

Human resilience and resettlement among the Islands of Four Mountains, Aleutians, Alaska

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Abstract

Combined archaeological, ecological, and geologic research on Chuginadak and Carlisle Islands in the Islands of Four Mountains (IFM) probed questions about the sustainability of human settlements over the past 4000 years in the face of geologic, ecological, and social hazards. We use a human ecodynamics approach to frame the investigation and present original archaeological evidence from this poorly known region of the remote Aleutian Islands. Several village sites occupied during the last four millennia are clustered in locations that were not damaged by earthquake-induced tsunamis; however, new geologic evidence indicates that at least one volcanic eruption forced humans to abandon one or more prehistoric village sites. Combined archaeological, ecological, and geologic analyses demonstrate resilient UnangaꝻ occupations of the IFM through long-term climate change as well as earthquakes, tsunamis, and volcanic eruptions with occasional community vulnerability to volcanic eruptions.

Keywords: Four Mountains; Aleutians; Archaeology; Prehistory; Radiocarbon dates; Resilience; Volcanism

INTRODUCTION

Among the 163 islands of the Aleutian chain, the Islands of Four Mountains (IFM) have among the steepest peaks with the smallest landmasses (Persico et al., 2018), one of the most persistently active volcanoes throughout the Holocene (Neal et al., 2015; Okuno et al., 2016, 2017), and a location known for generating devastatingly massive earthquakes in recent times (Johnson et al., 1994; Ruppert et al., 2007; Griswold et al., 2018). Long distances isolate the IFM from the larger landmasses and villages of adjacent island groups. Collectively, the small size and isolation limited ecosystem diversity, as shorter shorelines, fewer reefs, and smaller inland areas reduced foraging possibilities. Here we introduce and synthesize the results of our team whose research focused specifically on how paleoenvironmental conditions facilitated and/or challenged human arrival (Kuzmicheva et al., 2019;

Persico et al., 2018), how frequently geologic hazards imposed cultural responses (Okuno et al., 2017; Griswold et al., 2018), how people sustained themselves between and during hazardous events (Admiraal et al., 2018; Persico et al., 2018; Johnson, 2018; Rojek and Williams, 2018; Krylovich et al., 2019; Kuzmicheva et al., 2019; Vasyukov et al., 2019), and the duration of the hazardous impact in the archaeological record (Hatfield et al. 2016; Krylovich et al., 2019).

Our interdisciplinary team conducted research in the IFM to understand the resilience of Four Mountains people in an environmental setting with potentially limited resources and in response to both abrupt and long-term changes. Any indication of how frequently geologic hazards imposed cultural responses, how people sustained themselves between and during hazardous events, and for what duration exists in the archaeological record. To determine this resilience, we relied on archaeological data—the stratigraphic deposition at each site and the radiocarbon determinations—combined with the various contributions by our research team that included geologic research on tephra deposition, geologic research

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into site formation processes at the archaeological sites, zooarchaeological analysis of animal remains from archaeological middens, and isotope data from peat deposits.

During the summers of 2014 and 2015, our international team of archaeologists, ecologists, and geologists conducted interdisciplinary research in the IFM of the Aleutian Islands (Fig. 1). Separated from the Fox and Andreanof Islands by Samalga Pass and Amukta Pass, respectively, the IFM are composed of eight volcanic islands: Amukta, Chagulak, Yunaska, Herbert, Carlisle, Chuginadak, Kagamil, and Uliaga. Investigations targeted nine archaeological sites on Chuginadak, Carlisle, and Herbert Islands that consisted of intensive excavations at SAM0014, AMK0003, and SAM0016, and exploratory shovel testing and survey at SAM0047, SAM0031, SAM0034, SAM0035, SAM0017, and AMK008 (Fig. 2). This article presents ecological and geoarchaeological data from these IFM village sites to explore the vulnerability and resilience of their occupants to the ecosystem variability, climate change, volcanic eruptions, and tsunamis over four millennia of human occupation.

Historical, ethnographic, and archaeological background

The Russian treatment of Unanga̋ that followed Vitus Bering's expedition for the Russian Empire and subsequent interactions with the *promyshlenniki* (Russian fur traders) was harsh, particularly during the AD 1761–1762 hunting/trapping season. The Aleut people of the Four Mountains, Umnak, Unalaska, and Akutan Islands banded together to defend themselves against Russian fur trappers and traders

in what is now known as the “Aleut Revolt” (Laughlin, 1980, p. 128). In retaliation, circa AD 1763–1764, the Russians returned and destroyed Unanga̋ villages in the Four Mountains, on Samalga, and on the south side of Umnak (Laughlin, 1980, p. 128; Black, 1984, p. 86). In some accounts, this retaliation was done at the request of Umnak Aleuts (Veniaminov, 1984). Whatever the cause, in the IFM, the Russians killed nearly all of the men, while women and children either starved or were relocated to Umnak Island possibly as late as AD 1767 (Black, 1984, p. 44). By the AD 1770s, no Unanga̋ permanently inhabited the IFM (Veniaminov, 1984, p. 251), although fox trappers periodically used the islands until well into the twentieth century (Bailey, 1993).

Further historical accounts include that of James Cook and his crew who, while seeking the Northwest Passage during their third global voyage, visited the Aleutians in 1778, spending most of their time on Unalaska and mapping the IFM in passing (Hayes, 1999). By the time of Cook's third voyage, the Unanga̋ had not inhabited the IFM for almost a decade. In 1781, threatened by this English encroachment, Russian explorers produced a map of their Aleutian voyages, crudely depicting the IFM (Lovtsov et al., 1991). Also in response to English intrusion, Russia launched the Billings Expedition between 1785 and 1795, which created new, more accurate maps of the Aleutian Islands that included the IFM (Jones, 2014). During the 1830s, Father Veniaminov recorded the culture, geology, and natural history of the eastern Aleutians that documented the IFM (Veniaminov, 1984). From his work, we gain our richest knowledge of the IFM less than 70 years after indigenous people last inhabited these islands. In addition, stories passed down through the

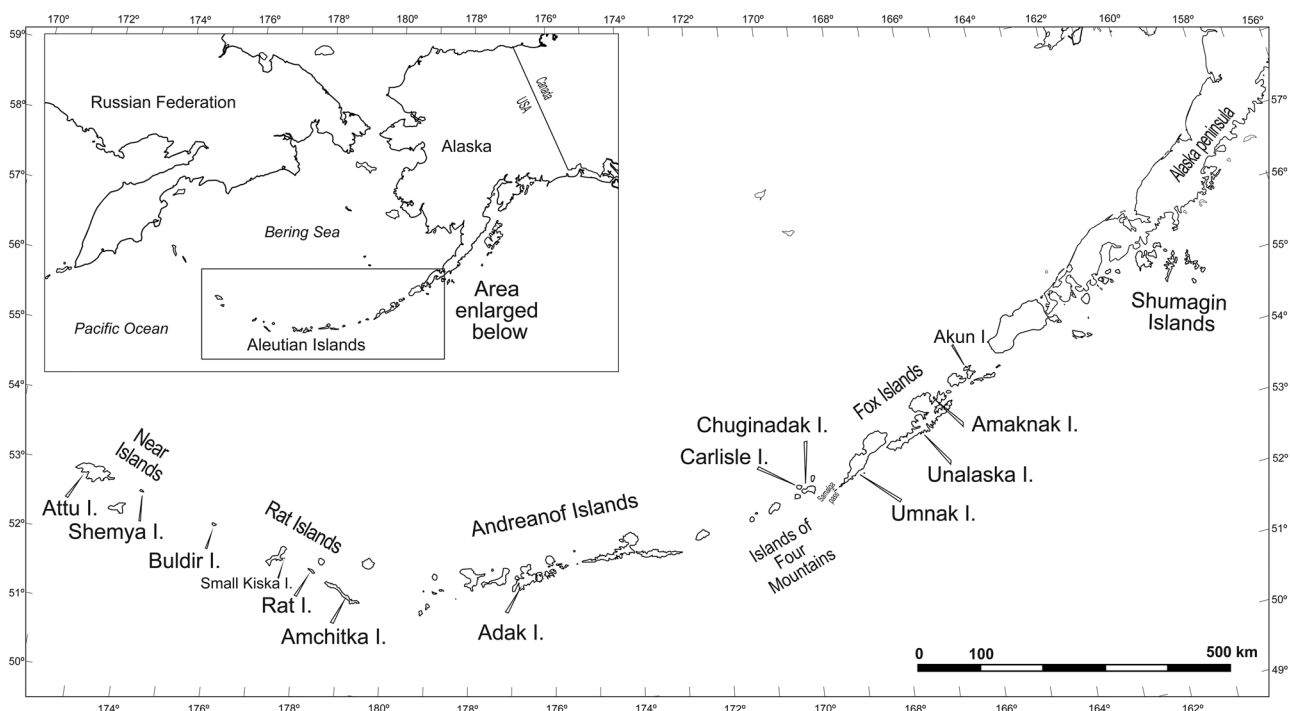


Figure 1. Map of the Aleutian Islands showing study area.

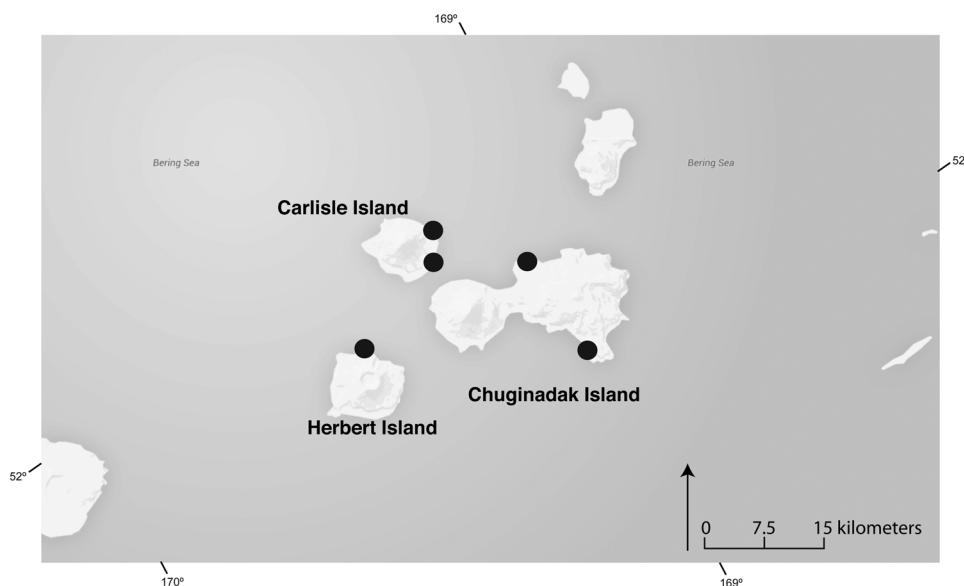


Figure 2. General locations of sites investigated in the Islands of Four Mountains.

generations provide some insight into what life was like in the Four Mountains, which include a story about starvation (Galaktianoff, N., Sr., “Lucky Charms: A Story from the Islands of Four Mountains,” recorded by Golodoff, S., Sinnott, K., Alaska Humanities Oral History Project with the Unalaska School; Golodoff, S., personal communication 2018).

Early archaeological investigations in the IFM were poorly documented (Dall, 1878; Jochelson, 1925) or focused almost exclusively on the richly appointed human burial caves for which the islands are famous (Hrdlička, 1945; Bank et al., 1950; Bank, 1953, 1956; Laughlin, 1980). McCartney (1972) conducted the first formal survey of the IFM, identifying 12 sites among the eight islands. Under the Alaska Native Claims Settlement Act (ANCSA), the U.S. Bureau of Indian Affairs (BIA) conducted mapping of surface features and surface collecting of 15 IFM village sites (Cooper, 1991; Fogarty, 1991a, 1991b; O’Leary, 1993a, 1993b, 1993c; Turk, 1993). These reconnaissance studies recovered a small amount of material and obtained a few radiocarbon dates (Hatfield and West, 2013; Hatfield et al., 2016). The archaeological site locations were ultimately conveyed to the Aleut Corporation and remain their property today. The BIA reports reveal how little we know about the Four Mountains archaeological record. This limited surface snapshot of Four Mountains cultural history is incongruous with the more robust eastern and central Aleutian ecological, oceanographic, and geologic data (e.g., Byrd et al., 2005; Call and Loughlin, 2005; Hunt and Stabeno, 2005; Ladd et al., 2005; Mordy et al., 2005; Nicolaysen et al., 2003, 2005; Pekar et al., 2005; Meleney et al., 2008; Tremayne and Brown, 2017).

