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## Hazards, Impacts, and Resilience among Hunter-Gatherers of the Kuril Islands

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### ARCHAEOLOGICAL APPROACHES TO CATASTROPHIC EVENTS IN THE HUNTER-GATHERER CONTEXT

This chapter explores hunter-gatherer vulnerability in the context of relative isolation and a highly dynamic natural environment. The setting is the Kuril Islands of the Northwest Pacific, and the data set is a 4,000-year record of human settlement and environmental history generated by the Kuril Biocomplexity Project, a large, interdisciplinary, and international research effort fielded from 2006 to 2008. The presupposition entering this project was that this relatively isolated, volcanic, earthquake- and tsunami-prone subarctic region should be among the more difficult habitats for hunter-gatherer populations to occupy consistently and, as a result, that the archaeological record should reflect periodic abandonments, at least in the most isolated (and smallest) central islands. The results of this study speak less to this heuristic presupposition than to the idea of resilience in the face of ecological impoverishment, catastrophic events, and climate changes. The history we are uncovering highlights the importance of linked social, economic, and demographic processes in conditioning vulnerability and shaping people's resilience in the environment.

Hazards and disasters are the focus of increasing interest in natural and social science, stimulated by growing media attention to disasters around the world. Calls for improved prediction of catastrophic events have generated

enhanced support for retrospective studies of historical pattern and periodicity in earthquakes, tsunamis, volcanic eruptions, floods, drought, climate change, and other natural hazards. Social science has entered this arena to better understand human responses to hazardous events and environmental change, most recently calling for more integrated research into the socio-natural dynamics of disasters (Blaikie et al. 1994; Oliver-Smith 1996; Oliver-Smith and Hoffman 2002; Sidle et al. 2004; Torrence and Grattan 2002). This latest turn recognizes that disasters are complex outcomes of linked social and environmental processes and that these histories often condition the severity of impacts on humans in the aftermath of extreme events.

Efforts to understand the socio-environmental dynamics of disasters have tended to focus on agricultural and industrial societies (but see Saltonstall and Carver 2002; Sheets 1999). From a comparative archaeological study of socio-ecological responses to explosive volcanic eruptions in Mesoamerica, Payson Sheets (1999) suggests that the impacts of such catastrophic events will scale with the degree of organizational complexity and investment in “built environment.” He argues that small-scale egalitarian societies, at least in Central America, had the most organizational resilience. If Sheets is correct in this conclusion, we should expect to see similar degrees of resilience in other contexts in which small-scale societies were exposed to catastrophic events. The Kuril Islands offer another case for investigating the resilience of such societies.

### THE KURIL ISLANDS

The Kuril Islands provide a semi-controlled setting for investigating the historical impacts of volcanism, tsunamis, and climate change on maritime hunter-gatherers over the past 4,000 years. As a group of ecologically simple and geographically small volcanic islands stretched across 1,100 km of stormy, subarctic ocean, these islands would seem to epitomize an extremely vulnerable environment for human settlement. The relative isolation of the central Kurils may explain why they were left unoccupied until roughly 4,000 years ago, a barrier rather than a bridge between the Japanese archipelago and Kamchatka (figure 1.1).

In biogeographical terms, the Kuril Islands\* are “stepping stone islands” between Hokkaido and the Kamchatka Peninsula—serving as both potential conduit and filter for the movement of plants, animals, and people between these larger landmasses. The islands serve largely as a filter to the expansion

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\* In this chapter “Kurils” refers to the “Greater Kuril” island chain linking Hokkaido to Kamchatka. A shorter string of islands, known as the “Lesser Kurils,” stretches approximately 100 km northeast from Hokkaido’s Nemura Peninsula. These islands are not discussed in this chapter.



1.1. *The Kuril Islands. Illustration by Ben Fitzhugh, based on cartographic projection by Adam Freeburg.*

of land-based plant and animal taxa limited in their ability to disperse across wide channels with fast marine currents. As a result, the islands from Iturup northeast to Onekotan have relatively low terrestrial biodiversity and are dominated by tundra meadow and alpine ecosystems and a few terrestrial mammals uncharacteristically good at colonizing new lands, such as fox and vole. Birds, by contrast, are abundant and diverse in the absence of most predators, and the Kurils support dozens of species of resident seabirds and migratory waterfowl (Hacker 1951). Marine mammals are also well represented today around the shores and near-shore waters of many of the Kuril Islands. Sea lions, fur seals, and harbor seals are the most common species today, especially in the central islands, where they haul out in large numbers and raise pups in the summer. Sea otters are abundant in some areas—especially around the northern and southern islands—while absent in others. Their distribution seems to reflect the ecological differences in shellfish and fish productivity and diversity, which are also highest in the northern and southern ends of the chain compared to the center. The resulting ecological picture is one of higher taxonomic diversity in both terrestrial and marine resources in the southernmost and northernmost

islands, which are also the largest and closest to “mainland” sources. The central islands—especially those from the Chirpoi Islands to Onekotan—have low biodiversity, and hunter-gatherers targeted marine mammals, birds (and their eggs), and limited varieties of fish. Archaeological evidence is consistent with a picture of reduced diversity in diets and more limited subsistence options in the central zone compared to the others (Fitzhugh et al. 2004).

