ARTIFACTS
MODULE

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Vocabulary:

Continued

Adze:
A stone blade that is ground, shaped, polished, and usually hafted to a handle to be used for woodcarving.

Applique:
Involves adding low-relief clay forms to a pre-formed vessel

Archaeological material:
Remains found in archaeological sites such as artifacts, plant and animal remains, and features.

Artifact:
An object made or used by people.

Assemblage:
An archaeologist's grouping of artifacts (such as pottery) from a site by form and function

Awl:
A tool usually made from animal bone with a pointed end used for sewing, punching holes in hides, or basket weaving.

Base:
The underside of a vessel, or that part of a vessel in contact with the surface it rests on during normal use

Bipoint:
A small piece of bone pointed at both ends; a bipoint was usually attached to a fishhook or shaft for catching fish.

Body:
Portion of the vessel between the orifice and the base, also sometimes called the belly

Chisel:
A tool with a tapered , beveled end that was usually attached to a handle and used for woodcarving.

Coiling:
The method of hand building an object of clay by successive additions of ropes, or coil, of clay

Cord-marked:
Refers to the process of impressing cord into the surface (either exterior or interior) of an object, often used in reference to the cord impressions found on ceramics

Core:
The inner piece of stone that remains after outer sections of the stone have been chipped and flaked away to make tools.

Cortex:
The outer layer of rock formed on the exterior of raw materials by chemical and mechanical weathering processes

Debitage:
Pieces of stone that have been removed from a tool during manufacture, sharpening or repair.

Drilling:
A method to create a perforation, hole, or hollowed area.

Vocabulary:

Continued

Fabric:
The composition of the fired ceramic, including clay, inclusions and pores; excluding surface treatment; often synonymous with body, paste or ware.

Flake:
A piece of stone that has been chipped away from a core or a larger flake; flakes were either used, shaped into other tools, or discarded.

Flintknapping:
The process of making stone tools by shaping a piece of stone with various flaking methods.

Graver:
A tool with a sharp point or edge usually hafted to a handle and used for incising fine lines or carving thin grooves in wood or bone artifacts.

Grinding:
A method of rubbing an abrading stone against the surface of an artifact to achieve a smooth finish.

Hammerstone:
A hard Cobblestone used to strike off lithic flakes from a lump of tool stone during the process of lithic reduction.

Harpoon:
A spear-like weapon with a barbed head used for hunting marine animals such as whales, sea mammals, or large fish.

Incised:
Figures or letters carved by hand or impressed by machine into the surface of an object; often used in reference to marks on pottery and ceramics.

Incising:
A method of cutting a fine line into the surface of an object, to engrave.

Inclusion:
Particulate matter, usually mineral in nature, present in a clay or fabric either natural or added by the potter

Indirect percussion:
A method of flaking stone; the hammer does not directly hit the artifact, but strikes an intermediary blunt-pointed tool.

Neck:
The part of the vessel between the shoulder and the rim, typically characterized by a marked constriction of the maximum body diameter.

Pecking:
A stone-working technique; shaping a stone by sharply and repeatedly hitting it with a stone of greater hardness.

Percussion Flaking:
A method used in making stone tools in which a percussion tool such as a striker or hammerstone removes flakes to shape the artifact.

Vocabulary:
Continued

Pressure Flaking:
A method used in making stone tools to remove small flakes from the edges of an artifact and refine precise details on the artifact using a bone or antler tool.

Procure:
To get by special effort; obtain or acquire; such as procuring resources by hunting, gathering and fishing.

Projectile point:
A particular kind of chipped stone tool that is pointed on one end and usually attached to a shaft such as an arrow or spear to be used for hunting or fishing.

Rim:
The area between the lip and the side wall or neck of the vessel

Scraper:
A chipped stone tool that was used somewhat like a knife for tasks such as scraping fish scales or hides.

Sherd:
A term archaeologsits use to refer to a broken fragment of pottery

Subsistence:
The activities required to meet the basic needs, usually referring to the quest for food.

Unipoint:
A bone tool pointed on one end.

Wedge:
A tool usually made of bone or antler and used with mauls and adzes for heavy woodworking tasks such as splitting wood planks for houses and canoes with mauls and adzes.

Background Information

The thousands of artifacts recovered from the Kuril Islands are incredibly diverse, representing many different types of artifacts and materials. Most of the material from the Kuril Islands consisted of stone artifacts, ceramics and bone artifacts. The stone artifacts represent numerous types of stone tools including cores, flakes, projectile points, blades, scrapers and hammerstones. These stone tools were made from a wide variety of raw materials including basalt, chert, and obsidian. Some of these stones like basalt and chert were available locally on the islands but some raw materials such as obsidian are only found naturally the island of Hokkaido or the Kamchatka peninsula.

Other artifacts found in the Kuril Islands include ceramics and bone artifacts. The ceramic artifacts are typically pieces of broken pots called sherds. Ceramic artifacts were most likely made locally on islands using a combination of clay and sand and hardened through firing the ceramics in open-air fires. Ceramic artifacts from the Kuril Islands also often have decorations with the most common being cord-marked pottery formed by impressing a cord onto the surface of the unfired vessel. Bone artifacts are also found throughout archaeological sites in the Kuril Islands. Bone artifacts are extremely versatile and were used for a wide variety of tasks including hunting, sewing and possibly even as pieces of jewelry. The bone tools were made from a variety of different animals but most commonly from sea lion, seals and even the occasional bird bone.

Name: ______________________

Analysis of Artifacts:

Describing Stone Artifacts

Introduction:

Stone artifacts are some of the most common artifacts found by archaeologists. Stone tools can be used for a wide variety of tasks, and they are durable and last a long time in the archaeological record. Using the collection of stone tools in your site, analyze the artifacts to help answer questions about how past humans lived.

Step 1:

Look at the whole collection of stone artifacts and divide the artifacts into two smaller groups based upon their size. Record the number of artifacts in each group.

Small Group: ____________ Large Group: ____________

Step 2:

Choose one artifact from each group and describe the artifact.

Small Stone Artifact

Lenght: __________cm

Width: __________cm

Color: __________

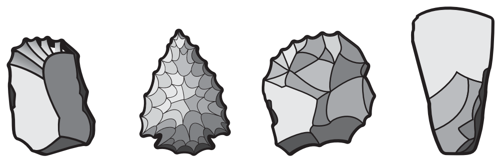
Texture: __________

Type (Circle on below):

Scraper **Flake**

Point **Adze**

Types of Tools:



Scraper Point Flake Adze

Large Stone Artifact

Lenght: __________cm

Width: __________cm

Color: __________

Texture: __________

Type (Circle on below):

Scraper **Flake**

Point **Adze**

Name: ______________________

Analysis of Artifacts:

Describing Stone Artifacts - Continued

Step 3:

Instead of sorting the stone artifacts based upon their size, try sorting the tools by their tool type. Once again, record the number of artifacts in each tool type.

Scrapers: ________ Points: ________

Flakes: ________ Adze: ________

Step 4:

Answer the following questions based on the tools from this site.

1. Looking at the variety of stone tools from the Kuril Islands, what activities were Kuril inhabitants likely engaging in?

2. The various rocks Kuril inhabitants used to make stone artifacts are quire diverse. What can this diversity in stone resources tell you about the mobility of people who lived in theKuril Islands? What additional information might be useful in answering this question?

Name: ______________________

Analysis of Artifacts:

Describing Ceramic Artifacts

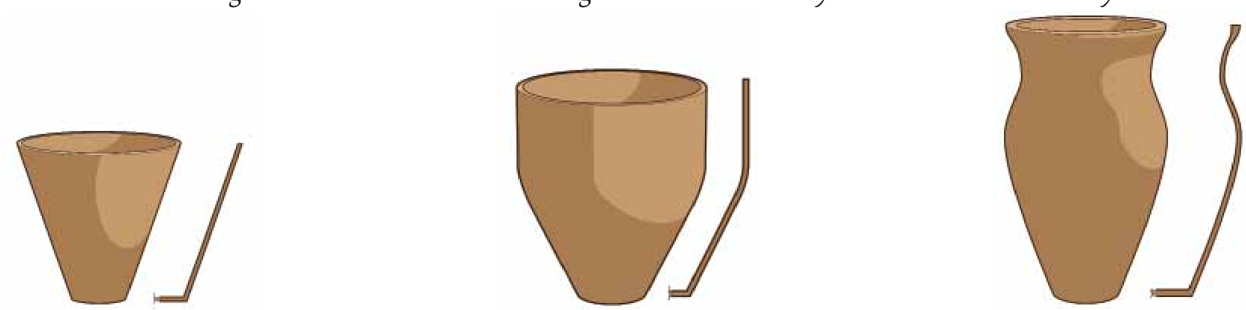
Introduction:

Ceramic artifacts are found throughout the Kuril Islands in many different shapes and with many different designs associated with them. Using the collection of ceramic artifacts from this site analyze the pottery to help understand why and how ancient people used these artifacts.

Step 1:

Using the assemblage of pottery sherds, attempt to refit the pottery vessel back together. Which of the vessel shapes do you think best represents the shape of your vessel? (Circle one)

Hint: Focus on fitting the rims and the bases back together and don't worry too much about the body sherds.



What sort of activities do you think ancient people might have used this vessel for?

Name: ______________________________

Analysis of Artifacts:

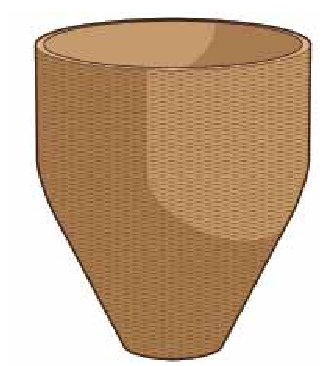
Describing Ceramic Artifacts - Continued

Step 2:

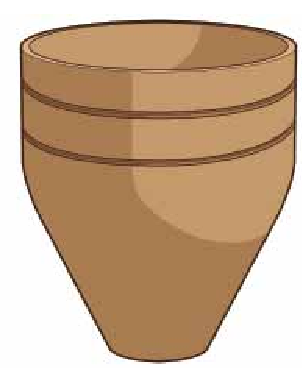
Looking at your ceramic vessel, study the decorative patterns and draw a sample of the decoration in the box provided below:

Given the sample examples below, how would you best describe the pattern on your vessel?

Cord-Marked



Incised



Applique

The decoration on my ceramic vessel is ____

Name: ______________________

Analysis of Artifacts:

Describing Ceramic Artifacts - Continued

Step 3:

Now compare the ceramic vessel pieces that you have with the other two ceramic vessel sherds.
What are some of the similarities between them?
What are some of the differences?

Similarities

Vessel 1 and Vessel 2: ______________________

Vessel 2 and Vessel 3: ______________________

Vessel 1 and Vessel 3: ______________________

Differences

Vessel 1 and Vessel 2: ______________________

Vessel 2 and Vessel 3: ______________________

Vessel 1 and Vessel 3: ______________________

Thinking critically, what might be some of the reasons why two pieces of pottery might look similar?

____

____

____

____

____

____

____

Name: ______________________________

Analysis of Artifacts:

Describing Bone Artifacts

Introduction:

Bone artifacts are extremely useful for living in the cold, maritime environment of the Kuril Islands. Using the collection of bone artifacts from this site, analyze the various ways ancient people used these artifacts to survive in the harsh environment.

Step 1:

Using the collection of finished bone tools, sort the tools into groups that relate to their function. Please give your group a name that relates to its function and briefly describe the artifacts in that group. (Depending upon your classification you may have 3 or 4 possible groups).

Group 1: ______________________________

Description: ______________________________

____

____

____

Group 2: ______________________________

Description: ______________________________

____

____

____

Group 3: ______________________________

Description: ______________________________

____

____

____

Group __: ______________________________

Description: ______________________________

____

____

____

Name: ______________________________

Analysis of Artifacts:

Describing Bone Artifacts - continued

Step 2:

Using the collection of finished and unfinished bone tools, further investigate the function fo bone tools and try to identify the process of making bone tools by matching the finished produt with their earlier forms.

Bone Artifact KBP Burke 0175

1. What do you think the function of this artifact was?

____

____

____

____

2. Which of the unfinisehd tools would have likely been turned into this type of artifact? (Please provide the artifact numbers?

____

____

____

3. Do the bones most likely used in the manufacture of this artifact come from a mammal or a bird? How can you tell?

____

____

Name: ______________________________

Bone Artifact KBP Burke 0185 or 0186

1. What do you think the function of this artifact was?

2. Which of the unfinisehd tools would have likely been turned into this type of artifact? (Please provide the artifact numbers?

3. Do the bones most likely used in the manufacture of this artifact come from a mammal or a bird? How can you tell?

Bone Artifact KBP Burke 0183 or 0184

1. What do you think the function of this artifact was?

2. Which of the unfinisehd tools would have likely been turned into this type of artifact? (Please provide the artifact numbers?

3. Do the bones most likely used in the manufacture of this artifact come from a mammal or a bird? How can you tell?

Name: ______________________________

Bone Artifact KBP Burke 0206/0207/0208/0209

1. What do you think the function of this artifact was?

2. Which of the unfinisehd tools would have likely been turned into this type of artifact? (Please provide the artifact numbers?

3. Do the bones most likely used in the manufacture of this artifact come from a mammal or a bird? How can you tell?

Bone Artifact KBP Burke 0182/0193/0194/0195

1. What do you think the function of this artifact was?

2. Which of the unfinisehd tools would have likely been turned into this type of artifact? (Please provide the artifact numbers?

3. Do the bones most likely used in the manufacture of this artifact come from a mammal or a bird? How can you tell?

CHRONOLOGY
MODULE

Table of Content

Vocabulary

Absolute Dating:

The process of determining when an event occurred along a calendrical timeline.

Biosphere:

The component of the Earth system which consists of all life on earth, including all avian, terrestrial, and aquatic species. The biosphere can be understood in terms of the abundance of living organisms on earth (global biomass) and in terms of its internal organization or systemic process (ecosystems).

Carbon-12 (^{12}C):

The most abundant stable carbon isotope occurring in nature. ^{12}C containes 6 protons and 6 neutrons.

Carbon-13 (^{13}C):

A naturally occurring, stable carbon isotope, which is considerably less abundant in the atmosphere than is ^{12}C but considerably more abundant than ^{14}C. ^{13}C contains 6 protons and 7 neutrons.

Carbon Cycle:

The process by which carbon flows throughout and is exchanged between various physical and biological systems (for example, the atmosphere, the oceans, and the biosphere). Because carbon is an essential ingredient for life on earth, it is critical that carbon be continuously available to organisms, so understanding how carbon is recycled through the carbon cycle is of central importance for biologists.

Carbon dioxide (CO_2):

A molecule consisting of two oxygen atoms and one carbon atom. Carbon dioxide molecules form in the atmosphere, and their carbon atoms can be either ^{12}C, ^{13}C, or ^{14}C atoms.

Dated event:

An event which is directly dated by a particular dating method. In the case of radiocarbon dating, the dated event is the time of death of an organism from which a sample is taken. The dated event may or may not be of direct interest to archaeological research.

Isotope:

A variant form of an element. Different isotopes of the same element have different numbers of neutrons in their atomic nuclei. For example, a ^{12}C atom has six neutrons in its nucleus, ^{13}C has seven, and ^{14}C has eight, yet all three are still carbon atoms and interact in the same chemical reactions in the same way.

Law of superposition:

A principle of geology which states that, in a sequence of geological layers, a lower layer of sediments was deposited before, and therefore is older than, overlying layers. This law only applies in cases where such layers have not been disturbed or mixed since the time of their deposition.

Vocabulary
Continued

Neutron:

A subatomic particle which has no charge. Together with protons, neutrons are one of the building blocks of the nuclei of atoms, but they can also occur free in nature.

Nitrogen-14 (^{14}N):

A common, naturally occurring, stable nitrogen isotope. ^{14}N contains 7 protons and 7 neutrons.

Radiocarbon (^{14}C):

A naturally occurring, radioactive carbon isotope, which is considerably less abundant than both ^{12}C and ^{13}C.

Relative dating:

The process of determining whether an event came before or after another event in time, without consideration for how much time intervened between the two or how long ago in the past they occurred.

Stratigraphy:

A sequence of layers at an archaeological site or a geological locale that represents the depositional history of that location.

Stratum (plural: strata):

A layer in a geological deposit having characteristics (age, color, composition) that make it distinguishable from other layers.

Target event:

An archaeological term used to refer to the event which is of interest to an archaeologist and for which they would like to estimate a date. Linking a particular "dated event" to the "target event" is one of the biggest challenges of historical sciences like archaeology and geology.

Years BP (years before present):

Scientists who use radiocarbon dating agreed to always report the radiocarbon dates using 1950 as the point of origin, the point from which time is counted back. So, a radiocarbon date which is presented as "537 years BP" means 537 years before present. In other words, it is 1413 AD.

Background Information

When cosmic rays excite atmospheric neutrons, some of these neurons collide with atmospheric nitrogen-14 (^{14}N), which is transformed into radiocarbon (^{14}C) as a result (see Appendix B). This ^{14}C constitutes a miniscule proportion of atmospheric carbon, alongside two considerably more abundant carbon isotopes: carbon-12 (^{12}C) and carbon-13 (^{13}C). All three of these carbon isotopes combine with atmospheric oxygen atoms to form carbon dioxide molecules. Through the process of photosynthesis, plants incorporate carbon from these carbon dioxide molecules into their tissues, maintaining a ^{14}C to ^{12}C ratio in equilibrium with the atmosphere as long as they are alive. In turn, animals eat plants or other animals, and the carbon in the plant or animal tissues that they consume is incorporated into their own tissues. When plants and animals die, they cease incorporating new carbon into their tissues and the "radiocarbon clock" starts ticking.

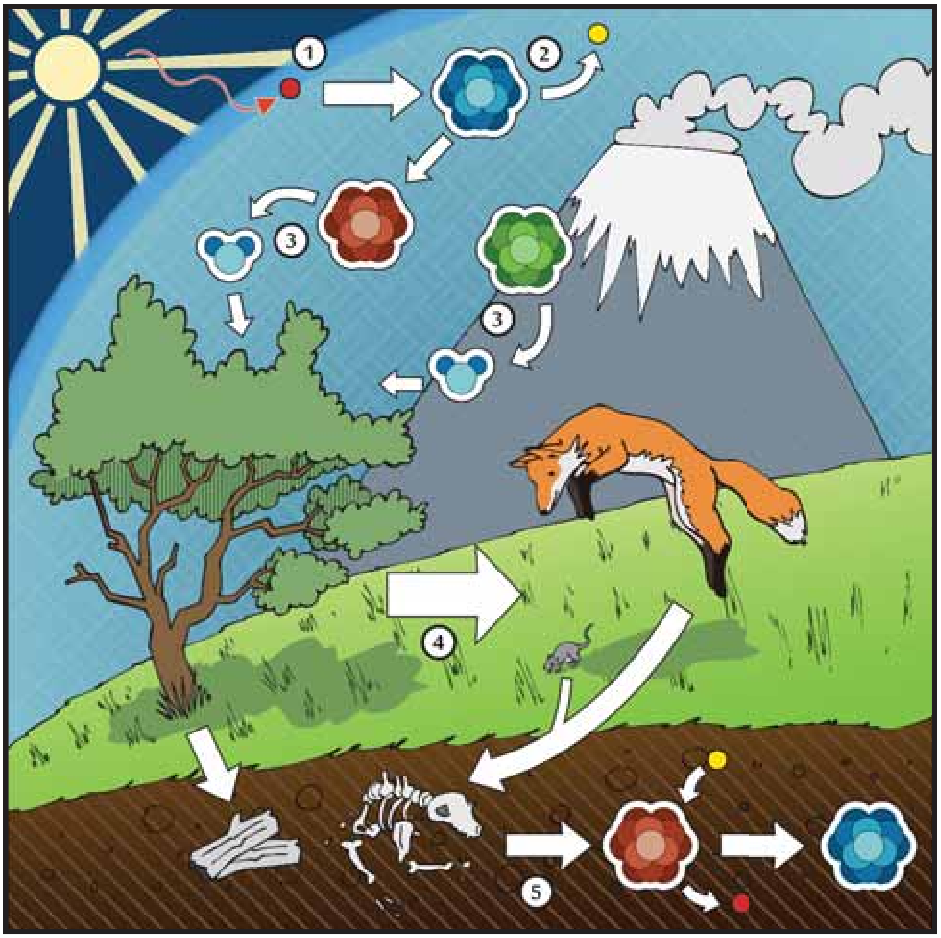
Radiocarbon is a radioactive isotope which decays back into ^{14}N at a constant rate: after approximately 5,700 years, half of the amount of ^{14}C which was originally in the sample converts back into ^{14}N. After another ~5,700 years, half of the remaining ^{14}C converts into ^{14}N. This process of radioactive decay continues indefinitely through time, but the amount of ^{14}C remaining in a sample becomes so small after approximately 50,000 years that laboratory machines have a hard time detecting it. Conversely, ^{12}C is a stable isotope, so the amount of ^{12}C that is present in a sample at the time of its death should remain constant over time.

Technicians who work at radiocarbon laboratories measure the amount of ^{14}C and ^{12}C remaining in a sample of organic material (such as wood, charcoal, bone collagen, shell, hair, seeds, or plant fibers). If they assume that the ratio of ^{14}C to ^{12}C that was originally present in the sample is identical to the ratio of modern atmospheric ^{14}C to ^{12}C, then they can use their measurement of the amount remaining in a sample to estimate the amount of time that has passed since the death of the organism that the sample came from, assuming a constant rate of radiocarbon decay.

If an archaeologist or geologist has good reason to believe that the death of a sample (the "dated event") corresponds closely in time with its deposition at an archaeological or geological site (the "target event"), they can use this sample's date to determine when it was deposited at the site, allowing them to begin to construct a timeline for the archaeological or geological history of that site.

Name: ______________________________

^{14}C in the Carbon Cycle.

