Kuril Burke Box

Biocomplexity of an island chain

Teacher's Manual

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Overview

Purpose:

The Kuril Biocomplexity Education Kit is an educational resource for teachers in Middle and High School science and social science classes, particularly for students in grades 7-10. We designed the kit around an actual interdisciplinary research project that combined the research interests and skills of archaeologists, ecologists, geologists, and climate scientists. The kit itself provides curriculum and activities to teach students about aspects of each of these disciplines and to encourage them to think about how sciences need to be integrated to better understand the relationships between physical, biological, and social processes.

We based the curriculum and activities in this kit on research conducted in the volcanic Kuril Islands between northern Japan and the Russian Kamchatka Peninsula. The researchers on this project sought to understand the relationships between geological processes (such as volcanic eruptions, earthquakes, and tsunamis), climate changes (increased or decreased sea ice, temperature, and storms), ecological processes (such as changing population dynamics and biogeographical distributions of plants and animals), and human settlement histories and economies. Scholars recognize that earth systems are connected in numerous ways over different spatial and temporal scales. Even so, research that explores the connections between traditionally-bounded scientific disciplines is often challenging to conduct and neglected in scientific education and practice. The Kuril research project and this education kit capitalize on the growing awareness that we cannot neglect interdisciplinary research. In this kit, you will find the resources to teach both disciplinary and interdisciplinary science to your students.

Project Background:

University of Washington initiated the Kuril Biocomplexity Project was initiated officially in 2005 when the National Science Foundation (NSF) granted the university a research award to begin work on a study of the "Biocomplexity of coupled natural and human systems" in the Kuril Archipelago. "Biocomplexity" was a term coined by then NSF Director, Rita Colwell in 1999 to refer to the complex and integrated nature of ecological systems. Scientists began to research biocomplexity to gain a better understanding of the ways that biological organisms and populations are dynamically intertwined with other systems. Humans have always been actors in the ecosystems in which they live (with impacts extending far beyond), and the Kuril Biocomplexity Project sought to disentangle some of these complex relationships by looking at the history of geological, climatic, biological, and anthropological developments in a relatively simple geographical context – a string of small islands for which the complexities would naturally be reduced. By virtue of its geography, the Kuril archipelago serves as a sort of yardstick, ranging from near continental islands at the margins (where migration into and out of the archipelago by plants, animals, and people was always relatively easy), to remote (and smaller) islands near the center of the chain (where migrations were more limited and, as a result, biodiversity much lower). Geography and biology are therefore closely related. When climatic factors are also considered, including the existence of a climatic gradient along the island chain and long-term climate change that have affected the archipelago directly and indirectly over the millennia, our understanding of the system is further complicated. Superimposed on these variables are the geological consequences of living in a subduction zone where volcanic eruptions, earthquakes, and tsunamis were relatively common occurrences. Finally, when we include the human hunter-gatherers who settled the Kurils, made a living there, engaged in trade with outside communities, and abandoned the archipelago numerous times throughout the last 4,000 years, our understanding of the region's biocompliexity reaches truly staggering proportions.

We started the project with many broad questions. For example: What was the history of catastrophic geological events across the island chain? What was the nature of climate change? When did people move into the islands and did they abandon parts or the entire chain at different times in the past? If so, why? How did human settlement relate to differences in the biodiversity (high on the ends, low in the center)? Were people more vulnerable to extinction/abandonment if they lived in some places compared to others? Did people cause ecological crashes/species extinctions through overharvesting or habitat disruption, and if so, was this more common on remote and more ecologically precarious islands? How did islanders interact with each other in different regions or with people outside of the island chain? Were people who were living in the remote central islands more insulated from changes occurring outside

of the island chain? Were they more vulnerable to isolation from opportunities connected to the outside? Three seasons of field work and six years of analysis have yielded answers to some of these questions and opened up many new questions that we continue to pursue. The exercises in this education kit will help students to get a taste for what it is like to try and study a few of these questions.