The Kuril Biocomplexity Project (KBP) was designed to study the integrated history of humans, flora, fauna, geology, oceanography, and climate as part of a single, coordinated, interdisciplinary research effort. Following preliminary work in 1999 and 2000 (Fitzhugh et al. 2002; Pietsch et al. 2003), KBP started fieldwork in the summer of 2006 with an interdisciplinary team drawn from the United States, Russia, and Japan. The three summers from 2006 to 2008 were spent locating, mapping, and testing archaeological sites; sampling volcanic ash deposits, lake water, and rocks; studying coastal stratigraphy for tsunami deposits; measuring wave run-up elevations from recent and older tsunami deposits; coring lakes and peat bogs for pollens and other climate and ecosystem proxies; and studying modern crustal motion to better understand the dynamics of Kuril seismicity. In the process KBP identified and tested 70 archaeological sites from Kunashir to the Shumshu Islands. Resulting data include site and landscape maps; radiocarbon dates (286 archaeological dates and 17 purely geological dates, all by the AMS method); stone, pottery, and bone artifacts; stratigraphic descriptions of archaeological and geological sediments; physical and geochemical analyses of volcanic ash samples; lake cores from the north, central, and southern islands; and stratigraphically sequenced peat samples from almost every island. Project teams are working from these data to conclusions and combining forces to better understand the integrated Late Holocene history of the Kurils. It is in the context of this emerging synthesis that we seek to draw preliminary conclusions about the hazards affecting human settlement and lifestyle in the Kurils.

### KURIL ISLAND ARCHAEOLOGICAL HISTORY

The oldest dated archaeological site in the Kurils is located in central Iturup Island and dated to about 8,000 years ago (ca. 6000 BC)\* (Vasilevsky and Shubina 2006; Yanshina and Kuzmin 2010; Zaitseva et al. 1993). It was occupied by a culture known as the Early Jomon. This one dated site and surface finds of Early and Middle Jomon pottery indicate the presence of people in the southern Kurils (closest to Hokkaido) during the Middle Holocene (ca. 6000

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\* Dates are given in calibrated calendar years BC or AD unless otherwise noted. Uncalibrated radiocarbon ages (raw dates) are designated as “rcybp.”

to 2500 BC). The next oldest radiocarbon dates, also from southern islands, begin to appear around 2500 BC and correlate with apparent stabilization of the local climate and vegetation (Anderson et al. 2009).

Between 1900 and 1400 BC we start to see evidence for settlement on many of the central and northern islands. This expansion conceivably relates to the spread of a more effective seafaring technology into the Japanese archipelago that would have facilitated greater movement into the Kurils, as it apparently did in the previous millennium in Island Southeast Asia (Oppenheimer and Richards 2001). In this very early phase of Kuril occupation, it is possible that people from southern Kamchatka might have colonized the northernmost islands of Shumshu and Paramushir. In general, however, all diagnostic cultural traits (predominantly decorated pottery) in this time and during the rest of history suggest southern origins, either starting in or passing through Hokkaido to get to the Kurils.

Our radiocarbon database indicates an abrupt jump in Kuril occupation beginning around 500 BC. This surge represents the leading edge of almost 1,500 years of more or less continuous settlement during the Epi-Jomon period, with substantial pit-house villages established on many of the Kuril Islands. The Epi-Jomon were a maritime-oriented hunting and fishing people who lived in the Kurils in small pit houses roughly 3–5 m in diameter and left behind cord-marked pottery, a variety of stone tools, and—in rare, well-preserved deposits—distinctive bone and wood artifacts, including barbed and toggling harpoon heads. The Epi-Jomon represent the continuity of Jomon hunting-and-gathering lifeways in Hokkaido and the Kurils at a time when Yayoi rice farmers had assimilated and displaced Jomon lifestyles in more southerly Japan (Habu 2004; Hudson 1999; Imamura 1996).

In the mid-first millennium AD a new culture, known as the Okhotsk, swept the southern shores of the Okhotsk Sea from origins in the Lower Amur, Sakhalin Island, or both (Amano 1979; Ono 2008). The Okhotsk culture colonized the Kurils sometime around AD 800, more or less replacing a waning Epi-Jomon population. From about AD 800 to 1300 the Okhotsk dominated the Kurils from south to north. They used distinctive thick-walled pottery, lived in larger oval to pentagonal houses ranging from 5 to 15 m in diameter, and pursued a range of game, from fish and shellfish to birds and sea mammals.\* During this interval, southern and central Hokkaido supported a culture known as Satsumon, derived from the assimilation of Hokkaido Epi-Jomon and immigrants from northern Honshu bearing a mixed hunting-gathering

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\* Epi-Jomon populations likely ate a similar range of foods in the Kurils, but faunal remains dating prior to the Okhotsk period were hard to come by in the highly acidic volcanic soils of the Kurils.

and millet farming subsistence economy (Crawford 1992, 2008; Crawford and Takamiya 1990).

Curiously, archaeological evidence of human settlement in the Kurils disappears around AD 1300–1400, at least for 200 years or so. This gap in evidence for Kuril occupation corresponds to the emergence of cultural traditions recognized as precursors of modern Ainu ethnic culture. In Hokkaido the emergence of the Ainu is characterized by complete abandonment of pit-house dwellings and pottery in favor of aboveground structures and imported iron and lacquer containers. In the Kurils and southern Kamchatka, however, archaeologically identified Ainu material culture includes the continued use of pit houses and the construction of “Naiji” pottery with internal lug handles reminiscent of the iron pots in use to the south.