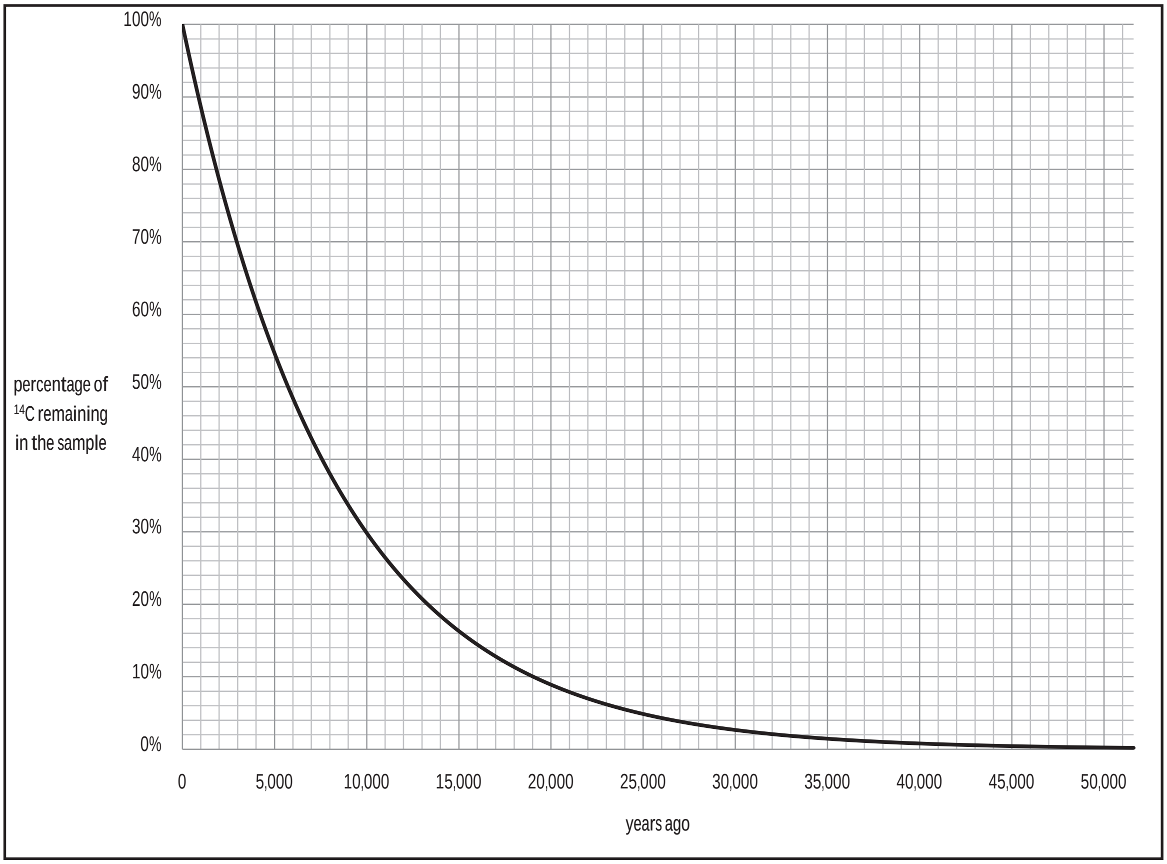


Describe in your own words the five steps in the radiocarbon formation and decay.

Name: ______________________________

Decay Curve Exercise

Continued



- What is the approximate age of an organic sample with 75% radiocarbon remaining? ____________________
- How much radiocarbon remains in a sample after 3 half-lives? ____
- What is the approximate age of an organic sample with 1/512 of the original radiocarbon remaining?

  ____
- How much radiocarbon remains in a sample after 25,000 years? ____

Name: ______________________________

The Research Plan

Phase 1

Part One

You are the head of an archaeology crew. You and your crew just returned from an excavation of a Test pit (Test Pit 1) at the Rasshua 1 site on Rasshua Island in the Kuril Island chain. After the excavation, your field assistants drew the stratigraphic column of one of the walls of the excavation. Using the drawing of the stratigraphy, you now have to answer the following questions in order to decide how you are going to establish the chronology, or the sequence of events, of this site.

1. Which layers can you date using ^{14}C? Why do you think so?

2. What materials would you date to find out the age of cultural occupations? Why?

3. What would you date to find out the age of layer B?

4. What materials would you date to find out the age of Ushishir tephra (Layer C)?

5. How would you test the idea that volcanic eruptions had a devastating consequence for human occupation?

Name: ______________________________

Part Two

After you answered these questions and decided which levels you wanted to date you sent your radiocarbon samples to a lab that processes the samples and determines the date of each sample. Take a look at the results that they sent back. Now answer the following questions to interpret what events took place at this site and how they are related to each other in time.

1. Are there any out of sequence dates? How would you explain them?
   (**Hint:** Think back to target and dated events and to what human or natural activities can disturb certain levels).

2. How long did humans occupy the site? Were there any gaps in occupation?

3. What is the age of artifact X? How did you determine it? What are the dated and target events for this sample?

Name: ______________________________

The Research Plan

Phase 3

Part Three

The last step in the process of archaeological analysis of a site is to write a narrative about how the layers of the site got there. This is the story about how people lived there and what events they experienced. In the space below, write the history of people at Rasshua 1 as you understand it from the dates you obtained and the stratigraphic sequence. Start from the bottom and explain how each layer formed and what are its chronological relationships with other layers. (In other lessons you learned or will learn about the artifacts and the food remains found at this site and will be able to understand the everyday lives of the people here better).

Name: ______________________________

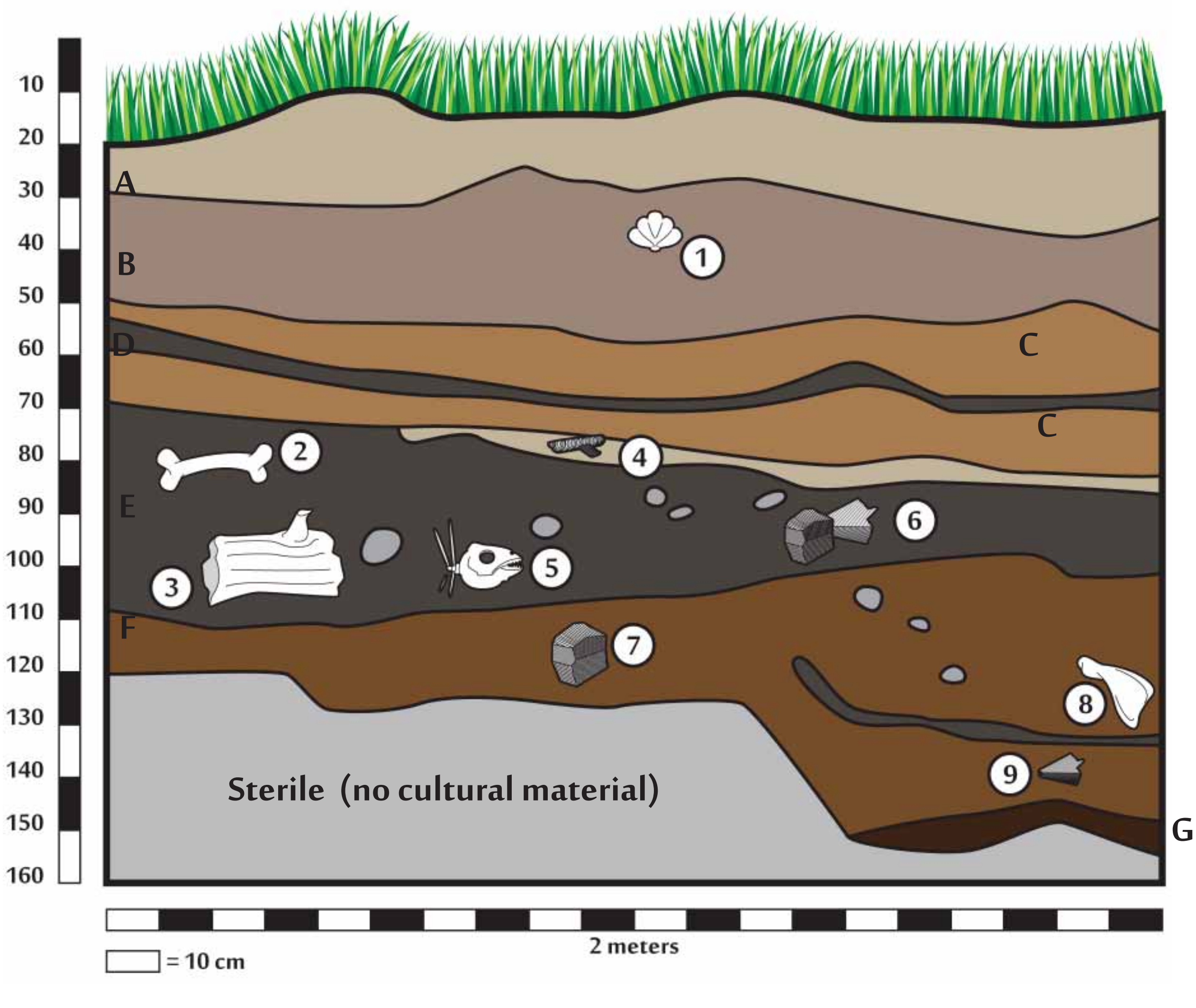
The Research Plan

Material #1

Rasshua 1 Test Pit 1 Excavation Profile

July 15, 2008

Erik Gjesfield and Molly Odell



Name: ______________________

Results of the Radiocarbon Dating of Rasshua 1 - Test Pit 1 Samples

Site	Lab Number	Measured date	Material	Stratigraphic position
Rasshua 1	OS - 79668	~1,950 years BP	Shell	Position #1
Rasshua 1	OS - 79669	~2,080 years BP	Bone	Position #2
Rasshua 1	OS - 79865	~2,020 years BP	Wood	Position #3
Rasshua 1	OS - 79670	~2,110 years BP	Charcoal	Position #4
Rasshua 1	OS - 79671	~2,210 years BP	Bone	Position #5
Rasshua 1	OS - 79720	~2,430 years BP	Charcoal	Position #6
Rasshua 1	OS - 79665	~2,860 years BP	Charcoal	Position #7
Rasshua 1	OS - 79666	~2,480 years BP	Bone	Position #8
Rasshua 1	OS - 79667	~2,660 years BP	Charcoal	Position #9

ZOOARCHAE-OLOGY MODULE

Table of Content

Zooarchaeology

Vocabulary

Adaptation:
An evolutionary change in a species in response to changing environmental conditions or moving into/utilizing a new habitat.

Articulate:
To intersect with another bone, either in a relatively mobile joint like a hip or shoulder, or a relatively immobile joint like ribs articulating with vertebrae.

Cancellous bone:
The inner portion of bone that is filled with a fine network, or lattice, of bony struts

Cortical bone:
The dense outer layer of a bone

Diaphysis:
The main shaft portion of a bone

Distal:
The end of a longbone that is oriented away from the core of the body

Epiphysis:
The end portion of bones; in juvenile animals the epiphysis and diaphysis are separate bones that gradually fuse together as the individual matures

Epiphyseal plate:
A thin layer of cartilage between the epiphysis and the diaphysis; this is where most bone growth occurs

Femur:
The thigh bone, or upper leg bone

Humerus:
The upper arm bone

Island biogeography:
The scientific study of the distributions of animal species living on islands

Linnaean Hierarchy:
The system used to organize all living things in a way that reflects their evolutionary histories

Medullary bone:
The hollow inner portion of a longbone shaft; medullary bone is filled with marrow, oil, or air

Ossification:
The process of converting cartilage into bone

Paleontology:
The scientific study of animal remains that reflect natural (i.e., non-human) patterns of animal activities or behavior

Phytogeography:
The scientific study of the distributions of different plant species

Proximal:
The end of a longbone that is oriented towards the core of the body

Quadrupedal:
Uses all four limbs for walking

Zooarchaeology:
The scientific study of animal remains that reflect patterns of human activities or behavior

Introduction:

This module introduces students to the discipline of **zooarchaeology** (pronounced either "zoh-ark-e-ol'-o-gee" or "zew-ark-e-ol'-o-gee") and highlights how zooarchaeology has been used in the Kurils Biocomplexity Project. Students will

- Examine and identify bones
- Learn how to determine age and sex of the bones, and
- Analyze zooarchaeological data from their lab work and (optional) data from the KBP Expeditions.

Zooarchaeology is an interdisciplinary field that combines zoology (the study of animals) and archaeology (the study of past human activities). Like its sister discipline, **paleontology**, zooarchaeology is focused on the study of bones, teeth, and shells. The difference between the two disciplines is that zooarchaeological samples are found in association with human activities and reflect human behavior (the "archaeology" part). Paleontological samples come from deposits that reflect natural geological processes but do not have any evidence of human activity.

How does zooarchaeology work?

The first step in any zooarchaeological analysis is to identify what animal the bone or shell sample has come from. Zooarchaeologists rely on the fact that animals that are closely related to each other tend to have similar-looking skeletons. Animals that are not closely related tend to have different-looking skeletons. The degree of difference or similarity usually scales with how closely related two species are.

Once a bone has been identified, there is a wide range of data that are typically documented for any given bone, including age-at-death, degree of fragmentation, presence of any cultural modifications such as cut-marks or burning, and so on.

One incredibly important aspect about zooarchaeological data is that the kinds of data recorded depend entirely upon what the research question is. If a zooarchaeologist is working in a region where little or nothing is known about how prehistoric peoples made a living, simply documenting what species of animals were used for food would be a significant contribution to our understanding of that culture.

In contrast, in an area where the basic diet is well-known, as in many areas of the Pacific Northwest, more elaborate research questions can be addressed, such as "How did the occurrence of tsunamis affect the availability of shellfish?" or "How did deer populations respond to human hunting pressure?" The kinds of data needed to answer these types of questions can vary quite a bit. But it all starts with being able to identify what species any given bone (or shell) comes from.

How to distinguish **fish** from **birds** from **mammals**

Introduction:

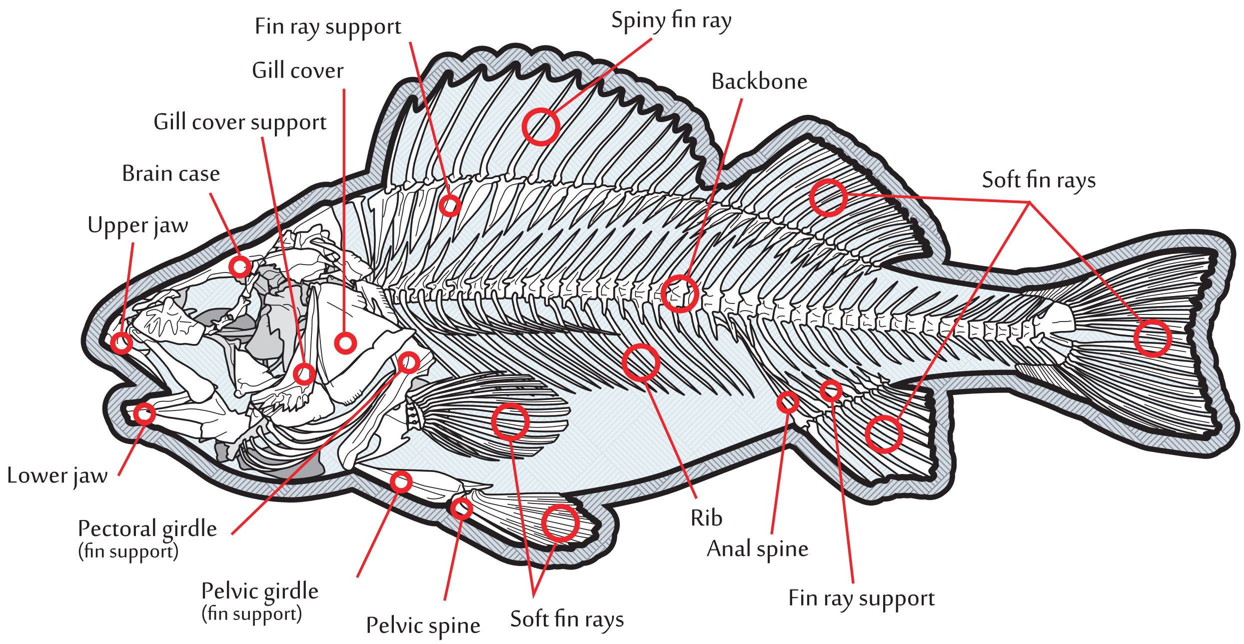
One of the most difficult aspects of teaching zooarchaeology is how to describe the ways to distinguish the bones from various classes of vertebrates (birds, fish, mammals). Fish bones, for the most part, are easily recognizeable because their skeletons are dramatically different from birds and mammals.

Look at the examples of fish bones provided, and you will see that this shows up in the individual bones, whether they be the vertebrae (cylindrical, often with spines projecting from them) or the cranial (skull) bones (usually thin, flat bones).

Teaching students how to distinguish bird bones from mammal bones is often much more difficult. Almost everyone has probably heard that bird skeletons are uniquely adapted for flight, with thin, hollow bones. While this is generally true, unfortunately, this characteristic alone can't be used to reliably distinguish bird bones from mammal bones. This is because there is a lot of overlap between birds and mammals in the external and internal structure of their bones.

First, let's look at the body plans of birds and mammals. Birds and mammals both evolved from a common ancestor that was quadrupedal (had four legs). Although some bone structures have changed over millions of years of evolutionary divergence, the overall body plan is still much the same in both groups.

This module will focus on only two skeletal elements: the **humerus**, or upper arm bone and the **femur**, or thigh bone (both of which are shaded black in the diagrams of the skeletons). Notice that the placement of these bones is the same in the raven as it is in the mammals.

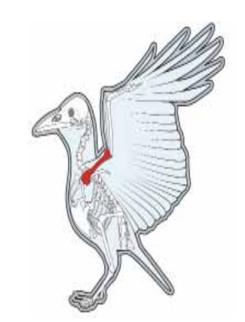


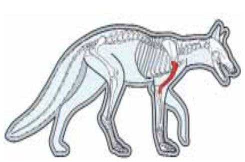
External Structure:

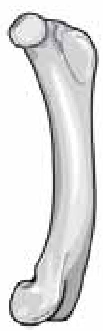
Because the structural requirements of a limb used for flight are so different from the structural requirements of a limb used for running, it is probably not surprising that bird humeri differ from mammal humeri in their external structure.

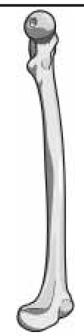
The biggest differences can be seen in the "head" of the humerus—the portion of the bone that fits into the shoulder joint. The head of a bird humerus tends to be broadly flared and a bit flattened, and is often noticeably hollow. In contrast, the heads of mammal humeri tend to be rounded and smooth, approximating a "ball - and - socket" joint (but see more on this with the femur), and are constructed of solid bone.

The femur provides a slightly different story. The legs of birds are used in much the same way as the legs of mammals—for supporting their body weight while walking. Consequently, the structural requirements are fairly similar, and the external structure of bird femora is not all that different from mammal femora (Figure xx). Both have a well-developed ball-and-socket joint that fits into the hip; both tend to be relatively straight-shafted; and both have a pair of surfaces at the knee joint that articulate with the shin bone.


Raven Humerus


Red Fox Humerus


Cormorant Femur


Human Femur

Internal Structure:

Now lets see what the bones look like on the inside. Find the longitudinally sectioned goose humerus and coyote humerus and examine them closely. As you can see, the main portion of the shaft of the goose humerus is thin-walled and hollow. The ends of the bones are filled with delicate struts of bone—these add structural support to the bone. Now look at the sectioned humerus from the coyote. Although the cortical bone is generally thicker than it is in the goose humerus, **the bone is hollow**. Furthermore, although the structure is a bit different, the ends of the coyote humerus are also filled with delicate struts of bone.

Special cases, and why it's difficult to generalize:

Turn now to the femora. There are subtle differences in the thickness of the cortical bone and the degree to which the ends are filled with bone struts. But both the goose femur and the coyote femur are hollow in the mid-shaft of the bone.

The patterns we've looked at so far are generalizations—they hold true for most species in most cases. Now let's look at some special cases where the general pattern doesn't hold.

- diving birds: cormorants, puffins, penguins (extreme)
- flightless birds: emu, ostrich
- swimming mammals: seals, sea lions, fur seals, cetaceans (extreme)

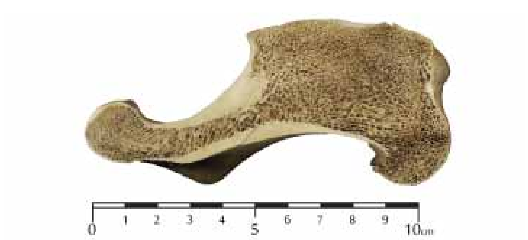
For instance, birds that spend a substantial part of their lives diving under water in search of food often have developed skeletal features to make this easier. Lightweight, hollow bones are not advantageous to a diving bird. Consequently, natural selection has resulted in the evolution of bones that are relatively dense, and may actually be filled with oil or other fluids.

Likewise, marine mammals like pinnipeds (seals and sea lions and fur seals) spend a substantial part of their lives in the water. The structural demands this puts on the skeleton are very different than if they were full-time terrestrial species, and this shows up in the internal bone structure. In pinnipeds, the entire shaft of the humerus and the femur is filled with spongy cancellous bone.

Goose Humerus

Coyote Humerus

Seal Humerus



Name: ______________________________

Excercise #1

Identifing Species

Introduction:

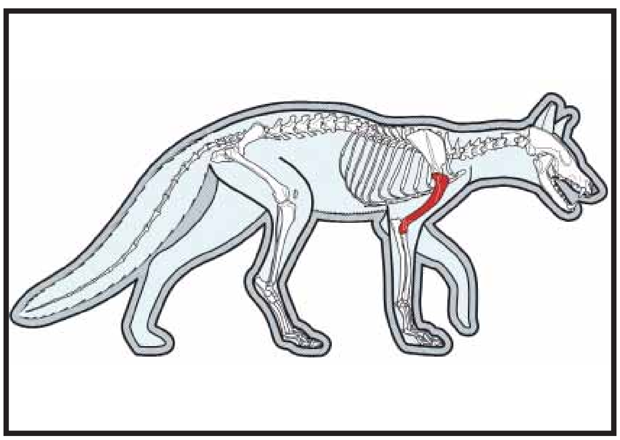
It may seem like an obvious first step, but one of the most common questions zooarchaeologists are asked by non-zooarchaeologists is: "Is this bone?" In fact, there are a lot of sticks and stones that do a great job of impersonating a bone. And, truthfully, bones, especially fragments of bone, can also sometimes look like sticks or stones.

But suppose you have something that you know is definitely a bone. The next step in a zooarchaeological analysis is to identify which particular bone, or fragment of a bone is represented in the sample.

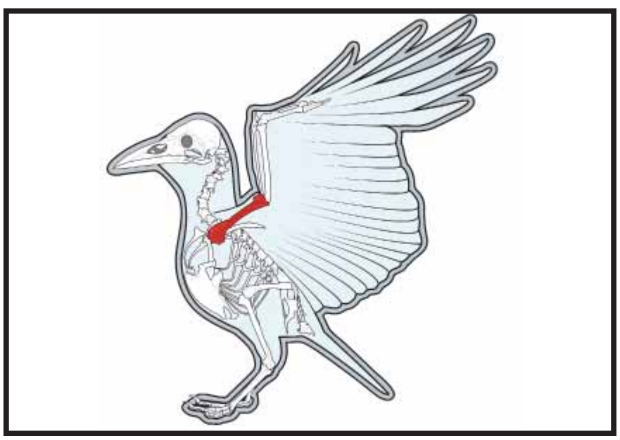
Finally, the zooarchaeologist has to determine what species of animal the bone sample has come from. Sometimes zooarchaeologists can determine even more from a bone, such as how old the animal was when it died, and whether it was a male or female (see "Age and Growth" sub-module for more information).

Each of these steps in the bone identification process requires that you know a lot about skeletal anatomy—a knowledge base that takes years and years of training and experience to accumulate.

You and your classmates will probably only be utilizing this Burke Box for a couple of weeks, and will probably only spend one or two class periods with the Zooarchaeology Module. That will probably not give you enough time to gain a full familiarity with skeletal anatomy. That is why this zooarchaeology sub-module—Identifying Species—will only focus on one skeletal element, the humerus (or upper arm bone).



Diagrammatic skeleton of a fox. The bone shaded black is the humerus.



