Radiocarbon, Vol 60, Nr 2, 2018, p 367–382 DOI:10.1017/RDC.2018.2

HOLOCENE HUMAN OCCUPATION OF THE CENTRAL ALASKA PENINSULA

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ABSTRACT. The Alaska Peninsula is a landscape defined by volcanic, tectonic, and glacial processes, and life throughout is conditioned on the interactions among them. During the middle Holocene (ca. 4100–3600 yr ago), intense caldera-forming eruptions of the Aniakchak and Veniaminof volcanoes changed the shape of the central portion of the Peninsula dramatically, and had significant and perhaps devastating impacts on both terrestrial and marine biota. Here we evaluate the severity of these impacts by tracking human settlement patterns using 75 unique radiocarbon (^{14}C) age determinations on buried cultural features from the central Alaska Peninsula. Coastal regions were re-colonized within a few hundred years while river systems most proximate to the volcanoes were uninhabited for up to 1500 years following the most severe eruptions. Patterns of human settlement may also document previously unrecorded landscape change throughout the region, and further contribute to our understanding of post-volcanic ecological succession.

KEYWORDS: Alaska, ecological succession, human settlement, volcanism.

INTRODUCTION

A major objective of the Chignik-Meshik Rivers Cultural Resource Reconnaissance project (Shirar et al. 2011, 2012, 2013; Shirar et al. forthcoming) was to establish a chronology of human occupation of the central Alaska Peninsula. In other parts of the peninsula and throughout southwest Alaska researchers have used a variety of methods to estimate the age of archaeological deposits, including radiocarbon (^{14}C) dating (e.g. Crowell and Mann 1996), tephrochronology (e.g. Dumond 2011), and identification of artifacts and/or architectural features belonging to temporally constrained cultural horizons (e.g. Steffian and Saltonstall 2004). However, because so little is known about the prehistoric cultural identities of the people of the central peninsula, and because the sequence, absolute age, and spatial distribution of tephra deposits have not been established, this project instead focused on radiometric age estimation of organic materials recovered from secure cultural and geological contexts. In addition to mapping out a framework of where and when people lived throughout the region, our goal with this chronological sampling was to improve our understanding of landscape change (both geomorphic and ecological) in response to volcanic activity.

This project produced 92 accelerator mass spectrometry (AMS) ^{14}C age determinations, sampled from a large array of field specimens (>350). Of these, 75 were taken from cultural contexts (including house floors, hearths, and other buried features) at 31 unique human settlements. An additional 17 come from non-cultural geomorphic contexts (including stratified bluff faces, river cuts, and peat and estuarine deposits) in five unique depositional settings, and will be described elsewhere. Here we describe the sampling, preparation, and measurement methods used in this project, illustrate patterns of human settlement across the central Alaska Peninsula during the Holocene, and provide preliminary insights about the effects of volcanism on ecological succession and human occupation.

Sample Selection

Sub-surface testing of presumed cultural deposits was designed to accomplish four primary goals: (1) to confirm that features visible on the surface were indeed cultural, (2) to evaluate the

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depth and superposition of different occupations, (3) to establish the age of these occupations, and (4) to assess the cultural affinities of these occupations. When secure cultural deposits (i.e. stratified, undisturbed, charcoal and artifact rich strata, often separated by tephra deposits and/or house floors and roofs) were encountered, excavators collected large pieces of in-situ charcoal from test unit plans and profiles, but not from the sediment sieves. Selection of samples for AMS ^{14}C dating focused on those from secure cultural components with taxonomic identification. Every effort was made to connect the uppermost cultural component with the architectural feature visible on the surface, thereby capturing the age of the feature type (e.g. single- and multi-room features of various configurations). When test units revealed more than one cultural component (usually separated by deposits of tephra), we sampled both for radiometric dating. Because much of our sub-surface testing revealed multiple cultural components, we elected to provide ages for as many as possible rather than to attempt discrimination of each component from deposits visible only in 50 × 50-cm test units. More expansive excavations of individual architectural features along with more extensive excavations from each site would surely produce a more detailed, and more tightly constrained chronology for each settlement. Likewise, more thorough excavations might reveal patterns of foundation building, structural refurbishing, and rebuilding that simply are not possible to untangle in small test units. However, our goal with this sampling design was to collect evidence for human occupation over a broad area, and across many millennia. AMS dating of cultural charcoals from multiple test units makes this possible.