According to the ethno-historic records beginning at the start of the eighteenth century, the Kuril Ainu (“Kuriles” or “Koushi”) lived throughout the northern, central, and southern Kuril Islands. They spoke distinctly northern and southern dialects of the Ainu language, different from those spoken in Hokkaido and southern Sakhalin. The Ainu suffix “-kotan” means village, suggesting that the islands of Onekotan, Kharimkotan, Shiashkotan, and Chirinkotan maintained Ainu villages. Stepan Krasheninnikov (1972) reports that the northern Kuril Ainu lived from Simushir to Shumshu and that the Simushir occupants traveled seasonally to Chirpoi Island to hunt birds and trade with southern Kuril Ainu coming from Urup. On Kunashir and Iturup, Igor Samarin and Olga Shubina (2007) have documented a number of *chasi*, or fortifications, they attribute to Ainu populations. The ethno-historical data therefore strongly suggest that Ainu lived in the Kurils prior to initial Russian contact in the early eighteenth century, while the archaeological evidence suggests they may not have been there more than a century earlier. Whatever the resolution of this discrepancy, we can clearly say that the Ainu did not maintain the substantial settlements in the Kurils (especially the central Kurils) that the earlier Epi-Jomon and Okhotsk settlers did. Something changed fundamentally in the nature of the human-environmental relationship at this time.

After contact with agents of expanding Russian and Japanese states, Kuril Ainu populations dwindled until the remaining residents were forcibly resettled on Shikotan Island in the Lesser Kurils in 1883. At the end of World War II the conquering Soviets sent the few surviving Kuril Ainu to Hokkaido, where it is believed the last member died in 1960 (Kaoru Tezuka, personal communication 2006). The rapidity of this depopulation in absence of evidence of significant genocide suggests fairly low population levels prior to contact.

Nineteenth- and twentieth-century occupation increasingly came to include Russian and Japanese outposts. These outposts were initially established to take advantage of the lucrative hunt for sea otter and fur seal pelts, but in the twentieth century they served the dual purposes of geopolitical military

competition and commercial fisheries. Three towns are currently located in the islands on Kunashir, Iturup, and Paramushir. Remote military bases and outposts strung throughout the Kurils, many initially established by the Japanese combatants in World War II, were occupied by Soviet/Russian military personnel until the late 1990s. The end of the Cold War and the economic collapse of the Russian Federation led to the abandonment of most such outposts. Today, only three of four people live regularly between Urup Island and Onekotan (personal observation 2006–2008).

In summary, archaeological evidence shows that the Kurils were more or less continuously and substantially occupied from approximately 3,000 years ago until about 800 years ago. They were used by what appears to have been a much more limited population since that time. It is likely that the human population was concentrated in the northern and southern ends of the islands for the past 800 years, as it is currently. Hence the central islands once again represent a geographical gap in human settlement, as they appear to have done prior to 1900 BC.

### KEY HAZARDS, PAST IMPACTS, AND HUMAN RESPONSES

Geologically, the Kurils are the product of the tectonic collision of oceanic and continental plates at the Kuril-Kamchatka subduction zone. This ongoing process causes relatively frequent volcanic eruptions, earthquakes, and tsunamis that make life challenging for island residents. In addition, the islands are beset by fog much of the year, subject to dramatic storms, and variably packed with winter sea ice. Changes in climate have implications for the frequency of storms and the productivity of the marine ecosystem. Combined with relative isolation, these conditions make the Kurils hazardous for human occupation, especially when population density was low and social networks harder to maintain between isolated settlements (Fitzhugh, Phillips, and Gjesfeld 2011). All of these factors make the Kurils (especially the remote and small central ones) seem as though they would be very risky places for anyone to live, especially hunter-gatherers depending on relatively unproductive ecosystems.

#### Hazard 1: Volcanic Eruptions

There are currently thirty-two known active volcanoes that have erupted at least once in the past 300 years, twenty of them since the end of World War II. While most eruptions are small and disrupt only a limited part of an island, some do produce extensive landslides and pyroclastic flows (slurries of superheated rocks, mud, and other debris) that affect the nearby landscape and ecology. Volcanic ash deposits have less dramatic impacts but can be accompanied by hot and lethal gases that affect organisms living close to an erupting volcano.



1.2. *Eruption of Sarychev Volcano on June 12, 2009, as photographed by the International Space Station. Image courtesy of Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center (ISS020-E-9048; <http://eol.jsc.nasa.gov>).*

Ash can then extend great distances, sometimes visibly layering the ground for tens of kilometers away from the eruption. Some ash deposits can be traced for more than 1,000 km through the Kuril chain as a result of favorable wind direction and sufficient volume of ejected matter. Ash can be mixed with toxic gases, and the sediment itself can be dangerous to inhale in large amounts. With sufficient deposition, volcanic ash will smother out plant growth and delay the return of vegetation cover until the ash itself has weathered into a viable soil (Griggs 1918).