Diagrammatic skeleton of a raven. The bone shaded black is the humerus.

Name: ______________________________

Excercise #1

Identifing Species

For the species identification, zooarchaeologists rely on the fact that animals that are closely related to each other tend to have similar-looking skeletons. Animals that are not closely related tend to have different-looking skeletons. The degree of difference or similarity usually scales with how closely related two species are.

The Artifacts Module discusses the fact that there are multiple ways to organize, or classify, artifacts. This flexibility allows researchers to analyze the artifacts in various ways depending on the research question they are interested in answering.

Zooarchaeologists already have a single, unifying organization structure in which to analyze the bones, teeth, and shells they find—the Linnaean Hierarchy. The Linnaean Hierarchy is named for Carl Linnaeus, the scientist from Sweden who formalized the system in 1735. This system organizes all the worlds' organisms into a hierarchical system that reflects the evolutionary history of those organisms—that is, how closely related they are.

Here is the hierarchy, with an example we will use throughout this module:

1. **Kingdom** → Animalia
2. **Phylum** → Vertebrata
3. **Class** → Mammalia
4. **Order** → Carnivora
5. **Family** → Canidae
6. **Genus** → Canis
7. **Species** → Canis familiaris, domestic dog

Look at the following table to see how all of this relates to skeletons.

Order	Family	Genus	Species	Common Name
Carnivora	Canidae	Canis	Canis familiaris	domestic dog
Carnivora	Canidae	Canis	Canis latrans	coyot
Carnivora	Canidae	Vulpes	Vulpes vulpes	red fox
Carnivora	Procyonidae	Procyon	Procyon lotor	raccoon
Carnivora	Phocidae	Phoca	Phoca vitulina	harbor seal
Carnivora	Otariidae	Callorhinus	callorhinus ursinis	northern fur seal
Artiodactyla	Cervidae	Odocoileus	Odocoileus virginianus	white-tailed deer
Artiodactyla	Cervidae	Odocoileus	Rangifer tarandus	black-tailed deer
Artiodactyla	Cervidae	Rangifer		caribou

Name: ______________________________

Excercise #1

Identifing Species

For instance, foxes and dogs are very closely related members in the Family Canidae. Not surprisingly, their skeletons look very similar. Likewise, white-tailed deer and black-tailed deer are closely-related species within the same Genus (Odocoileus), and have very similar-looking skeletons. Bones from the other species in the Order Carnivora listed in the table are more similar to each other than they are to bones from species in the Order Artiodactyla. Finally, bones from various species of mammals are more similar to each other than they are to bones from various species of other Classes, such as birds (Class AVES—see the "Identifying Class" sub-module).

Zooarchaeologists use this basic pattern, years of training, and lots and lots of reference skeletons (complete skeletons of known identity), to help them identify archaeological samples.

The exercises in this module will focus on only one skeletal element: the humerus, or upper arm bone (shaded black in the diagrams of the skeletons). You will learn the basics of how zooarchaeologists identify what species a bone comes from, using species that either are found in the Kuril Islands, or are closely related to species that are found in the Kuril Islands (as well as in Washington State).

List of species used in this sub-module:

herring gull (*Larus argentatus*)
common murre (*Uria aalge*)
double-crested cormorant (*Phalacrocorax auritus*)
snow goose (*Chen caerulescens*)

fur seal (*Callorhinus ursinus*)
harbor seal (*Phoca vitulina*)
deer (*Odocoileus virginianus*)
fox (*Vulpes vulpes*)

Lets start with some terminology for different parts, or landmarks, of the bones. These are the anatomical parts that help zooarchaeologists be consistent in the ways they describe bones from various species, as well as specific identification characters, or features, that can be used to distinguish different species from each other. (See figue on next page)

Name: ______________________________

Excercise #1

Identifing Species

Step 1:

Start with reference bones. Use either the set of mammals bones or the set of bird bones. Choose one bone and sketch (or trace) the outline of the bone. Using the slide from the slideshow, label at least four of these characters/landmarks.

Name: ______________________________

Excercise #1

Identifing Species

Step 2:

Using the landmarks identified in the drawings, describe how each of the three reference bones in the set you have selected (either mammals or birds) is different from each other. Some important aspects of the landmarks may be their size or shape.

Name: ______________________________

Excercise #1

Identifing Species

Step 3:

Now, identify the fragmentary bones in the "Unknowns" bagusing the reference collections. Remember that size and shape are the two characters that are most helpful in identifying a species. All of the species illustrated here (4 bird species, 4 mammal species) are represented (by fragments). But there are also bones from a species not represented here.

Record the appropriate species for each specimen in the table (see next page). Each species will be represented by one or more fragments of bone. If you think a bone specimen is not a good match to any of the species in your list, mark it as "unknown."

Examine the "unknown" bone/s closely. Which of the four reference species does it most resemble? (Hint: Remember that closely-related species typically have bones that look similar to one another).

Name: ______________________________

Excercise #1

Identifing Species

Specimen number	Species		Specimen number	Species
KBP Burke 0134			KBP Burke 0154	
KBP Burke 0135			KBP Burke 0155	
KBP Burke 0136			KBP Burke 0156	
KBP Burke 0137			KBP Burke 0157	
KBP Burke 0138			KBP Burke 0158	
KBP Burke 0139			KBP Burke 0159	
KBP Burke 0140			KBP Burke 0160	
KBP Burke 0141			KBP Burke 0161	
KBP Burke 0142			KBP Burke 0162	
KBP Burke 0143			KBP Burke 0163	
KBP Burke 0144			KBP Burke 0164	
KBP Burke 0145			KBP Burke 0165	
KBP Burke 0146			KBP Burke 0166	
KBP Burke 0147			KBP Burke 0167	
KBP Burke 0148			KBP Burke 0168	
KBP Burke 0149			KBP Burke 0169	
KBP Burke 0150			KBP Burke 0170	
KBP Burke 0151			KBP Burke 0171	
KBP Burke 0152			KBP Burke 0172	
KBP Burke 0153			KBP Burke 0173	

Possible species: Cormorant, Gull, Mallard, Murre, Deer, Fox, Fur seal, Harbor seal, Unknown. The unknown "challenging" bone should be the coyote (in bold).

Name: ______________________________

Excercise #1
Identifing Species

Additional Explorations

All of the bone sketches in this module were developed from three-dimensional digital images created by the Virtual Zooarchaeology of the Arctic Project (VZAP). These images are stored as portable document files, otherwise known as PDFs, and can be viewed on most computers. Each of the illustration files is included on the DVD in the Burke Box. Once the files are opened and activated, you can view the illustrated bone from any angle by simply dragging the mouse/cursor.

To view the three-dimensional illustrations, double-click on the PDF file you are interested in.

Single-click on the image to “activate” the 3D capabilities.

Click and hold the mouse, and then rotate the bone by “dragging” it in any direction.

Name: ______________________________

Excercise #2

Age and Growth

Step 1:

Using reference bones included in this section and the illustrations as a guide, separate the diaphysis (long bone shafts) into two piles, one for humeri and one for femora.

Step 2:

Using the illustrations **AND** the sorted bones, determine which of the loose end caps (unfused epiphyses) belong with the humeri and which belong with the femora.

Step 3:

Using the broad categories in the table below, how many bones of each age are in your sample of humeri? How many bones of each age are in your sample of femora? You do not need to count the reference bones in your totals. You can ignore the fact that the bones may be from different species. However, if an unfused epiphysis definitely fits onto a diaphysis, count the matched pair as ONE bone.

	Humerus	**Femur**
Juvenile (no fused epiphyses)		
Sub-adult (only one epiphysis fused)		
Adult (all epiphyses fully fused)		

Step 4:

Using the information about the age when different epiphyses fuse in different species of animals (see laminated handout), determine as precisely as possible the age-at-death for the samples listed below. (D = distal; P = proximal):

species	**bone**	**state of fusion**	**Age Estimate**
dog	humerus	D unfused; P unfused	**answer:**
red fox	femur	D unfused; P fused	**answer:**
deer	femur	D fused; P fused	**answer:**
harbor seal	femur	D unfused; P unfused	**answer:**
male fur seal	humerus	D fused: P unfused	**answer:**
female fur seal	humerus	D fused; P unfused	**answer:**
fur seal, sex unknown	humerus	D unfused; P unfused	**answer:**

Name: ______________________________

Excercise #2

Age and Growth

Step 5:

Coyotes are intermediate in size between dogs and red foxes. Assuming that their growth patterns are also intermediate between dogs and red foxes, fill in the following table with your predictions of the age of fusion for the humerus and femur.

species	Proximal Humerus	Distal Humerus	Proximal Femur	Distal Femur
dog	10 months	5-8 months	6-9 months	6-8 months
coyote	**ans:**	**ans:**	**ans:**	**ans:**
red fox	17 weeks	16 weeks	26 weeks	28 weeks

Name: ______________________________

Excercise #3

Quantification

Using the set of bones for the Quantification exercise answer the following questions:

<u>Question 1:</u>

Keeping in mind that this exercise includes only two skeletal elements (humerus and femur), outline the steps you would take to determine what the MNI (minimum number of individuals) is for the sample.

Now follow these steps to answer the following:

<u>Question 2:</u>

What is the MNI for this sample, and what was it based on?

<u>Question 3:</u>

Suppose that all of the skeletal elements in your sample came from different individuals. What is the maximum number of individuals that could be represented in your sample?

<u>Question 4:</u>

What is the NISP of the sample, and how does that relate to your answer to Question 3?

Name: ______________________________

Excercise #3

Quantification - Continued

Question 5:

What is the MNI for femora. Is it the same as for humeri? Why or why not? Which MNI would you use to represent the number of animals at the site?

Name: ______________________________

Analyzing Data

Part 1

The following set of exercises is based on realistic data for three archaeological sites in the Kuril Islands.

Step 1 (optional). Using the spreadsheet of raw data, tally the total number of specimens identified for each species (NISP), from each stratum, for each of the three archaeological sites. Put your totals in the appropriate boxes on the table "Bone ID NISP blank table" (data for Simushir, Stratum 1, are already provided).

PAY CAREFUL ATTENTION TO INFORMATION PROVIDED IN THE "COMMENTS" COLUMN OF THE DATA TABLE.

Step 2. Using either your results from Step 1, or the provided data table ("Bone ID NISP data"), answer the following questions:

1. Are there significant changes through time in the number of albatross that were harvested at Rasshua?

2. Do you think the changes in albatross use at Simushir are significant?

3. Is it safe to conclude that the people living on Ushishir did not own dogs? Why or why not?

4. List at least two hypotheses that could explain the increase in sea otters at Rasshua. Be sure to examine the dates of occupation (see "Stratigraphic dates" table in the spreadsheet).

Name: ______________________________

Analyzing Data

Part 1

Step 3 (optional). Using the spreadsheet of raw data, tally the minimum number of individuals (MNI) represented by the sample of bones for each species FOR ONE STRATUM from only ONE SITE (data for Simushir, Stratum 1, are already provided). Use information about the skeletal element that is represented, any age or sex information that is recorded, as well as information in the "Comments" column of the spreadsheet. Enter your MNI data in the appropriate boxes in the table "Bone ID MNI blank table," including what you based your calculations on (for instance, in Stratum 1 at Simushir, the MNI of salmon is 1 based on the presence of either bone, while the MNI of albatross is based on the presence of a single humerus).

Step 4. Using either your results from Steps 1 & 3, or the provided data tables ("Bone ID NISP data" and "Bone ID MNI data"), answer the following questions:

1. When the data are quantified using MNI instead of NISP, do you come to a different conclusion about the trend in albatross use at Rasshua? Why or why not?

2. When the data are quantified using MNI instead of NISP, do you come to a different conclusion about the trend in albatross use at Simushir? Why or why not?

Step 5. Imagine that you have lost the stratigraphic information from the deepest part of your excavations at Rasshua (Stratum 3 and Stratum 5). You still have the data table of identifications, but now you must recalculate the NISPs and the MNIs with these two strata combined. Fill out the table "Combined Strata Blank" and answer these questions:

1. How do the NISPs change relative to the original, un-combined strata?

2. Do the MNIs change in the same way? Why or why not?

Name: ______________________________

Analyzing Data
Part 2

Now you'll have the opportunity to explore real data from your own state! (requires internet access). You'll have an opportunity to explore the actual Kurils data in "**Analyzing Data, Part 3"**.

Archaeological and paleontological data are typically available to the public, especially if the project is funded through a federal agency like the National Science Foundation. Although the standard approach scientists use to make their data available is to publish their results in scientific and popular journals, the internet is an increasingly popular outlet for making data broadly available.

One of the most comprehensive on-line databases is called the "Neotoma Paleoecological Database." The database is named after a curious rodent called a pack rat (scientific name *Neotoma*), which has a habit of collecting scraps of vegetation and storing them in large piles in caves. These piles accumulate and in the right conditions can preserve for tens of thousands of years. Paleoecologists study the vegetation in these pack rat "middens" to understand how climate has changed through time.

The Neotoma database is an on-line archive of a wide range of paleoecological data, including pollen studies and mollusk studies, as well as paleontological and archaeological bone data.

To access this on-line database, open the URL for the "Neotoma Paleoecological Database" (using the web browser of your choice): **http://www.neotomadb.org**

You should see a screen that looks something like this (it changes occasionally, so don't be alarmed if it doesn't look exactly like this):

Use your mouse to move the cursor over the word "DATA" at the top left of the screen. When the line of words appears that reads "Overview Contribute Data Tilia FAQ Explore Data etc..." move the cursor to the word "Explore Data" and click on that to open the link.

Finally, click on the map or the "Go to the Neotoma Explorer" link at the bottom of the page to launch the "EXPLORER" function of Neotoma.

Name: ______________________________

Analyzing Data
Part 2 - Continued

[You can by-pass all of this by simply loading the following URL. However, this also by-passes interesting and potentially important back-ground information about the Neotoma database]. **http://www.neotomadb.org/data/category/explorer**

VERY IMPORTANT NOTE ABOUT NEOTOMA MAPPING FUNCTION: You must specify if you want Neotoma to search only within the area of the map visible on your screen, or if you want to search globally [see "Geographic Coordinates" at bottom left of screen]. Either approach works fine, just be aware that the area visible on your screen might determine how complete your search is.

The first search you will perform will be to find all the paleontological and archaeological data that have been recorded for Clallam County, which lies at the extreme northwest corner of Washington State.

To do that, start typing "United States" in the "Place Name" section of the Search window on the left-hand side of the screen. A drop-down list will appear. You can either scroll down through the list, or you can continue typing "United States_Washington_Cl...." until the following appears:

Once you have "United States_Washington_Clallam" showing in the "Place Name "section, click the "SEARCH" button at the bottom left corner of the screen.

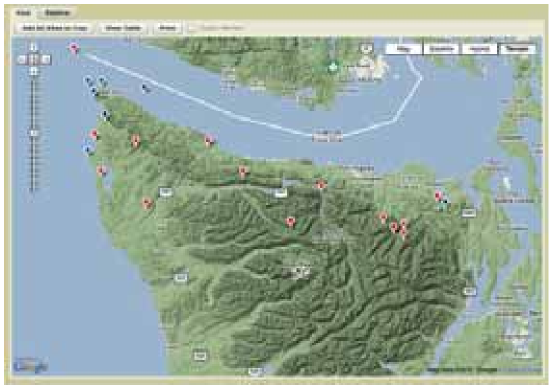
There are several ways to view the search results. Most immediately, you should see a map with several pin-flags showing the locations of sites with paleontological and archaeological data. Adjust the zoom level either by using

Name: ______________________________

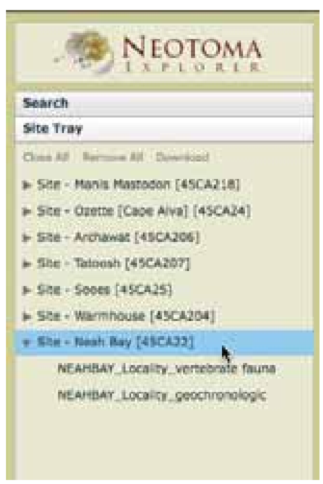
Analyzing Data

Part 2 - Continued

the slider on the left, or by double-clicking on the map (to re-center and zoom in). Blue pin flags represent archaeological/paleontological sites (there are 7 on the map), and red pin flags represent pollen sites (14 total, with some modern and some ancient).



You can also view the search results in table format by toggling the "View Map/View Table" button. To find data for a specific site, you need to load the site on the "Site Tray." To do this, either double-click on a pin-flag, or in the map view, click on the "Add All Sites To Tray" button.



To see what has been loaded onto the "Site Tray," click on the white bar at the bottom left corner of the screen (the white bar that says "Site Tray").

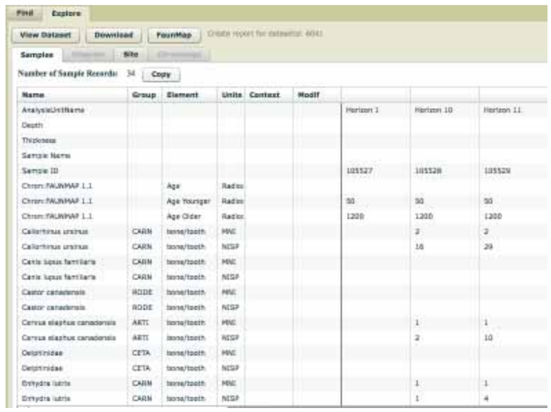
Now double-click on the site you are interested in. If it is a modern sample, the table entry will expand to show only one additional line of text, which will lead you to the data for that site (by double-clicking on the text). If the data are from an ancient site, the table entry will expand to show two additional lines: one for the data, and one for the geochronological information (i.e., the dating for that site).

Name: ______________________________

Analyzing Data

Part 2 - Continued

As an example, navigate to the data table for the archaeological site called "Neah Bay." It is represented by the blue pin flag out near the middle of the Strait of Juan de Fuca [this is not actually the true location of the site; the true location has been intentionally "blurred" to limit the amount of illegal and destructive looting of this sensitive archaeological site]. Double-click on the text that reads "NEAHBAY_Locality-vertebrate fauna" and you should see this table:


Find Explore

View Dataset Download FaunMap

Samples Site

Number of Sample Records: 34 Copy

Name	Group	Element	Units	Context	Modif			
AnalysisUnitName						Horizon 1	Horizon 10	Horizon 11
Depth								
Thickness								
Sample Name								
Sample ID						105527	105528	105529
Chron:FAUNMAP 1.1		Age	Radio					
Chron:FAUNMAP 1.1		Age Younger	Radio			50	50	50
Chron:FAUNMAP 1.1		Age Older	Radio			1200	1200	1200
Callorhinus ursinus	CARN	bone/tooth	MNI				2	2
Callorhinus ursinus	CARN	bone/tooth	NISP				16	29
Canis lupus familiaris	CARN	bone/tooth	MNI					
Canis lupus familiaris	CARN	bone/tooth	NISP					
Castor canadensis	RODE	bone/tooth	MNI					
Castor canadensis	RODE	bone/tooth	NISP					
Cervus elaphus canadensis	ARTI	bone/tooth	MNI				1	1
Cervus elaphus canadensis	ARTI	bone/tooth	NISP				2	10
Delphinidae	CETA	bone/tooth	MNI					
Delphinidae	CETA	bone/tooth	NISP					
Enhydra lutris	CARN	bone/tooth	MNI				1	1
Enhydra lutris	CARN	bone/tooth	NISP				1	4

Adjust the column widths if you need to by dragging-and-dropping the edges of the column, or by double-clicking on a column boundary. Here are some of the key components of the data table for Neah Bay:

Date of deposits: Ranges from 2,000 radiocarbon years BP to 50 radiocarbon years BP.

Species represented: *Callorhinus ursinus* (northern fur seal), *Canis lupus familiaris* (domestic dog, entered here as a sub-species of wolf, *Canis lupus*), and so on.

Quantification Units used: Both MNI (minimum number of individuals) and NISP (number of identified specimens) were recorded for this particular collection of bones [see the "QUANTIFICATION" lesson if you need to review quantification methods]. Occasionally species are recorded in Neotoma only as present/absent, with a "1" indicating that at least one bone was identified from that stratum.

Using the Neah Bay data table answer these questions:

1. How many horizons, or strata, are represented by the data? ______________________________

2. What is the total NISP for raccoons (*Procyon lotor*) for all horizons combined? ____________________

3. What is the total NISP for northern fur seals (*Callorhinus ursinus*) for all horizons combined? __________

4. What is the total MNI for northern fur seals (*Callorhinus ursinus*) for all horizons combined? ____________

Name: ______________________________

Analyzing Data

Part 2 - Continued

OTHER SEARCHES

You can also narrow your search by other search terms.

Start by first clearing the previous search results (unless you want to combine two or more searches). To do this, click on the "Remove All" button at the top of the Search Tray. Then click on the white bar at the top left corner of the screen (the white bar that says "Search").

To search for data for different species, use the "Taxon Name" section of the Search window. To see a map of all the sites that have a particular species (black-tailed deer (*Odocoileus hemionus*) in this example) recorded in them, start typing "Odocoile..." and use the drop-down list to select black-tailed deer.

Using the same approach as you did for extracting data for the Neah Bay site, answer these questions [Remember that the "Geographic Coordinates" setting may affect your search results]:

1. How many total sites are recorded in North America that contain black-tailed deer bones? ________________

2. Describe the geographic distribution of the sites that contain black-tailed deer bones.

____

____

____

____

____

____

____

3. How many sites in Washington State contain black-tailed deer bones? ______________________________

Name: ______________________________

Analyzing Data

Part 3

All of the zooarchaeological data for the Kuril Islands sites have also been entered into the Neotoma database.

In order to see the map distribution of all the sites with faunal remains, enter "Russia_Sakhalin [Sakhalinskaya]" into the "Place Name" section of the Search window.

1. How many sites in the Kuril Islands are reported to have faunal remains? ______________________________

2. Based on information presented in the Settlement modules of the Kurils Burke Box, what is the total number of archaeological sites recorded?______________________________

3. Are the answers to Question 1 and Question 2 the same? Why do you think this is the case?

____
____
____
____
____
____
____

TSUNAMI & STRATIGRAPHY
MODULE

Table of Content

Vocabulary

Exacavation:

A rectangular hole dug by scientists to see the stratigraphy

GPS:

A system of satellites that can be used by people to find the latitude and longitude of their location on Earth.

Marsh soil / peat:

Soil made of organic matter such as dead leaves and grass.

Soil

Dark upper layer of earth in which plants grow

Stratigraphy:

The study of accumulated sediments

Tephra:

Fragments of rock thrown into the air by volcanic eruption. Tephra is classified into different categories based on the size of the grains:

Name	Size
Ash	< 2 mm
Cinder	2 mm < x < 64 mm
Block or Bomb	> 64 mm

Topography:

Study of the shape of the earth's surface, specifically changes in elevation and the shape of a landscape

Tsunami:

A long-period wave generated by an impulse such as earthquakes, landslides, underwater volcanic eruptions, and meteor impacts

Volcano:

An opening in the earth's surface through which lava and gasses from below the earth's surface escape.

yr BP (years before present):

Date in the years before 1950 (e.g. 50 yr BP is the same as AD 1900).

