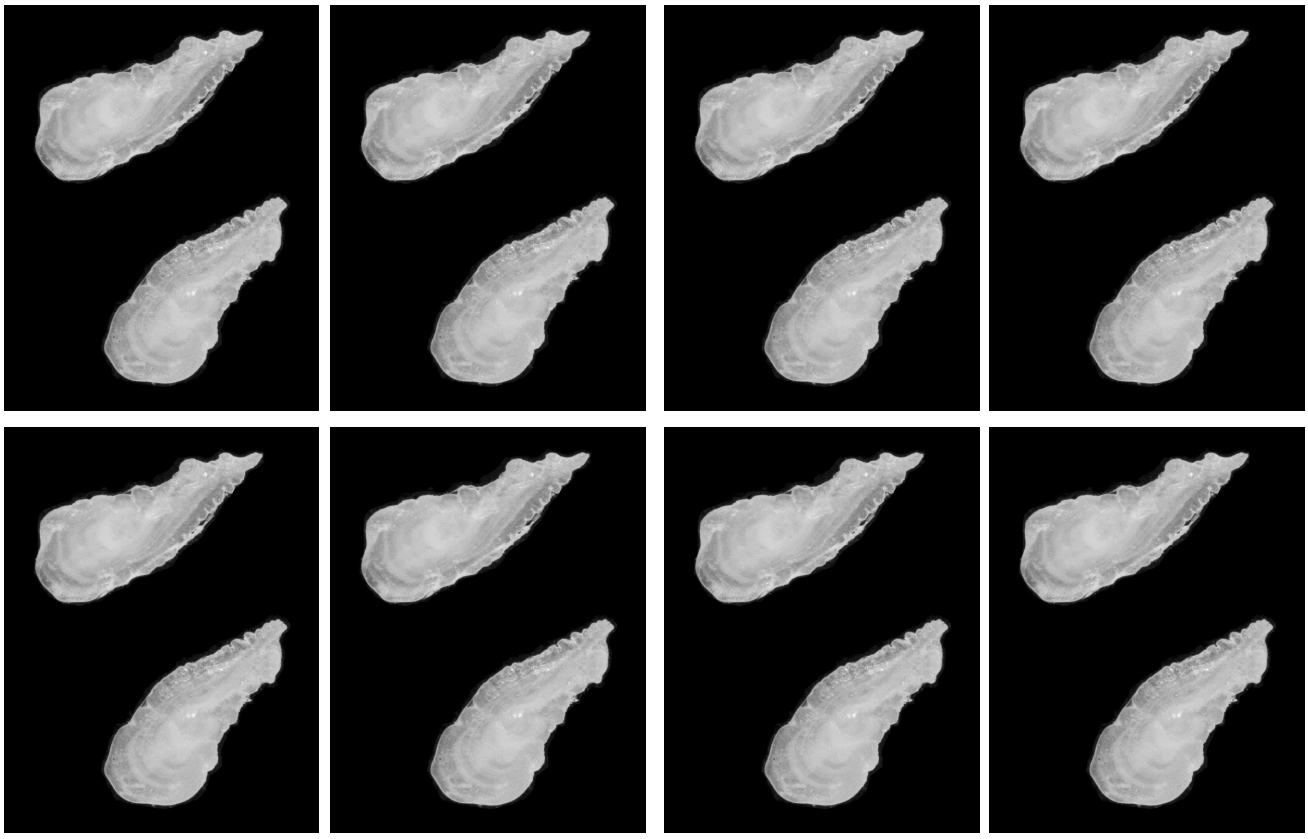
walleye pollock, *Theragra chalcogramma* (16 images per page) **Activity 4.3**: print 3 pages of otoliths and 2 pages of bones. **Activity 4.4** print 4 pages of otoliths and 3 pages plus 5 extra images of bones.