One particularly impressive explosive eruption ( $VEI = 4$ ) occurred during the period June 11–21, 2009, on Matua Island's Sarychev Peak. This eruption caught international attention because of the disruption it caused in flights between North America and East Asia. The eruption, documented by the International Space Station (figure 1.2), caused extensive pyroclastic flows and the partial collapse of the island's northwest face, leading to significant remodeling of coastal geometry. Because the ash plume went high into the atmosphere, ash had limited impact on the ground. Winds carried some of the sulfurous ash cloud east across much of the Pacific and some west across the Sea of Okhotsk, where it dusted parts of Sakhalin Island more than 600 km away. Interestingly, the southern flank of Sarychev Volcano and the adjacent coastal plane, including the location of a prehistoric archaeological site and an abandoned Soviet base, were minimally affected. A thin layer of ash and several



dead voles and foxes observed in this otherwise unaffected southern part of the island in August 2009 provide indirect evidence of lethal toxic gas emissions accompanying the eruption. At the same time, sea mammals and seabirds remained or returned to the island less than a month following the eruption (Nadezhda Razzhegava, personal communication 2009).

The 2009 eruption was one of the two most explosive eruptions in a series of thirteen for Sarychev Peak since 1923. For much of the past century, the now unoccupied Matua Island supported an active military base. While the documented eruptions of Sarychev were oriented away from human settlements and thus did not result in human fatalities, the geological evidence of the southeastern portion of the island suggests different eruption patterns in the past. A minimum of eleven pyroclastic flows and thick tephra deposits have buried that landscape since people started living on the island 2,500 years ago (Fitzhugh et al 2002; Ishizuka 2001). In the more distant past, the entire low-elevation promontory that supported known human occupation, which makes up the southeastern third of the island, was created by one or more massive cone collapses and landslides. Thus the history of this volcanic island supports the conclusion that the area, direction, and degree of impact of any given eruption are variable and unpredictable.

Matua's volcanic history is mirrored on that of other islands throughout the chain. Past flows and landslides have remodeled sections of several islands. Landslides often formed the best low-elevation foundation for subsequent human occupations, demonstrated by archaeological settlements placed on features of former landslides on the smaller islands of Makanrushi, Kharimkotan, and Ekarma. Kharimkotan, for example, has two low-elevation landforms, one on each side, that were created by landslides in the past 2,000 years. Living on the flanks of an active volcano is always inherently hazardous, and most of the central Kurils are little more than volcanic cones with narrow coastal benches suitable for human occupation.

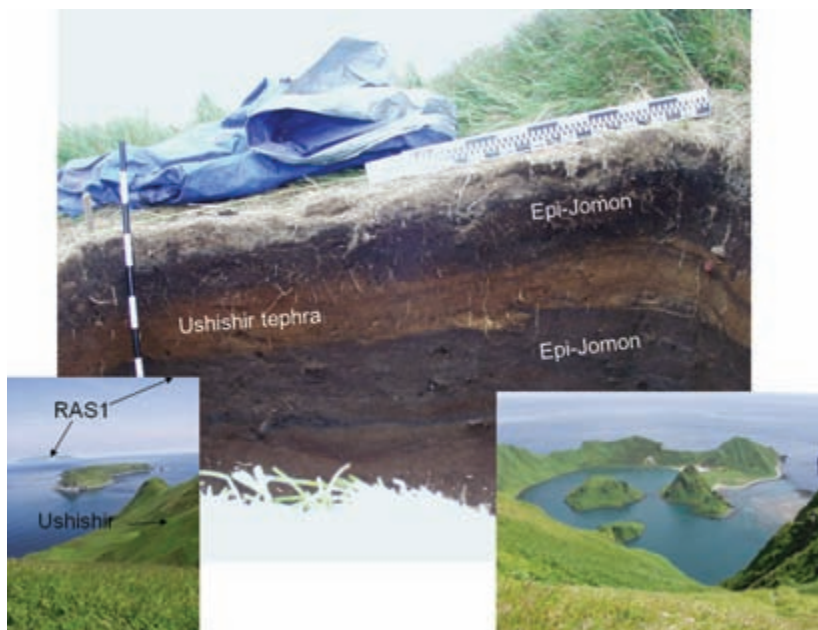
Ash deposits are less hazardous than lava flows and landslides, but they can extend over much greater areas and distances. Ash layers are ubiquitous throughout the Kurils and form one of the primary sources of sedimentary accumulation. Some of the more widespread tephtras are sourced to caldera-forming eruptions in Kamchatka and Hokkaido. Two caldera eruptions occurred in the Kurils in the Late Holocene: the eruptions of Medvezhya on Iturup Island about 400 BC and the eruption of Ushishir, ca. 200 BC.

Regarding the past impacts and responses to volcanic eruptions of the Middle to Late Holocene, based on dated and chemically correlated tephra deposits sampled during the KBP, Mitsuhiro Nakagawa and colleagues (2009) report that eruption frequency and intensity in the Kurils was highly variable during the Holocene. The central Kurils appear to have consistently produced the greatest frequencies of eruptions in all time periods (they contain

a greater proportion of the volcanoes in the chain), compared to the north and south. Major (but comparatively small) eruptions that left limited local ash deposits are found in relatively high frequencies. For example, for the last 2,000 years, Nakagawa and colleagues (2009: figure 7) document nine major eruptions between Kunashir and Chirpoi Islands (southern Kurils), nineteen between Simushir and Rasshua (central Kurils), and more than thirty from Chirinkotan/Shiaskotan to Shumshu (northern Kurils). Small eruptions that left limited local ash deposits are found in relatively high frequencies through time, though declining with age, probably as a result of soil formation processes that limit their identification in older strata. On the other hand, large (plinian- and caldera-forming) eruptions show distinct unevenness through time, with five such eruptions in the early Holocene (9500–6500 rcybp; ca. 8700–5400 BC), a hiatus in the Middle Holocene (6500–4000 rcybp; 5400–2500 BC), and eight in the Late Holocene (4000 rcybp/2500 BC to present). Four of the large eruptions in the Late Holocene occurred between 3,000 and 2,000 years ago during a time of rapid population growth in the Kurils. Population densities appear to have remained high in the Kurils throughout this interval of high volcanic activity, declining dramatically only approximately 800 years ago, long after the most intense volcanic interval had ceased. Thus, at the aggregate scale we conclude that volcanic eruptions posed minimal disruption to the human settlement history of the Kurils. These events might even have helped support human settlement by providing enhanced nutrients to the nearby marine system and stimulating increased biological productivity.