Ours is the first interdisciplinary research program in the IFM region to bring more modern, interdisciplinary research tools and methodologies previously employed on other North

Pacific island groups (e.g., Fitzhugh, 2003; Maschner et al., 2009; Corbett et al., 2010; West et al., 2012). By design, our investigation sought a deep temporal understanding of Four Mountains prehistory through documentation of the stratigraphic relationships between anthropologically related features and artifacts with natural deposits. Summarizing initial results of Hatfield et al. (2016), the 2014 field season established radiocarbon evidence for four components at SAM 0016 located on southern Chuginadak: one date between 3275 and 3444 cal yr BP (see Supplementary Tables 1 and 2), one date between 792 and 912 cal yr BP, two dates between 550 and 680 cal yr BP, and one date between 293 and 421 cal yr BP (Supplementary Table 1). Isolated shovel tests at three other sites yielded a few dates contemporary to these components. Along the northeast part of Carlisle Island, SAM0017 dated between 3338 and 3545 cal yr BP. The shovel test profile and radiocarbon date from the newly discovered SAM0047, located on the northern side of Chuginadak, revealed a single occupation component dating between 791 and 914 cal yr BP. Finally, two dates were obtained from shovel tests on Herbert Island both indicating one occupation between 315 and 464 cal yr BP. Combining the 2014 results (Hatfield et al., 2016) and the new results presented by this study allows the first assessment of landscape level settlement to address questions of continuity and resilience during periods of abrupt environmental change during the last ~4000 years.

We use a human ecodynamics approach (Walker and Salt, 2006; Crumley, 2007; Kirch, 2007; Fitzhugh, et al., 2018; Hutchinson et al., 2018), drawing on resilience theory and historical ecology, to interpret human occupations in the Four Mountains—their ability to respond to natural disasters and to long-term environmental changes, as well as to the ecological variability in their ecosystem (Kirch and Hunt,

1997; Lawson et al., 2005; Erlandson and Fitzpatrick, 2006; Moss et al., 2006; Walker and Salt, 2006; Crumley, 2007; Fitzpatrick and Keegan, 2007; McGovern et al., 2007; Rick et al., 2008; Butler et al., 2018a, 2018b; Hutchinson et al., 2018). Kirch (2007) utilized environmental archaeology, geography, anthropology, and ecology to investigate the interwoven relations between humans and their environment in Hawaiian archipelago. Similarly, our goal is to understand the occupation on the Four Mountains within the context of the geologic events (volcanic eruptions and tsunamis), long-term ecosystem and climate fluctuations, and prehistoric subsistence strategies to look at how the IFM shaped resilience and vulnerability. Similar to the research by Barton et al. (2018) in the central Alaska Peninsula, in this article, we focus on the occupation history evidenced by the stratigraphic and radiocarbon evidence to understand human resilience or vulnerability through time in the IFM in the face of volcanic eruptions (Okuno et al., 2017), site formation processes (Persico et al., 2018), climatic changes (research which is ongoing, but see Savinetsky et al. [2010]), and tsunamis (see Griswold et al., 2018), among other environmental/human relationships.

METHODS

This research project used standard archaeological, ecological, and geologic procedures to collect cultural, biological, and geologic samples from prehistoric village sites on Carlisle, Chuginadak, and Herbert Islands to gain information about (1) shifts in faunal compositions across time and space, (2) changes in material culture over time, (3) the eighteenth-century Russian/Aleut conflict, and (4) impacts of, and reactions to, geologic processes including volcanic eruptions and major subduction zone earthquakes. A wide array of information resulting from these methods is not included herein (i.e., material culture change over time); however, for this article, we focused on the stratigraphic evidence of occupations in the Four Mountains. During 2014 and 2015, we shovel tested several sites (SAM0047, SAM0016, SAM0031, AMK0003, and AMK0008), excavated units at three sites (SAM014, SAM016, and AMK003), and extracted samples from vertical and horizontal exposures that included charcoal, artifacts, faunal remains, ecofacts, soil samples, and sediment cores from four sites (SAM0014, SAM0017, SAM031, and AMK003). One outcome of this reconnaissance is that our team recorded a new site (SAM0047) on Chuginadak Island. The amount of material recovered from each of the nine sites varied by the intensity of investigation.

To understand the role the IFM people played in the larger prehistoric Aleutian theater, we focused on two village sites: SAM0014 (Tana Aguna) on Chuginadak Island and AMK0003 (Ulyagan) on Carlisle Island. Excellent natural exposure of the stratigraphy in deep gullies and beach cliffs flanking sites allowed our team to investigate long habitation sequences without requiring excavation of large horizontal areas. This approach was both efficient, given limited field time, and sensitive to the impending loss of cultural material

because of erosion. At sites on Chuginadak and Carlisle, we sampled natural stratigraphic layers to identify past volcanic and geomorphological events (see Persico et al., 2018).

At both sites, we identified chipped and ground stone artifacts, bone tools, sedimentary layers, volcanic tephra, faunal remains, and charred plant remains. The W.M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory, University of California, Irvine, dated materials from SAM0014, SAM0016, SAM0017, SAM0047, AMK0003, and AMK0008, as well as AMK0009 (Supplementary Table 1). Conventional ^{14}C ages were calibrated to “calendar” years in the CALIB 7.1 program (<http://calib.org/calib/>) using calibration curves IntCal09 for terrestrial material and Marine13 for marine material (Stuiver et al., 2017). Sediment from a profile at SAM0014 and at AMK0003 was characterized using grain-size and micromorphological analyses.

RESULTS

At Tana Aguna (SAM0014) and Ulyagan (AMK0003), we investigated the stratigraphy, material culture, occupation history, and volcanic eruptive histories. Both sites are large villages intermittently occupied over the last four millennia. Tana Aguna (SAM0014) is a village characterized by small to medium oval surface features similar to most Aleutian prehistoric villages. In contrast, Ulyagan (AMK0003) has fewer small to medium oval features and is instead characterized by L-shaped longhouses and *umqan* features (large A-shaped trenches) that are similar to those excavated by Veltre and McCartney (2001) at Reese Bay, on Unalaska, 150 miles west of the IFM. Faunal evidence suggests year-round occupations of these sites (Krylovich et al., 2019). We recovered chipped stone projectile points, bifacial knives, flake tools, burins, ulus, among other chipped stone, bone, and ivory tool fragments, debitage, and debris. Supplementary Tables 1 and 2 compile the radiocarbon dates obtained from six sites, including paired samples for determination of the marine reservoir effect (West et al., 2019). Supplementary Tables 2 and 3 list the recovered materials by site, unit, and level.

Tana Aguna (SAM0014)

This north Chuginadak village is situated roughly 30 m above sea level (m asl) on an alluvial fan at the base of Tana volcano 11 km east of Cleveland (known as Chuginadak in Unangan Tanuu) volcano. This site has 67 mapped cultural features (house and other depressions) within an 80 m diameter area (O’Leary, 1993a). These are predominantly oval depressions. We recovered abundant faunal remains in addition to bone, ivory, chipped stone, and ground stone artifacts from two excavated units (1 × 2 m in size) and one profile exposure (Supplementary Table 3; also see Krylovich et al. [2019] for faunal discussion). Eighteen radiocarbon dates range between 300 and 3800 cal yr BP (Supplementary Tables 1 and 2). Five of these dates were from crowberry (*Empetrum nigrum*)—a local woody plant used as fuel for a fire at the

time of occupation, thus directly dating human activity. Other radiocarbon-dated samples include three from terrestrial feeding goose (*Branta hutchinsii*) bones, found in midden layers, which similarly reflect time of occupation and do not require correction for the marine reservoir effect. We selected bones of Irish lord fish (*Hemilepidotus* sp.), which require correction for the marine reservoir effect given their marine feeding environment. Using these terrestrial and marine paired dates, a correction factor, 495 ± 20 yr, was developed to adjust for the marine reservoir effect in the Four Mountains region (West et al., 2019). Another eight dates were obtained from unidentified species of wood (charcoal), handpicked from the stratigraphy, and useful for interpreting human occupation and environmental response choices. These samples, however, may include driftwood collected from beaches by the inhabitants and/or include “old wood” portions of trees (the inner rings of trees that stop exchanging carbon after they are laid down). Both such samples potentially are older than the occupation layer in which the wood was found and thus may not correlate with stratigraphic relationships determined using the native terrestrial crowberry, the terrestrial goose bones, and the corrected fish bones.

The stratigraphy at Tana Aguna (SAM0014) is interpreted based on two unit excavations and one profile exposure. Unit 1 is a 0.5×1.5 m unit on the edge of house pit 1 and excavated to 105 cm below the surface (cmbs). Deposits included unsorted cultural fill (silty loam) above a midden (Fig. 3). The cultural fill is associated with a single calibrated date (307–459 cal yr BP) taken from 60 cmbs (Supplementary Table 1). This layer of unsorted cultural fill is redeposited from either roof fall or house construction. Midden deposits are below this layer, which Krylovich et al. (2019) group into two depositional components: (1) an upper midden with sea urchin (*Echinus*) and shellfish remains and (2) a lower midden with some invertebrate remains. The upper shell midden includes layers A and B (60–90 cmbs), and the lower midden includes layers C–E (90–105 cmbs). Ten dates from the midden deposits span 2150 to 2850 cal yr BP (Supplementary Table 1). Although the strata appeared

distinct during excavations, radiocarbon dates suggest that layers B and E are inverted with layers A, C, and D; this date inversion suggests some type of past disturbance. No significant tephra or ash layers were observed in the stratigraphy of unit 1. Stratigraphic mixing is not unexpected given construction of semi-subterranean houses across thousands of years (Johnson and Wilmerding, 2001).

Tana Aguna, unit 2, is a 1×1 m unit within house pit 17 and excavated to approximately 40 cm below surface. We identified two cultural features interpreted as floors; the upper component ranging from 490 to 530 cal yr BP, and the lower component ranging between 1715 and 1820 cal yr BP (Supplementary Table 1; Fig. 4). The upper deposits above Floor #1 are composed of very dark-brown silt loam with mixed igneous lithics and cultural material (Supplementary Table 4). The deposit between Floors #1 and #2 includes layers C and D. Layer C is a pocket of gritty silt loam with fragments of griddlestone associated with a hearth. Cultural material included a snub-nosed hafted scraper or knife, a graver, and other lithic artifacts (see Supplementary Table 3). Layer D consisted of silt loam sediment with igneous lithics and pockets of light-gray ash and cultural material that included a projectile point/knife fragment, a knife, and other artifacts (Supplementary Table 3). Like SAM0014, unit 1, we excavated this house feature prior to tephrochronologist Okuno’s identification of the CR02 sequence and Okmok II ash layer in the IFM (Okuno et al., 2017). However, we collected samples of sediment in this unit to determine at a later date sources of ash and tephra as well as other sediment attributes.