Educational Objectives:

The purpose of this education kit is to use the Kurils as a focus for scientific education. We designed every exercise in this kit with the goal of teaching basic scientific concepts and applications to students. The most important goal is to give students an understanding of what it means to be a scientist and how field scientists collect and analyze data. Students who complete the exercises in this kit should be able to see themselves as scientists. By focusing on the practice of field work linked to data analysis, this exercise should expand student understanding of scientific practice beyond the laboratory experiments that are often central in scientific curricula. Also, with a range of different sciences covered, the kit gives students a broader survey of the diversity of scientific activities (at least in the earth, atmospheric, life, and human sciences). By providing insights into how several different scientific fields engage in research in a common region, the modules in this kit should help students see the interrelationships between fields of knowledge and how the earth, atmosphere, life, and social systems are in fact connected in dynamic systems. It should prepare students to see the world more holistically and perhaps become interested in scientific careers that pursue interdisciplinary research questions.

Washington State "Essential Academic Learning Requirements" (EALRs)

Introduction:

While this kit should be well-suited to middle and high school curricula elsewhere, we specifically developed this kit toward satisfying some of the core elements prescribed by the Washington State EALRs. The kit is especially focused on exposing students to the practice of **science** but also covers related areas in **social studies.**

Science Requirements:

6th - 8th Grades

EALR 2: Inquiry
6-8th grade: Questioning and Investigating.
LESSON: All lessons

6-8 INQA: Scientific inquiry involves asking and answering questions and comparing the answers with what scientist already know about the world.

6-8 INQC: Collecting, analyzing and displaying data are essential aspects of all investigations

6-8 INQE Models are used to represent objects, events, systems, and processes. Models can be used to test hypothesis and better understand phenomena, but they have limitations.

EALR 3: Application
6-8th grade: Science, Technology, and Problem Solving
LESSON: Artifacts

6-8 APPH: People in all cultures have made and continue to make contributions to society through science and technology.

EALR 4: Earth and Space
6-8th grade: Cycles in Earth Systems
LESSON: Tsunami & Stratigraphy, Natural Hazards

6-8 ES2G Landforms are created by processes that build up structures and processes that break down and carry away material through erosion and weathering.

6-8th grade: Evidence of Change
LESSON: Tsunami & Stratigraphy, Natural Hazards

6-8 ES3A: Our understanding of Earth History is based on the assumption that processes we see today are similar to those that occurred in the past.

6-8 ES3B: Thousands of layers of sedimentary rock provide evidence that allows us to determine the age of Earth's changing surface and to estimate the age of fossils found in the rocks.

6-8 ES3C: In most locations sedimentary rocks are in horizontal formation with the oldest layers on the bottom. However, in some location, rock layers are folded, tipped or even inverted, providing evidence of geologic events in the distant past

6-8 ES3D: Earth has been shaped by many natural catastrophes, including earthquakes, volcanic eruptions, glaciers, floods, storms, tsunami, and the impacts of asteroids.

EALR 4: Life Science
6-8th grade: From Cells to Organisms
LESSON: Zooarchaeology

6-8 LS1E: In classifying organisms, scientists consider both internal and external structures and behaviors.

6-8th grade: Flow of Energy Through Ecosystems
LESSON: Paleoclimate, Biogeography

6-8 LS2D Ecosystems are continuously changing. Causes of these changes include non-living factors such as the amount of light, range of temperatures, and availability of water, as well as living factors such as the disappearance of different species through disease, predation, habitat destruction and overuse of resources or the introduction of new species

9-12th grades
EALR 2: Inquiry
9-12th grade: Conducting Analyses and Thinking Logically
LESSON: All Lessons

9-12 INQA: Scientists generate and evaluate questions to investigate the natural world.

9-12 INQC: Conclusions must be logical, based on evidence, and consistent with prior established knowledge.

9-12 INQE: The essence of scientific investigation involves the development of a theory or conceptual model that can generate testable predictions.

9-12 INQF: Science is a human endeavor that involves logical reasoning and creativity and entails the testing, revision, and occasional discarding of theories as new evidence comes to light.

EALR 3: Application
9-12th grade: Science, Technology, and Society
LESSON: All Lessons

9-12 APPD: The ability to solve problems is greatly enhanced by use of mathematics and informational technologies.