Background Information

Stratigraphy and the relation between the stratigraphy of different sites allow scientists to identify and date past natural disasters. Stratigraphic layers can record tsunamis, volcanic eruptions, and changes in environment. Using many data points, scientists can estimate the size of past natural disasters based on the area affected by a specific event.

During certain types of volcanic eruptions a mixture of hot gasses, rock fragments, and molten rock are pushed into the atmosphere. The mixture is carried by the prevailing wind. Recent incidents, such as the shut down of airports in Europe due to the eruption of an Icelandic volcano, were due to volcanic particles in the atmosphere. Because of gravity and the cooling, the mixture falls back to earth, creating layers of unconsolidated volcanic rock, called tephra. Typically the largest grains are found near the volcano and the smallest grains are carried further. Tephra is described based on the size of the grains and the chemistry of the rocks. Different volcanoes and often even different eruptions from the same volcano have different ratios of elements in their tephra. Because these layers are widespread and represent a short period of time (hours to weeks), scientists can date these layers and use them to correlate between sites.

Tsunamis are long-period waves generated by some type of impulse such as an earthquake or landslide. They differ from normal wind waves because they move the entire water column even in the deep ocean. When the waves come into shore, they both erode part of the shoreline and deposit sediment over low-lying areas. In the geological record these layers can be identified in areas where sand is not common, such as bogs and marshes. These layers can also contain fragments of marine shell or microscopic marine organisms such as diatoms or foraminifera. These indicate that the sediment originated from the ocean and were transported to the freshwater environment. By counting the number of tsunami deposits in a time period, scientists can find the frequency of tsunami events. By tracing the layers inland scientists can determine the frequency of larger and smaller events.

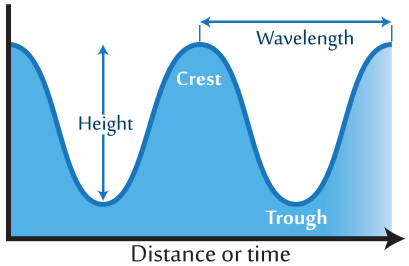
Background Information

Continued

Tsunami waves compared to wind waves

Wavelength:

- Wind waves: 100 - 200 m
- Tsunami: 200 - 500 km



Velocity:

(both types of waves move slower as they move onto the shore)

- Wind waves: 90 km/hr
- Tsunami: 950 km/hr (as fast as jet planes) in deep water

Period:

(time between two successive waves)

- Wind waves: 5 - 20 sec
- Tsunami: 10 min to 2 hrs

Name: ______________________________

Exercise 1

Plotting topographic profiles

Introduction:

Your goal is to determine how often big tsunamis affect the Kuril Island coasts using the same method that tsunami scientists use.

Exercise 1:

Plotting topographic profiles

Measuring coastal topography is the first step in identifying tsunami deposits and determining how big the tsunamis were. Open the Excel spreadsheet provided on-line or on a CD in the Burke Box. Use Excel to make a graph of the surface of the coastal plain. Distance should be your x-axis and elevation your y-axis; label your axes. Circle the points on your topographic plots where we dug excavations.

How far inland and at what elevation did we dig excavations? (refer to the spreadsheet for the most accurate numbers; look at the profile to get an idea of distance and elevation)

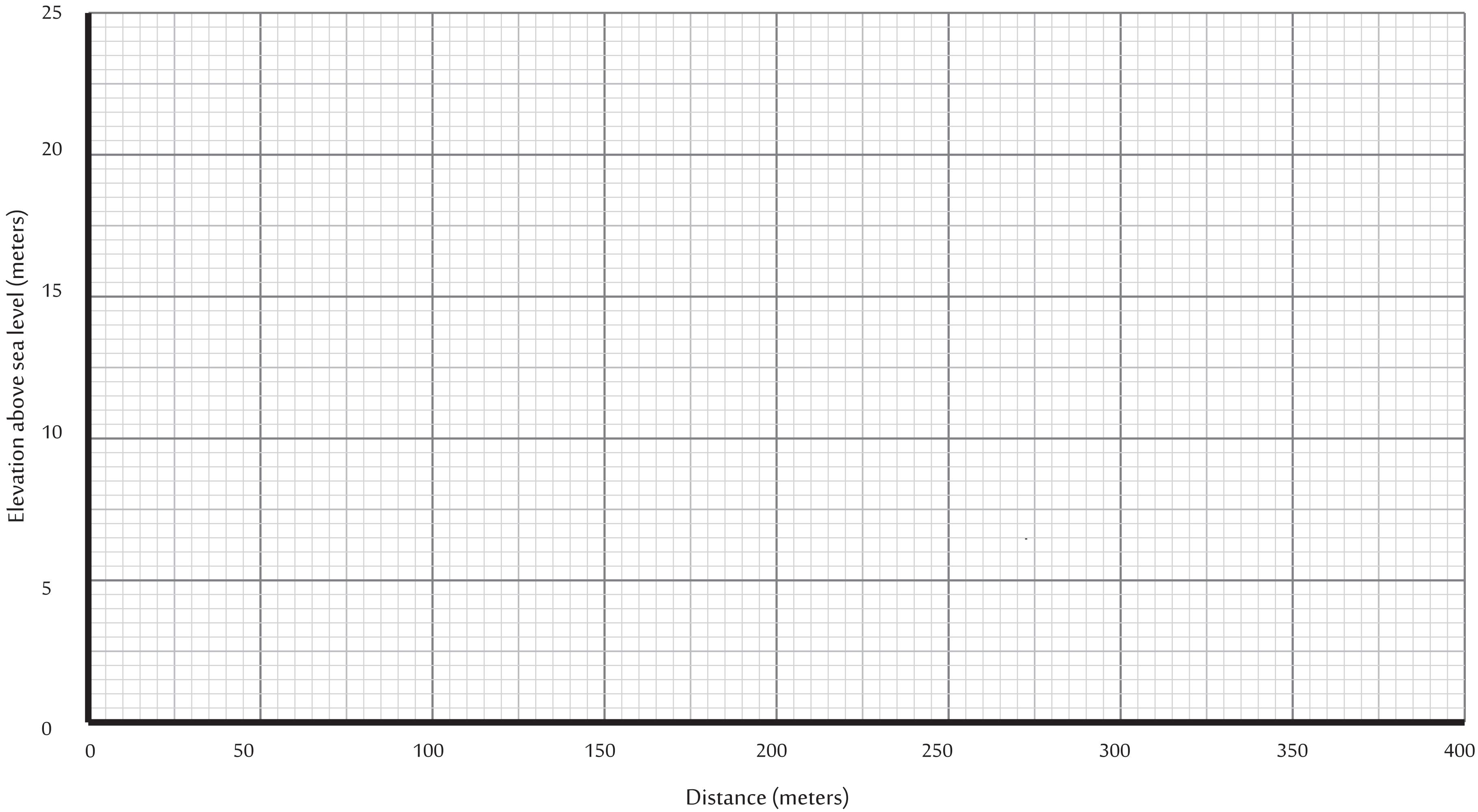
	Site 1	Site 2	Site 3	Site 4
Distance (in meters)				
Elevation (in meters)				

Name: ______________________

Exercise 1

Plotting topographic profiles - Continued

Dushnaya Bay
Simushir Island
Profile 2



Name: ______________________________

Exercise 1

Plotting topographic profiles - Continued

	distance (in meters)	elevation (in meters)	Notes	
1	361	20.0	edge of birch forest, quite flat past here	
2	335	19.1	excavation 102 near here	SITE 4
3	313	18.5		
4	290	17.9		
5	269	17.2		
6	247	17.0	low point	
7	227	17.5	excavation 101	
8	217	18.5		
9	207	19.7	scattered pine shrubs	
10	197	21.4	top of slope	SITE 3
11	191	20.8		
12	183	17.7		
13	182	16.6		
14	179	15.8	step in slope	
15	176	15.1		
16	172	13.1		
17	170	12.6		
18	164	10.1		
19	161	9.0		
20	157	8.1	base of slope, tall flowers above	
21	154	8.0	small ridge	
22	152	7.8		
23	150	7.4	edge of marsh	
24	147	7.2	mid marsh	
25	145	7.4	edge of marsh	
26	144	7.5		
27	141	7.1	edge of marsh	
28	139	7.0	mid marsh	
29	137	7.1	edge of marsh	
30	135	7.1	marshy area	SITE 2
31	130	7.4	[no point 32]	
33	126	8.0	ridge crest	

Name: ______________________

Exercise 1

Plotting topographic profiles - Continued

34	123	7.3		
35	122	6.7	floated debris, 2006 runup	
36	117	6.6	beach grass starts; people disturbance	
37	114	7.2		
38	111	7.4		
39	108	6.7	trough	
40	104	7.3		
41	101	7.7	ridge crest	
42	98	7.4	people disturbance	
43	95	7.5	excavation near here	
44	92	7.3		
45	91	7.2	edge of ridge	
46	87	4.4	change in slope	
47	84	4.0	trough with short flowers; less beach grass	
48	81	4.6		
49	76	4.9		
50	70	5.4	excavation near here	SITE 1
51	67	3.9		
52	65	3.7	low spot	
53	59	4.4		
54	55	5.1	ridge	
55	53	4.6	beach grass	
56	51	4.5	top edge of scarp; cleaned cliff face for excavation	
57	50	2.8	base of scarp, sandy	
58	42	2.8	top of small berm; a little vegetation	
59	38	2.0		
60	34	1.5		
61	31	1.0	top of stream bank	
62	30	0.4	high tide	
63	26	0.5	stream edge	
64	20	0.6		
65	12	0.7	high point	
66	4	0.4	rock edge	
67	0	0.0	mid-rock outcrop, water level 3:40 PM	
			more rocks about 100 m out to sea	

Name: ______________________________

Exercise 2

Drawing stratigraphic sections

On the template provided and using our written descriptions, draw what we saw in each excavation. Site 1 is already drawn for you to help you get started. Each person in a group should draw one section. Then line the sections up from seaward (site 1) to landward (site 4).

1. How many sand deposits are there in each excavation?

Tsunamis can leave behind sand layers typically less than 25 cm thick.

	Site 1	Site 2	Site 3	Site 4
Number of tsunami deposit				

2. Are there more tsunami deposits at lower or higher excavations?

____

3. Are there more tsunami deposits closer or farther from the ocean?

____

4. What might be the source of other, thicker sand deposits?

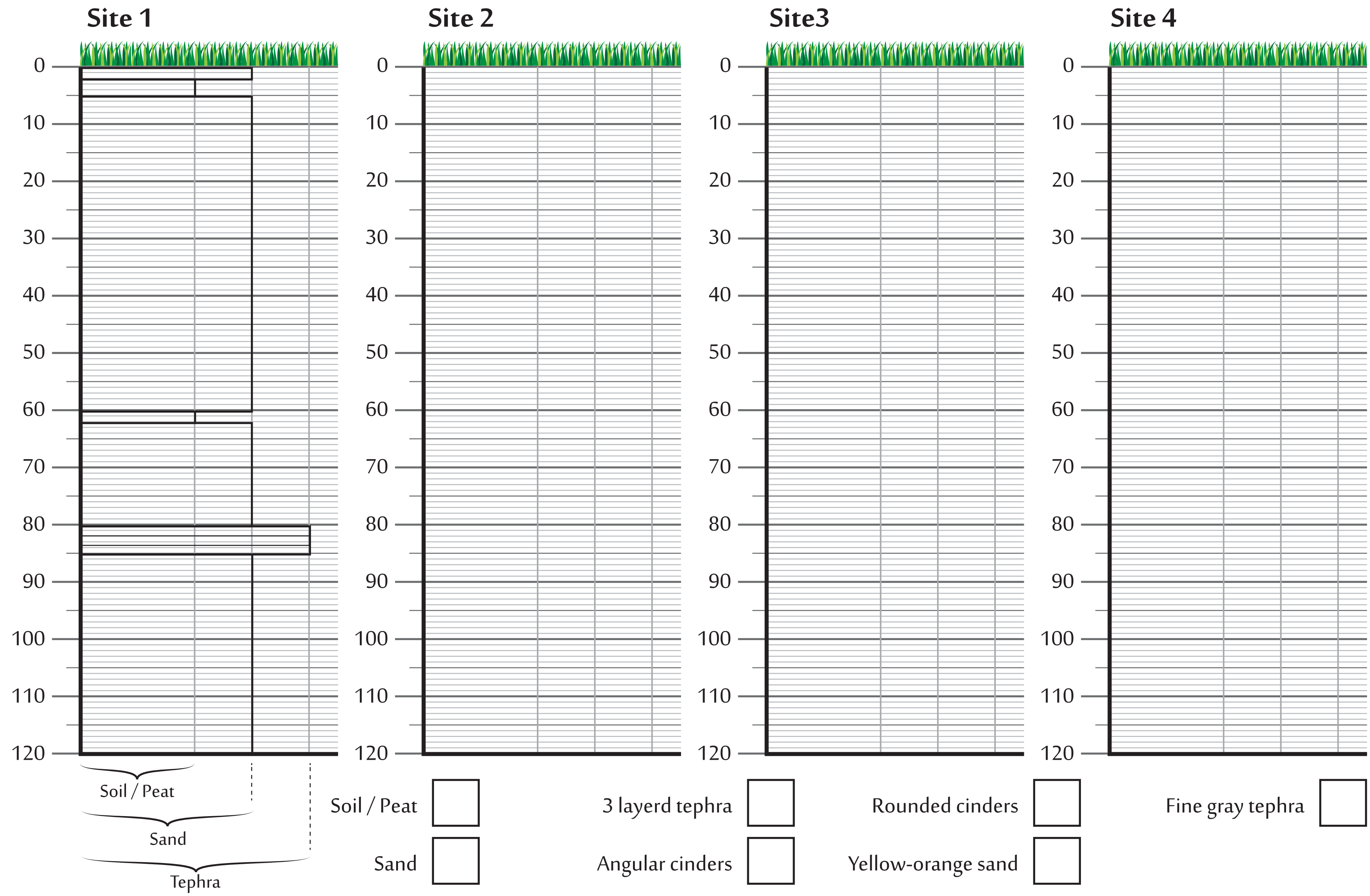
____

____

Name: ______________________________

Exercise 2

Drawing stratigraphic sections - Continued



Soil / Peat ☐

Sand ☐

3 layerd tephra ☐

Angular cinders ☐

Rounded cinders ☐

Yellow-orange sand ☐

Fine gray tephra ☐

The Kuril Biocomplexity Project: www.kbp.org

Name: ______________________________

Exercise 2

Drawing stratigraphic sections - Continued

Notes from exacavations, Profile 2 (2006 & 2007)

Dushnaya Bay, Simushir Island

Site 1

Excavation 96

Vegetation: beach grass & flowers

Depth (cm)	Description
0-2	gray sand - new in 2007 survey
2-5	soil with roots
5-60	gray sand, top has roots
60-62	soil
62-80	gray sand
80-85	tephra, 3 layers, gray and brown
85-120	sand

Site 2

Excavation 98

Vegetation: moss, sedges, marsh

Depth (cm)	Description
0-4	vegetable mat [soil]
4-6	gray sand
6-13	marsh soil [peat]
13-15	gray sand
15-25	marsh soil [peat]
25-27	gray sand
27-34	tephra, 3 layers, gray and brown
34-40	marsh soil [peat]
40-44	clean gray sand
44-47	marsh soil [peat]
47-49	gray sand
49-51	marsh soil [peat]
51-52	clean sand
52-65	marsh soil [peat] with 2 thin sand layers
65-69	coarse gray cinders, sharp edges
69-76	marsh soil [peat]
76-78	sand
78-84	marsh soil [peat] with 1 thin sand layer
84-86	tephra [volcanic ash] [red and black cinders]
86-90	marsh soil [peat]
90-93	sand
93-94	marsh soil [peat]
94-109	sand
109-111	tephra, fine-grained, gray
111-114	sand [peaty]; sample of wood for dating
114-116	marsh soil [peat], sample for radiocarbon

Name: ______________________________

Exercise 2

Drawing stratigraphic sections - Continued

Site 3

Excavation 100

Vegetation: grasses, flowers, a few pine shrubs

Depth (cm)	Description
0-6	soil with roots
6-10	soil
10-12	gray sand
12-20	tephra, 3 layers, gray & reddish brown
20-24	soil
24-25	gray sand
25-30	coarse gray cinders
30-35	soil with thin sand layer; charcoal sample
35-38	tephra, fine gray and orangish
38-40	soil
40-43	sand
43-44	tephra
44-70	sand
70-80	gray cinders
80-95	sand
95-98	soil
98-115	sand
115-118	tephra, yellow sand

Site 4

Excavation 102

Vegetation: grasses, flowers, shrubs, near birch

Depth (cm)	Description
0-6	soil with roots
6-9	soil, silty gray
9-15	tephra, 3 layers, red-gray and red-brown
15-20	soil with a little sand
20-25	coarse gray cinders, angular grains
25-26	soil
26-28	tephra, fine, medium gray to reddish
28-32	silty soil, possible volcanic ash
32-33	fine cinders, tephra
33-35	sily soil, possible volcanic ash
35-49	gray cinders, clean, smooth grains
49-54	sily soil, possible volcanic ash
54-59	tephra,orange-yellow sand
59-70	soil, silty
70-100	soil, cimpact

Name: ______________________________

Exercise 3

Correlating tephra layers between stratigraphic sections

Write the description from the excavation notes of each tephra layer next to the corresponding layer on your stratigraphic column. Draw a line between layers that have very similar descriptions (similar thicknesses, color, grain size, etc.). These lines represent timelines. We call these tephras marker tephras. Label the tephra with numbers starting with 1 at the topmost marker tephra.

1. How many marker tephras are in the different sites:

	Site 1	**Site 2**	**Site 3**	**Site 4**
Number of marker tephras				

2. The shoreline on this profile has built outward into the sea as time has gone on, so that some land at the seaward sites is younger than the volcanic eruptions that generated some of the tephras.

   How many tsunami deposits are located above each tephra layer in each excavation? If the tephra is not present, leave the space blank.

	Site 1	**Site 2**	**Site 3**	**Site 4**
Above tephra 1				
Above tephra 2				
Above tephra 3				
Above tephra 4				
Above tephra 5				

Name: ______________________________

Exercise 3

Correlating tephra layers between stratigraphic sections

Continued

3. What is the thickness of sediment between each tephra layer in each site?

	Site 1	**Site 2**	**Site 3**	**Site 4**
Above tephra 1				
Between 1 & 2				
Between 2 & 3				
Between 3 & 4				
Between 4 & 5				

4. How do the thickness of sand and soil between tephra layers change as you travel inland and uphill?

5. What might be two reasons for the change in thickness of marshy soil/peat along the profile?

Name: ______________________________

Exercise 4

Adding time to your stratigraphic sections

We just received from the lab the results of radiocarbon dating of organic material for our summer's fieldwork. The charcoal in Site 3 is dated to be 900 yrs BP and the wood in Site 2 is 1100 yrs BP. Your volcanology colleagues have chemically identified the 3-layered tephra as being a 200 yrs BP eruption of the local Prevo volcano and the yellow sandy tephra as being from a gigantic eruption of Medvedzhia Volcano ~2000 yrs BP. Add notes on your stratigraphic sections to indicate the age of all these layers.

About how old is the tephra made of gray cinders?

Name: ______________________________

Exercise 5

Homework

Based on all that you now know about the coastal stratigraphy, you can calculate how often tsunamis affect this region. How many tsunami deposits are located between known dates in your stratigraphy? Write an "X" if there are no sediments in a certain age-range in a site.

1. Wrtie the number of sand layers (tsunami deposit) that are in each site (Write an "X" if there are no sediments in a certain age-range in a site).

Yrs BP	Site 1	Site 2	Site 3	Site 4
in the last 250 yrs		3		
0-1,000				
1,000-2,000				
0-2,000				

2. What is the maximum number of tsunamis per 1000 years we observed? ______________________________
3. What is the maximum number of tsunamis per 2000 years we observed? ______________________________

4. Take the numbers in the chart above, and divide by the time interval to get tsunami frequency: For example, in Site 2, there are three sand layers above the 250-year-old tephra 1 (from Prevo volcano). So the frequency there in that time period was 250 years divided by 3 tsunamis, or about 80 years – one tsunami on average per 83 years.

Frequency of tsunami deposits (years)

Yrs BP	Site 1	Site 2	Site 3	Site 4
in the last 250 yrs		83		
0-1,000				
1,000-2,000				
0-2,000				

5. What is the frequency of tsunamis (total # of tsunami/total time) for this one particular bay:
   - for low-lying areas (Site 2)? 1 tsunami per _______ years
   - for high areas (Site 3)? 1 tsunami per _______ years

Name: ______________________________

Exercise 5

Homework - Continued

6. If the average lifespan of a person is 80 years old, how many tsunami would they see in their lifetime?

7. How does the frequency of tsunamis you calculated from the Kuril Islands compare with the general frequency on the pacific caost of Washington State (1 large tsunami per 500 years)?

8. How long has the low-lying part of the coastal plain existed? Why are there only young tephra in the seaward excavations?

9. Compare the thickness and thickness variations of tephra and of tsunami deposits in your stratigraphic sections. Where do you find the thickest tsunami deposits and why? Why do tsunami deposits vary in thickness more than tephra layers?

Name: ______________________________

Exercise 5

Homework - Continued

10. You are planning to build a community at Dushnaya Bay. Your community will depend on boats to fish for food. How can you use the information from this exercise to help you plan your village? What would you consider when choosing the site of your village? What frequency of tsunamis do you think is acceptable for a community?

SETTLEMENT

Student exercises

Table of Content

Vocabulary

Deposit:

Sediment put down on the earth surface in the past either by natural or human action. An archaeological deposit was created by people in the past. It can include soil, artifacts, features, or other traces of human activity that signals anthropogenic (human) involvement in the deposition process. Deposits usually form layers or "strata" that stack up horizontally like a layer cake with the oldest at the bottom and the youngest at the top. As a result the oldest archaeological deposits (or geological deposits, such as volcanic ash layers) are found below younger ones, allowing us to develop histories of events by studying the stratigraphy. Even so, material within deposits can be out of place (for a number of reasons, like the action of burrowing animals) resulting in the possibility of misinterpretation of the stratigraphy of a site or excavation. (see Stratigraphy Module)

Distribution:

An arrangement of values according to some variable/s. For example, a geographical distribution may refer to locations of settlements according to their latitude and longitude coordinates (the variable). Or we could talk about the distribution of pottery, according to its style (the variables).

Histogram:

A graph visually representing the distribution of data points by showing how many data points lie within each range of two values. The distance between these two values is referred to as bin size; bins are usually of equal size.

Landscape:

In archaeological usage, a geographical space larger than a settlement that relates to the activities of people across space. This concept is usually used to discuss the ways past people interacted with the environment and each other in their regular movements between settlements, hunting grounds, agricultural fields, institutional facilities, monuments, resource extraction locations, etc. The area of a landscape, while left vague, typically covers areas larger than individual settlements, towns, or cities, to include multiple settlements, towns and/or cities as well as their hinterlands. Cultural landscapes like this changed through time in the past as human activities on them changed. It is an archaeological challenge to try and untangle the changing organization of human life on landscapes from the study of the archaeological sites that are found on them.