Archaeological evidence of direct volcanic impacts is difficult to confirm. Many archaeological deposits contain volcanic ash lenses preserved within archaeological layers, suggesting that small eruptions had minimal impact on occupation. In cases where archaeological deposits are capped by relatively thick volcanic layers, it is tempting to imagine a cataclysmic destruction of settlements and the abandonment of the location or death of the occupants (see Dumond 2004; Dumond and Knecht 2001). Geoarchaeologically, such conclusions are rarely warranted. Lacking significant agents of deposition other than volcanic eruptions and human activity, the termination of human deposits could have occurred decades or centuries prior to the formation of the volcanic layers that cap them.

This problem is exemplified at the site Rasshua 1 on southern Rasshua Island. Roughly 2,400 years ago, this site was heavily occupied by Epi-Jomon hunter-gatherers. About 2,200 years ago, Ushishir Volcano erupted 25 km to the south, leaving behind a sunken caldera that now constitutes Yankitcha Island. On Rasshua 1, there is an approximately 15-cm-thick layer of pumice-ash that was probably twice as thick before it compressed (figure 1.3). It is easy to imagine a Pompeii-like scene of people fleeing and becoming asphyxiated in the ash and gas, but in fact we do not know if people were even present on the



13. *Composite photo collage in which the outer/lower frames show the caldera rim of Ushishir Volcano with Rasshua Island in the distance. The central image shows the 20-cm-thick, 2,000-year-old Ushishir volcanic ash layer found in excavation on Rasshua Island sandwiched between Epi-Jomon archaeological strata (Rasshua 1, Test Pit 2). Ushishir photos by Volodimir Golubtsov; inset photo by Ben Fitzhugh.*

site at the time the eruption occurred. Cultural deposits are also superimposed above this thick tephra layer. Radiocarbon ages from above and below bracket the tephra between  $1990 \pm 30$  rcybp (OS-67131) and  $2430 \pm 25$  rcybp (OS-67086). Currently, we cannot say when the Ushishir tephra fell within this interval. If at the beginning, it could have been the event that forced an abandonment of the site. Additional radiocarbon dates may help reduce this interval. Unfortunately, the lack of precision of radiocarbon dating will continue to put limits on the certainty with which we can link archaeological and geological events based on these kinds of data. Only rarely are archaeologists fortunate enough to find direct and unequivocal evidence of volcanic impacts in the form of evidence of catastrophic mortality (e.g., Cooley 2003) or structural damage from ash deposition preserved in ash molds (Shimoyama 2002).

What we can conclude from the Kuril evidence so far is that the small-, medium-, and large-scale eruptions between 3,000 and 1,000 years ago deterred human occupation in the Kurils little, if at all. The islands may have been abandoned for intervals following major eruptions and ash deposition,

but reoccupation proceeded apace within at most a few hundred years. Ecosystems were likely damaged locally by the larger eruptions, depending on the character of landscape modification and burial of surface vegetation, but the ecological effects beyond individual islands or even on different parts of the erupting volcano often remained minimal. On balance, volcanic ash deposits probably improved plant productivity on land and phytoplankton productivity in the water more often than not (Griggs 1918). There is no evidence that people exercised specific settlement strategies to minimize the risks of volcanic impacts. While it is likely that eruptions occasionally destroyed settlements and resulted in human deaths, these factors were insufficient to discourage or shape patterns of human settlement. Volcanic hazards were tolerated by maritime hunter-gatherers throughout occupation history.

### **Hazard 2: Earthquakes and Tsunamis**

Earthquakes are most hazardous for people living in large, brittle, and tall buildings or dependent on a fixed infrastructure (Sheets, this volume). Prior to the mid-twentieth century, occupants of the Kurils lived in semi-subterranean pit houses or, in very recent times, single-story aboveground log structures, and the most direct hazard from earthquakes would have been localized landslides in locations where the lay of the land forced settlements up against steep hillsides. More significant, large subduction zone earthquakes often cause major tsunamis that affect coastal occupants and the ecosystems they depend on. In November 2006, four months after the completion of the first KBP field expedition, a major earthquake near the central Kurils sent tsunami waves onshore throughout the region, reaching as high as 20 m above normal high-tide level (MacInnes et al. 2009b). These waves inundated one of our (fortunately abandoned) 2006 summer outpost camps. A slightly smaller earthquake and tsunami followed in January 2007 in the same region. The combination of these events damaged much of the coastline, moved large rocks and concrete bunkers from World War II, and ripped up shallow subtidal and intertidal ecosystems.