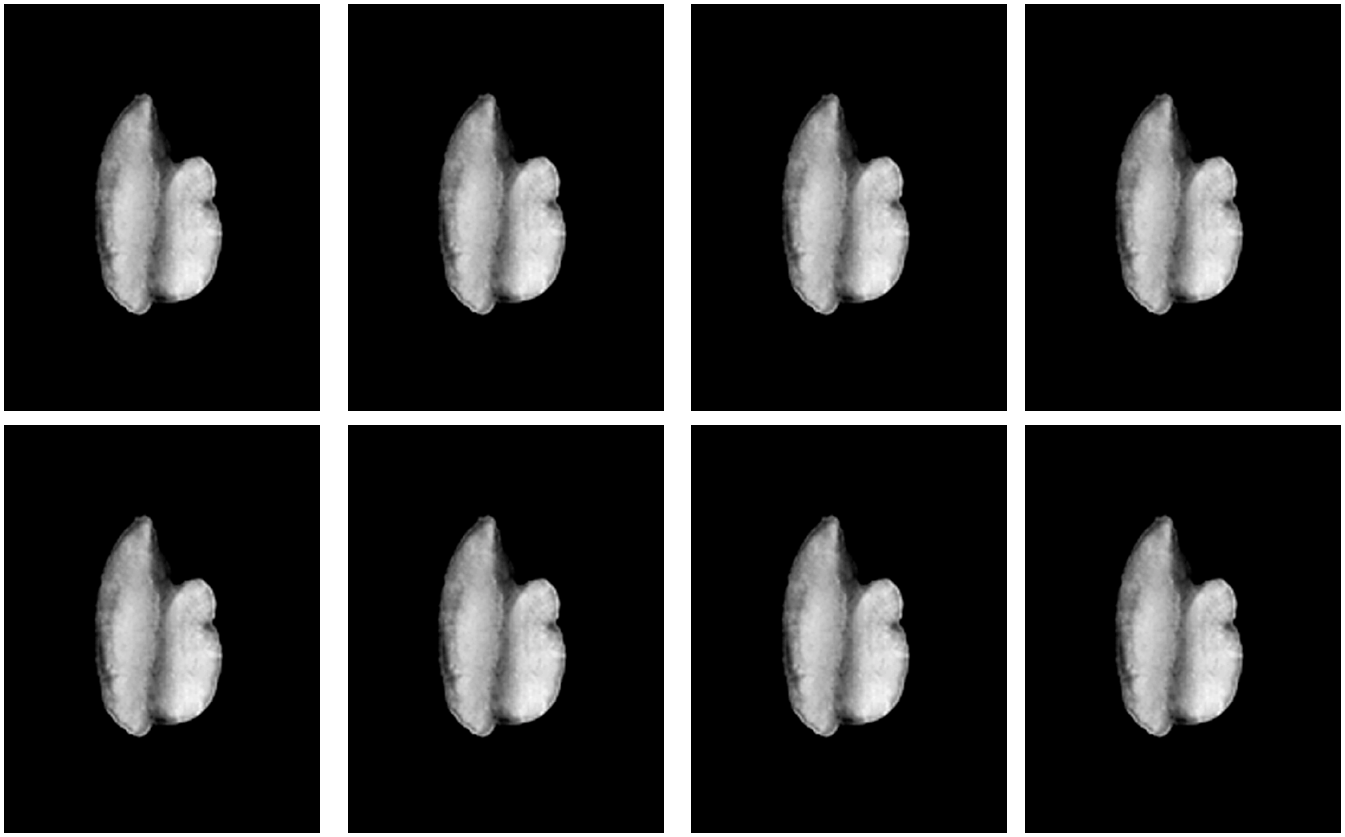
Pacific cod, *Gadus macrocephalus* (8 images per half page)