Radiocarbon Date:

A numerical date which approximates time of death of an organism (plant or animal) based on the amount of radioactive carbon (prone to decay) that remains in it. Radiocarbon dates are often used by earth scientists and archaeologists to understand the time lines of events, geological or cultural, respectively.

Vocabulary

Continued

Settlement:

A location occupied by a group of people for some period of time. Settlements can be recognized by archaeologists by the cultural remains such as artifacts (stone tools, pottery, etc.) and features (remains of house structures or depressions, hearths, etc.) and by changes to local vegetation (human activities often enrich soils inviting lush vegetation).

Settlement Pattern:

A distribution of settlements during a specific time period. Settlement pattern studies reveal information about initial colonization of areas by people and eventual changes in their habitation and/or resource use.

Site:

A location in space. This term is used by researchers to refer to a location where data have been collected. In archaeology this term has a more specific meaning and refers to a location where archaeological materials/deposits are found in place on the landscape. The term has the implication of a concentration of archaeological material surrounded by little or no archaeological material. Archaeological sites are often the remains of settlements, though they could also have been created by any other kind of human activity in the past.

yr BP (years before present):

Date in the years before 1950 (e.g. 50 yr BP is the same as AD 1900).

Background Information

Archaeologists seek to understand how people lived in the past based on the material remains people left behind, in the form of artifacts, features (e.g., house storage pits, house structures, and sometimes monumental buildings), and other traces of their activities (e.g., transformed soils, chemical stains). Some archaeological questions require the analysis of the distribution of artifacts, soil deposits, and features at specific locations called "sites," but an important part of archaeology also asks questions about changes at the broader scale of cultural landscapes. The analysis of settlement distributions across landscapes is called "settlement pattern analysis." Archaeologists use this approach to discover where people lived at different times in the past. Archaeologists generate this kind of understanding through survey, the process of looking for archaeological sites across vast areas of land.

The Kuril Biocomplexity Project surveyed the entire Kuril Archipelago between 2006 and 2008, finding a total of 68 different archaeological sites, distributed from the southern island of Kunashir to the northernmost island of Shumshu. These sites can be presented on a map showing their distribution throughout the islands. By itself this information indicates that people have lived throughout the island chain, but it does not tell us anything about how they came to live there or when, whether or not colonization occurred in a single event or multiple times, from which direction people came, or who they were.

To put archaeological settlement distributions into a historical framework, archaeologists need to assign ages to site occupations. One of the most common ways to do this today is to find organic material in the archaeological deposit (such as wood, charcoal, bone, seeds, or textiles) and submit this to a special laboratory for radiocarbon dating (see Chronology module). If the site has a deep archaeological deposit comprising multiple archaeological layers, it is important to collect several dates from different layers or depths. If the site covers a large area, it is also important to collect dates from across the site. These dates then help the archaeologist determine the history of occupation at the site and ultimately how the site formed. Combining dates from many sites provides critical information for building a picture of changes in the distribution of populations across space. This is often done by building histograms, which describe the changing frequency of settlements over time, per some standard interval (commonly labeled a "bin," e.g., per 200-year interval). As forms of statistical description, such histograms are convenient tools for looking at changes in the frequency of archaeological materials deposited over time. However, archaeologists also need to think carefully about a number of factors that can bias the pattern observed in such histograms. For example, we don't want our results to be influenced by the possibility that some sites or regions have been studied more intensively than others. To avoid these problems, we often decide to include only one date per site per histogram bin, or only one date per portion of a site per bin. Doing so minimizes the possibility that we are dating multiple samples deposited by the same group of people – in other words, double-counting them – while counting other groups only once.

Introduction

Archaeologists sometimes estimate the history of human settlement across a region by comparing the relative proportions of **radiocarbon dates** from different site locations.

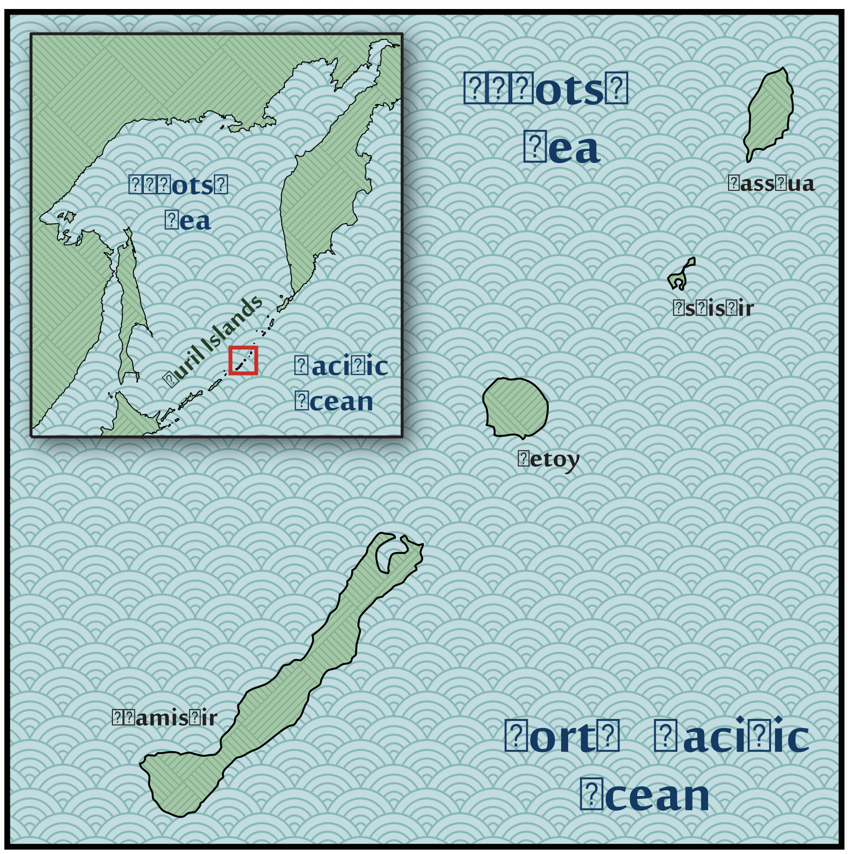
To do this, the first step is to generate a large set of **samples** for dating. That is done by finding sites through **survey**, excavating test pits and collecting charcoal, bone and other organic materials within the archaeological **strata** or **deposits**.

The next step is to submit as many of these samples as possible to a lab set up to determine the ages of the samples (for more detail on radiocarbon dating see the Chronology Module). While radiocarbon dating is expensive (between $300 and $600 per sample), having a large number of dates is important to get a clear picture of past history. The samples submitted should be randomly selected from the total to make sure that the results do not over-emphasize just one kind of site, or time period.

When the lab sends back the results, the third step is to count the number of dates per time period and to look at changes through time. A larger number of dates in one time period than another might tell us that more people were living in the region during that period compared to other times.

The fourth step is to try and explain the changes seen in the histograms. In this exercise, you will practice doing the third and fourth steps of this process using actual data from the Kuril Islands.

During the Kuril Biocomplexity Project, archaeologists worked in the segment of the island chain shown on this map.



Introduction

Using survey techniques, archaeologists found prehistoric human settlements, which they tested to find datable materials. They then sent organics like wood and charcoal to be dated to find out when each island was occupied. The attached table of radiocarbon dates shows the results from these tests (Fig 1 & 2). To be able to tell whether there were significant changes in the populations of different islands (or even abandonments of some islands) your task is to compare the dates from each island. To do this, you will construct histograms from radiocarbon dates. Histograms are graphs plotting the frequency (quantity or number) of radiocarbon dates from each of a given interval or "bin" size (e.g., 100, 200, or 400 years per time step). A histogram is a convenient way to look at changes through time.

Step 1 :

Plot the number of dates on the graphs provided, grouping them into sets per time interval (bin). Your teacher will indicate whether you will plot dates using the same interval on all three islands or take one island and use three different bin sizes for the dates from that island.

For example, if you are using bins having 100-year bin widths, you would count the number of dated samples that fall between 1,600 and 1,699 years BP (before present), then 1,700 to 1,799 years BP, and so on. If you have counted eight samples falling between 1,600 and 1,699 years BP, you would then shade in a bar that is eight units high in the column between 1,600 and 1,700 years BP. Follow the same procedure for all intervals.

Step 1:

After drawing/completing the histograms, answer the following questions :

Question 1:

a. How similar are the occupation histories of the different regions?

b. Does it look like people live in all three regions at the same time?

c. Did they leave all three regions at the same time?

Question 2:

If the histograms differ by region, are the patterns complementary? That is, might people have abandoned one island in favor of one of the other two?

Step 1

Shimushir

Sample Number	^{14}C Age (years BP) reported with error term
AA-44258	1003 ± 43
AA-44259	1121 ± 38
AA-44260	1164 ± 44
AA-44261	1011 ± 40
AA-44262	1818 ± 43
AA-44263	935 ± 42
AA-40944	1695 ± 36
AA-44264	1732 ± 43
AA-44265	897 ± 38
OS-59199	1940 ± 40
OS-59197	1600 ± 25
OS-59381	1090 ± 25
OS-59421	1300 ± 30
OS-59346	1740 ± 30
OS-59201	1650 ± 25
OS-59202	1260 ± 30
OS-59203	1700 ± 30
OS-59204	1820 ± 30
OS-67420	1800 ± 25
OS-67269	1470 ± 30
OS-67616	1100 ± 30
OS-67586	1690 ± 30
OS-67617	1570 ± 25
OS-67470	1930 ± 35
OS-67471	1280 ± 25
OS-67587	1850 ± 30
OS-67472	1930 ± 30
OS-67492	1650 ± 30
OS-67588	1100 ± 30

Ushishir

Sample Number	^{14}C Age (years BP) reported with error term
OS-59419	1130 ± 25
OS-67329	1390 ± 30
OS-59418	1090 ± 30
OS-80150	430 ± 25
OS-80149	615 ± 25
OS-59420	100 ± 25

Rasshua

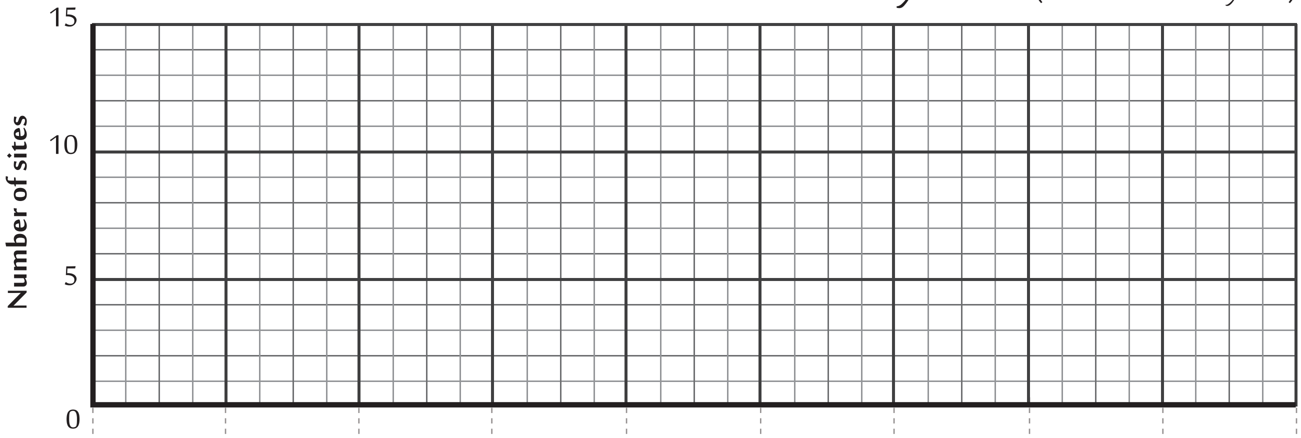
Sample Number	^{14}C Age (years BP) reported with error term
OS-67086	2430 ± 25
OS-67143	3260 ± 30
OS-67330	2570 ± 30
OS-67130	30 ± 30
OS-67131	1990 ± 30
OS-79721	905 ± 25
OS-79722	1000 ± 30
OS-79861	1860 ± 30
OS-79724	935 ± 25
OS-79726	950 ± 25
OS-79744	915 ± 30
OS-79863	2250 ± 25
OS-79864	2010 ± 30
OS-79862	1920 ± 25
OS-79727	245 ± 25
OS-79725	1820 ± 25
OS-79723	1100 ± 35
OS-79865	2020 ± 30
OS-79866	2040 ± 25
OS-79867	2040 ± 30
OS-79868	2160 ± 35
OS-79741	1700 ± 35
OS-79742	925 ± 30
OS-79743	3280 ± 35
OS-79728	315 ± 30
OS-79731	215 ± 25
OS-79730	205 ± 35
OS-79729	225 ± 30
OS-79896	2640 ± 30
OS-79600	1930 ± 25
OS-80139	1120 ± 50
OS-79601	1000 ± 25
OS-79602	3450 ± 30
OS-79603	1940 ± 30
OS-79594	1970 ± 30
OS-79595	1280 ± 25
OS-79596	905 ± 25
OS-79597	1970 ± 25
OS-79598	2260 ± 30
OS-79599	835 ± 30
OS-80015	1810 ± 25
OS-80016	1920 ± 30
OS-80017	2130 ± 25
OS-80018	2080 ± 25
OS-80019	1720 ± 25
OS-80020	1670 ± 30
OS-79668	1950 ± 25
OS-79669	2080 ± 25
OS-79670	2110 ± 25
OS-79671	2210 ± 25

Sample Number	^{14}C Age (years BP) reported with error term
OS-79720	2430 ± 25
OS-79665	2860 ± 25
OS-79666	2480 ± 35
OS-79667	2660 ± 25
OS-79604	2490 ± 25
OS-79664	170 ± 30
OS-79859	2230 ± 30
OS-79860	830 ± 25
OS-67133	130 ± 25
OS-67134	1720 ± 30
OS-67135	1100 ± 35
OS-67136	1190 ± 35

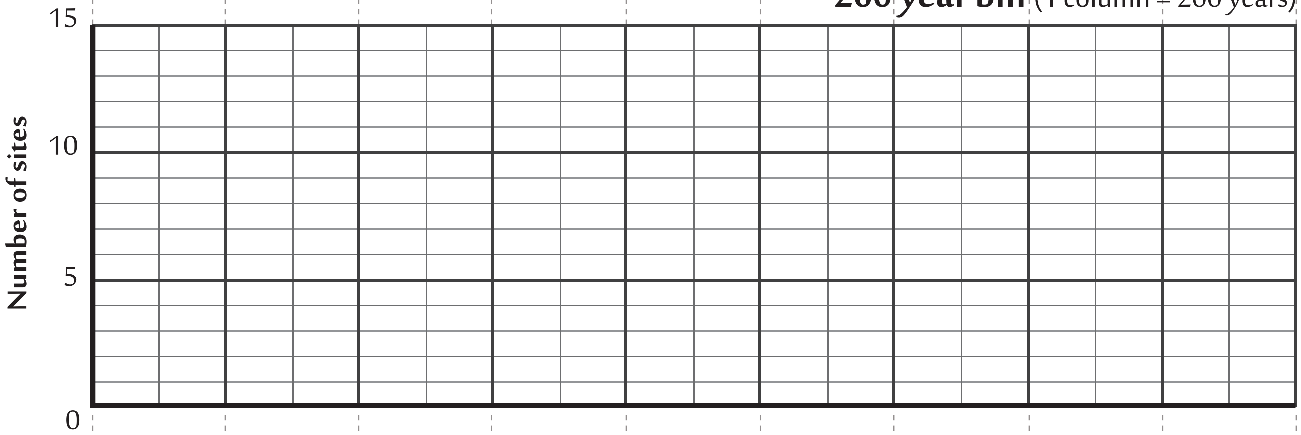
Name: ______________________________

Step 1:
Question 1 - Simushir

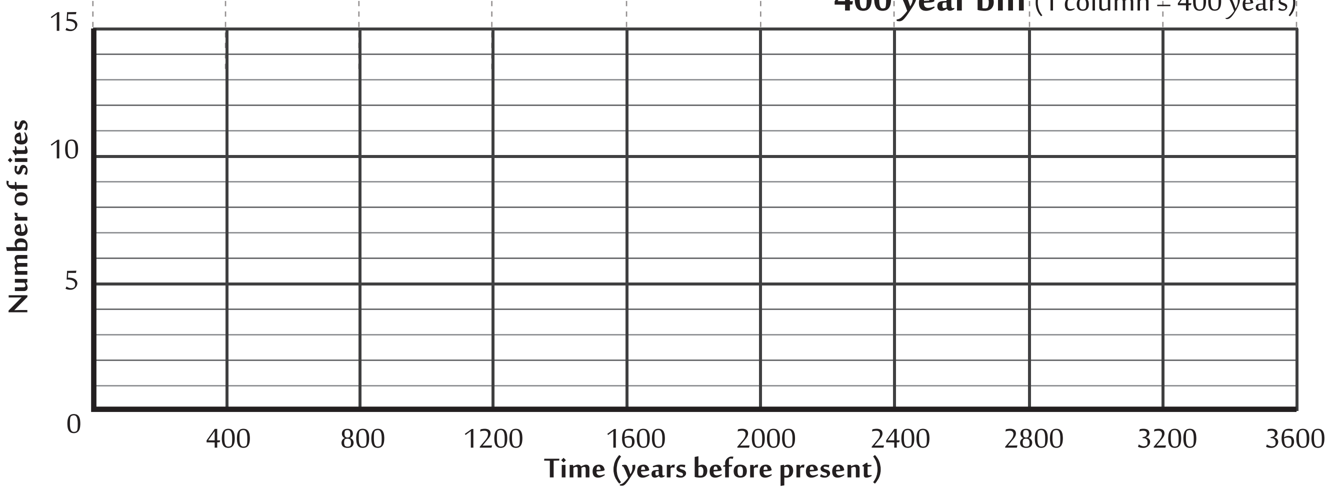
100 year bin (1 column = 100 years)



200 year bin (1 column = 200 years)



400 year bin (1 column = 400 years)

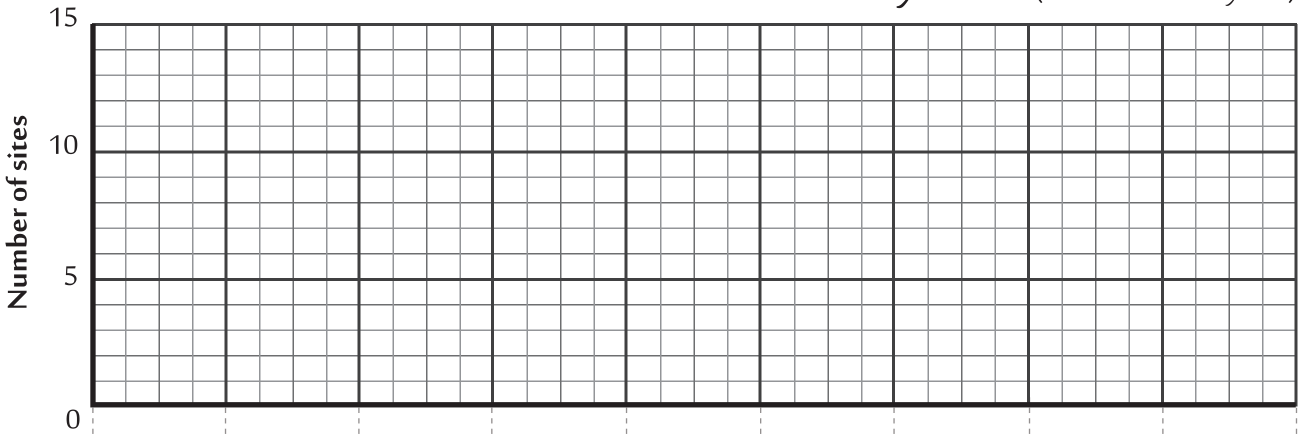


Name: ______________________________

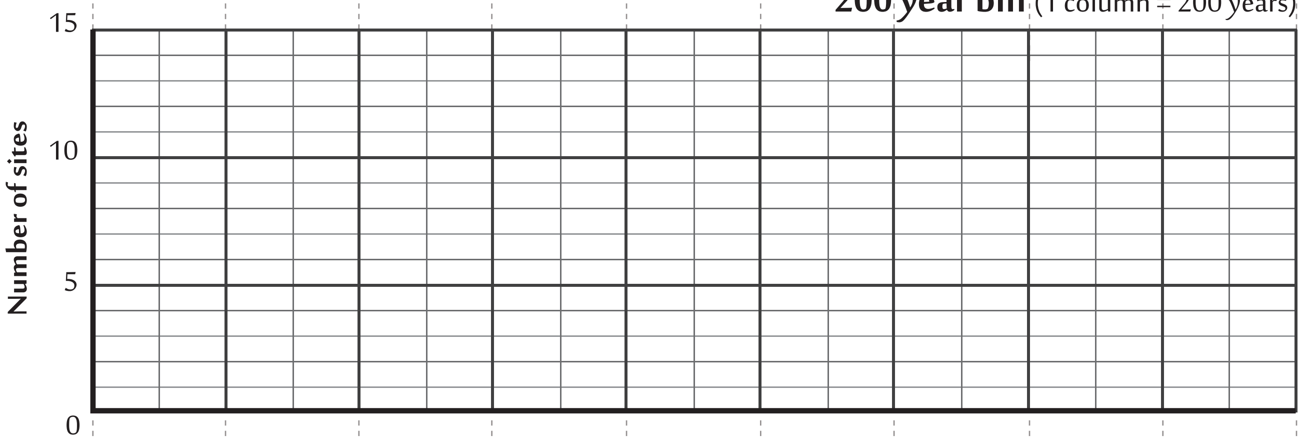
Step 1:

Question 1 - Ushishir

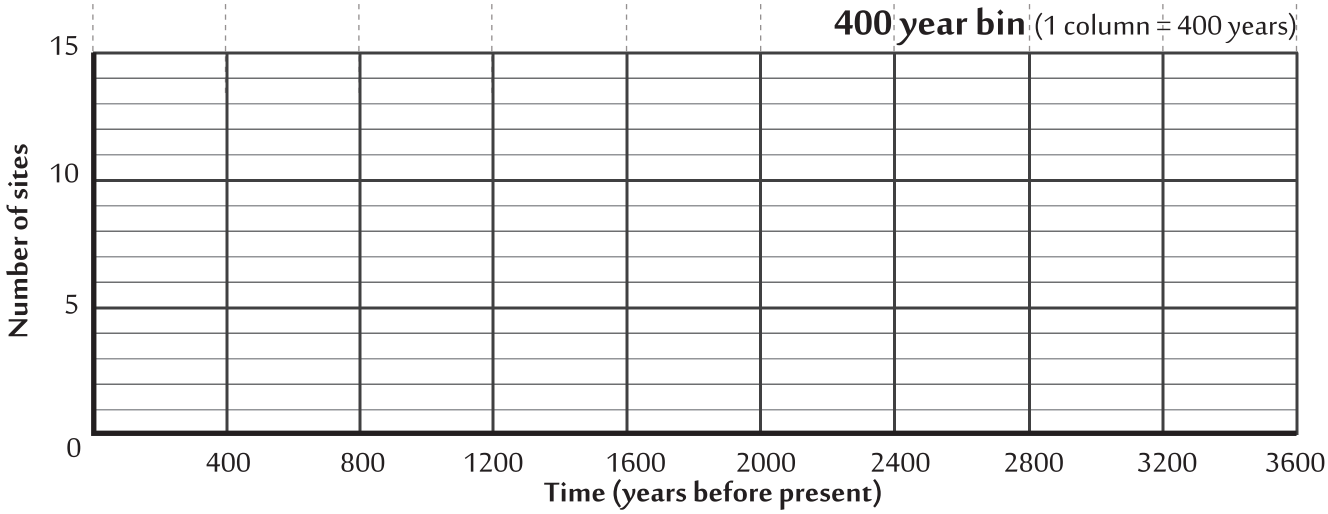
100 year bin (1 column = 100 years)