Sample Identification

Due to the chemistry of volcanic soils that mantle much of the Alaska Peninsula (Ping et al. 1988), organic materials (including bone) in most contexts do not preserve for more than a few centuries. Therefore, inert carbon from burned wood is the most common material available for ^{14}C dating, and the taxonomic identity of each piece of carbonized wood is critical for estimating the age of human activity. The central peninsula is essentially treeless, with woody vegetation consisting of low-lying alder (*Alnus* spp.), willow (*Salix* spp.), poplar (*Populus* spp.), and shrub birch (*Betula* spp.). Prehistoric inhabitants would have also had access to large pieces of driftwood on both the Pacific and the Bering Sea Coasts. Because the coast was never more than 30 km away, driftwood from large, exotic trees was surely incorporated into the building materials, tools, and fuels of the prehistoric inhabitants. To avoid this "old-wood" problem (Schiffer 1986), which is potentially exacerbated when large old trees circulate around the North Pacific, we focused our charcoal sampling on locally abundant, short-lived taxa (namely *Salix* spp., *Populus* spp., *Alnus* spp., and *Betula* spp.). When such taxonomic resolution was not possible, we also considered sampling unidentifiable hardwoods. Softwoods, and conifers of all kinds (including spruce, which is abundant on the northern peninsula, only 300 km away) were avoided. A single piece of unidentified charcoal, associated with several samples of softwood charcoal, was chosen for AMS (Beta-357204). Certainly willows, alders, poplar, and birch can occasionally live to great age, can float around in oceanic gyres, and can be preserved in some surface settings, but carbonized wood specimens from these taxa are likely only a few decades older than when their wood was used by humans. Large conifers on the other hand may be centuries older, and well outside the variance imposed by instrumental error in AMS measurement and the variance in the calibration curve. In only a few cases did we select cultural charcoal samples without taxonomic identification (see Table 1); these age estimates should be viewed with some caution, even though charcoal from coniferous, or otherwise exotic trees is rare.[1]

[1]All taxonomic identification reports are available online (Barton et al. 2018).

https://doi.org/10.1017/RDC.2018.2 Published online by Cambridge University Press

Table 1 ^{14}C age determinations from cultural contexts. Calibrated with OxCal 4.2 (Bronk Ramsey 2009) using the IntCal13 calibration curve (Reimer et al. 2013). The 2σ upper and lower range and median reflect the 95.4% probability output from OxCal. Context and provenience of each can be found in print (Shirar et al. 2011, 2012, 2013; Shirar et al. forthcoming) and in the online dataset (Barton et al. 2017).