The West Ravine (WR) profile (Figs. 5 and 6) is located on the western side of Tana Aguna in an erosional gully that contains a robust stream only after rainstorms. We cleaned two sections of this profile (Main and North) along the same wall but separated by slumped ground surface approximately 1.5 m wide. We collected a handful of artifacts and burned wood for radiocarbon dating. The grain-size analysis of 28 samples taken from the Main WR profile reveals a distinct

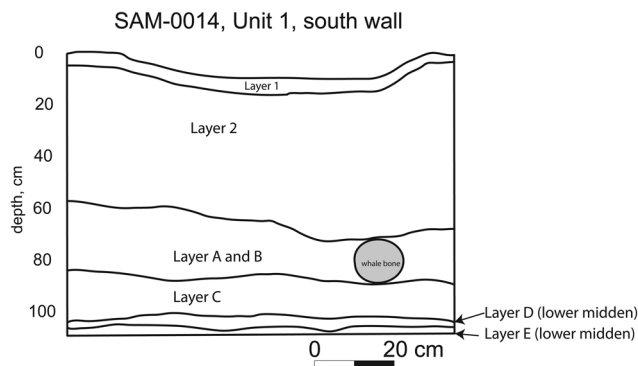


Figure 3. Tana Aguna (SAM0014), unit 1, south wall profile, drawn by O.A. Krylovich and modified from Krylovich et al. (2019). Strata are measured in centimeters (cm) and include the following: layer 1, sod; layer 2, sediment; layers A and B, midden with sea urchin; layers C, D, and E, cultural fill with faunal remains

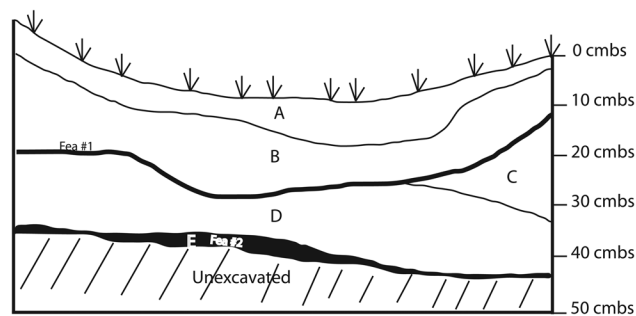


Figure 4. Tana Aguna (SAM0014), unit 2, stratigraphic profile, drawn by K.M. Bruner. Strata are measured in centimeters below surface (cmbs) and include the following: root zone (A); cultural fill (B); cultural feature (Fea #1); gritty sand layer (C); cultural fill, level 5 (D); and cultural fill with Feature #2 (Fea #2), cultural feature (E).

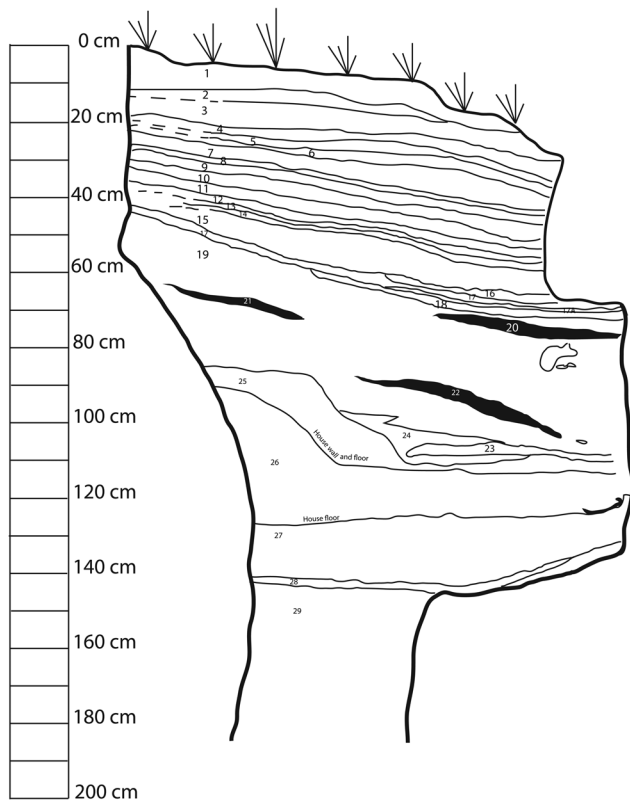


Figure 5. Tana Aguna (SAM0014) West Ravine Main stratigraphic profile, drawn by V.L. Hatfield. Strata are measured in centimeters (cm) and include the following: sod (1), sediment (2), tephra (3), sediment (4), tephra (5), sediment (6), CR02 tephra (7), sediment (8), tephra (9), sediment (10), tephra (11), sediment (12), ash (13), sediment (14), tephra (15), sediment (16), sediment with charcoal (17), tephra (discontinuous light-gray ash, possibly Okmok II) (18), cultural deposits (19), cultural features (20–23), cultural fill (24–26), and alluvium (27–29).

~50-cm-thick tephra in stratum 7 that consists of 90% sand-sized particles in the <1 mm aliquot (Fig. 7). We correlate this layer with the coarse lapilli tephra member of the CR02 tephra. The soil analysis aided in identifying natural sediment and tephra layers, as well as cultural layers. Cultural features identified in the profile include a pit house and floor features below intercalated ash/tephra and sediment layers in the Main Section (Fig. 5, strata 19–26). Using radiometric dating, we identified three cultural occupations in the ravine profile: (1) the youngest dated to 2159–2339 cal yr BP (stratum 20), (2) the lowermost for the Main Section dated to 2963–3141 cal yr BP (stratum 26), and (3) the lowermost in the North Section dated to 3694–3830 cal yr BP (sample taken from charcoal lens at 193 cm below datum (cmbd), at the base of stratum 17). We recognized a sequence of eight tephra and nine sediment layers (strata 2–18) in the Main Section, which included the CR02 sequence, in layer 7, identified by Okuno et al. (2017). Okuno also tentatively identified the Okmok II eruption as stratum 18 Main Section and stratum 12 North Section. Cultural layers lie below the intercalated

tephra and sediment layers in the Main Section from stratum 19 to stratum 26. Cultural deposits consist of fill (roof and/or house construction) and four discrete cultural features (strata 20–23) that tend to have finer grain size than the surrounding fill (Fig. 7). Alluvial strata (strata 27–29) show an increasingly greater proportion of sand with increasing depth and lay at the base of the cultural deposits. Stratum 15, a thick volcanic ash, corresponds to stratum 5 in the North Section (Fig. 6). Importantly, these correlations suggest that erosion has removed the younger layers exposed in the Main Section from the upper North Section that is located closer to the shoreline. The North Section contains a sequence of two tephra and three sediment layers (strata 2–6). Cultural deposits in the WR North Section profile include cultural fill (strata 7, 9, 11, and 13) and a black charcoal-rich floor or other cultural feature (stratum 10). Stratum 12 is a discontinuous ash or tephra (possibly Okmok II) corresponding with stratum 18 in the WR Main Section.

Tana Aguna village radiocarbon dates, features, and artifacts are consistent with other Aleutian sites dating between 3800 and 500 years ago (Knecht and Davis, 2001; Corbett et al., 2010; Hatfield, 2010; West et al., 2012). The round semi-subterranean house features at this village lack the stone foundations seen in some eastern Aleutian houses dating between 4000 and 2500 years ago. The house/floor features are consistent with the features seen across the Aleutian chain; so too is the cultural material. Deposition between floor features in unit 2 and the tephra deposition exposed in the WR profile indicate volcanism affected the occupation at this site. Whether this ash deposition caused abandonment is difficult to determine especially given the overlapping dates between the WR profile and unit 1. The amount of ash deposition witnessed in the WR profile with a lack of cultural deposition, however, does suggest periods of abandonment, especially combined with the dates from the other sites, which indicate a significant gap in occupation, discussed subsequently.

Ulyagan (AMK0003)

Located on southeast Carlisle Island, the Ulyagan site sits on an alluvial fan, approximately 30 m asl. A deep erosional gully with an ephemeral stream bisects the village and houses and *umqan* features occur on both sides. Initial geomorphological analysis indicates that the stream flowed more consistently in the past (Persico et al., 2018). We excavated five units and recovered metal artifacts, a glass bead, and many bone and stone artifacts (Supplementary Table 4). At Ulyagan, 32 radiocarbon dates range from 150 cal yr BP to 3800 cal yr BP. These dates include 14 on crowberry (*Empetrum nigrum*), 3 on terrestrial feeding geese (*Branta hutchinsii*), 6 on Irish lords (*Hemilepidotus* sp.), and 9 on unknown wood (Supplementary Table 1). Terrestrial and marine paired dates were obtained from Ulyagan (see Supplementary Table 1 and West et al. [2019] for provenience) to develop a correction factor, 495 ± 20 yr, to adjust the marine reservoir effect in the Four Mountains region.

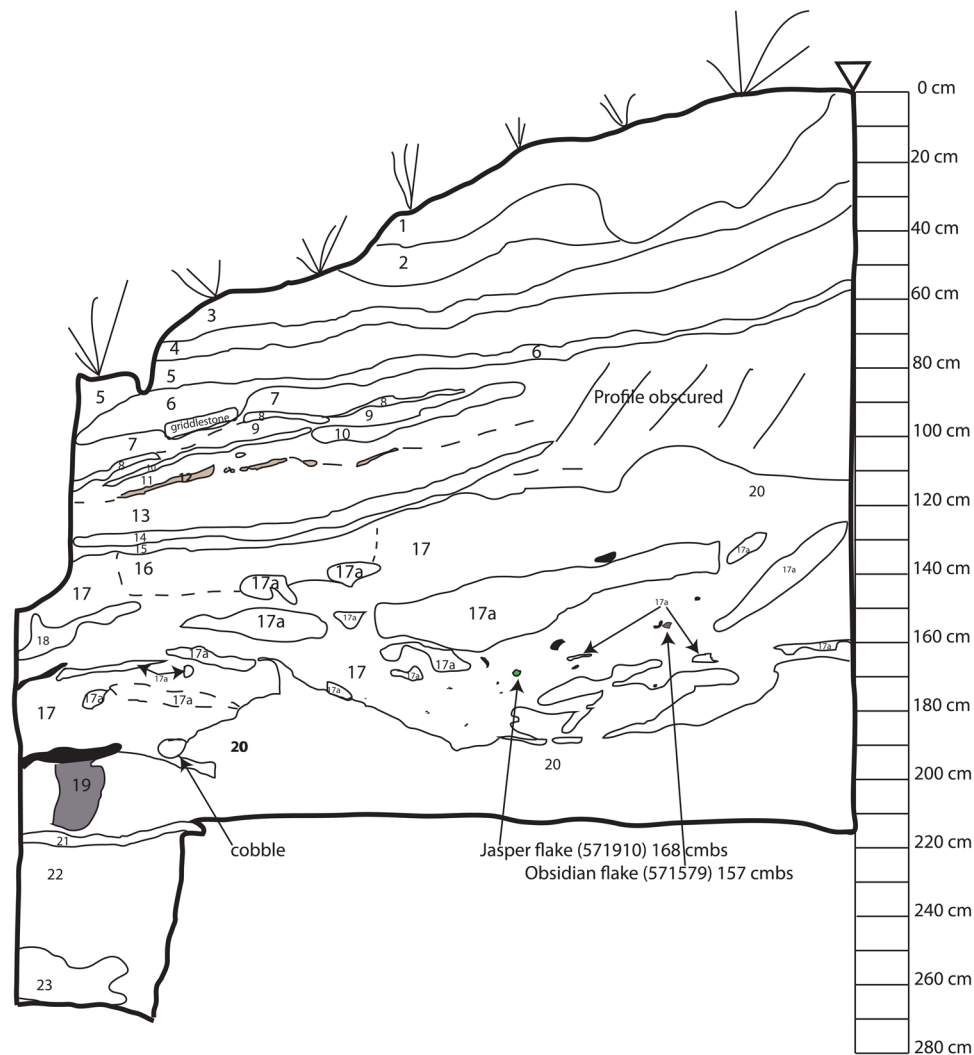


Figure 6. Tana Aguna (SAM0014) West Ravine North stratigraphic profile, drawn by V.L. Hatfield. Strata are measured in centimeters (cm) and include the following: sod (1), sediment (2), tephra (3), sediment (4), CR02 tephra (5), cultural deposits with charcoal and griddlestone (6), cultural fill (7), cultural feature (8), cultural fill (9), cultural feature (10), cultural fill (11), tephra (discontinuous light-brownish-gray ash, correlating with the main profile stratum 18, possibly Okmok II eruption) (12), cultural fill (13), sediment or tephra (14), sediment (15), cultural fill (very mixed) (16–18), possible posthole or other cultural fill (19), alluvium (disturbed) (20), cultural layer (21), alluvium (disturbed) (22), cultural deposit in slump (23). cmbs, centimeters below surface.