200 year bin (1 column = 200 years)



400 year bin (1 column = 400 years)

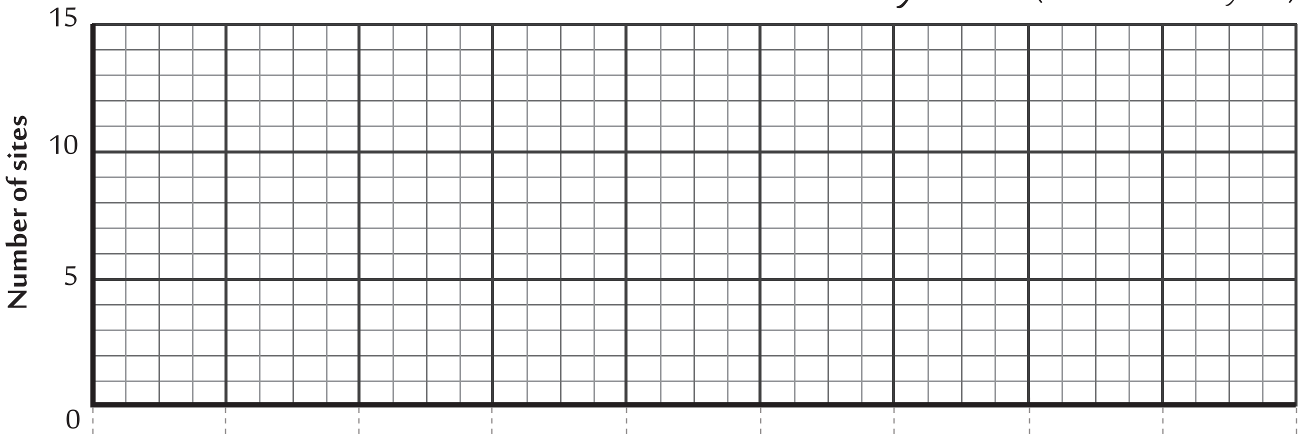


The Kuril Biocomplexity Project: www.kbp.org

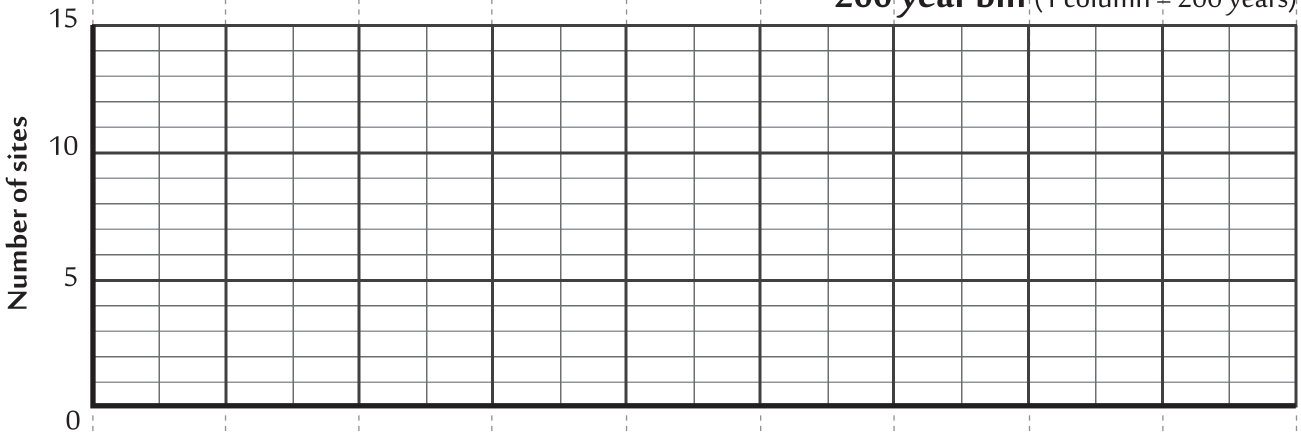
Name: ______________________________

Step 1:
Question 1 - Rasshua

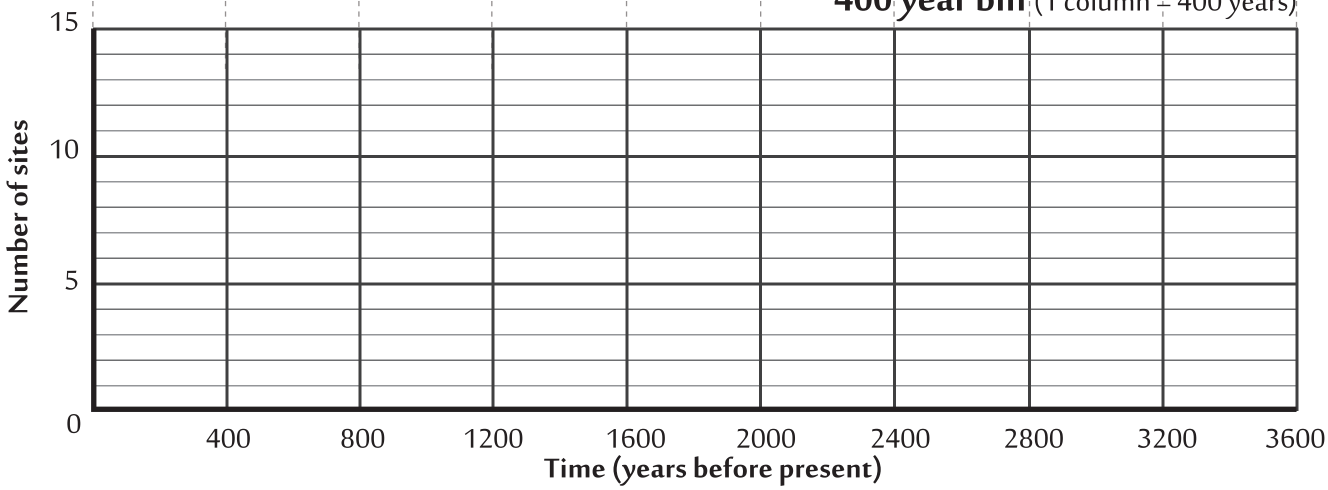
100 year bin (1 column = 100 years)



200 year bin (1 column = 200 years)



400 year bin (1 column = 400 years)



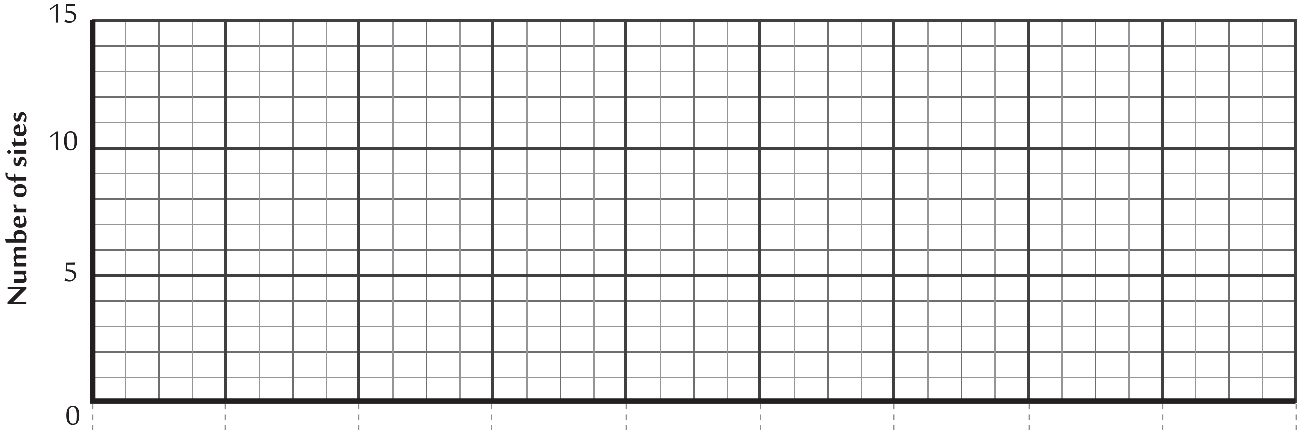
Name: ______________________________

Step 1:

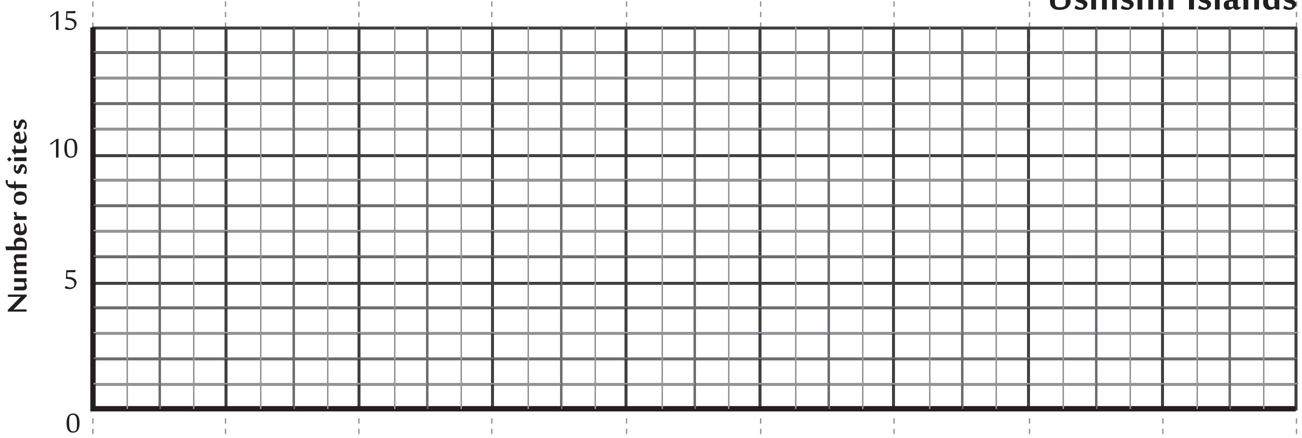
100 year Bin

(1 column = 100 years)

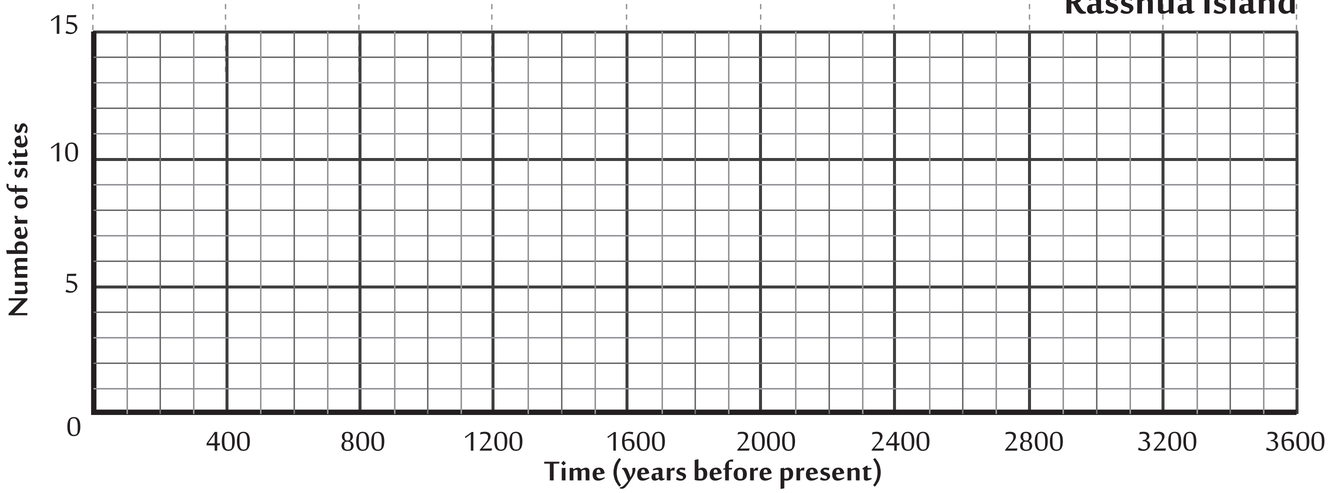
Simushir Island



Ushishir Islands



Rasshua Island



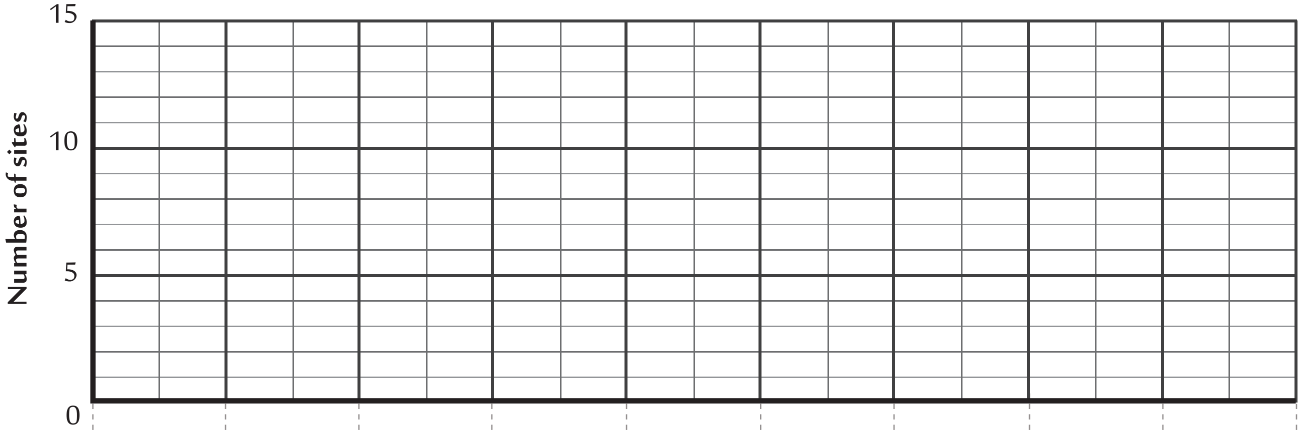
Name: ______________________________

Step 1:

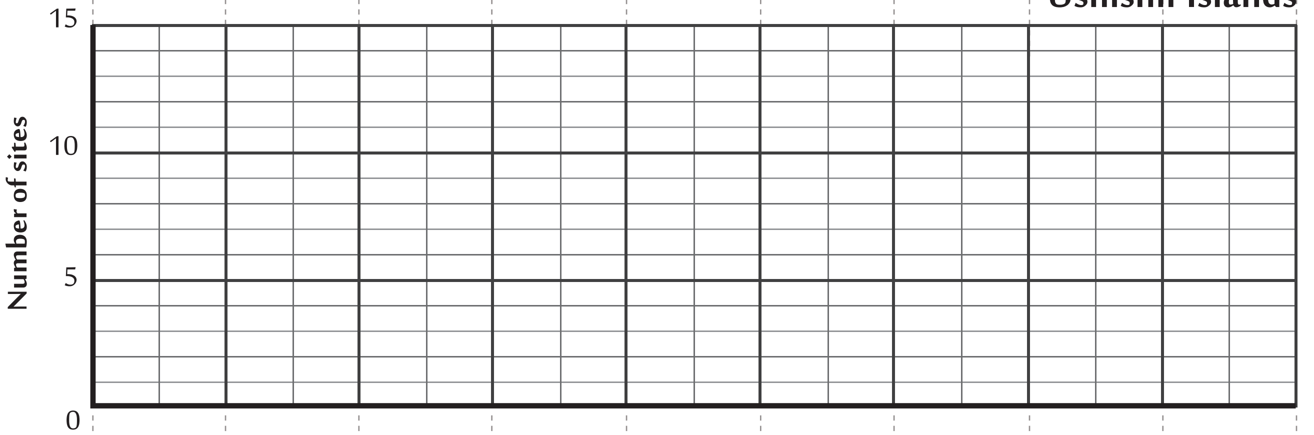
200 year Bin

(1 column = 200 years)

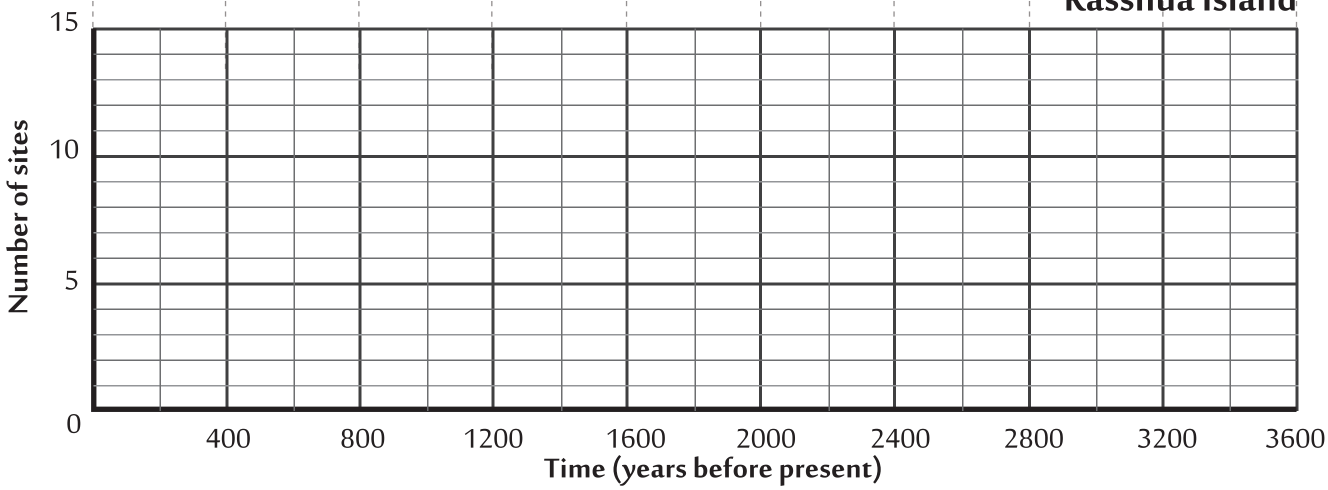
Simushir Island



Ushishir Islands



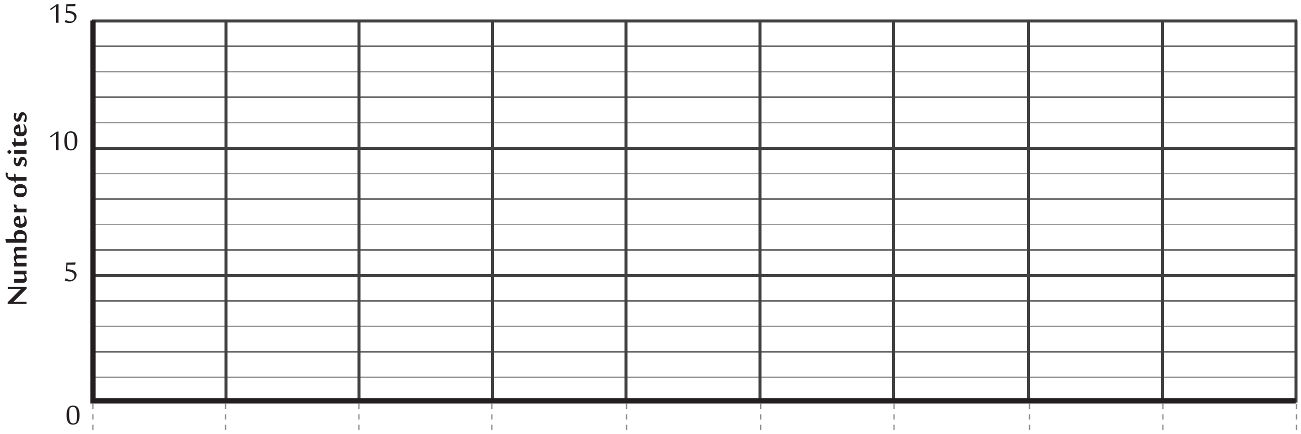
Rasshua Island



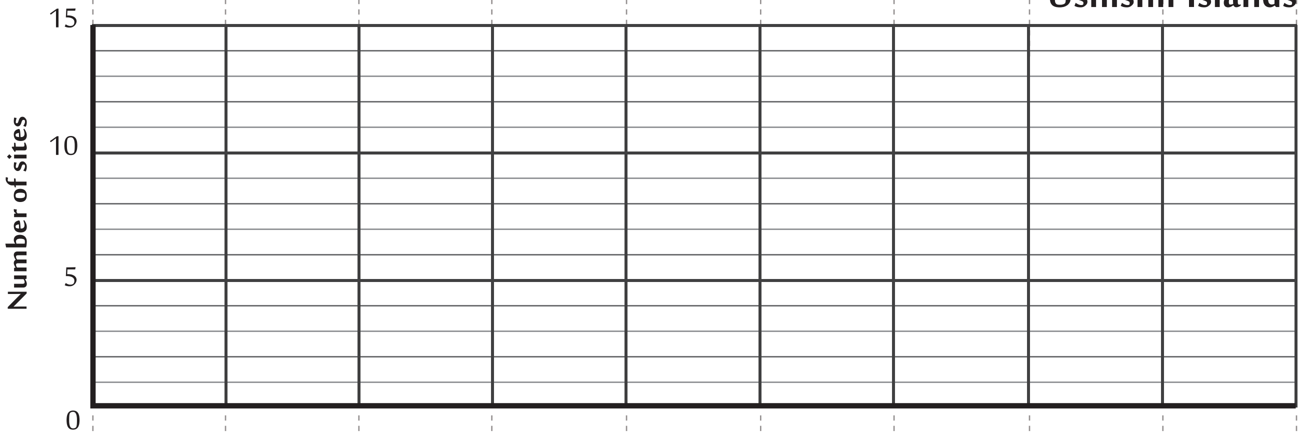
Name: ______________________________

Step 1:
400 year Bin
(1 column = 400 years)

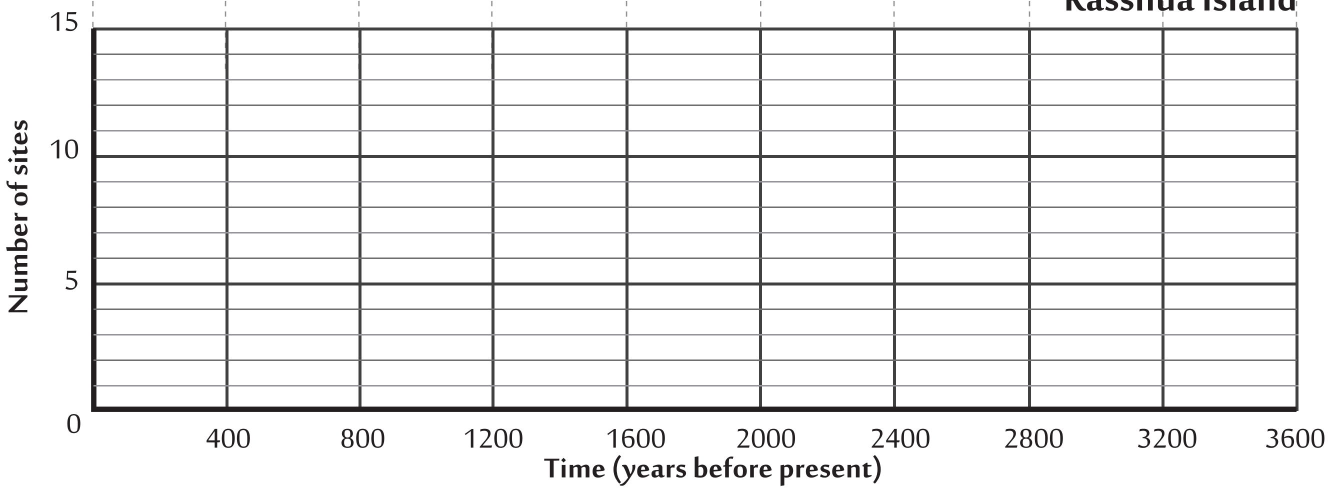
Simushir Island



Ushishir Islands



Rasshua Island



Step 2 - Introduction:

Now you are going to compare your population histories with information about environmental impacts and changes, to see if you can explain why settlement patterns changed over time.