Site nr	Region	Material	Sample taxon	$\delta^{13}C$	Lab nr	^{14}C yr BP	±	2σ calBP–	2σ calBP+	2σ calBP median	Field report (Shirar et al. year)
CHK-104	Chignik drainage–Alec River	Charcoal	*Salix/Populus*	–27.1	Beta-312530	1160	30	1177	983	1080	2012
CHK-104	Chignik drainage–Alec River	Charcoal	*Alnus*	–25.3	Beta-312531	1180	30	1221	999	1112	2012
CHK-104	Chignik drainage–Alec River	Charcoal	*Alnus*	–25.2	Beta-312547	1180	30	1221	999	1112	2012
CHK-111	Chignik drainage–Alec River	Charcoal	*Alnus*	–24.3	Beta-292746	280	40	470	152	370	2011
CHK-122	Chignik drainage–Alec River	Charcoal	*Alnus*	–25.6	Beta-312540	1160	30	1177	983	1080	2012
CHK-123	Chignik drainage–Alec River	Charcoal	*Alnus*	–24.9	Beta-312541	1540	30	1525	1363	1451	2012
CHK-107	Chignik drainage–Bear Skin Crk	Charcoal	*Salix/Populus*	–25.43	UGAMS-12786	1292	22	1285	1181	1240	2013
CHK-108	Chignik drainage–Black Lake	Charcoal	Unidentified hardwood	–24.5	Beta-292743	290	40	468	155	379	2011
CHK-108	Chignik drainage–Black Lake	Charcoal	*Alnus*	–26.7	Beta-292747	370	40	505	315	426	2011
CHK-108	Chignik drainage–Black Lake	Charcoal	*Salix/Populus*	–26.5	Beta-299602	1040	30	1050	918	951	2011
CHK-109	Chignik drainage–Black Lake	Charcoal	*Alnus*	–24.4	Beta-292745	150	40	285	0	151	2011
CHK-109	Chignik drainage–Black Lake	Charcoal	*Alnus*	–25.7	Beta-292748	380	40	510	315	437	2011
CHK-110	Chignik drainage–Black Lake	Charcoal	Unidentified hardwood	–25.4	Beta-292744	250	40	437	0	297	2011
CHK-110	Chignik drainage–Black Lake	Charcoal	Unidentified hardwood	–25.4	Beta-299603	1420	30	1368	1290	1322	2011
CHK-110	Chignik drainage–Black Lake	Charcoal	*Salix/Populus*	–23.7	Beta-299604	1480	30	1412	1305	1363	2011
CHK-005	Chignik drainage–Chignik Lake	Charcoal	*Alnus*	–25	Beta-299609	1880	30	1885	1728	1828	2011
CHK-005	Chignik drainage–Chignik Lake	Charcoal	*Alnus*	–25.1	Beta-299605	1890	30	1895	1733	1839	2011
CHK-005	Chignik drainage–Chignik Lake	Charcoal	*Salix*	–27.01	UGAMS-12784	3996	24	4521	4419	4478	2013
CHK-005	Chignik drainage–Chignik Lake	Charcoal	*Salix*	–23.5	UGAMS-12785	4145	24	4822	4580	4689	2013
CHK-005	Chignik drainage–Chignik Lake	Charcoal	*Alnus*	–22.4	Beta-299606	4190	40	4844	4584	4724	2011
CHK-014	Chignik drainage–Chignik Lake	Charcoal	Unidentified hardwood	–26.3	Beta-299607	1150	30	1174	979	1060	2011
CHK-014	Chignik drainage–Chignik Lake	Charcoal	*Alnus*	–24.2	Beta-299608	1200	30	1236	1010	1126	2011
CHK-157	Chignik drainage–Red Salmon Creek	Charcoal	*Salix*	–25.66	UGAMS-12789	2123	24	2291	2004	2099	2013
CHK-105	Chignik drainage–Upper Chignik River	Charcoal	Unidentified hardwood	–23.1	Beta-299601	1970	30	1994	1865	1919	2011
CHK-116	Chignik drainage–Upper Chignik River	Charcoal		–24.3	Beta-357206	340	30	481	311	390	2013

Table 1 (*Continued*)