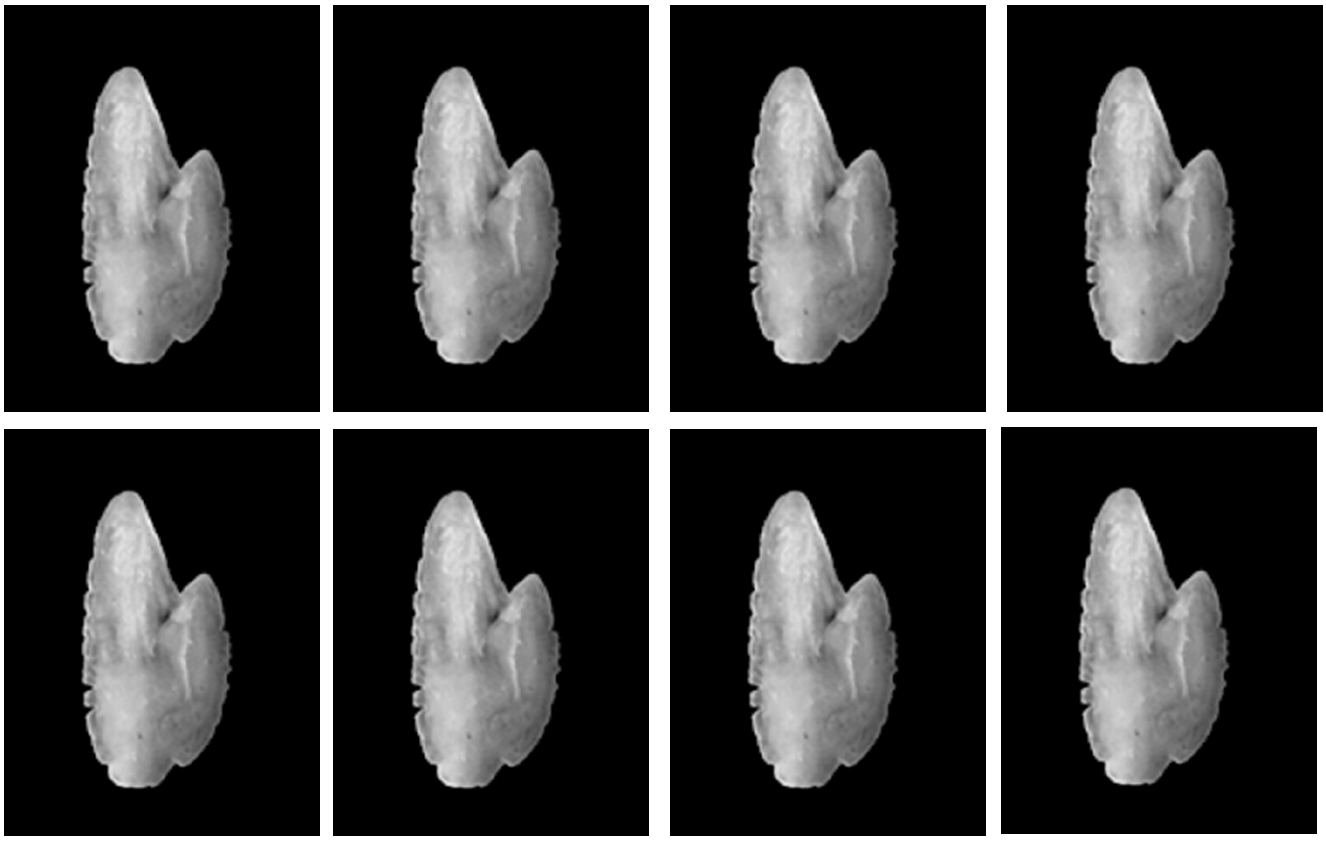
Northern smoothtongue, *Leuroglossus schmidti* (8 images per half page)