Units 1 and 2 are associated with house pit 36; unit 1 is located in the interior of the house, and unit 2 is located on the eastern exterior adjacent to the gully. We excavated unit 1 to 20 cmbs and discontinued because of time limitations. Recovery included a metal knife fragment, an unidentified metal, some griddlestones, charcoal, and debitage (Supplementary Table 4). Given the sparse excavations, the stratigraphy of this unit is not described here. One radiocarbon date on a burned wood, apparently part of house construction and likely driftwood, ranges from 10 to 273 cal yr BP (Supplementary Table 1).

We excavated Ulyagan unit 2 as a 1 × 1 m unit to 105 cmbs and continued excavation as a 50 cm diameter shovel probe to 150 cmbs. The stratigraphy of the west wall shows a small portion of layers 1 and 2, the grass/duff zone mixed with pumiceous tephra (Fig. 8). Below this horizon is a thick

midden deposit (Crockford, 2016; also see Krylovich et al., 2019). This midden (called the layer 3 midden) was 60–75 cm thick and encompassed layer 3b, a thick redeposited tephra that, although very thick on the western edge (as seen in the profile), did not occur on the eastern half of the unit. We excavated the midden in arbitrary levels (levels 2–6). Cultural materials from layer 3 midden included a glass bead, chipped stone tools and debris, and bone tools and debris (Supplementary Table 3). Three radiocarbon dates (ranging from 0 to 287 BP) indicate the layer 3 midden formed during the historic period (Supplementary Table 1).

Ulyagan unit 2 layers 4 and 5, separated from layer 3 midden by the CR02 sequence, are cultural layers composed of a fine loam. Layer 6 is another tephra layer. Layers 7 and 9 are dark, charcoal dense cultural deposits that may be a floor or other burned features; a golden brown tephra (layer 8)

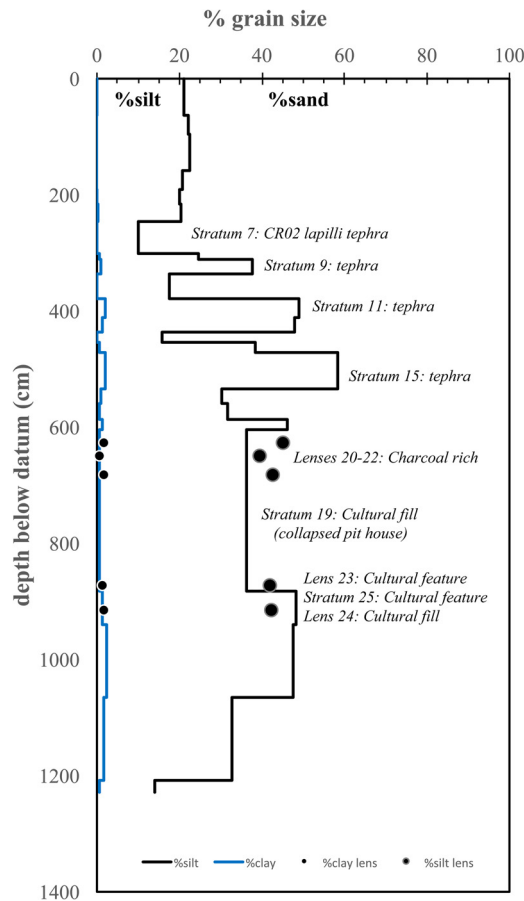


Figure 7. (color online) Graph showing percent grain size of samples from Tana Aguna (SAM0014) West Ravine Main stratigraphic profile.

separates layers 7 and 9. A gray ash (layer 10) occurs below layer 9, and the bottommost deposit, layer 11, is a mottled ash. These lower levels produced little to no cultural material because of the limited excavated volume.

Unit 3 was located on the southern edge of the Ulyagan site and measured 0.50×0.25 m. Located along the erosional edge of the site, the stratigraphy is compressed, compared with other units, because the unit is not located within a pit house. We excavated unit 3 to 135 cm below ground surface into debris flow deposits that predate human occupation. The profile shows the CR02 tephra sequence in levels 14 and 15 with four cultural layers above the CR02 tephra and one or two cultural layers below (Fig. 9). Dates on unidentified wood ($n = 4$) and crowberry ($n = 3$) are grouped into four periods: 800–960 cal yr BP, 1700–1900 cal yr BP, 3077–3230 cal yr BP, and 3615–3815 cal yr BP (Supplementary Table 1).

Ulyagan unit 4 is located west of unit 3 along the southern erosional edge of the Ulyagan village, situated along a natural exposure above the beach. We excavated this unit to 3.0 m below ground surface using different excavation unit sizes and screening methods: the upper 1.05 m excavation measured a 1.5×0.5 m unit and was water screened; the middle excavation, from 1.05 to 2.00 m below datum, measured 0.25×0.5 m and was wet screened; and the lower section,

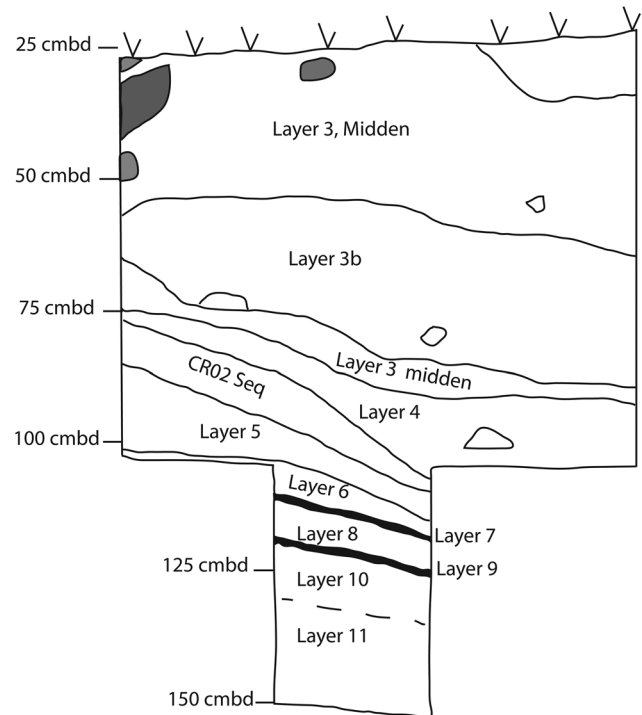


Figure 8. Ulyagan (AMK0003), unit 2, stratigraphic profile of the west wall, drawn by K.M. Bruner. Strata are measured in centimeters below datum (cmbd) and include the following: layer 3, midden; layer 3b, redeposited tephra; CR02 tephra; layer 4, cultural deposits; layer 5, cultural deposits; layer 6, tephra; layer 7, dark charcoal lens (cultural feature); layer 8, tephra; layer 9, dark charcoal lens (cultural feature); layer 10, ash; and layer 11, mottled ash.

from 2.0 to 3.0 m below datum, measured 0.45×1.0 m and was an unscreened shovel test (Fig. 10). Fourteen radiocarbon dates (see Supplementary Table 1) on crowberry ($n = 7$), unknown wood ($n = 2$), and Irish lord fish (*Hemilepidotus* sp., $n = 4$) date prior to the CR02 tephra (levels 14 and 15) and document at least four occupations: (1) 1850–1900 cal yr BP (levels 10 and 13); (2) 2100–2350 cal yr BP (levels 14, 17, 19, and 20), (3) 2700–2900 cal yr BP (levels 15–16); and (4) 3640–3830 cal yr BP (levels 32–33). Several of the dates are inverted—levels 17, 19, and 20 dating earlier than levels 15 and 16. This is likely because of house construction, consistent with features noted in excavation (Fig. 10). The excavation of the house potentially occurred around 2100–2350 cal yr BP resulting in mixed deposits with older (2700–2900 cal yr BP) materials.

Ulyagan unit 5, located on the eastern side of Ulyagan village, across the gully that bisects the site, was a 1.0×0.5 m unit excavated to approximately 1.15 m in depth. The cultural layers include an upper layer (30–75 cm) with sea urchin and vertebrate remains; a middle layer (75–85 cm) of dark brown loam with low concentrations of faunal remains; and a lower midden (85–115 cm) with abundant faunal remains (see Krylovich et al. [2019] for figure and additional descriptions). These deposits all occur above the CR02 tephra sequence.

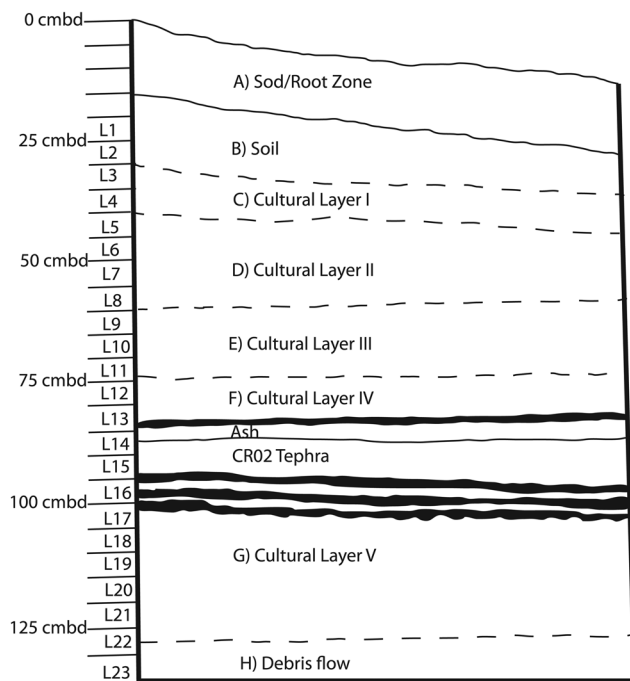


Figure 9. Ulyagan (AMK0003), unit 3, stratigraphic profile of the north wall, drawn by O.A. Krylovich. Strata are measured in centimeters below datum (cmbd) include: sod/root zone (A); sediment (B); cultural fill, layer I (C); cultural fill, layer II (D); cultural fill, layer III (E); cultural fill, layer IV (F); CR02 sequence of ash and tephra layers in levels 14 and 15 (Ash and Tephra); cultural fill, layer V (G); and debris flow deposits (H). L1 through L23 are excavation levels and are 5 cm thick.

Six radiocarbon dates (four on crowberry wood and two on fish) indicate an occupation from 309 to 499 cal yr BP (see Supplementary Table 1).

DISCUSSION

The IFM are remote and isolated. Little to no research has been conducted at these archaeological sites; thus we are only in the beginning stages of understanding the occupation sequence of humans and the impact natural and cultural events had on their ability to thrive in this region. However, based on the ecological and geoarchaeological evidence we gathered from the IFM, the prehistoric residents of the village sites appear resilient through dynamic long-term and abrupt events, including volcanic eruptions. Based on the radiocarbon dates we obtained (Supplementary Table 1), the occupation of these islands range from the Russian contact era to 4000 cal yr BP. All of the investigated sites are large villages and were likely used contemporaneously, indicating a substantial population of IFM villages during the past 4000 years. Deglaciation timing and spatial patterning, sea level change, and sea ice extent undoubtedly influenced colonization of these islands (Persico, et al., 2018). There is some indication that people colonized these islands around 7000 years ago (Kuzmicheva et al., 2019), but we do not have stratigraphic or radiocarbon evidence of this event. Further

research in the Four Mountains may yet result in an extended time depth for the human occupations in these islands.

Although Ulyagan (AMK0003) and Tana Aguna (SAM0014) villages provide the most information regarding occupation range, seasonality, geologic hazard response, and resource use, all of the sites taken together indicate an intensive occupation of the island group. Based on radiocarbon dates from all of the sites investigated, excluding dates on fish bones, there are two significant gaps in the occupation sequence: (1) between 2100 and 1950 cal yr BP and (2) between 1700 and 1000 cal yr BP (Fig. 11, Table 1; Supplementary Table 1). In the WR profile, the CR02 sequence appears to be one of many eruptions, sandwiched between two or three tephra/ash deposits above and three or four tephra/ash deposits below this sequence. Given the degree of volcanism witnessed in the WR profile, it is likely volcanic eruptions are the cause of these hiatuses. The Okmok II caldera-forming eruption at ca. 2000 cal yr BP may have caused some disruption in the IFM. It was a large eruption occurring 126 km (80 mi.) east of the Four Mountains that directly or indirectly affected villagers. Because the Okmok II ash layer evident in Tana Aguna and Ulyagan is quite thin, a direct ecological and human mortality impact is unlikely. Certainly, we found no unusual accumulation of unbroken artifacts or other sign of rapid abandonment associated with either the CR02 tephra sequence or Okmok II ash layer in any excavated profile. Nonetheless, the Okmok II eruption would have caused significant land and sound vibrations that may have caused people to abandon the Four Mountains. Between 1700 and 1000 cal yr BP, there may have been a long sequence of eruptions, of which the CR02 sequence was one, and the repeated eruptions likely caused a 700-yr hiatus.