EALR 4: Physical Science
9-12th grade: Chemical Reactions
LESSON: Chronology

9-12 PS2F: All forms of life are composed of large molecules that contain carbon. Carbon atoms bond to one another and other elements by sharing electrons, forming covalent bonds. Stable molecules of carbon have four covalent bonds per carbon atom.

9-12 PS2J: The number of neutrons in the nucleus of an atom determines the isotope of the element. Radioactive isotopes are unstable and emit particles and/or radiation. Though the timing of a single nuclear decay is unpredictable, a large group of nuclei decay at a predictable rate, making it possible to estimate the age of materials that contain radioactive isotopes.

Social Studies Requirements:

EALR 4: Earth and Space Science
9-12th grade: Energy in Earth Systems
LESSON: Settlement, Biogeography, Paleoclimate

9-12 ES2D: The Earth does not have infinite resources; increasing human consumption impacts the natural processes that renew some resources and it depletes other resources including those that cannot be renewed.

9-12th grade: Evolution of the Earth
LESSON: Chronology, Paleoclimate, Tsunami & Stratigraphy, Natural Hazards

9-12 ES3A Interactions among the solid Earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the Earth system. We can observe changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hunderds of millions of years.

9-12 ES3B: Geologic time can be estimated by several methods.

9-12th grade: Maintenance and Stability of Populations
LESSON: Paleoclimate, Biogeography

9-12 LS2B: Living organisms have the capacity to produce very large populations. Population density is the number of individuals of a particular population living in a given amount of space.

EALR 2 Economics: The student applies understanding of economic concepts and systems to analyze decision-making and the interactions between individuals, households, businesses, governments, and societies.
LESSON: Natural Hazards, Paleoclimate, Biogeography, Settlement

2.1 Understands that people have to make choices between wants and needs and evaluate the outcomes of those choices.

6th grade: GLE 2.1.1

2.4 Understands the economic issues and problems that all societies face.

9/10th grade: GLE 2.4.1

12th grade: GLE 2.4.1

EALR 3: Geography: The student uses spatial perspective to make reasoned decisions by applying the concepts of location, region, and movement and demonstrating knowledge of how geographic features and human cultures impact environments.

LESSON: Natural Hazards, Paleoclimate, Biogeography, Settlement

3.1 Understands the physical characteristics, cultural characteristics, and location of places, regions, and spatial patterns on the Earth's surface.

6th grade: GLE 3.1.3, 3.1.2
7th grade: GLE 3.1.1, 3.1.2
9/10th grade: GLE 3.1.2
11th grade: GLE 3.1.1

3.2 Understands human interaction with the environment.

6th grade: GLE 3.2.1, 3.2.2, 3.2.3
7th grade: GLE 3.2.2
9/10th grade: GLE 3.2.1, 3.2.3

EALR 4: History The student understands and applies knowledge of historical thinking, chronology, eras, turning points, major ideas, individuals and themes of local, Washington State, tribal, United States, and world history in order to evaluate how history shapes the present and future.

LESSON: Chronology, Natural Hazards, Settlement

4.1 Understands historical chronology

9/10th grade: GLE4.1.1

4.2 Understands and analyzes causal factors that have shaped major events in history

7th grade: GLE 4.2.2

4.4 Uses history to understand the present and plan for the future.

6th grade: GLE 4.4.1
7th grade: GLE 4.4.1

EALR 5: Social Studies Skills The student understands and applies reasoning skills to conduct research, deliberate, form, and evaluate positions through the processes of reading, writing ,and communicating.

LESSON: All lessons

5.1 Uses critical reasoning skills to analyze and evaluate positions.

6th grade: GLE 5.1.2

5.2 Uses inquiry – based research

6th grade: GLE 5.2.1
7th grade: GLE 5.2.1

Overview and objectives of each module

Chronology:

Overview:

In this module, students will be introduced to the radiocarbon dating method, which archaeologists and geologists frequently use to determine when the events which interest them occurred. During this lesson, the teacher will instruct the students about the concepts foundational to the radiocarbon dating method. This lesson will require students to identify suitable and unsuitable materials for radiocarbon dating, use a graph to determine the age of samples based on the amount of radiocarbon that is present in them, and do a take-home writing assignment in which they will design a plan for constructing a timeline of events at an archaeological site.