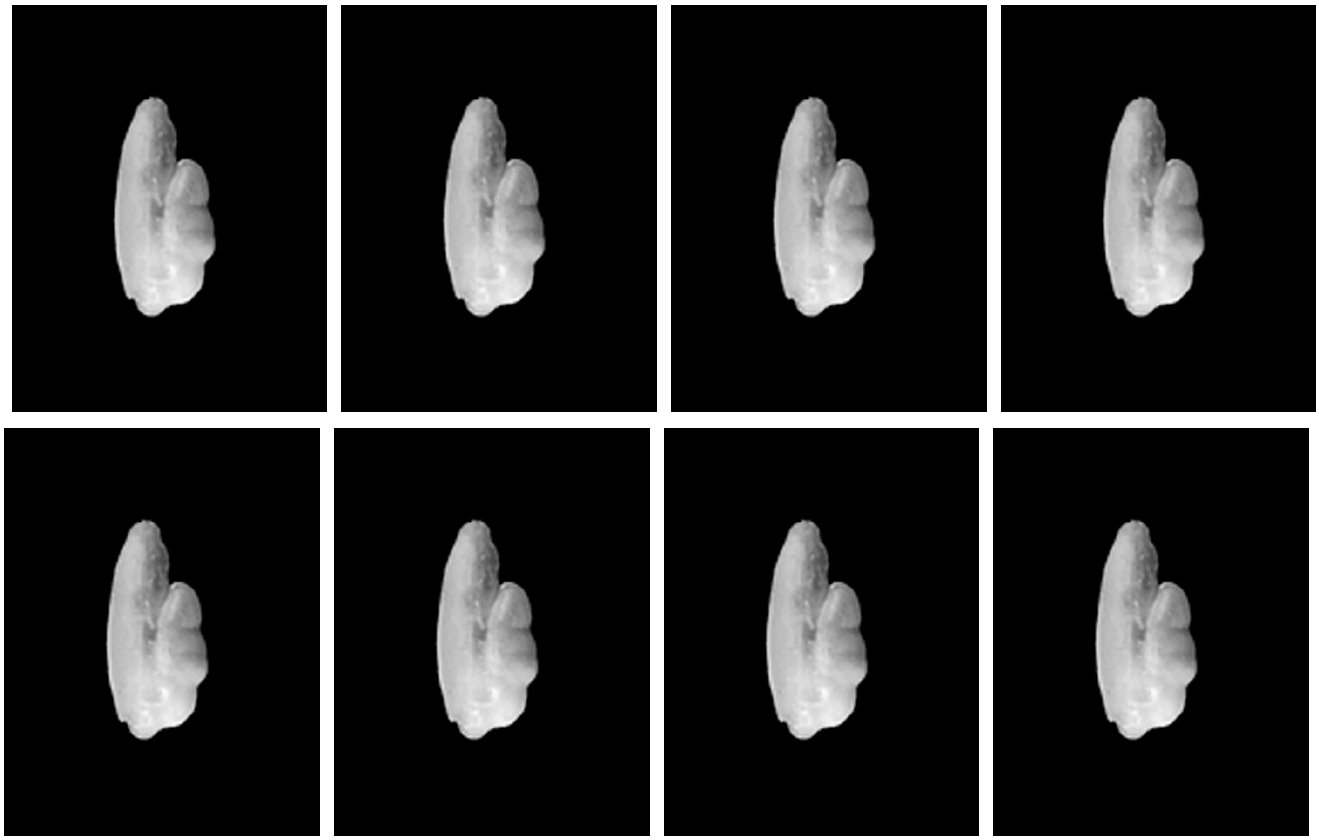
coho salmon, *Oncorhynchus kisutch* (8 images per half page)