Both hiatus periods (2100–1950 and 1700–1000 cal yr BP) are associated with an increase in values of nitrogen isotope (Kuzmicheva et al., 2019). Kuzmicheva et al. (2019) note high values of heavy nitrogen isotopes prior to 6900 cal yr BP, associated with high bird populations, followed by a drop in nitrogen isotope levels associated with a decrease in number of birds, potentially indicating human predation during the initial human colonization of the Four Mountains. Following colonization, there are two notable increases in nitrogen isotope levels, one around 1900 cal yr BP and one at 1100 cal yr BP, suggesting humans were not in the area hunting birds during these times. Nitrogen isotope values increase after 1000 years ago, which Kuzmicheva et al. (2019) associated with the return of human occupants to the Four Mountains, and the very low values at 500 cal yr BP reflect an intense human predation on birds in the area. Sampling error or unseen social causes are other possible explanations of the hiatuses, and further research is needed to evaluate these time gaps. It is possible that some event resulted in the death of Four Mountains occupants, and the 700-yr gap, for instance, reflects the amount of time for other Aleutian villages to recolonize these islands. Many of the possible scenarios are invisible in the archaeological record.

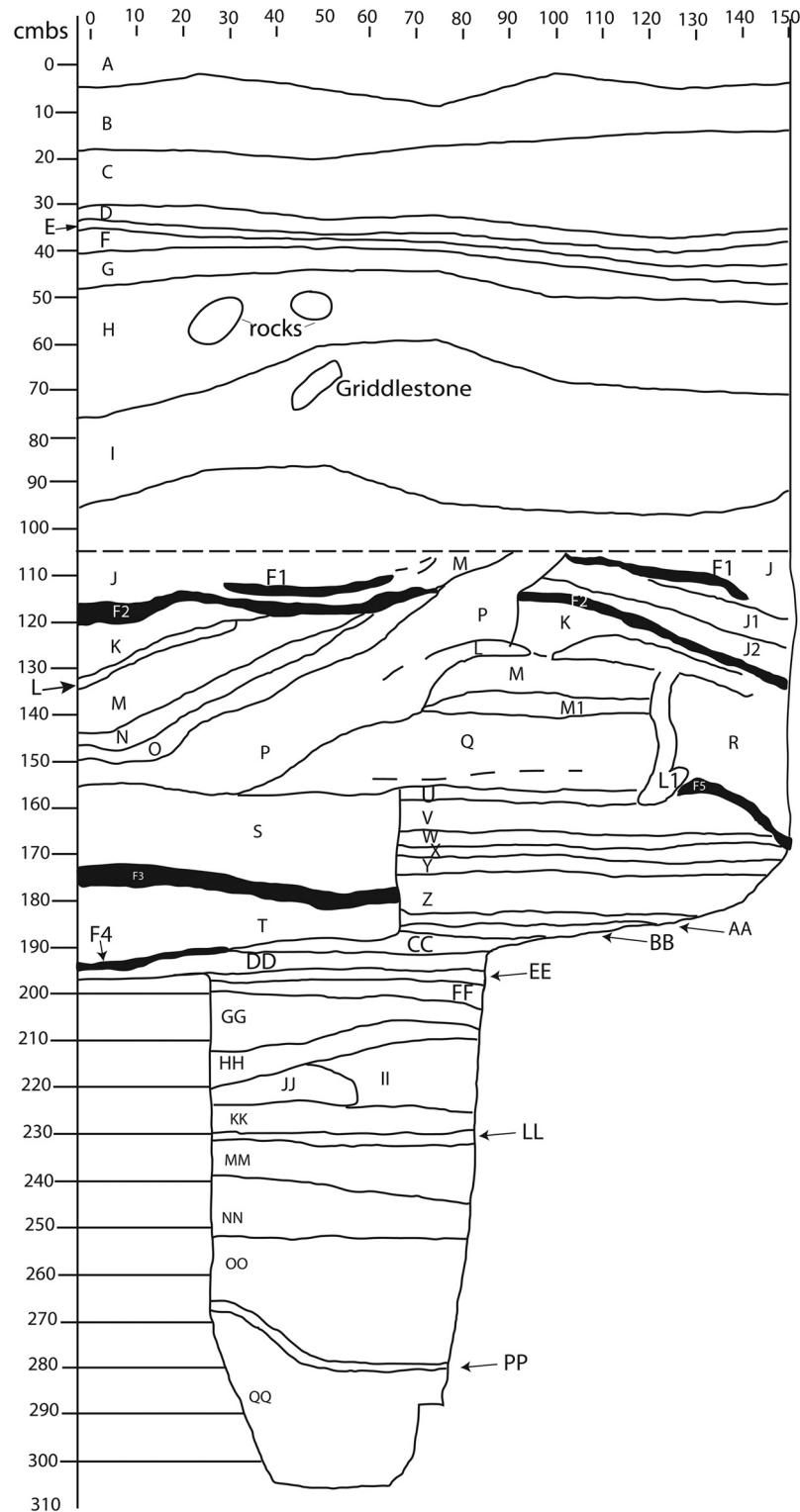


Figure 10. Ulyagan (AMK0003), unit 4, stratigraphic profile, north wall. The upper section (separated from lower section by dashed line) is postexcavation, drawn by O.A. Krylovich, and is set back 50 cm from the lower section, drawn by V.L. Hatfield. Strata are measured in centimeters below surface (cmbs) and include the following: above ground surface (A); sod/root zone (B); sediment with some cultural material (C–E); CR02 tephra (F–G); cultural fill (H); cultural layer, midden (I); cultural fill (J); cultural fill (J1); cultural fill (J2); floor feature: dark brown to black (F1); cultural feature, floor (F2); noncultural sediment (K); tephra (L); tephra (L1); noncultural sediment (M and M1); tephra (N); tephra, perhaps the same as Q (O); noncultural: fluvial sediment (P); tephra (Q); cultural fill above house floor F5 (R); cultural fill, above F3 feature (possible floor) (S); possible floor, cultural feature (F3); cultural fill–roof fall/fill above feature F4 (T); tephra (U); noncultural sediment (V–W); tephra (X–Y); noncultural sediment (Z); tephra (AA–BB); noncultural sediment (CC); tephra (DD); noncultural, possibly tephra (EE–FF); debris flow (GG); tephra (HH); debris flow (II–JJ); fine ash (KK); tephra (LL); debris flow (MM); tephra (NN); debris flow (OO); tephra or ash (PP); and debris flow (QQ).

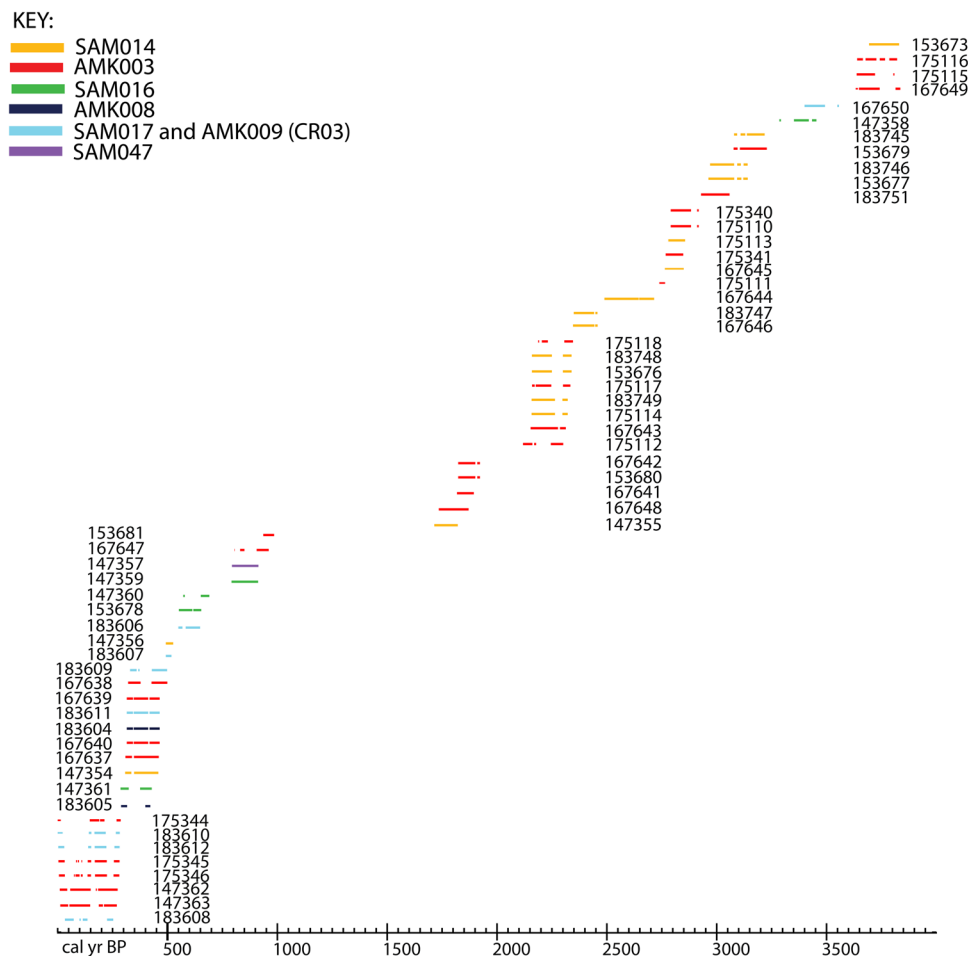


Figure 11. (color online) Radiocarbon date ranges from youngest (bottom) to oldest (top). An occupation hiatus is apparent between 2100 and 1950 cal yr BP and between 1700 and 1000 cal yr BP. See Table 1 and Supplementary Table 1 for dates, materials dated, and provenience information. These dates were calibrated with CALIB 7.1 (Stuiver et al., 2017).

Village locations, sizes, and resilience

Most of the IFM village sites, including Ulyagan and Tana Aguna, are situated on debris flow deposits, and we suppose the age of settlements at these sites is restricted by the development of sediment on habitable landforms (see Persico et al., 2018). Surface features at most of the sites in the IFM are predominantly oval house pit and smaller pit features (McCartney, 1972; Wraley, 1990; Fogarty, 1991a, 1991b; Cooper, 1991; O’Leary, 1993a, 1993b, 1993c; Turck, 1993; Hatfield and West, 2013; Hatfield et al., 2016). The larger are likely Unanga \acute{x} houses, typically semi-subterranean—an adaptation to the frequent strong winds—that were used year-round. Two exceptions are AMK0003, which has longhouses and *umqan* features, and SAM0016, which has multiroom houses and *umqan* features (Cooper, 1991; O’Leary, 1993b, 1993c; Hatfield and West, 2013; Hatfield et al., 2016). The longhouses at AMK0003 are associated with the Russian contact period, similar to the longhouses documented by Veltre and McCartney (2001) at the Reese Bay site on Unalaska Island. Longhouse architecture construction and use appear to be a late manifestation, no more than 800 years old;

however, only a few of these features have been dated (Corbett, 2003). Rectangular houses are documented at the Amaknak Bridge site and other eastern Aleutians sites between 3000 and 1000 cal yr BP (Knecht and Davis, 2008; Davis and Knecht, 2010; Rogers, 2011), and complex longhouses are documented ethnohistorically in the eastern Aleutians by Veniaminov and Captain Cook (Veniaminov, 1984, p. 262; McCartney and Veltre, 2002, p. 251; Corbett, 2003; Rogers, 2011). *Umqan* features are similarly young in age, no more than 600 years old (Aigner and Veltre, 1976; Aigner et al., 1976; O’Leary and Bland, 2013). At SAM0016, 18 of the 52 surface features are large communal multiroom houses and are assumed to be late in age as well (O’Leary, 1993b, 1993c; Hatfield et al., 2016).