Site nr	Region	Material	Sample taxon	$\delta^{13}C$	Lab nr	^{14}C yr BP	±	2σ calBP–	2σ calBP+	2σ calBP median	Field report (Shirar et al. year)
CHK-116	Chignik drainage–Upper Chignik River	Charcoal	*Salix*	–25.32	UGAMS-12787	1284	22	1281	1181	1235	2013
CHK-140	Meshik drainage–Blue Violet Creek	Charcoal	*Salix*/*Populus*	–28.17	UGAMS-12791	1217	22	1235	1064	1137	2013
CHK-140	Meshik drainage–Blue Violet Creek	Charcoal	*Salix*/*Populus*	–24.89	UGAMS-12790	1461	22	1389	1306	1346	2013
CHK-141	Meshik drainage–Blue Violet Creek	Charcoal	*Salix*	–25.06	UGAMS-12792	1706	22	1695	1554	1605	2013
CHK-139	Meshik drainage–Braided Creek	Charcoal	*Angiosperm*	–26.32	UGAMS-12788	1481	23	1405	1315	1364	2013
SUT-022	Meshik drainage–Meshik Lake	Charcoal	Unidentified hardwood	–25.2	Beta-299600	1190	30	1229	1005	1119	2011
CHK-058	Meshik drainage–Meshik River	Charcoal	*Alnus*	–23.4	Beta-312528	1620	30	1569	1412	1514	2012
CHK-059	Meshik drainage–Meshik River	Charcoal	*Salix*/*Populus*	–25.5	Beta-312542	1150	30	1174	979	1060	2012
CHK-059	Meshik drainage–Meshik River	Charcoal	*Alnus*	–25.2	Beta-312529	1490	40	1520	1302	1375	2012
CHK-113	Meshik drainage–Meshik River	Charcoal	*Alnus*	–25.8	Beta-312544	1150	30	1174	979	1060	2012
CHK-113	Meshik drainage–Meshik River	Charcoal	*Alnus*	–25	Beta-312535	1280	30	1288	1176	1231	2012
CHK-113	Meshik drainage–Meshik River	Charcoal	*Alnus*	–25.7	Beta-312546	1430	30	1376	1293	1327	2012
CHK-113	Meshik drainage–Meshik River	Charcoal	*Alnus*	–26.1	Beta-312532	1470	30	1405	1305	1355	2012
CHK-113	Meshik drainage–Meshik River	Charcoal	*Salix*/*Populus*	–24.2	Beta-312545	1490	30	1514	1307	1372	2012
CHK-113	Meshik drainage–Meshik River	Charcoal	*Alnus*	–25.2	Beta-312534	1550	30	1528	1377	1462	2012
CHK-113	Meshik drainage–Meshik River	Charcoal	*Alnus*	–26	Beta-312533	1580	30	1540	1404	1468	2012
CHK-117	Meshik drainage–Meshik River	Charcoal	*Alnus*	–24.5	Beta-312536	1570	30	1534	1394	1467	2012
CHK-118	Meshik drainage–Meshik River	Charcoal	*Alnus*	–26.3	Beta-312537	1230	30	1262	1068	1163	2012
CHK-119	Meshik drainage–Meshik River	Charcoal	*Alnus*	–25.8	Beta-312538	1210	30	1255	1059	1133	2012
CHK-120	Meshik drainage–Meshik River	Charcoal	*Alnus*	–23.7	Beta-312543	1510	30	1521	1328	1391	2012
CHK-120	Meshik drainage–Meshik River	Charcoal	*Alnus*	–25.3	Beta-312539	1560	30	1530	1386	1466	2012
CHK-125	Ocean River drainage	Charcoal		–25.1	Beta-357210	270	30	436	152	318	2013
CHK-125	Ocean River drainage	Charcoal		–25	Beta-357207	310	30	465	301	387	2013
CHK-125	Ocean River drainage	Charcoal		–23.4	Beta-357208	310	30	465	301	387	2013
CHK-125	Ocean River drainage	Charcoal	*Alnus*	–24.32	UGAMS-12800	759	23	727	669	687	2013
CHK-125	Ocean River drainage	Charcoal	*Salix*	–25.99	UGAMS-12799	967	23	933	796	857	2013
CHK-125	Ocean River drainage	Charcoal		–24.1	Beta-357209	1190	30	1229	1005	1119	2013
CHK-125	Ocean River drainage	Charcoal	*Salix*	–25.93	UGAMS-12794	1508	23	1517	1337	1386	2013
CHK-125	Ocean River drainage	Charcoal	*Salix*	–25.08	UGAMS-12797	1715	22	1696	1560	1616	2013
CHK-125	Ocean River drainage	Charcoal	*Alnus*	–26.7	UGAMS-12795	1868	23	1872	1731	1813	2013
CHK-125	Ocean River drainage	Charcoal	*Betula*	–27.78	UGAMS-12801	1953	23	1970	1827	1902	2013

CHK-125	Ocean River drainage	Charcoal	*Alnus*	–24.86	UGAMS-12803	2572	24	2755	2544	2734	2013
CHK-125	Ocean River drainage	Charcoal	*Betula*	–26.02	UGAMS-12802	2644	23	2783	2743	2759	2013
CHK-125	Ocean River drainage	Charcoal	*Alnus*	–25.05	UGAMS-12796	2724	23	2862	2768	2815	2013
CHK-125	Ocean River drainage	Charcoal	*Alnus*	–22.8	UGAMS-12798	3416	24	3810	3589	3664	2013
CHK-125	Ocean River drainage	Charcoal	*Alnus*	–24.91	UGAMS-12793	3523	24	3875	3715	3784	2013
CHK-126	Ocean River drainage	Charcoal	*Salix*	–25.29	UGAMS-12804	1011	23	969	832	934	2013
CHK-127	Ocean River drainage	Charcoal		–24.5	Beta-357211	250	30	429	0	295	2013
CHK-127	Ocean River drainage	Charcoal	*Alnus*	–26.15	UGAMS-12805	2461	23	2707	2380	2582	2013
CHK-128	Ocean River drainage	Charcoal	*Salix*	–26.48	UGAMS-12807	503	23	545	507	526	2013
CHK-128	Ocean River drainage	Charcoal	*Salix*	–25.65	UGAMS-12806	1248	23	1271	1085	1215	2013
CHK-129	Ocean River drainage	Charcoal	*Salix*	–26.74	UGAMS-12808	603	24	652	545	603	2013
CHK-129	Ocean River drainage	Charcoal	*Alnus*	–24.98	UGAMS-12809	1215	23	1234	1063	1135	2013
CHK-130	Ocean River drainage	Charcoal		–24.9	Beta-357204	240	30	425	0	287	2013
CHK-130	Ocean River drainage	Charcoal		–25.6	Beta-357205	260	30	431	0	304	2013
CHK-130	Ocean River drainage	Charcoal	*Salix*	–25.5	UGAMS-12812	415	24	517	335	491	2013
CHK-130	Ocean River drainage	Charcoal	*Salix*	–24.85	UGAMS-12811	1981	25	1990	1881	1929	2013
CHK-130	Ocean River drainage	Charcoal	*Salix*	–24.81	UGAMS-12813	2526	23	2742	2498	2619	2013
CHK-130	Ocean River drainage	Charcoal	*Salix*	–25.9	UGAMS-12810	3458	25	3828	3642	3722	2013
CHK-133	Ocean River drainage	Charcoal	*Salix*	–24.92	UGAMS-12814	417	23	518	337	493	2013