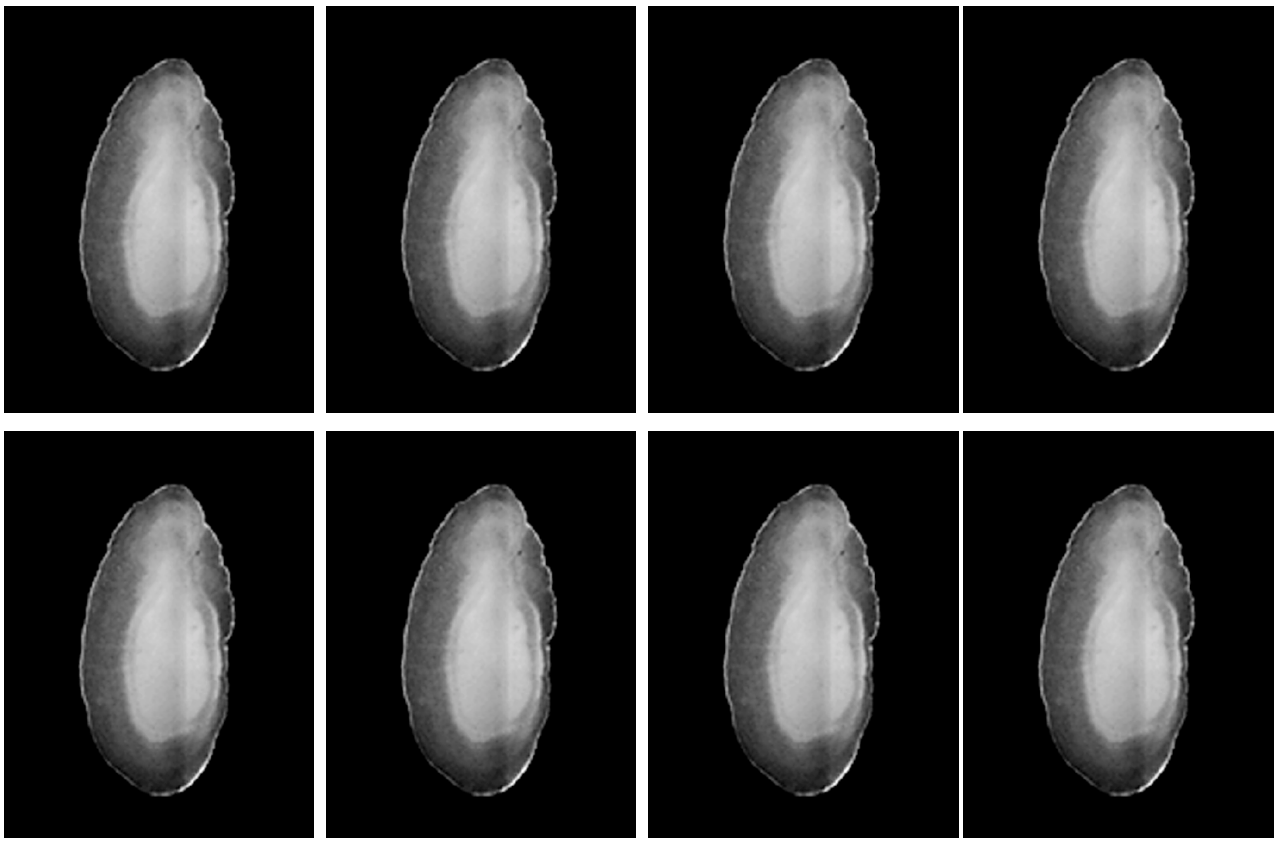
Pacific herring, *Clupea pallasii* (8 images per half page)