The prehistoric human populations in the Four Mountains were resilient in their response to the restricted subsistence resources (Krylovich et al., 2019; Vasyukov et al., 2019) and periodic volcanic eruptions. They were not affected by tsunamis at all (Griswold, et al., 2018). The limitations in resources that resulted from occupying small islands with little to no reef development and no large bays may have limited

Table 1. Radiocarbon dates from Islands of the Four Mountains associated with Figure 11. ST, shove test; WRM, West Ravine, Main Section; WRN, West Ravine, North Section. AMK009 was investigated by Lucille Johnson (Johnson 2018). For additional information on these dates, see Supplementary Tables 1 and 2. Fea X is Feature X; OBSE, OBSW, GSW < and IFSE are provenience designations.

Lab #	Provenience	¹⁴ C yr BP	Calibrated 2-sigma range (probability) (cal yr BP)
153673	SAM014, WRN, 193 cm	3480 ± 20	3694–3830 (100)
175116	AMK003, unit 4, level 32	3455 ± 14	3643–3669 (17.7), 3681–3730 (50.8), 3746–3770 (8.0), 3803–3808 (2.5)
175115	AMK003, unit 4, level 33	3430 ± 15	3636–3719 (99.3), 3803–3808 (0.7)
167649	AMK003, unit 3, layer 2	3430 ± 20	3614–3624 (1.5), 3629–3723 (93.4), 3795–3817 (5.1)
167650	SAM017, Fea X, 95–100 cm	3230 ± 20	3338–3481 (98.3), 3537–3545 (1.7)
147358	SAM016, ST 2, 40 cm	3150 ± 20	3275–3282 (1.2), 3342–3409 (91.2), 3424–3444 (7.6)
183745	SAM014, unit 1, layer C	2990 ± 15	3079–3093 (7.0), 3109–3130 (6.3), 3138–3218 (86.8)
153679	AMK003, unit 3, layer 21	2990 ± 20	3077–3095 (9.0), 3106–3228 (91.0)
183746	SAM014, unit 1, layer D	2910 ± 15	2970–3079 (89.8), 3093–3110 (4.9), 3122–3141 (5.2)
153677	SAM014, WRM, 132 cm	2905 ± 20	2963–3079 (89.6), 3093–3112 (5.2), 3121–3141 (5.2)
183751	AMK003, unit 4, level 17	2865 ± 15	2929–3058 (100.0)
175340	AMK003, unit 4, level 10	2760 ± 15	2791–2883 (97.6), 2911–2918 (2.4)
175110	AMK003, unit 4, level 16	2760 ± 15	2781–2883 (97.6), 2811–2918 (2.4)
175113	SAM014, unit 1, layer D	2730 ± 15	2780–2856 (100)
175341	AMK003, unit 4, level 13	2710 ± 15	2768–2848 (100)
167645	SAM014, unit 1, layer C	2710 ± 20	2764–2850 (100)
175111	AMK003, unit 4, level 15	2620 ± 20	2739–2765 (100)
167644	SAM014, unit 1, layer A	2485 ± 20	2489–2645 (75.9), 2647–2715 (24.1)
183747	SAM014, unit 1, layer E	2385 ± 15	2349–2442 (96.7), 2448–2457 (3.3)
167646	SAM014, unit 1, layer E	2375 ± 20	2346–2443 (96.2), 2446–2458 (3.8)
175118	AMK003, unit 4, level 19	2275 ± 15	2187–2192 (0.9), 2204–2231 (13.0), 2306–2346 (86.2)
183748	AM014, unit 1, layer A	2250 ± 20	2159–2250 (63.7), 2300–2339 (36.3)
153676	SAM014, WRM, 78 cm	2250 ± 20	2159–2250 (63.7), 2300–2339 (36.3)
175117	AMK003, unit 4, level 19	2245 ± 15	2160–2172 (3.6), 2176–2247 (65.5), 2300–2334 (30.9)
183749	AMK003, unit 4, level 32	2245 ± 15	2160–2172 (3.6), 2176–2247 (65.5), 2300–2334 (30.9)
175114	SAM014, unit 1, layer B	2230 ± 15	2157–2264 (84.5), 2298–2322 (15.5)
167643	AMK003, unit 4, level 17	2215 ± 20	2153–2277 (85.9), 2287–2313 (14.1)
175112	AMK003, unit 4, level 17	2165 ± 15	2118–2161 (43.3), 2169–2178 (2.3), 2245–2301 (54.4)
167642	AMK003, unit 5, level 13	1925 ± 20	1823–1901 (94.0), 1910–1923 (6.0)
153680	AMK003, unit 3, layer 1	1925 ± 20	1823–1901 (94.0), 1910–1923 (6.0)
167641	AMK003, unit 4, level 10	1905 ± 20	1818–1894 (100.0)
167648	AMK003, unit 3, layer 15	1870 ± 20	1735–1871 (100.0)
147355	SAM014, unit 2, level 5	1835 ± 20	1715–1821 (100.0)
153681	AMK003, unit 3, layer 4	1045 ± 20	927–976 (100.0)
167647	AMK003, unit 3, layer 4	1000 ± 20	805–806 (0.4), 831–850 (6.5), 906–961 (93.2)
147357	SAM047, ST 1, 50 cm	930 ± 20	794–914 (100.0)
147359	SAM016, ST 2, 40 cm	925 ± 20	792–912 (100.0)
147360	SAM016, ST 2, 30–40 cm	715 ± 25	572–579 (2.3), 652–690 (97.7)
153678	SAM016, ST 3, 26–30 cm	615 ± 20	552–613 (61.2), 618–653 (38.8)
183606	AMK009, #1, OBSE	605 ± 15	550–568 (20.6), 583–648 (79.4)
147356	SAM014, unit 2, level 4	450 ± 20	493–526 (100.0)
183607	AMK009, #2, OBSW	440 ± 15	493–518 (100.0)
183609	AMK009, #4, 3GSW/S135	370 ± 15	330–359 (28.6), 367–373 (1.0), 429–498 (70.4)
167638	AMK003, unit 5, level 6	370 ± 20	321–377 (34.8), 428–499 (65.2)
167639	AMK003, unit 5, level 10	355 ± 15	319–382 (46.8), 386–391 (1.8), 426–484 (51.4)
183611	AMK009, #5	335 ± 15	315–343 (20.5), 346–312 (49.8), 418–464 (29.6)
183604	AMK008, ST 1, 0–20 cm	335 ± 15	315–343 (20.5), 346–312 (49.8), 418–464 (29.6)
167640	AMK003, unit 5, level 16	335 ± 15	315–343 (20.5), 346–312 (49.8), 418–464 (29.6)
167637	AMK003, unit 5, level 2	325 ± 20	309–338 (20.5), 348–434 (79.5)
147354	SAM014, unit 1, 60 cm	320 ± 20	307–336 (20.5), 348–459 (79.5)
147361	SAM016, ST 2, 20 cm	275 ± 20	286–324 (59.4), 375–428 (40.6)
183605	AMK008, ST 2, 40 cm	270 ± 15	289–316 (85.4), 399–422 (14.6)
175344	AMK003, unit 2, layer 3	190 ± 15	0–14 (20.0), 146–189 (46.1), 193–213 (11.1), 268–287 (22.8)
183610	AMK009, #41, 31NE	170 ± 15	0–23 (18.4), 142–154 (9.7), 168–219 (54.8), 265–283 (17.1)

(Continued)

Table 1. Continued.

Lab #	Provenience	¹⁴ C yr BP	Calibrated 2-sigma range (probability) (cal yr BP)
183612	AMK009, #6, OBSE	160 ± 15	3–30 (19.2), 139–153 (11.2), 169–222 (53.1), 259–282 (16.5)
175345	AMK003, unit 2, layer 3	155 ± 15	4–32 (20.6), 84–88 (0.6), 92–97 (0.8), 108–111 (0.5)
175346	AMK003, unit 2, layer 3	150 ± 15	6–33 (21.1), 74–78 (0.7), 81–100 (4.4), 106–114 (1.8), 136–152 (12.0), 170–224 (43.3), 255–281 (16.6)
147362	AMK003, unit 1, level 4	130 ± 25	10–44 (15.8), 57–150 (46.4), 174–178 (0.8), 184–273 (37.0)
147363	AMK003, unit 2, level 3	120 ± 25	12–48 (15.2), 54–149 (52.3), 187–206 (3.6), 211–269 (28.9)
183608	AMK009, #3, IFSE	75 ± 15	33–73 (62.0), 99–105 (1.1), 114–136 (14.9), 225–253 (22.0)

the number of settlements noted in these islands. Historic/ethnographic stories about starvation suggest these were difficult islands for subsisting on local resources. Vasyukov et al. (2019) suggest they may have adapted to resource restrictions by adopting alternative strategies by transporting foxes and/or dogs as food resources for lean times. However, overall, findings by Krylovich et al. (2019) indicate IFM occupants utilized a diverse resource base.

Tsunamis, volcanoes, and resilience

No site reported herein showed clear evidence of inundation by paleotsunamis. Modeling of tsunamis (Griswold et al., 2018) indicates that even unusually large tsunamis were too small to reach the elevation of inhabited sites, including accounting for typical values of coseismic subsidence (Bourgeois, 2006). Bering Sea–side sites are protected from direct onslaught of subduction zone tsunamis, and the Pacific Ocean sites are high enough to avoid being inundated during realistic tsunami scenarios (Griswold et al., 2018). If a tsunami were large enough to inundate a site, internal stratigraphy should reveal layers characteristic of a tsunami—that of clean (non-soily) deposits of sediment in similar composition to the beach or adjacent shallow offshore substrate (Morton et al., 2007). However, the cobble-boulder or bedrock beaches adjacent to most sites in the IFM are unlikely to allow for the creation of tsunami deposits in the first place (Bourgeois and MacInnes, 2010), thus making the conclusion from modeling untestable.

Volcanism is evident at both of the sites, and two tephra are dated—the CR02 tephra at 1050 cal yr BP (Okuno et al., 2017) and the Okmok II ash dated at 2030 cal yr BP (Begét, et al., 2005; Okuno et al., 2017). On Chuginadak, the CR02 tephra sequence was identified in the WR profile (Main, stratum 7 and North, stratum 5) at Tanaġ Agunaġ (SAM0014). Tephra and ash layers occur above and below this sequence. Below the CR02 sequence is the Okmok II ash, dated at 2030 cal yr BP (Begét, et al., 2005; Okuno, et al., 2017). The younger floor feature in unit 2, house pit 17 (circa 500 cal yr BP) at Tanaġ Agunaġ affirms that people reoccupied this village in spite of numerous volcanic tephtras that covered earlier occupations, as revealed in the WR profiles. On Carlisle, the Ulyagan village similarly was occupied for roughly 4000 years and definitely returned after eruptions.

The tephra from eruptions prior to known human occupations are noted in units 3 and 4. In the unit 4 profile wall, the prehistoric excavation of a house pit cut through intercalated ash and sediment/debris flow deposits. In unit 3, the cultural component appears to be deposited directly above the CR02 tephra.

CONCLUSIONS

The research conducted by an interdisciplinary and international group of researchers is the first comprehensive investigation of the prehistoric and historic human occupation in the IFM. This research contributes substantially to current understanding of prehistoric lifeways in the Aleutian archipelago. The archaeological record of the IFM reveals the sustainability and resilience of the Unangaġ people to environmental change during the four millennia prior to the arrival of Russians into the Aleutian chain. Tsunamis, earthquakes, and volcanic eruptions are known to affect other archaeological sites (see VanderHoek and Myron, 2004; Losey, 2005; Ludwin et al., 2005, 2007; Barton et al., 2018). We find no evidence that paleotsunamis affected either the Tana Aguna or the Ulyagan village in prehistory, and perhaps their location atop a cliff of unconsolidated sediment buffered villages from unusual waves. Interestingly, Griswold et al. (2018) documented the wave height that inundated the IFM was substantially lower (9 m asl) on Bering Sea shorelines compared with Pacific shorelines (18 m asl). The excavated and tested sites in our study were located within the passes of the Four Mountains on high landforms, although it is unclear whether this choice of village location related more to protection from prevailing storm directions, infrequent tsunami events, or human incursions. Unfortunately, the few villages in this region do not facilitate a robust statistical analysis of the question of village site choice. Volcanism, however, did affect the IFM villagers. The two hiatuses in occupation noted previously may reflect sampling error or unseen social events, but most likely are associated with the volcanism of this very active area.