Pretreatment, Measurement, and Calibration

All selected samples were sent to one of two labs over the course of three years for pretreatment, graphitization, and AMS measurement: Beta Analytic, Inc. (lab code Beta-) processed 54 samples; the Center for Applied Isotope Studies at the University of Georgia (lab code UGAMS-) processed another 38.[2]

Both labs pre-process carbonized wood samples with a standard acid-alkali-acid (HCl-NaOH-HCl) wash sequence before drying, combustion, and graphitization (following methods described in Hedges et al. 1989 and Vogel et al. 1984, respectively).

Both labs measure graphite $^{14}C/^{13}C$ ratios using an accelerator mass spectrometer and correct by comparison to measurement of a known reference standard (Oxalic Acid; see lab reports for specifics). Age estimates are calculated using the Libby ^{14}C half-life (5568 yr), and corrected for isotopic fractionation using an independent measurement of $^{13}C/^{12}C$, calculated relative to the PDB standard. Corrected lab results are presented in ^{14}C years before present (^{14}C yr BP), conventionally before AD 1950.

General Observations

All age estimates generated by this project are sufficiently precise to meet contemporary objectives for good ^{14}C "hygiene" (see Kennett et al. 2008; Spriggs 1989). Measurement error across all cultural samples was tight, no samples with marine reservoir effects were used (no marine or aquatic taxa were sampled, and the $^{13}C/^{12}C$ of all samples fall squarely in the range of terrestrial C_3 plants), and we made every effort to eliminate the "old-wood" problem by sampling charcoal from local, short-lived hard-wood taxa. Although nine samples were not identified taxonomically, it is unlikely that any come from exotic old wood because charcoal from such wood was exceedingly rare in the total identified assemblage, and none of the results fall outside of expectation given their archaeological context.

Analytical Framework

To evaluate spatial and temporal patterns of human land-use in relation to volcanic activity and landscape change, we combine calibrated ^{14}C probability distributions (referenced here as summed probability distributions, or SPDs) from multiple samples taken from similar contexts. Combining ^{14}C age estimates in this way serves two useful purposes: (1) it provides a graphical illustration of the probability that some spatially explicit analytical unit (a house, a settlement, or a region) was active at any given time; and (2) it enables both graphical and quantitative comparisons among different analytical units. In cultural terms, we can evaluate the contemporaneity of different houses, the cycles of occupation and abandonment in a single settlement, or broad patterns of human activity in different river drainages.

Over the past 30 years, use of aggregated ^{14}C age estimates (both calibrated and uncalibrated) has become more sophisticated and more creative, in both method and application (Weninger 1986; Rick 1987; van Andel et al. 2003; Gamble et al. 2004; Barton et al. 2007; Brown 2017; Hutchinson and Crowell 2007; Shennan and Edinborough 2007; Kelly et al. 2013). Increasingly analysts have come up with different ways to improve the precision for each date (e.g. Bayliss 2009; Kennett et al. 2014) and new ways of aggregating and analyzing multiple calibrated dates (e.g. Brown 2015; Woodbridge et al. 2014). Yet there are still concerns about the robustness of the resulting SPD, and therefore concerns about the utility of it for investigating population

[2]All original lab reports are available online (Barton et al. 2018).

patterns, particularly relative and absolute demographic dimensions (Michczynski and Michczynska 2006; Surovell and Brantingham 2007; Buchanan et al. 2008; Culleton 2008; Surovell et al. 2009; Collard et al. 2010; Bamforth and Grund 2012; Williams 2012; Shennan 2013; Contreras and Meadows 2014; Drennan et al. 2015).