Objectives

- To understand the difference between timelines based on relative dating and absolute dating.
- To understand how radiocarbon dating works, what objects can be dated, and the limitations of the method.
- To understand how archaeologists use radiocarbon dating to reconstruct human history and investigate links between natural hazards and human occupation.

Tsunami & Stratigraphy:

Overview:

This module uses stratigraphy to teach students to understand how records of past events (in this case past tsunamis and volcanic eruptions) are archived in soils in coastal plains in the Kurils. Students will learn primary research techniques that scientists in the Kurils use to determine how often tsunamis have occurred in the past. Students will be introduced to the concept of correlation, learning how to interpolate points of observation into a defined surface.

Natural Hazards:

Ojectives:

Students will learn:

- How geologists study stratigraphy in the field
- How to describe stratigraphic sections
- How to plot stratigraphic sections
- How to correlate stratigraphic units across topographic profiles and between locations
- How to interpret past events from stratigraphy
- How to use observations to make predictions about future hazards

Overview:

Humans primarily care about natural hazards when events affect individuals by destroying or disturbing habitation, livelihoods, food resources, and daily activities. Natural hazards contribute to difficulties encountered in surviving in the remote, harsh landscape in the Kurils.

This module teaches students to understand how environment (with a focus on natural hazards) contributes to daily life, human activities, and cultural decision-making.

Students will be introduced to the natural hazards that occur in the Kuril Islands, including volcanic eruptions, earthquakes, tsunamis, and landslides, as well as to how and why these events occur. Students will learn to assess hazard potential and relate this to where and how one would want to live. Students will practice communication skills, including distilling and relaying complicated information.

Ojectives:

- Students will learn to assess hazard potential and relate this to where/ how one lives or wants to live.
- Students will practice distilling complicated information, effectively conveying it to their classmates, and discussing decision-making.
- Students will consider the difference between oral and written histories.
- Students will practice reading and interpreting maps.

Overview and objectives of each module

Continued

Paleoclimate:

Overview:

Students are introduced to methods that palynologists use to interpret past landscapes and associated climatic conditions. Through the introduction to basic concepts such as biostratigraphy, proxy data, and analog analysis students will reconstruct the vegetation and climate histories of the southern Kuril Islands over the last ~8,000 radiocarbon years. Students will explore: 1) the relationship between modern climate and modern vegetation; 2) the relationship between modern and ancient vegetation using pollen data; and 3) the application of these relationships to infer past climatic change. Through the exercises the students will: 1) learn how to apply the basic principles of palynology; and 2) improve their appreciation of the dynamic nature of the environment, recognizing that modern ecosystems and climate patterns are not static and can change dramatically through time. Reconstructing paleoenvironments is a key tool that aids archaeologists to better understand possible human-environmental interactions, such as how changes in past environments may or may not have influenced human activities.

Objectives:

- To teach students how palynologists infer past plant communities and how paleovegetation reconstructions act as proxy measurements of past climate.
- To engage students in the analysis and interpretation of biostratigraphic data.
- To allow students to explore the relationship of vegetation types to broader climatic conditions.
- To engage students in the examination of how past conditions may help us understand possible responses of the environment to future climate changes.

Biogeography:

Overview:

This module deals primarily with the geography of the Kuril Islands and the constraints that this geography puts on the numbers and kinds of animals (including humans) able to inhabit the islands. The scientific study of this relationship is called island biogeography. For information on the distribution of plants (phytogeography) and how this might have changed through deep time, please consult the Paleoclimate teaching module.

Goal:

To familiarize students with the science of biogeography, as well as the wide range of physical and geological processes that help to structure biogeographic patterns.

Zooarchaeology:

Objectives:

- Students will be able to explain how animals can populate islands.
- Students will be able to compare animal distributions in time and space and create hypotheses for changes over time or differences in space.

Overview:

This unit provides an introduction into the science of zooarchaeology. This includes information on skeletal anatomy of birds, fish, and mammals, as well as specific information on how zooarchaeologists identify different species of animals based only on skeletal remains. Finally, methods of quantifying identified bones will be covered.