The KBP research has shown that tsunamis of this magnitude occurred throughout the Middle to Late Holocene. Sand deposits sandwiched between peat and tephra layers at elevations above storm wave levels testify to these past events. Modeling and geological evidence suggest that the Pacific coasts facing the Kuril-Kamchatka trench were most prone to this hazard, as compared to the Okhotsk (western) coasts. Perhaps as a result, we found most archaeological sites on the Okhotsk sides of islands, though this could in part also reflect sampling bias, given greater opportunities to land and survey on the calmer Okhotsk Sea sides of islands. More significant, most archaeological sites were located on elevated landforms, between 20 and 40 m (and in one extreme case

at 100 m) above sea level atop terraces fronted by steep banks. While archaeological sites located closer to shore on beaches or low platforms near good landings could have been selectively lost to erosion, it seems likely that the high elevation of existing archaeological sites throughout the Kurils reflects a strategy for mitigating the hazards of tsunamis.

For mariners making a living from the sea, tsunamis also posed a hazard to boaters working in shallow water or at the shore at the time of a tsunami strike. As with volcanic events, people undoubtedly perished from tsunamis and, unless their wooden dugout vessels were carried to the tops of terraces, they sometimes lost their boats. Ecological damage as a result of tsunamis remains unquantified, but tsunamis probably have significant if not long-lasting impacts on the ecological productivity of littoral zones. On the other hand, tsunami disturbance on Pacific coasts combined with more protected “buffer” zones on Okhotsk Sea sides contributes resilience to the system at the scale of islands and larger regions. As long as populations did not get too large, these occasional impacts would have only required modest relocation, not island abandonment.

While our research has not provided any evidence of direct tsunami impacts on human settlements, the persistence of what appear to be substantial populations throughout the central islands during the Late Holocene in spite of evidence of major tsunamis on the order of once every 500–1,000 years suggests that tsunami events themselves caused little, if any, change in the course of human settlement history or culture. The one adaptive response evident in our data is placement of settlements on high terraces and in more protected locations.

### **Hazard 3: Weather and Climate Change**

Somewhat less catastrophic, but potentially no less hazardous, are unpredictable changes in weather and climate that could affect the ability to navigate the islands and potentially alter the productivity of the marine environment. Weather is used here to indicate daily to annual patterns of atmospheric conditions, especially as they interact with the sea surface and marine currents to produce changing fog, surf, and wave patterns, which are inherently hazardous in this oceanic landscape. The Kurils are statistically the foggiest place on earth, and it is rarely possible to see the horizon and often, in fact, little more than the boat in which one is sitting. Modern navigators, including KBP scientists, rely almost entirely on GPS and navigational charts to find their way through the Kurils. Earlier mariners had to learn the landscape more or less by feel and read clues in the waves and currents, birds, and marine organisms to move between and along islands. Fog is most prevalent in summer months when storms are less frequent and less severe.

Large storms pass through the Kurils year-round but with particular intensity between September and May. Winter storms are more violent and bring hazardous sea ice and other debris into the Sea of Okhotsk and the southern (and sometimes northern) Kurils. Boat landings in storms are particularly perilous and would have been exceedingly challenging on many of the smaller islands, with little or no protection from wind and swells. Storm waves and wind can push large logs and ice high up the beach and onto low coastal benches or terraces, creating hazards for beached boats and any residences placed too close to sea level. Understanding how weather and currents interact to create dangerous conditions would have been a prerequisite to settling the central Kurils for any past colonists.

Changes in the patterns, frequency, and intensity of weather over periods ranging from decades to millennia constitute climate change. Changes at these scales altered the dynamics of storminess, the hazardousness of travel, and productivity of the marine ecosystem in ways that should be reflected in human adaptations and possibly in changes in the nature of settlement, as they affect the sustainability of the food supply and the maintenance of social networks through the islands (discussed later). In cold climates, the North Pacific low-pressure system tends to intensify, causing strong northerly winds to accelerate the Oyashio Current that brings nutrient-enriched cold Arctic waters south from the Bering Sea to the Kurils (Qiu 2001).

This same mechanism intensifies the counterclockwise circulation of the Sea of Okhotsk, bringing iron-enriched waters from the mouth of the Amur River to eastern Hokkaido and the southern Kurils. In warmer climate periods the Oyashio Current, including the Okhotsk gyre, weakens, and a more stratified surface layer limits the degree of nutrient enrichment available for photosynthesis and primary production (*ibid.*). The North Pacific low-pressure system is strongest in winter months when light is least available in the subarctic waters of the Kurils and the Sea of Okhotsk. As a result, increased winter mixing actually tends to reduce primary productivity by limiting the penetration of available light into the water column, despite availability of nutrients. In the south, off the east coast of Hokkaido and the southernmost Kurils, where winter light is stronger, primary productivity correlates with Oyashio Current strength (Chiba et al. 2008). While the mechanisms are still to be fully understood (e.g., Schneider and Miller 2001), primary productivity overall should be enhanced in the southernmost Kurils/Hokkaido in cold periods, while in the central and northern Kurils primarily, productivity is actually observed to increase somewhat in warmer periods when spring light returns to the region (Chiba et al. 2008; Heileman and Belkin 2008). Thus, in a general way we can expect that cold climates would have enhanced the biomass available for maritime hunter-gatherers in the southern Kurils, while warmer climates could have made these islands less attractive. On the other hand, warm climate declines in

productivity in the south could have drawn people farther north to the modestly productive central and northern islands.