While the concerns surrounding these debates are well placed, and continued discussion will surely improve the accuracy, precision, and strength of our analytical tools, even in its infancy the SPD is a useful depiction of the likelihood of human activity in the past. For the purpose of this project, which looks at patterns across ~5,000 years over a large geographic area, we are comfortable with the basic level of imprecision associated with calibrated SPDs. Modeled approaches to reducing the calibrated variance by relying on priors such as stratigraphic relationships, blankets of volcanic tephra, or tightly seriated artifact chronologies are unlikely to improve the results of the current study. We simply do not know enough about the cultural or volcanic sequences to warrant this, though anticipate that the results of this project will make future efforts possible. Furthermore, we do not use the SPD as a robust demographic estimator in this study, but rather as a useful graphical depiction of occupation periods in the region. The intent here is to provide a preliminary periodization, and to offer preliminary comparisons.

All graphical SPDs in this report were produced using the CalPal software package (Weninger et al. 2007) using the IntCal13 calibration curve (Reimer et al. 2013). Note that there will be minor differences between the calibrated age ranges produced by CalPal and those produced by OxCal, the latter of which are presented in Table 1.

Analytical Units

On the most basic level, our primary goal with this project was to figure out when different places were occupied in relation to the timing of volcanically induced landscape change. We also wanted to know when distinct settlements were occupied and abandoned, and how these patterns might reveal something about how people (and different behaviors, subsistence strategies, and technologies) moved about the landscape. Finally, we hoped to learn something about the timing and distribution of diagnostic cultural attributes known to discrete times and places outside the study region with the hopes of drawing some connection to larger, super-regional population-level processes. This final objective proves the most difficult because our sampling strategy produced so few diagnostic elements (namely artifacts). The only truly ubiquitous diagnostic cultural effects we have are architectural features visible immediately underneath the surface (see Shirar et al. forthcoming). Here we confine our efforts to evaluating broader patterns of occupation, both inside and outside of the study area.

Our survey design targeted a variety of different land-forms and drainages throughout the study area for the purpose of understanding how volcanic activity might have affected biotic productivity (and as a result, human activity) in different settings. For a coarse-grained analysis of ^{14}C data we divide the study area into three analytical units based on contemporary watersheds: the Meshik, Chignik, and Ocean River drainages (see Figures 1 and 2). ^{14}C data are summarized for these units, which include all data collected during this project and all previously recorded ^{14}C data, as reported in both the literature and the Alaska Heritage Resources Survey (AHRS) database.[3] Though all of the ^{14}C data collected for the current project are reasonably precise, the same cannot be said of all previously reported age estimates, some of which were measured decades ago. Regardless of precision, all available age estimates were

[3]Access to the AHRS database is available by request to qualified investigators. See http://dnr.alaska.gov/parks/oha/ahrs/ahrs.htm.