Objectives:

- Students will be able to explain how skeletal anatomy reflects the organization of the Linnaean Hierarchy and how that knowledge can help identify species or class of animal fro bones.
- Students will learn the patterns of bone growth in mammals and will practice using this knowledge to identify age and sex of animals based on their bones.
- Students will learn some of the techniques used by zooarchaeologists when analyzing archaeological bone samples.
- Students will practice using zooarchaeological data to create hypotheses about past interaction of animals, humans, and their environments.

Settlement:

Overview:

In this module, students will be introduced to statistical distributions to address questions about historical changes in human settlement patterns and to raise questions about the causes of these changes. Through an exercise designed to engage students in statistical data manipulation, they will learn how archaeologists use radiocarbon-dated settlements to reconstruct changes in the intensity of occupation in different locations. They will then compare these patterns to explore changes in settlement over time and space. The final component of this module gives students a chance to think about possible causes of historical changes in settlement distributions through correlation with environmental phenomena such as volcanic eruptions. Exercises engage students in quantitative and basic descriptive statistical manipulations (data aggregation and histogram construction) and in hypothesis formation and testing. The exercise is designed to convey the important realization that human settlement is not static but changes, sometimes dramatically, over time.

Goals:

- To teach students how archaeologists interpret settlement history based on site distributions and radiocarbon dates, and how they seek to explain change through analysis of correlations with environmental phenomena and changes in culture.
- To engage students in the analysis and interpretation of distribution data.
- To engage students in interpretations about human-environment interactions.
- To engage students in integrative/ systemic thinking exercises

Objectives:

- Students will learn how to observe changing frequencies of dated archaeological settlements by organizing data into histogram form and they will learn how differing the intervals ("bins") of a histogram can change the graphical representations. This is a basic aspect of scientific data analysis and a descriptive statistical procedure.
- Students will learn to compare proxy data for environmental events and human settlement and to develop and evaluate hypotheses about the causes of human settlement change. Correlation is a basic aspect of scientific reasoning. Students will also learn to examine critically the methods used and the strength of conclusions.

Artifacts:

Overview:

This module focuses on the artifacts recovered in the Kuril Islands. Students will examine, identify, and analyze replica artifacts included in the kit to learn how ancient people lived and what they ate.

Goals:

- To introduce the basic features of artifacts and their value to archaeologists.
- To develop students' critical thinking skills about how people used material objects to live and interact with the environment around them.

Objectives:

- Students will examine and analyze artifacts using skills such as drawing, measuring, and writing.
- Students will identify the different material types used by ancient humans to make artifacts (stone, ceramic, bone).

Conclusion

Field research in the remote Kuril Islands is exotic, especially for American scholars and students, and as such has the potential to captivate student attention in some of the same ways that cultural icons such as Indiana Jones have done for generations. Conducting cooperative field research with a team of American, Russian, and Japanese scholars in remote settings, involving travel on ships and small boats (often in fog and sometimes in rough seas), set against the dramatic backdrop of the vast ocean, snowcapped volcanic peaks, lush green vegetation, and vibrant wildlife, makes the experience captivating for the adventurous spirit. We have tried to convey some of this drama and beauty in the slide shows and narratives. On the other hand, the reality of research anywhere is one of hard, careful, and systematic work. Students are exposed to this dimension of research as well in the lessons and exercises. We hope that this combination of captivating imagery and scientific reality both engages students and encourages them to learn more about scientific practice. While the Kurils are far from the Western U.S., the issues examined in this research are of direct relevance for the residents of the western seaboard of the U.S., where residents face earthquakes, tsunamis, volcanic eruptions, ongoing and dramatic climate changes, struggles with the preservation of wildlife, and the survival of economic systems dependent on both wild and cultivated plants and animals (salmon, sea lions, orca whales, spotted owls, forests, agricultural productivity, etc.). The Kuril Biocomplexity Education Kit provides an opportunity for teachers to engage students with research activities drawn from an actual interdisciplinary project — using real scientific data in most cases — with both exotic appeal and practical relevance for the lives of students in the Western U.S.

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