With the exception of the hiatuses, the occupation of the IFM appears to have been resilient, with villagers exploiting the diverse maritime and terrestrial resources available. Although restricted by their location on high bluffs with narrow beaches and high-energy maritime ecosystems, the IFM villagers utilized sophisticated technologies, exploited

high-quality resources, and appear well-adapted to the region. The diverse resources represented in the middens reflect resources that were accessible year-round. It is possible the presence of fox and dog in the 500-yr-old midden from the Ulyagan village indicates some resource stress, as suggested by Vasyukov et al (2019), but the general diversity reflected does not support this.

Additional archaeological evidence from the IFM may eventually fill the gap between the early settlements of the eastern Fox Islands that began 9000 years ago (Knecht and Davis, 2001) and those of the central Andreanof Islands that were occupied by 7000 years ago (West et al., 2012); however, our research did not reveal the antiquity anticipated. Our data do support continuity from 4000 years ago until contact with a shift sometime after AD 1000 in population dynamics (West et al., 2019) and technology. The analysis by Kuzmicheva et al. (2019) suggests the arrival of humans to the Four Mountains ca. 7000 cal yr BP. Additional research is needed to identify locations that correlate with the initial settlement of these islands as populations moved westward into the central and western Aleutians. Based on our findings, it is clear that the Four Mountains villagers were in contact with other Unangâ populations as well as with people farther east. Lamentably, the economic exploitation by Russians and European Americans combined with their greater technological resources resulted in loss of life and culture to which now only the ethnohistorical, historical, and archaeological records bear witness.

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SUPPLEMENTARY MATERIAL

The supplementary material for this article can be found at <https://doi.org/10.1017/qua.2018.149>.

REFERENCES

- Admiraal, M., Lucquin, A., von Tersch, M., Jordan, P.D., Craig, O.E., 2018. Investigating the function of prehistoric stone bowls and griddle stones in the Aleutian Islands by lipid residue analysis. *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2018.31>.
- Aigner, J.S., Veltre, D.W., 1976. The distribution and pattern of Umqan burial on southwest Umnak Island. *Arctic Anthropology* 13, 113–127.
- Aigner, J.S., Veltre, D.W., Fullem, B.B., Veltre, M., 1976. An infant Umqan burial from southwest Umnak Island. *Anthropology* 13, 128–131.
- Bailey, E.P., 1993. Introduction of foxes to Alaskan Islands—History, Effects on Avifauna, and Eradication. Resource Publication 193. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.
- Bank, T.P., II, 1953. Cultural succession in the Aleutians. *American Antiquity* 19, 40–49.
- Bank, T.P., II, 1956. *Birthplace of the Winds*. Crowell, New York.
- Bank, T.P., II, Spaulding, A.C., Miller, H.A., Bank, J.F., 1950. *The University of Michigan Expedition to the Aleutian Islands, 1948-49*. Botanical Gardens and Museum of Anthropology, University of Michigan, Ann Arbor.
- Barton, L., Shirar, S., Jordan, J.W., 2018. Holocene human occupation of the central Alaska Peninsula. *Radiocarbon* 60, 367–382.
- Begét, J.E., Larsen, J.F., Neal, C.A., Nye, C.J., Schaefer, J.R., 2005. *Preliminary Volcano-Hazard Assessment for Okmok Volcano, Umnak Island, Alaska*. Report of Investigation 2004-3, 1 sheet, scale 1:150,000. Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Fairbanks, AK.
- Black, L., 1984. *Atka: An Ethnohistory of the Western Aleutians*. Alaska History No. 24. Limestone Press, Kingston, ON, Canada.
- Bourgeois, J., 2006. A movement in four parts? *Nature* 440, 430–431.
- Bourgeois, J., MacInnes, B.T., 2010. Tsunami boulder transport and other dramatic effects of the 15 November 2006 central Kuril Islands tsunami on the island of Matua. *Zeitschrift für Geomorphologie* 54, 175–195.
- Butler, V.L., Bovy, K.M., Campbell, S.K., Etnier, M.A., 2018a. Exploring ecodynamics of coastal foragers using integrated faunal records from Čixwic̄n village (Strait of Juan de Fuca, Washington, U.S.A.). *Journal of Archaeological Science: Reports* (in press). <https://doi.org/10.1016/j.jasrep.2018.09.031>.
- Butler, V.L., Bovy, K.M., Campbell, S.K., Etnier, M.A., Sterling, S.L., 2018b. The Čixwic̄n project of northwest Washington State, U.S.A.: opportunity lost, opportunity found. *Journal of Archaeological Science: Report* (in press). <https://doi.org/10.1016/j.jasrep.2018.03.010>.
- Byrd, V.G., Renner, H.M., Renner, M., 2005. Distribution patterns and population trends of breeding seabirds in the Aleutian Islands. *Fisheries Oceanography* 14S, 139–159.

- Call, K.A., Loughlin, T.R., 2005. An ecological classification of Alaskan Steller sea lion (*Eumetopias jubatus*) rookeries: a tool for conservation/management. *Fisheries Oceanography* 14S, 212–222.
- Cooper, D.R., 1991. *Report of Investigation for Site CR-2*. The Aleut Corporation, BLM AA-12203. Bureau of Indian Affairs, ANCSA Office, Anchorage, AK.
- Corbett, D., 2003. Ulaq, Ulagamaax, Barabaras. Paper presented at the 30th Annual Meeting of the Alaska Anthropological Association, Fairbanks, AK.
- Corbett, D.G., West, D., Lefèvre, C. (Eds.), 2010. *The People at the End of the World: The Western Aleutians Project and the Archaeology of Shemya Island*. Aurora Monograph Series, 7. Alaska Anthropological Association, Anchorage, AK.
- Crockford, S.J., 2016. *Islands of the Four Mountains: Vertebrate Fauna from Carlisle Island Site AMK-003 (CR-02)*. Final report.
- Crumley, C.L., 2007. Historical ecology: integrated thinking at multiple temporal and spatial scales. In: Hornborg, A., Crumley, C.L. (Eds.), *The World System and the Earth System: Global Socioenvironmental Change and Sustainability since the Neolithic*. Routledge, New York, pp. 15–28.
- Dall, W.H., 1878. On the remains of later pre-historic man obtained from caves in the Catherina Archipelago, Alaskan territory and especially from the caves of the Aleutian Islands. *Smithsonian Contributions to Knowledge* 22, 318–366.
- Davis, R.S., Knecht, R.A., 2010. Continuity and change in the eastern Aleutian archaeological sequence. *Human Biology* 85, 507–524.
- Erlanson, J.M., Fitzpatrick, S.M., 2006. Oceans, islands, and coasts: current perspectives on the role of the sea in human prehistory. *Journal of Island and Coastal Archaeology* 1, 5–32.
- Fitzhugh, B., 2003. *The Evolution of Complex Hunter-Gatherers: Archaeological Evidence from the North Pacific*. Kluwer Academic/Plenum, New York.
- Fitzhugh, B., Butler, V.L., Bovy, K.M., Etnier, M.A. 2018. Human ecodynamics: A perspective for the study of long-term change in socioecological systems. *Journal of Archaeological Science*, in press
- Fitzpatrick, S.M., Keegan, W.F., 2007. Human impacts and adaptations in the Caribbean Islands: an historical ecology approach. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh* 98, 29–45.
- Fogarty, M.E., 1991a. *Report of Investigation for Site CR-1. The Aleut Corporation, BLM AA-12202*. Bureau of Indian Affairs, ANCSA Office, Anchorage, AK.
- Fogarty, M.E., 1991b. *Report of Investigation for Site CR-3. The Aleut Corporation, BLM AA-12204*. Bureau of Indian Affairs, ANCSA Office, Anchorage, AK.
- Griswold, F.R., MacInnes, B.T., Higman, B., 2018. Tsunami-based evidence for large eastern Aleutian slip during the 1957 earthquake. *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2018.39>.
- Hatfield, V., 2010. Material culture across the Aleutian archipelago. *Human Biology* 82, 525–556.
- Hatfield, V., Bruner, K., West, D., Savinetsky, A., Krylovich, O., Khasanov, B., Vasyukov, D., et al., 2016. At the foot of the smoking mountains: the 2014 scientific investigations in the Islands of the Four Mountains. *Arctic Anthropology* 53, 141–159.
- Hatfield, V., West, D., 2013. Determination of Eligibility of Sites of Interest to the Islands of the Four Mountains Project: Geological Hazards, Climate Change, and Human/Ecosystems Resilience in the Islands of the Four Mountains, Alaska. Report prepared for Alaska Office of History and Archaeology. University of Kansas, Lawrence.
- Hayes, D., 1999. *Historical Atlas of the Pacific Northwest: Maps of Exploration and Discovery: British Columbia, Washington, Oregon, Alaska, Yukon*. Sasquatch Books, Seattle, WA.
- Hrdlička, A., 1945. *The Aleutian and Commander Islands and Their Inhabitants*. Wistar Institute of Anatomy and Biology, Philadelphia, PA.
- Hunt, G.L., Stabeno, P.J., 2005. Oceanography and ecology of the Aleutians Archipelago: spatial and temporal variation. *Fisheries Oceanography* 14S, 292–306.
- Hutchinson, I., Butler, V.L., Campbell, S.K., Sterling, S.L., Etnier, M.A., Bovy, K.M. 2018. Impacts of resource fluctuations and recurrent tsunamis on the occupational history of Ciixicen, A Salishan village on the southern shore of the Strait of Juan de Fuca, Washington State, U.S.A. *Journal of Archaeological Science*, in press
- Jochelson, W., 1925. *Archaeological Investigations in the Aleutian Islands*. Carnegie Institute of Washington, Publication 367. Carnegie Institute of Washington, Washington, DC.
- Johnson, J.M., Tanioka, Y., Ruff, L.J., Satake, K., Kanamori, H., Sykes, L.R., 1994. The 1957 Great Aleutian earthquake. *Pure and Applied Geophysics* 142, 3–28
- Johnson, L. 2018. The stone and bone artifacts from Asxaana-ġ Cave, Islands of the Four Mountains, Alaska. *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2018.42>
- Johnson, L., Wilmerding, E., 2001. Bringing the house down: modeling construction and deconstruction of Aleut semisubterranean houses. In: Dumond, D. (Ed.), *Archaeology in the Aleut Zone of Alaska: Some Recent Research*. University of Oregon Anthropological Papers No. 58. Department of Anthropology and State Museum of Anthropology, University of Oregon, Eugene, pp. 127–149.
- Jones, R.T., 2014. *Empire of Extinction: Russians and the North Pacific's Strange Beasts of the Sea, 1741-1867*. Oxford University Press, New York.
- Kirch, P.V., 2007. Hawaii as a model system for human ecodynamics. *American Anthropologist* 109, 8–26.
- Kirch, P.V., Hunt, T.L. (Eds.), 1997. *Historical Ecology in the Pacific Islands: Prehistoric Environmental and Landscape Change*. Yale University Press, New Haven, CT.
- Knecht, R., Davis, R., 2001. A prehistoric sequence for the eastern Aleutians. In: Dumond, D. (Ed.), *Archaeology in the Aleut Zone of Alaska, Some Recent Research*. University of Oregon Anthropological Papers No. 58. Department of Anthropology and State Museum of Anthropology, University of Oregon, Eugene, pp. 269–288.
- Knecht, R., Davis, R., 2008. The Amaknak Bridge site: cultural change and the Neoglacial in the eastern Aleutians. *Arctic Anthropology* 45, 61–78.
- Krylovich, O., Vasyukov, D., Khasanov, B., Hatfield, V., West, D., Savinetsky, A., 2019. Hunter-gatherers subsistence and impact on fauna in the Islands of Four Mountains, Eastern Aleutians, Alaska, over 3000 yr. *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2018.127>.
- Kuzmicheva, E.A., Smyshlyaeva, O.I., Vasyukov, D.D., Khasanov, B.F., Krylovich, O.A., Okuno, M., West, D.L., Hatfield, V.L., Savinetsky, A.B., 2019. A 7300-yr-old environmental history of seabird, human, and volcano impacts on Carlisle Island (the Islands of Four Mountains, eastern Aleutians, Alaska). *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2018.114>.