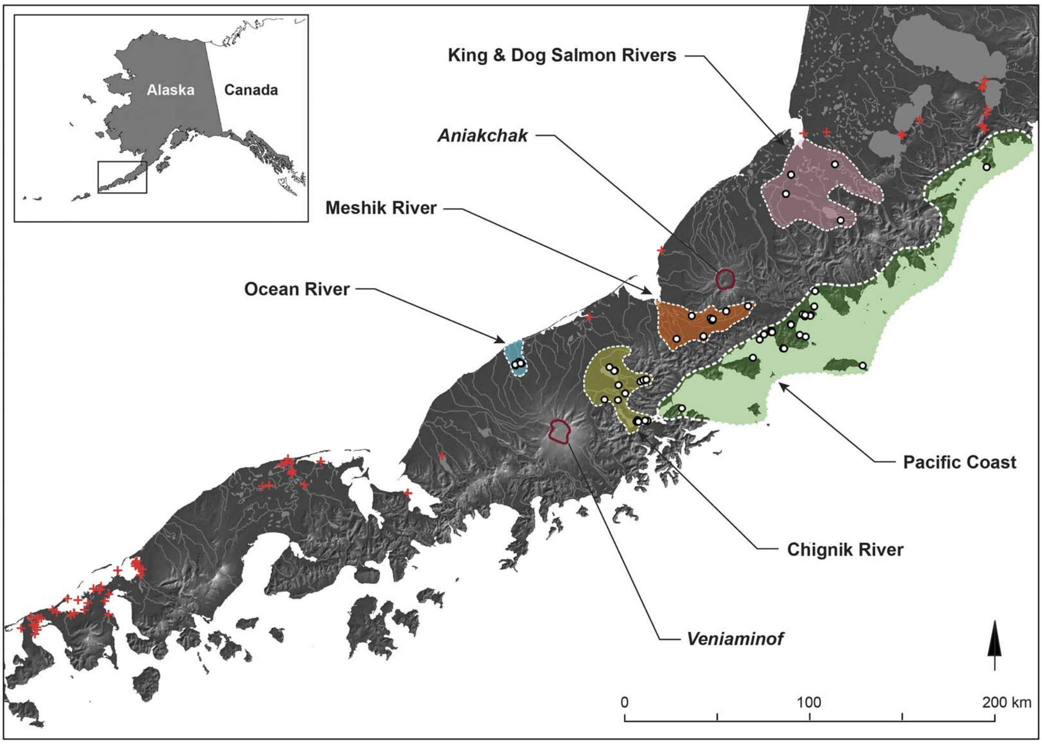

Figure 1 Analytical units of the central Alaska Peninsula. White circles depict locations of ^{14}C dates included in distinct areas; red crosses depict locations with ^{14}C dates from elsewhere in the central and lower peninsula.

calibrated and added to the SPDs for each analytical unit. For the Meshik, Chignik, and Ocean River drainages, most (or all) of the ^{14}C data come from this project; we include previously reported data to ensure that we did not miss important periods of human occupation not captured in our survey (see Table 2).

Analytical units from inside the study area are then compared to analytical units outside of, but adjacent to, our study area, namely the King Salmon and Dog Salmon River drainages, and the Pacific Coast. Comparison of these five discreet spatial units enables a comparison of the timing of human activity in different areas, and enables us to visualize patterns of occupation, abandonment, and re-occupation, and ultimately an assessment of how these patterns match up with chronological evidence for volcanism and landscape change (see Shirar et al. forthcoming). These five analytical units are then compared to a compilation of ^{14}C data (including our own) from the broader region of the central and lower Alaska Peninsula (roughly from the southern end of Becharof Lake in the northeast to False Pass in the southwest). While this broad, regional compilation may not include all existing ^{14}C data, the sample is sufficiently large to illustrate general patterns of activity throughout the region during the middle and late Holocene.

RESULTS

Summed probability distributions of calibrated ^{14}C dates for each analytical unit are presented in Figure 2 to reveal general patterns of occupation. The time frames of known volcanic events (namely, the catastrophic mid-Holocene eruptions of Veniaminof and Aniakchak) are also provided graphically in Figure 2 to enable comparison. Note that the age estimates for these