When archaeologists were looking for the settlements left behind by the prehistoric inhabitants of the Kurils, geologists were researching the geological history of the islands, using radiocarbon dating and other methods to determined when the largest volcanic eruptions and tsunamis in the area occurred. Meanwhile, paleoclimatologists studied lake cores and other evidence to determine when the climate was wetter or drier, cooler or warmer, in the region.

Examine the results of their studies. Compare these results to the histograms you created. You might want to indicate on your histograms when these environmental events or changes occurred. This will help you to see the relationships between human populations and natural conditions. Then answer the following questions.

Question 3:

a. Do the patterns of movement correspond to **catastrophic events** recorded for the region? (see tables on next page). For example, can you justify an argument that volcanic eruptions or tsunamis, or climate changes forced island abandonment or movement of population from one island to another?

b. How convincing are your conclusions to you (how well do the patterns match up?)

Name: ______________________________ **Step 2**

Question 4:

Step back and look critically at the analyses you conducted. Do you think there may be problems with the way this analysis was done?

a. Are there problems with the data sets and what would be needed to reduce those problems, if any?

b. What assumptions do you think go into doing this analysis (list several)? For example what has to be assumed to treat a single radiocarbon date as an indication of a unit of population (number of people)?

c. Are there problems with these assumptions?

d. How convincing are the correlations between settlement changes and environmental effects?

Name: ______________________________

Part 2:
Natural Events Data

Climate:

Age of Event	Notes
0-200 years BP	warm
200-700 years BP	cold/dry
700 - 1,100 years BP	warm
1,100-2,000 years BP	cold/dry
2,000-2,400 years BP	cooling

Climatic conditions were determined using proxies such as lake cores

Tsunami:

Number	Age if the Event	Notes
1	100 years BP	
2	400 years BP	
3	700 years BP	
4	800 years BP	
5	900 years BP	
6	1,250 years BP	
7	1,500 years BP	
8	1,600 years BP	
9	2,750 years BP	(possibly)
10	2,900 years BP	(possibly)

Tsunami ages were determined by dating layers of beach sand deposited by the large waves on the affected islands.

Eruptions:

Volcano	Island	Age of the Event
Zavaritsky 1	Simushir	1,000 years BP
Us-Kr	Ushishir	2,000 years BP
CKr	Iturup*	2,400 years BP
Sarychev	Matua **	2,600 years BP

Volcanic eruption ages were determined by dating tephras left from each eruption.

Notes:

*Iturup Island is over 200 km south of Simushir Island

**Matua Island is ~40 km north of Rasshua Island

Years BP: years before present (before 1950)

NATURAL HAZARDS
MODULE

Table of Content

Vocabulary

Lahar:

A mudflow or debris flow that starts on a volcano. Lahars can travel up to 60 mph and are very destructive.

Oral history:

Stories passed from one generation to the next through verbal communication

Resilience:

The ability of a person or community to recover readily from adversity such as a natural hazard

Seal and sea lion haul-outs:

Rocky outcrops and beaches where seals and sea lions come out of the water and are easy to hunt

Tsunami:

A wave generated by an impulse such as earthquakes, landslides, underwater volcanic eruptions, or meteor impacts

Volcano:

An opening in the earth's surface through which lava and gasses from below the earth's surface escape.

Written history:

Stories passed from one generation to the next through written communication

Background Infromation

The Kuril Islands are one of the most geologically hazardous places to live in the world. Active volcanoes erupt many times in one person's lifetime, large earthquakes and tsunamis occur ever few generations, and other natural hazards, such as flooding, lahars, and large storms, also are common. One of the goals of the Kuril Biocomplexity Project is to understand how people living in the Kuril Islands responded to catastrophic events, and how human interactions could reduce the vulnerability of the island population.

Today, many natural hazards (but not all) are continuously monitored by government agencies around the world using seismometers, Global Positioning Systems, many types of satellites, and oceanographic buoys. Volcanologists monitor volcanoes to see if they are become more and more active while seismologists and oceanographers can immediately register on seismometers when an earthquake has occurred and use buoys around the ocean to determine if a tsunami was generated. See the list of websites below to learn more about recent events and see if there are any active volcanic or tsunami warnings.

Before the technological innovations of the 20th and 21st centuries, monitoring of natural hazards was not easy. Written records, especially historical archives, provided some estimates of how frequently a nearby volcano might erupt, how often earthquakes or tsunamis occurred, and how large those events were.

In the absence of written records, such as was the case in the Kuril Islands for thousands of years, the only means of knowing the hazards of a region is through orally exchanging knowledge. Children can be taught to read the signs of increasing activity of a volcano, and can be told through stories what happened during past eruptions. Large earthquakes can be followed by big tsunamis, so children can be taught to vacate the beach. Oral traditions are a means of protecting settlements, especially in the situations where the recurrence of events spans more than one generation. Often myths and legends can contain a kernel of truth on how to survive natural hazards. In our techno-savy culture, this can be a hard idea to grasp—that ancestors we never met could instruct us how to survive (or what to expect) in a natural disaster through a story that our parents and grandparents repeated.

Background Infromation

Continued

U.S.websites for monitoring volcanoes, earthquakes and tsunamis:

Smithsonian and USGS Global Volcanism Program -
Weekly Volcanic Activity Report
http://www.volcano.si.edu/reports/usgs/

USGS - U.S. Volcanoes and Current Activity Alerts
http://volcanoes.usgs.gov/

USGS - Cascade Volcano Observatory Weekly Update
http://volcanoes.usgs.gov/cvo/current_updates.php

USGS - Latest Earthquakes in the World
http://earthquake.usgs.gov/earthquakes/recenteqsww/Quakes/quakes_all.php

NOAA - Pacific Tsunami Warning Center
http://ptwc.weather.gov/

NOAA - West Coast/Alaska Tsunami Warning Center
http://wcatwc.arh.noaa.gov/

USGS booklet -
"Surviving a Tsunami - Lessons from Chile, Hawaii, and Japan"
http://pubs.usgs.gov/circ/c1187/

Name: ______________________________

Written exercise

Small group discussion

Introduction:

Discussion topic #1:

You and your team are going to make a settlement on an island. You will get food on the island by hunting, gathering and fishing. Make a list of 5 - 10 things you want and 5 - 10 things you do not want on the island. Think about landscape features and desirable resources. Do not list things items that you could bring with you or build such as dwellings or tools.

10 things you want:	10 things you do not want:
1: ______________________	1: ______________________
2: ______________________	2: ______________________
3: ______________________	3: ______________________
4: ______________________	4: ______________________
5: ______________________	5: ______________________
6: ______________________	6: ______________________
7: ______________________	7: ______________________
8: ______________________	8: ______________________
9: ______________________	9: ______________________
10: ______________________	10: ______________________

Name: ______________________________

Written exercise

Group activity

Discussion topic #2:

Your group will be given a map of an island and your village location. You will also receive a short oral history of your village. Compare the location of the current village to the wish list you made in made in Discussion topic #1.

What are the best attributes of your village?

What are the most prominent hazards?

Name: ______________________________

Written exercise

Group activity

Discussion topic #3:

Elect one member of your group to be the explorer.
The explorer will take the map of the entire island chain and travel around to other villages. At the other villages the explorer will interview the villagers about

1. natural hazards
2. resources
3. possible new village locations.

The explorer should take notes of the island chain about potential locations and their pros and cons. The explorer should interview 5-6 other groups.

The other members of your group will remain in your village (at your desks). The village will answer the questions of other group's explorers.

Name: ______________________________

Written exercise

Group activity

Discussion topic #4:

After your interviews are complete, explorers should return to their village and the group will discuss and choose where to build a new village. You cannot build a village in a site where there is already a village.

Write a paragraph about why you chose your village site including the frequency and type of natural hazards you expect to experience and your proximity to resources.

Name: ______________________________

Homework:
Oral history

The Kuril Islands are not the only location prone to natural hazards. Western Washington is also prone to natural hazards. This activity is designed to look at how we understand natural hazards in western Washington.

Oral history:

1. How long have you lived in western Washington? What natural hazards do you remember occurring here? How many of each type of event do you remember? (Storms, landslides, earthquakes, tsunamis, volcanic eruptions)

2. Natural hazards are often more dangerous to transient populations. People who have recently moved to an area do not know the natural hazards an area is prone to or how to respond.

   Example: During the 2004 tsunami in the Indian Ocean, very few people died on Simeulue Island. People in the village remembered stories of a large tsunami in 1907 and taught younger generations to run to high ground after strong earthquakes. On nearby islands, the populations near the coast did not have as long of a history and many people died.

   a. How long has your family lived in western Washington? ______________________________

   b. Talk to some of your family that has lived here a long time. What natural hazards do they remember?

Name: ____________________

Worksheet:
Oral history

c. How many of each type of event do they remember? (Storms, landslides, earthquakes, tsunamis, volcanic eruptions)

d. Based on your families oral history, are you well do you know about all of the natural hazards in Washington?

3. Based on your family's knowledge, what do you think are the most common natural hazards in western Washington? What do you think are the most severe?

Name: ______________________

Worksheet:
Written history

Written history:

1. The Puget Sound was first explored in 1792 by George Vancouver. The first permanent settlement 1833 (Fort Nisqually). Arrival of the transcontinental railroad of the railroad in 1888. How good do you think the record of natural hazards is before 1792? ______________________

   Between 1792 and 1833? ______________________

   Between 1833 and 1888? ______________________

   Since 1888? ______________________

2. Look at the chart of Major events in Washington State. Which natural hazards are not included in the list?

   ____

   Why? ______________________

   Based on the written records in the chart, what is the most common natural hazard in western Washington?

   ____

3. What natural hazards would we not know about if not for the geological record?

   ____

4. The 1700 Cascadia earthquake is known from written records but the event occurred before there were written records in Washington. How do you think this occurred?

   ____

Name: ______________________________

Worksheet:
Mordern planning

Modern planning:

1. Look at the natural hazards map of western Washington. It has been stylized to be similar to the maps you used in class. Given what you have learned about natural hazards, where would you build a village? Pick four locations for villages considering proximity to resources and natural hazards and mark them on the map.

2. What current city in Washington—Seattle, Tacoma, Everett or Bremerton-- is subject to the greatest threat from natural hazards? Why?

3. The map shows zones of hazard for tsunamis, landslides and lahars. What other hazards are we subject to in Washington? Are these events more frequent or less frequent? Do you think these events cause more or less damage? If you are building a town, what hazards would you consider a planning priority, one that happens every year but causes local damage (Floods and landslides), or one that occurs on average every hundred years or more but causes widespread damage (Large earthquakes and lahars)?

PALEO-CLIMATE MODULE

Table of Content

Paleoclimate

Vocabulary

Analog analysis:
A method for analyzing and interpreting paleoenvironments that can be based on either statistics or qualitative observations. The basic principle is that of uniformitarianism – the present is the key to the past. In our exercises we rely on defining qualitative modern pollen-vegetation-climate relationships to aid in interpreting past changes.

Biostratigraphy:
The spatial relationship between biological indicators found in sedimentary deposits. These relationships have a time component: in unmixed deposits the lowermost sediments are the oldest and uppermost units the youngest.

Conifers/Coniferous:
Plants with needle-like leaves.

Deciduous:
Plants that shed there leaves in winter, often having broad leaves. Note that larch, a conifer, is deciduous.

Deposit:
Sediment put down on the earth's surface in the past either by natural or human action. An archaeological deposit was created by people in the past. It can include soil, artifacts, features, or other traces of human activity that signals anthropogenic (human) involvement in the deposition process. Deposits usually form layers or "strata" that stack up horizontally like a layer cake with the oldest at the bottom and the youngest at the top. As a result the oldest archaeological deposits (or geological deposits, such as volcanic ash layers) are found below younger ones, allowing us to develop histories of events by studying the stratigraphy. Even so, material within deposits can be out of place (for a number of reasons, like the action of burrowing animals) resulting in the possibility of misinterpretation of the stratigraphy of a site or excavation. (see Stratigraphy Module).

Gradient:
Change in one variable with respect to another variable. In palynology this change is always in respect to geography or spatial distribution, for example a temperature or a vegetation gradient reflects changes in climate or vegetation over a specific region.

Paleo:
Prefix indicating "past."

Palynology:
The study of pollen and spores. The applications are widespread from providing pollen counts during allergy season to interpreting paleoenvironments. A palynologist is a specialist in the field of palynology.

Pollen:
Microscopic grains produced by higher plant forms (angiosperms and gymnosperms; flower and seed producing plants), containing male genetic material required for sexual reproduction. A dusting of pollen is often seen on surfaces as a yellowish powder during the flowering season. Note: pollen is both the singular and plural form. It is incorrect to refer to "pollens."

Vocabulary

Pollen assemblage:
The combination of pollen and spores that characterize a specific pollen zone in a diagram or a specific vegetation type in modern studies.

Pollen diagram:
The basic tool for interpreting palynological records. It consists of an x-y plot of pollen and spore values vs. depth or time. Values, plotted along the x-axis, are usually percentages but can also represent pollen accumulation rates. The shallowest depths and youngest ages appear at the top of the y-axis.

Pollen spectrum/spectra:
Percentages of all pollen and spores from a single (spectrum) or multiple (spectra) sediment samples. Pollen assemblages consist of 2 or more spectra.

Proxy data:
A type of data that is used as a substitute measure for another parameter. For example, current temperatures can be measured using a thermometer. However, it is impossible to directly measure paleotemperatures because paleothermometers do not exist. Therefore, we use another data type or "proxy" (e.g., pollen) which has a known relationship to temperature (e.g., different vegetation types have different temperature requirements) to infer past changes.

Radiocarbon date:
A numerical date which approximates time of death of an organism (plant or animal) based on the amount of radioactive carbon (prone to decay) that remains in it. Radiocarbon dates are often used by earth scientists and archaeologists to understand the time lines of events, geological or cultural, respectively.

Spore:
A microscopic grain produced by lower plant forms (cryptograms) and containing genetic material for asexual reproduction. Unlike the higher plants, cryptograms have no true flowers or seeds.

Years BP (years before present):
The amount of time which has passed between the occurrence of an event and the year A.D. 1950.

Zone:
1) The combination of plant communities into a unique vegetation type that has a regional geographic distribution and is associated with specific climatic characteristics;
2) used in pollen diagrams as a basic unit for interpretation; each pollen zone represents a change in vegetation type and must include at least 2 pollen spectra.

Background Information

Knowledge of past landscapes and climate is an important element of interdisciplinary studies of the past. Although these types of investigations are valuable in and of themselves, they can provide essential information to archeologists who wish to better understand possible human-environment interactions. Such research also can provide useful insights into questions related to future climates and likely landscape responses (e.g., by looking at warm periods in the past, palynologists hypothesize that arctic tundra will disappear and be replaced by birch, poplar, and larch forests).

Many types of paleoenvironmental data are used to unravel the past. Here we focus on palynology, the study of microscopic pollen and spores (to simplify we will use only pollen in our discussion and examples). By taking cores from organic deposits, such as lakes or peats, palynologists can trace the vegetation history of a region by counting the numbers of pollen grains. Their percentages reflect the plants, and thus plant communities, that produced them. Unfortunately, there is not a one-to-one relationship between plants and pollen, although the greater the relative percentage of a given pollen type, the greater the number of plants on the landscape. Therefore, the first step in reconstructing the paleovegetation is determining the characteristic pollen "signature" that identifies modern vegetation types. The modern pollen rain is sampled from the most recent deposits in a lake or peat, for example from a 1-cm^3 specimen of sediment taken from the mud-water interface of a lake. The pollen percentages are plotted and then can be evaluated qualitatively (e.g., by comparing the pollen assemblages to a map of vegetation types) or using statistical analyses. Once the modern pollen-vegetation relationships are established, then paleovegetation can be inferred by searching for analogs of the ancient pollen samples to modern ones. Often this is done qualitatively, as we will do in our exercises, but standard statistical analyses are also used.

Because paleoclimatologists do not have thermometers or rain gages buried in their sites, they must rely on proxy data (i.e., data that indirectly reflects climate). Pollen is one of the best proxies because: 1) vegetation types are strongly controlled by climate; 2) the relationship between modern pollen assemblages and differing vegetation types is well established; and 3) pollen is an abundant and ubiquitous fossil. The first step for inferring paleoclimate is to determine the relationship of present-day vegetation and climate in the study region. This can be done by comparing gradients in maps of temperature or precipitation to vegetation maps (qualitative method) or by assigning modern climate values to the modern pollen sites (quantitative method). Next the fossil samples are counted and plotted in a pollen diagram. Based on the pollen assemblage, scientists then can interpret the past climate either qualitatively (e.g., cooler and drier than present) or with numerical values taken from the modern climate assignments.

Name: ______________________________

Question Set 1

Activity 1 Questions: Climate and Vegetation; Modern Calibration

Question 1:

If you wanted to live in the warmest area of the Kuril Islands during the summer, which island would you choose? The coolest island during summer? If you wanted to live in the warmest island during winter, would you have to move from your summer island? In each case, what type of vegetation would grow on your island?

Question 2:

Access to fresh water can be a problem in the Kuril archipelago, because some islands have no fresh water and other islands have only small streams. Rain and snow, of course, are also sources of fresh water. If you could not depend on a stream for water, which island(s) might you chose for a summer (winter) settlement, based on the map of July (January) precipitation? If you lived in the Kuril Islands 1,000 years ago, what other landscape elements might you consider in your winter settlement?

Name: ______________________________ **Question Set 1**

Activity 1 Questions: Climate and Vegetation; Modern Calibration

Question 3:

If you were the chief palynologist, how would you summarize the qualitative vegetation-climate relationships for the other scientists working on the Kuril Biocomplexity Project? Fill out the table below to answer this question: first give each vegetation zone a ranking (e.g., vegetation with the warmest July temperatures is given a rank of 1; coolest July temperatures a rank of 4). Rank only those climate variables that influence the vegetation. Provide a qualitative description (e.g., warm, wet summers; warmest, wettest winters) for each vegetation type.

Vegetation type	July temp. rank	Janurary precip. rank	Qualitative description
Meadows with thickets			
Meadow			
Birch forest			
Conifer forest			
North temperate forest (Kunashir)			
South temperate forest (Hokkaido)			

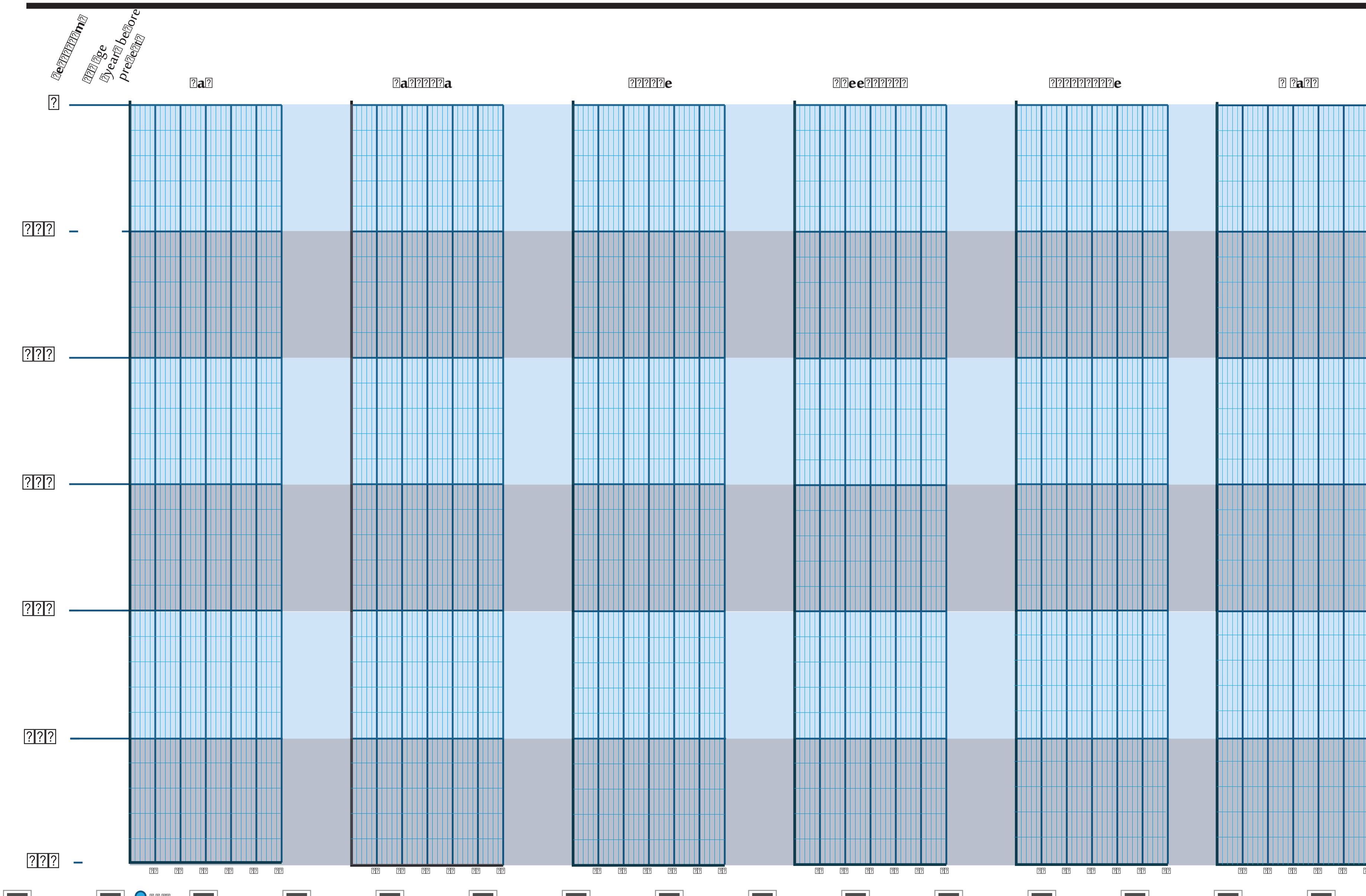
Name: ______________________________ **Activity 2**

Activity 2: Pollen Diagram Plotting and Interpretation

Instructions:

As the chief palynologist on the project, you have spent a month doing field work and 6 months in the laboratory. Now you are ready to interpret your data. Using the pollen diagram template and the quantitative results of pollen counting from a core from the Kuril Islands, which you can find on the next pages, create a pollen diagram to visually represent changes in Kuril vegetation through time. Don't forget to plot the radiocarbon dates to have an idea of when the changes in vegetation took place. Do you see distinctive pollen assemblages for the different vegetation types? How many? What is the pollen "signature" for each vegetation zone?