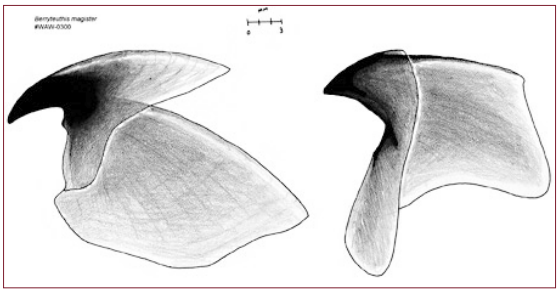
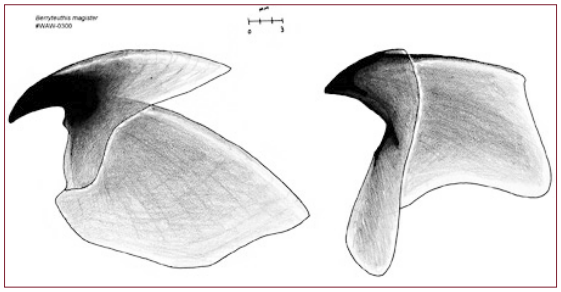
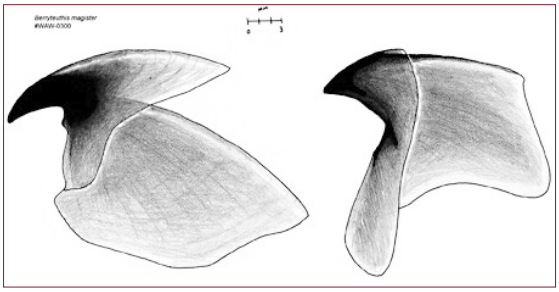
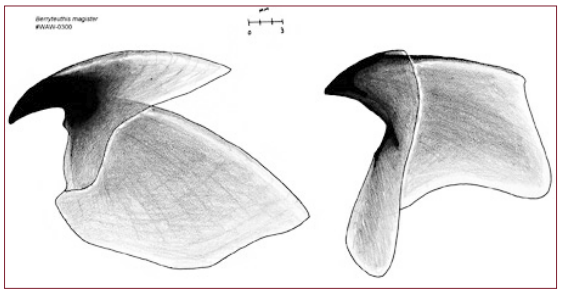
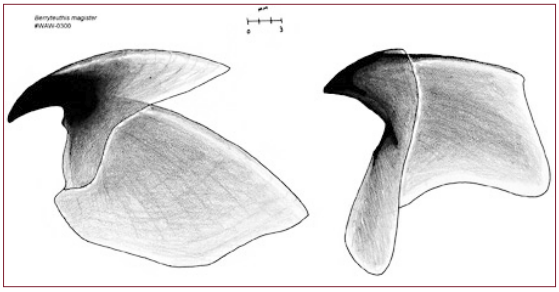
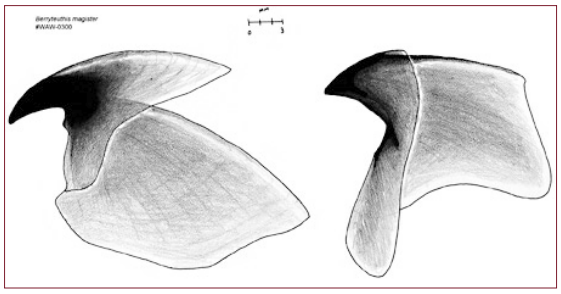
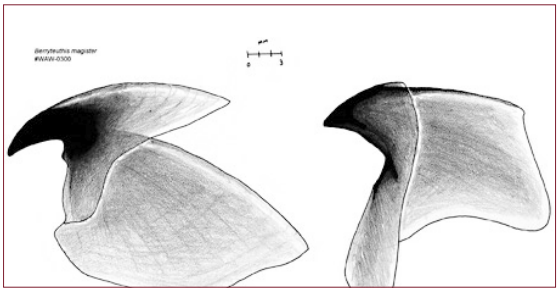
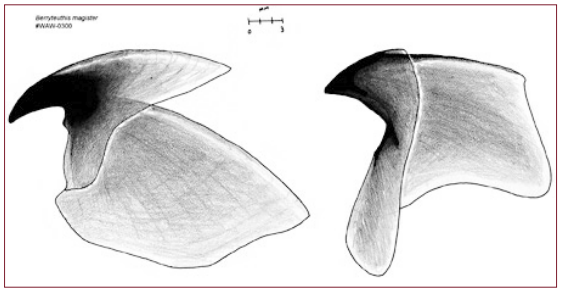
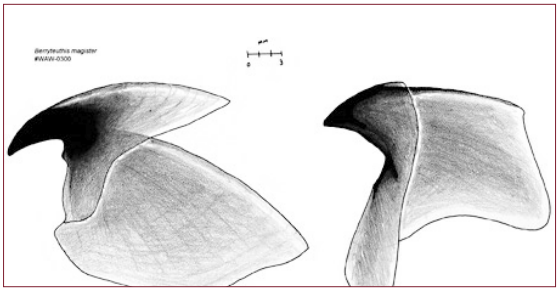
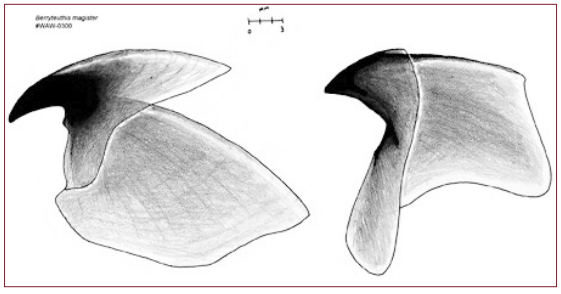
Atka mackerel, *Pleurogramma monopterygius* (8 images per half page)