A combination of climate proxies from Hokkaido (Tsukada 1988; Yamada et al. 2010), the mainland surrounding the Sea of Okhotsk (Korotky et al. 2000), and marine cores in the Sea of Okhotsk (Kawahata et al. 2003) leads us to believe that climate changes occurred on the order of every 600–1,200 years over the past 2,500 years. Records are not perfectly correlated between sources but generally show reversals of climate from warm to cold (ca. 400 BC) to warm (between AD 200 and 800) and then to cold (AD 1200), shifting to warm again in roughly AD 1800. These conditions should have translated into changes in the marine productivity of the Kurils, but these factors did not generate consistent responses in human settlement history.

According to the productivity expectations discussed earlier and assuming that food was the limiting factor in human population densities following colonization, during colder climate phases we would expect the southern Kurils to have been most densely populated during the intervals between 400 BC to AD 200–800 and between AD 1200 and 1800, while the central and northern islands should have seen population expansion in the warmer phases. In fact, the first major population explosion throughout the archipelago occurred during the major cold phase of 400 BC to AD 200 and continued through the following warm phase. On the other hand, the AD 1200–1800 cold phase corresponds to what appears to be a near abandonment of the central Kurils as discussed earlier, in contrast to expectations. Whether we expect population expansion into the central and northern Kurils to be driven by crowding in the south (because of high productivity there) or by the relative benefits of marginally better foraging to the north during warmer periods, the historical patterns are inconsistent with expectations. Clearly, climate change is an insufficient—though probably contributing—causal variable in the changes observed (cf. Hudson 1999).

#### **Hazard 4: Socioeconomic Isolation and Integration**

In the context of the hazards already outlined, the more isolated Kuril Islands produce another kind of hazard for human settlers—that of social isolation and greater difficulties in maintaining vibrant networks for critical information flow, marriage alliances, and support in times when local conditions deteriorated in any part of the archipelago (Fitzhugh, Phillips, and Gjesfeld 2011). Social networks are easier to maintain when population densities are higher and settlements are closer together. In the central Kurils, maintaining networks between small and distant islands required more costly expeditions, which were all the more essential given the hazards of isolation. These connections would have linked the Kurils economically and socially with the more

densely populated regions of Hokkaido and Kamchatka. These links, then, also tied the Kurils to the broader socio-political and economic “world systems” of these larger regions (Hudson 2004). These links, in turn, provided useful materials (like obsidian: Phillips and Speakman 2009) and information. They also engaged the occupants of the Kurils in broader flows of economic and political relations. These connections, essential as they were for reducing the negative consequences of geographic isolation, also tied the islanders to the broader historical patterns of the region and made them potentially vulnerable to socioeconomic and political changes beyond the Kurils.

The more interesting dynamics in this context occurred to the south of the Kurils, where Hokkaido served as the last substantial enclave of the Jomon hunter-gatherer-fisher tradition after rice agriculturalists took over the rest of the Japanese archipelago. Despite the expansion of agricultural populations south of Hokkaido around 500 BC, there is little evidence that Kuril occupants were drawn into substantial long-distance economic interdependencies. In this regard, we consider the Kuril occupants of the Jomon and Epi-Jomon periods to have been largely self-sufficient, while relying on neighbors primarily for security in times of local hardships. This situation changed between AD 700 and 1000 with the Okhotsk settlement. Okhotsk people were connected by economic exchange with Manchuria and may even have been motivated to expand around the Sea of Okhotsk and into the Kurils by the desire to provide valuable furs to the East Asian markets (Hudson 1999). At the same time, Japanese markets stimulated the expansion of the northeastern frontier, gradually drawing northern Honshu and eventually Hokkaido into lucrative trade relations. As southern products such as iron pots, lacquer-ware bowls, and firearms were traded north, northern products such as seal furs, eagle feathers, and salmon were passed south. Political powerbrokers emerged to control this trade, eventually imposing stringent demands on indigenous hunters for increased production of tradable commodities. This development and a somewhat parallel process from the north ultimately led to Japanese and Russian competition for control of the Kurils and the ejection of Kuril Ainu from the archipelago (Walker 2001).

Social connectedness with Hokkaido and Kamchatka appears to have had different implications for Kuril occupants through time. In general, Kamchatka appears to have been a source of obsidian for central and northern Kuril islanders (Phillips and Speakman 2009), despite stronger cultural affiliations to the south. We currently have no evidence for adverse impacts resulting from these northern connections and indeed can speculate that connections with the north may have proved beneficial for Ainu during the interval AD 1200–1800, when increased pressure was mounting on the southern Kurils for commodity production. The dearth of Ainu settlements in the central Kurils could reflect a relocation to the north by Ainu eager to escape the political and economic



pressures of ruthless traders to the south. In the southern Kurils and Hokkaido, pressure put on Ainu for commodity production eventually resulted in a number of revolts—most famously one on Kunashir in 1789 that was put down by Japanese military force, marking a turning point in direct Japanese interest in the Kuril Islands (Walker 2001).

It appears that the major impact to successful hunter-gatherer settlement in the Kurils is as much or more social as it is environmental. During Okhotsk settlement, the Kurils were at least marginally connected to an expanding mercantile system of exchange in marine products with mainland East Asian polities. The warmer and wetter climate may have encouraged expanding human populations and the exploitation of a productive niche for marine mammal hunting. Okhotsk people may have colonized the Kurils more as entrepreneurs capitalizing on a lucrative natural resource zone than as a “naturally” expanding population simply looking for new subsistence opportunities. Whether they pushed Epi-Jomon peoples out or assimilated them is yet unclear.