Name: ______________________



Pollen Percentages

Depth (cm)	oak	magnolia	spruce	tree birch	shrub pine	grass
0	0	0	1	40	23	10
10	0	0	1	37	20	8
20	0	0	0	35	20	10
25	0	0	0	30	22	10
30	0	0	0	25	25	15
40	0	0	0	28	25	12
50	0	0	1	37	23	8
60	0	0	0	40	20	10
80	0	0	0	40	20	10
100	0	0	1	40	21	9
120	0	0	1	40	22	12
140	0	0	1	40	20	10
160	0	0	2	37	18	8
180	0	0	5	35	20	10
190	0	0	30	20	15	5
200	0	0	37	20	15	5
210	0	0	40	20	15	5
230	30	5	7	13	12	3
240	33	5	5	12	13	3
250	35	5	5	15	15	5
270	50	7	0	10	5	3
290	55	10	0	7	5	3
320	60	15	0	5	2	3
350	55	12	0	5	2	3
370	55	10	0	5	5	3
400	50	10	0	7	5	3
410	45	9	0	10	5	3
430	35	5	0	12	12	5
450	33	5	0	12	12	5
480	35	5	0	15	15	5
500	30	5	0	15	15	5
520	2	0	0	2	20	10
540	0	0	0	0	25	15
550	0	0	0	1	25	15
560	0	0	0	0	10	15
580	0	0	0	0	2	30
600	0	0	0	0	2	45

Radiocarbon Dates

Depth	Date	Error
75	500	10
125	2100	40
250	4000	75
370	5300	60
420	6100	100
560	8060	80
600	8970	50

Name: ____________________

Question Set 2

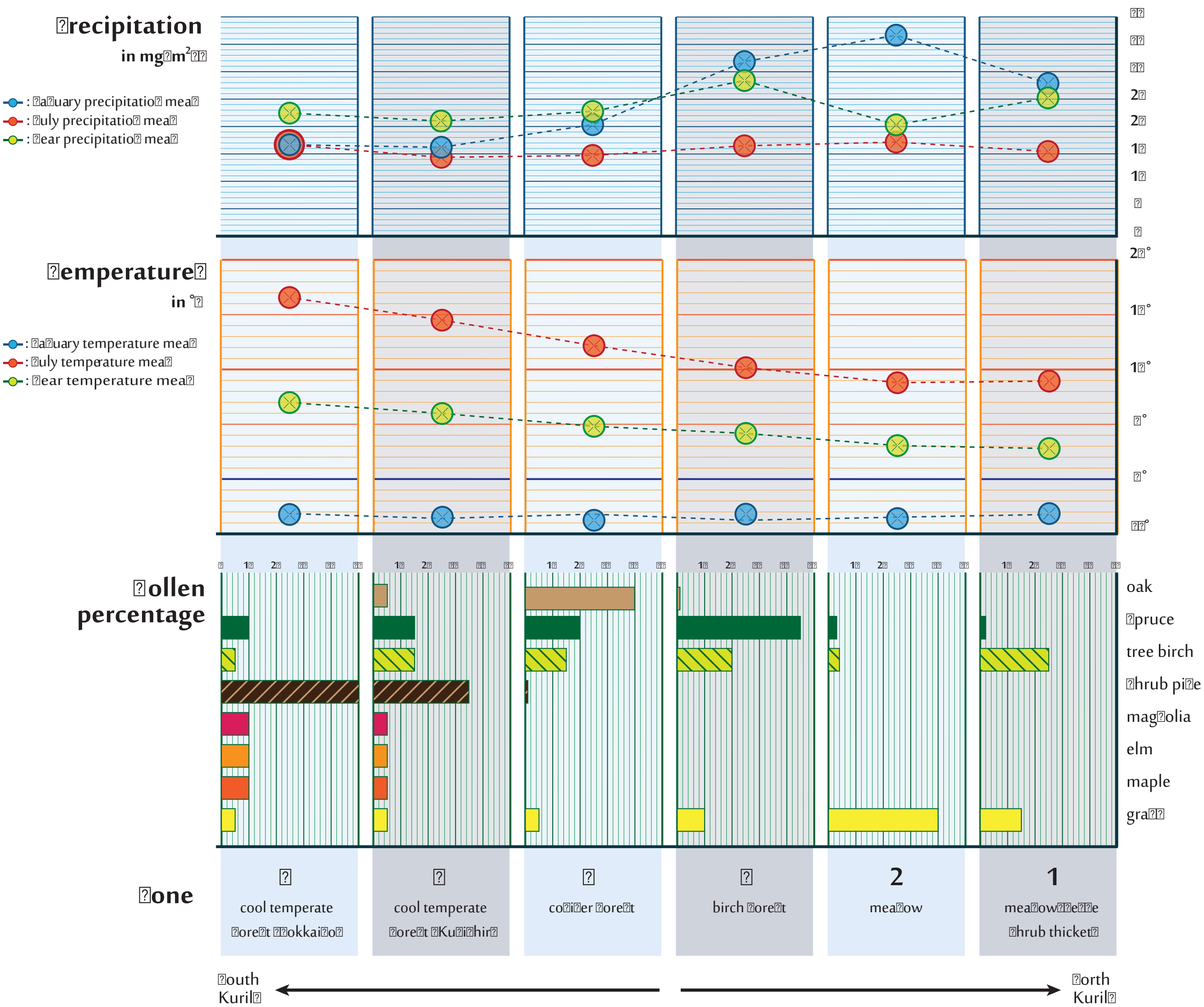
Activity 2: Pollen Diagram Plotting

Describe the vegetation history of your island for your colleagues. Use the handout called "Modern vegetation type & climate change by latitude" to determine how climate changes through the 8,000 years recorded in the core.

Name: ______________________________

Activity 2

Modern vegetation type and climate change by latitude



BIO-GEOGRAPHY
MODULE

Table of Content

Vocabulary

Biogeography:
The scientific study of how geography affects where different species of animals live (see also **phytogeography**)

Chlorophyll A:
A pigment used by plants to store energy from the sun through the process of photosynthesis.

Colonize:
To establish a breeding population in an area that had not previously been occupied.

Disperse:
To spread outward from a species' native home range. To "disperse to" a new area simply means to arrive there safely (see also colonize).

Distribution (two meanings):
1. The geographical patterning or location/s of something (e.g., the distribution of sea ice in the Sea of Okhotsk).
2. In statistics, the patterning or spread of a series of data points (e.g., the distribution of radiocarbon dates through time)

Fast ice:
Ice that is connected to shore.

Pack ice:
Free-floating chunks of ice that drift across the ocean pushed by wind and water circulation.

Phytogeography:
The scientific study of how geography affects where different species of plants live (see also biogeography).

Phytoplankton:
Free-floating plants that are usually made up of a single cell. Phytoplankton get their energy from the sun, and make up the base of the food chain.

Primary productivity:
A measure of how much of the sun's energy is captured by plants and made available in the food chain.

Zooplankton:
Free-floating microscopic and macroscopic animals.

Background Information

The Kuril Island Chain is part of a volcanic island arc that began forming 90 million years ago (during the Cretaceous Period) when an oceanic tectonic plate collided with the Siberian continent. The oldest island in the chain is Urup, which emerged from the sea 4.21 million years ago.

Island chains have a variety of characteristics that make them special in the biological world. They come in all manner of different shapes and sizes. Given that different kinds of animals have different home ranges, the size of an island can have a significant influence on the kinds of animals that are able to survive there.

By the same token, the distance between islands, or between any given island and the mainland will influence what species are likely to disperse to an island as well.

This is due to the fact that there are only three paths animals can take to get to an island:

- By land
- By sea
- By air

There are, of course, different options within each of these paths. For instance, "by land" can involve crossing dry land during periods of lower sea level. But it could also involve walking across sea ice.

Likewise, one image of how animals might arrive "by sea" involves swimming. This works well for marine mammals and fish. But for most terrestrial mammals this is only feasible for crossing narrow gaps between islands.

Consider, though, that small animals may raft across water crossings on logs, vegetation, or ice. And when it comes to water travel, humans have been very good at making boats for many thousands of years.

Finally, the "by air" pathway is limited to those animals that can fly such as insects, birds, and bats. In this module, we will deal exclusively with birds, although both insects and bats are found throughout the Kurils.

All of these limitations will influence which species can (a) disperse to and (b) successfully colonize islands within the Kuril Island Chain.

Even for many of the animals that can easily swim or fly to islands, such as birds or pinnipeds (seals, fur seals, and sea lions) can easily fly or swim to islands, they are often still tied to terrestrial habitat as part of their breeding cycle. Sea birds, for instance, often nest on cliffs or in burrows. Likewise, even though pinnipeds can stay at sea months or years at a time, they must return to land to mate and give birth to their pups.

This need to return to shore makes sea birds and pinnipeds particularly vulnerable to predation by terrestrial predators such as foxes, bears, and humans.

For a more detailed consideration of how the geography of the islands and the geological history may have affected the resulting animal distributions, examine Figure 1, which shows the relative distances between the islands and the depths of the passes between them. Even during the Last Glacial Maximum (LGM), when world-wide sea levels were 150 m lower than they are today, only a few islands were connected to their neighboring mainlands (Kunashir to Hokkaido, in the south, and Paramushir and Shumshu to Kamchatka, in the north).

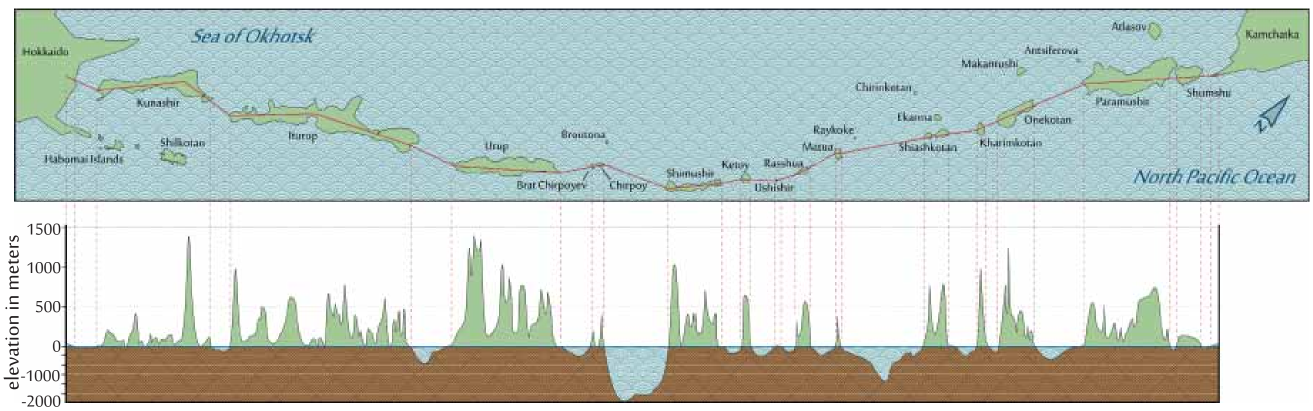


Figure 1: Kuril islands topo / bathy profile

There are two more important pieces to the biogeography "puzzle" at work in the Kuril Islands: sea ice distribution, and the distribution of marine nutrients. Sea ice primarily plays a role as a dispersal mechanism for terrestrial mammals, but sea ice is also important to several species of pinnipeds, including ringed seals and walrus. In most places in the northern hemisphere, northern areas tend to have more ice accumulation than southern areas. But this is not the case in the Kuril Islands. Counter-intuitively, sea ice concentrations in the Kurils tend to be highest in the southern portion of the island chain. This is because sea ice produced in the northern Sea of Okhotsk circulates counter-clockwise in ocean currents, and accumulates in late spring around Kunashir and Iturup, and occasionally Urup, as well. The presence of sea ice provides an important avenue of dispersal for terrestrial mammals coming to the Kurils from Hokkaido.

Another factor that plays a crucial role in determining the distributions of animals throughout the Kuril Islands is the distribution of marine nutrients. Marine nutrients are not uniformly distributed throughout the ocean—they get concentrated in certain areas by a variety of mechanisms. The greatest concentrations actually tend to be on or near the ocean floor, due to the accumulation of dead and decomposing phytoplankton and zooplankton from near the surface. However, phytoplankton, the very base of the food chain, require sunlight and nutrients in order to thrive. As a result, phytoplankton growth is highest in those areas where marine nutrients are brought to the surface from the ocean floor through a process called upwelling.

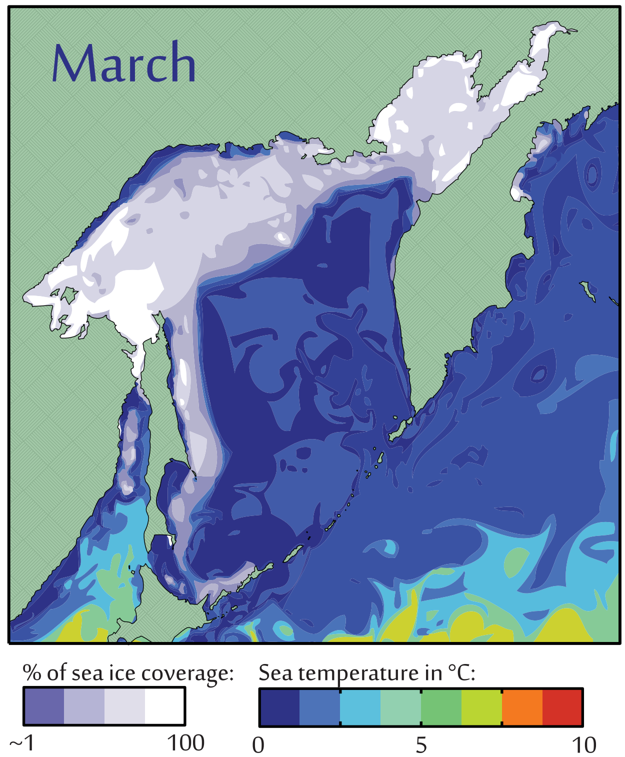


Figure 2: Average sea ice concentration in the Sea of Okhotsk and the Kuril Islands in March.

One of the areas that this happens consistently in the Kurils is in the passes between the islands. With each tidal exchange, huge volumes of water pass between the Pacific Ocean and the Sea of Okhotsk. This exchange of water between the passes results in very well-mixed, nutrient-rich water close to the surface (see Figure 3).

Areas that support high phytoplankton growth also support large populations of zooplankton (feeding on the phytoplankton), which also supports high populations of larger marine predators. (see Figure 4)

Finally, it is quite likely that these concentrated areas of high marine productivity influenced the distribution of human settlements in the Kuril Islands. Please refer to the "Settlement Module" for more information.

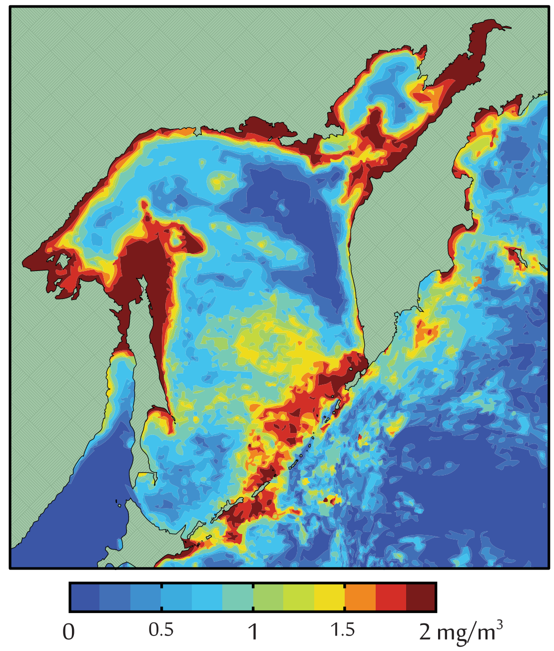


Figure 3: July average concentrations of chlorophyll over 10 years (1999-2008), which is an index of primary productivity (phytoplankton growth).

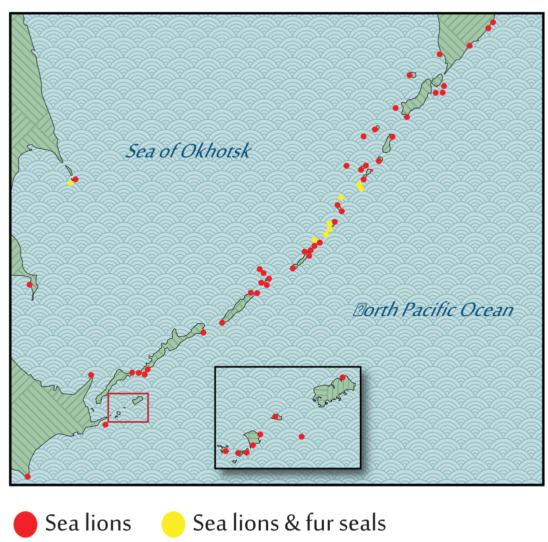


Figure 4: Map showing the distribution of sea lion and fur seal colonies. Note that on large islands, the colonies tend to be located towards the ends of the island (near the passes)

Name: ______________________________ **Excercise #1**

Examine the lists of terrestrial mammal species that are native to Hokkaido, Japan, and Kamchatka, Russia. Based on what you know about these species, which would you predict would be able to colonize the Kuril Islands. Does it matter if they are colonizing from the south (from Hokkaido) or from the north (from Kamchatka)? Why?

List of Terrestrial Mammals Spicies in Hokkaido

Name and number of spieces	Able to disperse?	Able to colonize?
Brown Bear (1)		
Marten (1)		
Pica (1)		
Rabbit (1)		
Red Fox (1)		
River Otter (1)		
Shrew (6)		
Sika Deer (1)		
Squirrel (6)		
Vole (3)		
Weasel (2)		

List of Terrestrial Mammals Spicies in Kamchatka

Name and number of spieces	Able to disperse?	Able to colonize?
Brown Bear (1)		
Marten (1)		
Moose (1)		
Pica (1)		
Rabbit (1)		
Red fox (1)		
Reindeer (1)		
Shrew (5)		
Squirrel (2)		
Vole (6)		
Weasel (2)		
Wolf (1)		
Wolverine (1)		

Which of these species might be beneficial to humans?

Which of these species might be detrimental to humans?

Name: ______________________________

Excercise #2
Continued

Now examine the map showing the number of land mammal species that occurs naturally on islands and the adjacent mainland. Island size and distance to the mainland are the two main factors that influence the number of land mammal species any given island can support. For each of the islands identified in Figure 1, indicate which of those two factors you think is MOST important, and indicate why.

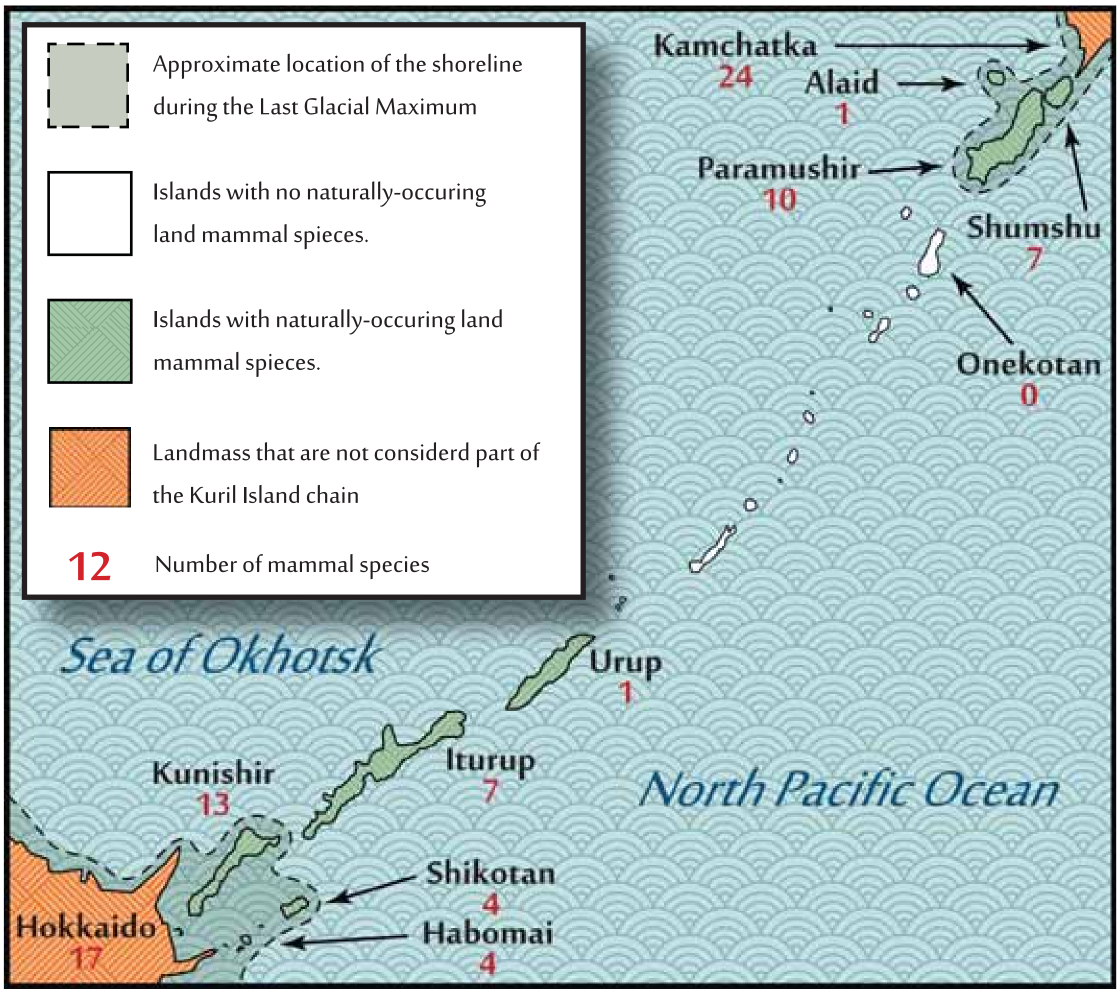


Figure 1: Number of land mammal species that occurs naturally on islands and the adjacent mainland.

Alaid: ______________________________

Shumshu: ______________________________

Paramushir: ______________________________

Urup: ______________________________

Iturup: ______________________________

Kunashir: ______________________________

Shikotan: ______________________________

Habomai: ______________________________