Pacific sand lance, *Ammodytes hexapterus* (8 images per half page)



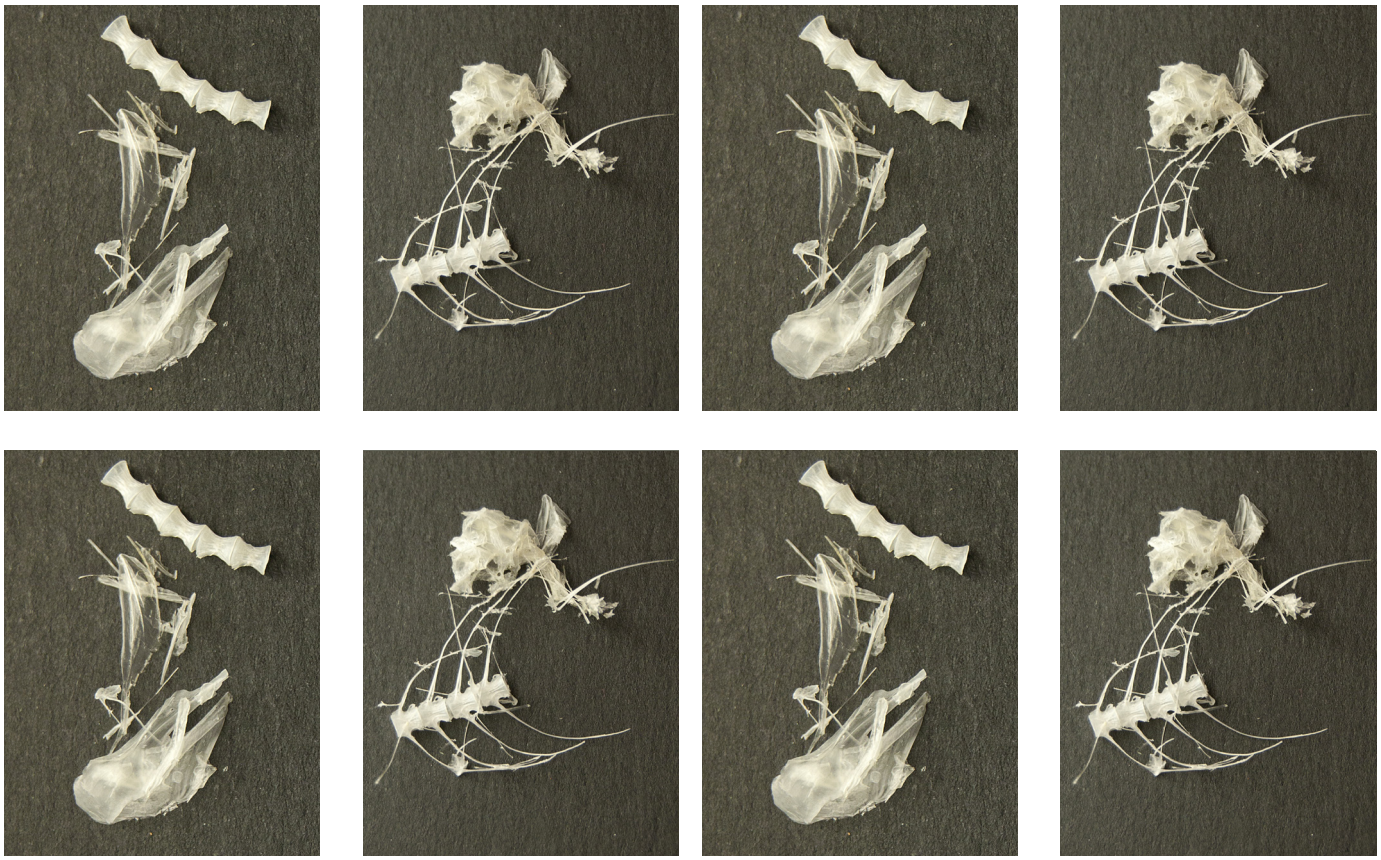
squid, *Berryteuthis magister* (10 images per page)

walleye pollock, *Theragra chalcogramma* (16 images per page) **Activity 4.3**: print 3 pages of otoliths and 2 pages of bones. **Activity 4.4** print 4 pages of otoliths and 3 pages plus 5 extra images of bones.

Pacific cod, *Gadus macrocephalus* (8 images per half page)

Northern Smoothtongue, *Leuroglossus schmidti* (8 images per half page)



Pacific herring, *Clupea pallasii* (8 images per half page)

Pacific sand lance, *Ammodytes hexapterus* (8 images per half page)

coho salmon, *Oncorhynchus kisutch* (8 images per half page)

Atka mackerel, *Pleurogramma monopterygius* (8 images per half page)