- Ladd, C., Hunt, G.L., Jr., Mordy, C.W., Salo, S.A., Stabeno, P.J., 2005. Marine environment of the eastern and central Aleutian Islands. *Fisheries Oceanography* 14S, 22–38.
- Laughlin, W.S., 1980. *Aleuts: Survivors of the Bering Land Bridge*. Holt, Rinehart, and Winston, New York.
- Lawson, I.T., Church, M.J., McGovern, T.H., Arge, S.V., Woollet, J., Edwards, K.J., Gathorne-Hardy, F.J., et al., 2005. Historical ecology on Sandoy, Faroe Islands: palaeoenvironmental and archaeological perspectives. *Human Ecology* 33, 651–684.
- Losey, R.J., 2005. Earthquakes and tsunami as elements of environmental disturbance on the Northwest Coast of North America. *Journal of Anthropological Archaeology* 24, 101–116.
- Lovstov, V.F., Black, L., Pierce, R.A., 1991. *The Lovstov Atlas of the North Pacific Ocean: Compiled at Bol'sheretsk, Kamchatka, in 1782 from Discoveries Made by Russian Mariners and Captain James Cook and His Officers*. Limestone Press. Kingston, ON, Canada.
- Ludwin, R.S., Dennis, R., Carver, D., McMillan, A.D., Losey, R., Clague, J., Jonientz-Trisler, C., Bowe chop, J., Wray, J., James, K., 2005. Dating the 1700 Cascadia earthquake: great coastal earthquakes in native stories. *Seismological Research Letters* 76, 140–148.
- Ludwin, R.S., Smits, G.J., Carver, D., James, K., Jonientz-Trisler, C., McMillan, A.D., Losey, R., et al., 2007. Folklore and earthquakes: Native American oral traditions from Cascadia compared with written traditions from Japan. *Geological Society, London, Special Publications* 273, 67–94.
- Maschner, H.D.G., Betts, M.W., Cornell, J., Dunne, J.A., Finney, B., Huntly, N., Jordan, J.W., et al. 2009. An introduction to the biocomplexity of Sanak Island, western Gulf of Alaska. *Pacific Science* 63, 673–709.
- McCartney, A.P., 1972. *An Archaeological Site Survey and Inventory for the Aleutian Islands National Wildlife Refuge, Alaska 1972: A Report Submitted to the Wilderness Study Branch, U.S. Fish and Wildlife Service, Anchorage, Alaska*. U.S. Fish and Wildlife Service, Anchorage, AK.
- McCartney, A.P., Veltre, D.W., 2002. Longhouses of the eastern Aleutian Islands, Alaska. In: Frohlich, B., Harper, A., Gilberg, R. (Eds.), *To the Aleutians and Beyond*. National Museum of Denmark, Copenhagen, pp. 249–265.
- McGovern, T.H., Vésteinsson, O., Friðriksson, A., Church, M., Lawson, I., Simpson, I.A., Einarsson, A., et al., 2007. Landscapes of settlement in northern Iceland: historical ecology of human impact and climate fluctuation on the millennial scale. *American Anthropologist* 109, 27–51.
- Meleney, P., Nicolaysen, K., Dehn, J., 2008. Petrogenetic modeling of pre-2004 lavas from Mt. Cleveland, Chuginadak Island, AK. *Eos Transactions, American Geophysical Union* 89, Fall Meeting Supplement, abstract V43H-04.
- Mordy, C.W., Stabeno, P.J., Ladd, C., Zeeman, S., Wisegarver, D.P., Salo, S.A., Hunt, G.L., Jr., 2005. Nutrients and primary production along the eastern Aleutian Island Archipelago. *Fisheries Oceanography* 14S, 55–76.
- Morton, R.A., Gelfenbaum, G., Jaffe, B.E., 2007. Physical criteria for distinguishing sandy tsunami and storm deposits using modern examples. *Sedimentary Geology* 200, 184–207.
- Moss, M.L., Yang, D.Y., Newsome, S.D., Speller, C.F., McKechnie, I., McMillan, A.D., Losey, R.J., Koch, P.L., 2006. Historical ecology and biogeography of North Pacific pin-nipeds: isotopes and ancient DNA from three archaeological assemblages. *Journal of Island and Coastal Archaeology* 1, 165–190.
- Neal, C.A., Izbekov, P., Nicolaysen, K.P., 2015. Preliminary analysis of a postglacial tephra section at Mount Cleveland Volcano, Chuginadak Island, Aleutian Arc. *Geological Society of America, Abstracts with Programs* 47, 11.
- Nicolaysen, K., Allen, S., Dehn, J., Moore, R., Weis, D., 2003. Continued magmatic unrest: geochemical evolution of recent eruptions from Mt. Cleveland, Aleutian Arc, AK. *Eos Transactions, American Geophysical Union* 84, Fall Meeting Supplement, abstract V31E-0974.
- Nicolaysen, K., Bridges, D., Swapp, S., 2005. Crustal control on crystallization depths? Preliminary evidence from Mt. Cleveland, Chuginadak Island, eastern Aleutians Arc. *Eos Transactions, American Geophysical Union* 86, Fall Meeting Supplement, abstract V21D-0655.
- Okuno, M., Izbekov, P., Nicolaysen, K.P., Nakamura, T., Savinetsky, A.B., Vasyukov, D.D., Krylovich, O.A., et al., 2016. Radiocarbon dating on tephra layers and archaeological sites in the Islands of Four Mountains, Alaska. In: ¹⁴C & Archaeology: 8th International Symposium, Edinburgh, p. 106.
- Okuno, M., Izbekov, P., Nicolaysen, K.P., Sato, E., Nakamura, T., Savinetsky, A.B., Vasyukov, D.D., et al., 2017. AMS radiocarbon dates on peat section related with tephra and archaeological sites in Carlisle Island, the Islands of Four Mountains, Alaska. *Radiocarbon* 59, 1771–1778.
- O'Leary, M., 1993a. *Report of Investigation for the Aleut Corporation BLM AA-12210 (Site UL-1)*. Bureau of Indian Affairs, ANCSA Office, Anchorage, AK.
- O'Leary, M., 1993b. *Report of Investigation for the Aleut Corporation BLM AA-12206 (Site CG-2)*. Bureau of Indian Affairs, ANCSA Office, Anchorage, AK.
- O'Leary, M., 1993c. *Report of Investigation for the Aleut Corporation BLM AA-12208 (CG-4)*. Bureau of Indian Affairs, ANCSA Office, Anchorage, AK.
- O'Leary, M., Bland, R.L., 2013. Aleut burial mounds: Ulaakan and Umqan. *Alaska Journal of Anthropology* 11, 139–168.
- Pekar, K., Nicolaysen, K.P., Bridges, D., Dehn, J., 2005. Prehistoric lahar and tephra sequences on Mt. Cleveland, Islands of Four Mountains, eastern Aleutian Islands. *Eos Transactions, American Geophysical Union* 86, Fall Meeting Supplement, abstract V33B-0681.
- Persico, L., Lanman, H., Loopesko, L., Bruner, K., Nicolaysen, K., 2018. Geomorphic processes influence human settlement on two islands in the Islands of Four Mountains, Alaska. *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2018.112>.
- Rick, T.C., Erlandson, J.M., Braje, T.J., Estes, J.A., Graham, M.H., Vellanoweth, R.L., 2008. Historical ecology and human impacts on coastal ecosystems of the Santa Barbara Channel region, California. In: Rick, T.C., Erlandson, J.M. (Eds.), *Human Impacts on Ancient Marine Ecosystems: A Global Perspective*. University of California Press, Berkeley, pp. 77–101.
- Rogers, J.S., 2011. Architecture and complex hearth features at the Amaknak Bridge site, eastern Aleutian Islands, Alaska. *Arctic Anthropology* 48, 92–112.
- Rojek, N.A., Williams, J.C. 2018. Present-Day Assemblage of birds and mammals in the Islands of Four Mountains, Eastern Aleutians, Alaska. *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2018.36>
- Ruppert, N.A., Lees, J.M., Kozyreva, N.P., 2007. Seismicity, earthquakes and structure along the Alaska-Aleutian and Kamchatka-Kurile subduction zones: a review. In: Eichelberger, J., Gordeev, E., Izbekov, P., Kasahara, M., Lees, J. (Eds.), *Volcanism*

- and Subduction: The Kamchatka Region. Geophysical Monograph Series 172. American Geophysical Union, Washington, DC, pp. 129–144.
- Savinetsky, A.B., Kisleva, N.K., Khassanov, B., 2010. Paleoenvironment—Holocene deposits from Shemya Island. In: Corbett, D.G., West, D., Lefèvre, C. (Eds.), *The People at the End of the World: The Western Aleutians Project and the Archaeology of Shemya Island*. Aurora Monograph Series 7. Alaska Anthropological Association, Anchorage, AK.
- Stuiver, M., Reimer, P.J., Reimer, R.W., 2017. CALIB 7.1 (accessed August 30, 2017). <http://calib.org>.
- Tremayne, A.H., Brown, W.A., 2017. Mid to late Holocene population trends, culture change and marine resource intensification in western Alaska. *Arctic* 70, 365–380.
- Turck, T.J., 1993. *Report of Investigation for the Aleut Corporation BLM AA-12201*. Bureau of Indian Affairs, ANCSA Office, Anchorage, AK.
- VanderHoek, R., Myron, R., 2004. *Cultural Remains from a Catastrophic Landscape: An Archaeological Overview and Assessment of Aniakchak National Monument and Preserve*. Research/ Resources Management Report AR/CRR-2004-47. U.S. Department of the Interior, National Park Service, Aniakchak National Monument and Preserve, Anchorage, AK.
- Vasyukov, D.D., Krylovich, O.A., West, D.L., Hatfield, V.L., Savinetsky, A.B. 2019. Ancient canids of the Aleutian Islands (new archaeological discoveries from the Islands of Four Mountains). *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2019.2>
- Veltre, D., McCartney, A., 2001. Ethnohistorical archaeology at the Reese Bay site, Unalaska Island, Alaska. In: Dumond, D. (Ed.), *Archaeology in the Aleut Zone of Alaska, Some Recent Research*. University of Oregon Anthropological Papers No. 58. Department of Anthropology and State Museum of Anthropology, University of Oregon, Eugene, 87–104.
- Veniaminov, I., 1984. Notes on the Islands of the Unalaska District. Translated by Black, L.T., Geoghegan, R.H. Alaska History No. 27. Elmer E. Rasmuson Library Translation Program, University of Alaska, Fairbanks; Limestone Press, Kingston, ON, Canada.
- Walker, B., Salt, D., 2006. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Island Press, Washington, DC.
- West, D., Hatfield, V., Wilmerding, E., Lefevre, C., Gualtieri, L., 2012. *The People Before: The Geology, Paleoecology, and Archaeology of Adak Island, Alaska*. BAR International Series 2322. Archaeopress, Oxford, UK.
- West, D., Khasanov, B., Krylovich, O., Hatfield, V., Khasanov, T., Vasyukov, D., Savinetsky, A., 2019. Refining the Paleo-Aleut to Neo-Aleut transition using a new ΔR for the eastern Aleutian Islands, Alaska. *Quaternary Research*, this volume. <https://doi.org/10.1017/qua.2018.91>
- Wraley, J.H., 1990. *Notes on Surface Archeological Finds and Newly Discovered Burial Caves on Carlisle Island, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, May 20, 1990–June 16, 1990*. U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Homer, AK.