A colder climate—perhaps with lower productivity in the more remote and least ecologically diverse central islands—in combination with a growing political economy to the south, drawing Kuril populations into expanding economic ties with power centers in Hokkaido and mainland Japan, seems to have had the effect of precipitating the relative abandonment of most of the Kurils. In this context we can expect that the central and northern Kuril Ainu took advantage of the geographic characteristics of the Kurils to create isolation from undesirable networks to the south. Following Russian incursion into the northern islands, this process was exercised in reverse when a group of northern Ainu relocated to the central island of Rasshua to escape Russian taxation demands (V. O. Shubin, personal communication 2008).

### RESILIENCE AND VULNERABILITY

These comparisons lead us to broader considerations of human vulnerability and resilience in small-scale, mobile hunter-gatherer populations compared with larger and more densely packed, sedentary, territorial, and infrastructurally rooted populations such as those examined in the remainder of this volume. Several conclusions can be drawn from the Kuril case study.

First, it is becoming clear that natural hazards in the Kurils had relatively little impact on the viability of occupants, once they had developed the capacity to settle and make a living in the islands at all. This is consistent with Sheets’s (1999) argument that small-scale societies tend to be most flexible in the face of environmental “catastrophe.” While this conclusion is consistent with general expectations for mobile populations living in low population densities, it is somewhat surprising in an environment like the Kurils, which by all expectations should have held hunter-gatherer populations close to the edge

of sustainable settlement. The evidence does not currently support a notion of the Kurils as marginal in this fashion, though we cannot yet explain why Epi-Jomon and Okhotsk populations abandoned the island chain 1,300 and 800 years ago, respectively—if in fact they did. Perhaps environmental crises played some role as catalysts in weakening resident populations' holds and opening up the islands for a change of occupants.

Second and perhaps more interesting, the Kuril case highlights the importance of *socio-ecological* dynamics in the history of human settlement. We are coming to see Kuril history, as in other parts of the world, as fundamentally reflecting a complex integration of social, political, and economic factors interacting with environmental and geographical ones. Hunter-fisher-gatherers in the Kurils were not “complex hunter-gatherers” in the organizational sense used to refer to ethnographic peoples of the North American Pacific Northwest (Ames and Maschner 1999), the Channel Islands off California (Arnold 1996), the Calusa of Florida (Marquardt 1988), or the Middle Jomon of northern Honshu (Habu 2004). They lived in smaller groups and worked out their subsistence needs and procured tradable commodities in an ecologically limited and geographically challenging oceanic environment, but they maintained social and economic contacts throughout and beyond the chain and came to use the island geography strategically and politically as it suited them. They suffered the consequences of localized natural disasters, but their lifestyles and persistence in the Kurils appear to have been highly resilient to such factors. From a settlement perspective, the vulnerability of Kuril occupation (though not necessarily of the occupants) therefore seems to lie more in Kuril occupants' social interdependence with the outside world and ultimately in the contingency of expanding political powers that took interest in controlling the Kurils' natural fur wealth through territorial acquisition.

## CONCLUSION

Vulnerability and resilience provide a framework for considering the ways small-scale hunter-gatherer populations may be affected by hazards in the natural environment. In this chapter I have shown that the occupants of the Kuril Islands of Northeast Asia were surprisingly resilient to natural events such as volcanic eruptions, earthquakes, tsunamis, and climate variability but less resilient ultimately to outside pressures from competing groups and expanding demand for Kuril commodities. The result is a richer and more nuanced story of socio-ecological dynamics only starting to emerge from the data produced by the Kuril Biocomplexity Project's years of interdisciplinary research.

The value of this emerging picture for contemporary hazard management is not that small and mobile societies are more resilient to natural hazards, though that is clearly one conclusion. Societies of the twenty-first century do

not have the luxury of returning to states of such flexibility. The implication is rather that vulnerability is inherently a complex socio-ecological condition. Ironically, the near abandonment of the Kuril Islands and ultimate extinction of Kuril Ainu populations in recent centuries are products of the *increasingly* interconnected and global scale of socio-political and economic interaction. The Kurils are actively contested in international disputes between Russia and Japan, but on the ground they are a backwater of the civilized world, squeezed of their cultural, economic, and geopolitical vitality in times past by changes in the currents of global politics. Geologically and ecologically as active as ever, these islands sit largely abandoned, waiting for the next cycle of human interest and activity.

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## **UNDERSTANDING HAZARDS, MITIGATING IMPACTS, AVOIDING DISASTERS**

### **Statement for Policy Makers and the Disaster Management Community**

Hazards exist everywhere, and in many cases it is impractical to avoid them. The question to ask is, how can lessons from the past help us see what succeeded and what did not? What worked in the Kurils was a deep historical knowledge about the frequency and potential extremes of hazardous events so people could live in the least vulnerable places, maintain capacities for flexible response to catastrophes when they occurred, and maintain resilient and redundant infrastructures. Extrapolating from the archaeological Kuril situation to modern communities, with their higher population densities, heavier infrastructural requirements, and critical dependencies on non-local resource distribution networks, we can conclude that hazard planning has to include capacity building for decentralized response systems. Families, households, and local communities need to have the ability to respond creatively, with decision decentralization supported by higher governmental institutions so responses can scale with capacity. This also requires systems for rapid and decentralized information sharing.