APPENDIX VII LAB 4.3 REFERENCE KEY Scat Detective

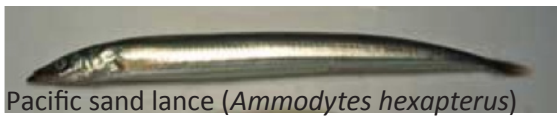

squid

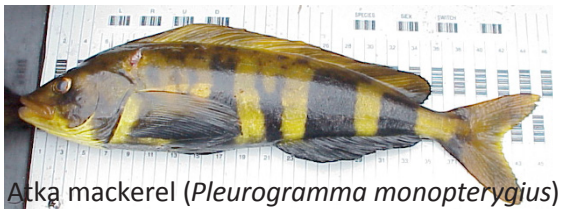

Pacific cod (*Gadus macrocephalus*)

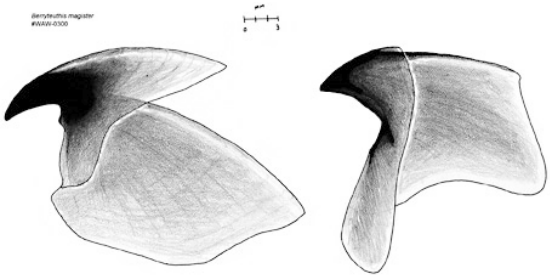

northern smoothtongue (*Leuroglossus schmidti*)


Pacific herring (*Clupea pallasii*)


coho salmon (*Oncorhynchus kisutch)*


Pacific sand lance (*Ammodytes hexapterus*)

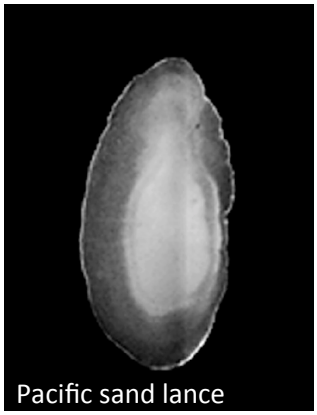

Atka mackerel (*Pleurogramma monopterygius*)



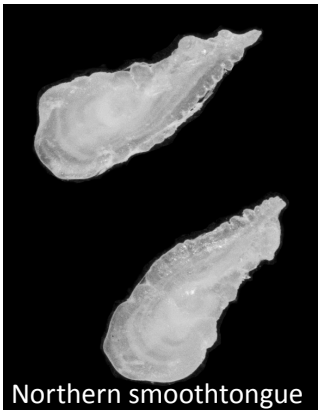
squid beak

Pacific cod
Gadus macrocephalus

walleye pollock
Gadus chalcogrammus



Pacific sand lance
Ammodytes hexapterus



Northern smoothtongue
Leuroglossus schmidti

Pacific herring
Clupea pallasii

coho salmon
Oncorhynchus kisutch

Atka mackerel
Pleurogramma monopterygius

APPENDIX VII LAB 4.3 REFERENCE KEY Scat Detective


Pacific cod
Gadus macrocephalus


Pacific cod
Gadus macrocephalus

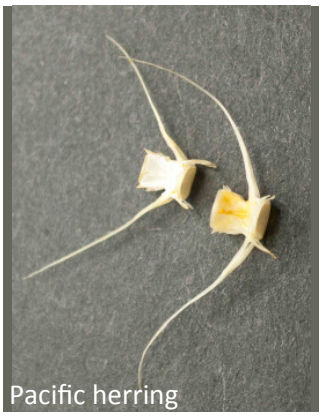

walleye pollock
Gadus chalcogrammus

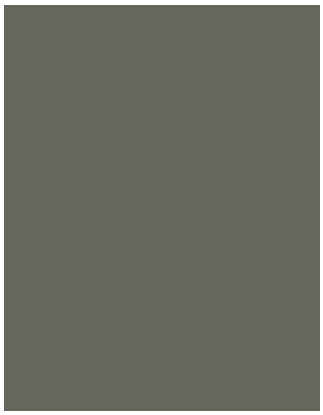

walleye pollock
Gadus chalcogrammus


walleye pollock
Gadus chalcogrammus


Northern Smoothtongue
Leuroglossus schmidti


Northern Smoothtongue
Leuroglossus schmidti


Pacific herring
Clupea pallasii


Clupea pallasii


Pacific herring
Clupea pallasii


Pacific sand lance
Ammodytes hexapterus


Pacific sand lance
Ammodytes hexapterus


coho salmon
Oncorhynchus kisutch


coho salmon
Oncorhynchus kisutch


Atka mackerel
Pleurogramma monopterygius


Atka mackerel
Pleurogramma monopterygius