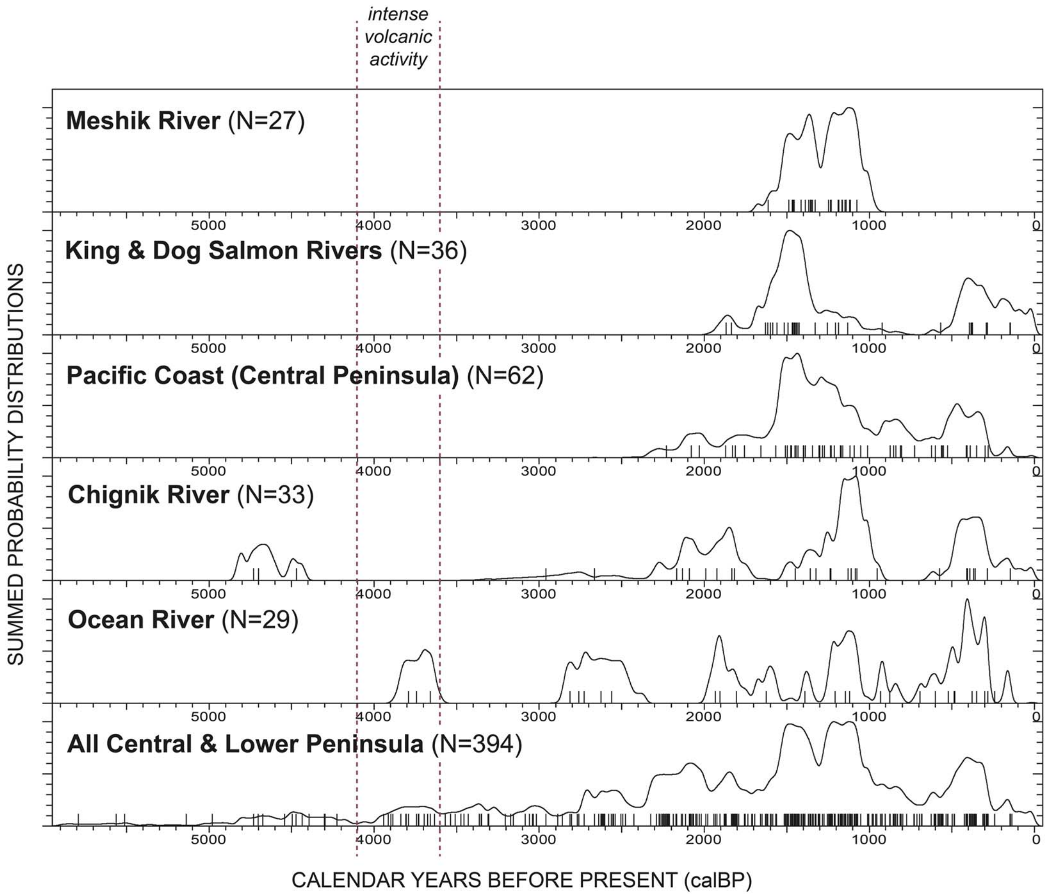

Figure 2 Summed probability distributions of calibrated ^{14}C dates from different analytical units, both inside and outside of the study area, corresponding to those illustrated in Figure 1. Produced using the CalPal software package (see text for justification).

Table 2 ^{14}C age determinations by analytical region. All data and data sources included in this analysis are available online. Note: the category "All central & lower peninsula" represents all cultural dates from this project plus another 319 previously reported ^{14}C dates from archaeological sites both inside and outside the 5 analysis areas. Sites outside appear as crosses in Figure 1.

Region	Nr of ^{14}C dates	Nr of dated settlements	Nr of dates collected this project
Meshik River	27	12	20
King & Dog Salmon Rivers	36	4	0
Pacific Coast	62	24	0
Chignik River	33	16	26
Ocean River	29	7	29
All central & lower peninsula	394	132	75

eruptions vary widely, and are the subject of considerable debate (Miller and Smith 1987; Beget et al. 1992; Pearce et al. 2004; VanderHoek 2009; Blackford et al. 2014; Davies et al. 2016); we use them here with caution.

The compilation of all dates from the central and lower Alaska Peninsula suggests that the region was first occupied just prior to 5100 cal BP. There is little evidence for human occupation of the region for the next 1000 years; whether this is because there were few people in the region, or because settlements during this interval have evaded archaeological detection, cannot be addressed with the current data. However, the absence of occupation evidence from ca. 4150–3950 cal BP may reveal the devastating impact of the caldera-forming eruption of Veniaminof, estimated as occurring between ca. 4100–3900 cal BP (Miller and Smith 1987), but this must remain speculative. What we can say is that some parts of the peninsula were occupied from ca. 4000 cal BP to the present day, this in spite of the purported impact of the Aniakchak II eruption of ~3700 cal BP[4]. This alone does not evaluate the full effects of the Aniakchak II eruption on human habitation, cultural and/or linguistic diversity, or landscape change: it merely notes that people continued to live somewhere in the region, in spite of those effects. We can see that the abundance of evidence for human occupation (in the form of ^{14}C dates) increases after 2500 cal BP, and peaks from about 1500–900 cal BP. A more robust sampling of these cultural and geological contexts would be necessary to interpret the peaks and troughs of this SPD as a demographic proxy.

A number of important points (both certain and speculative) can be made from observations of the discreet analytical units in varying proximity to the volcanoes of the region. First, though our survey was designed to identify the nature and distribution of human activity prior to the major mid-Holocene eruptions, we encountered this in only one place: the mouth of Chignik Lake (specifically, at CHK-005). The SPD for the entire Chignik River drainage also suggests that the mid-Holocene eruptions had a significant effect on human activity, as there is no evidence for it from ca. 4400–3100 cal BP. Assuming the date for the Aniakchak II eruption is correct (ca. 3700 cal BP) it took another 700 years for people to occupy the region at a detectable intensity. However, it was not for another 1400 years (by 2300 cal BP) that the Chignik drainage saw an increase in the abundance and distribution of settlements (see Table 3).

The SPD from the Ocean River drainage (centered on settlements around Wildman Lake) tells another part of the story. First, in spite of the fact that this small region is immediately north and downslope of the Veniaminof volcano, people lived there soon after its major caldera-forming eruption (ca. 3900–3800 cal BP). If the combination of dates for this eruption can be taken at face value (ca. 4000 cal BP)[5], this means that the region was habitable within 200 years. Whether this means that the effects of the eruption were minimal on the north slope of the volcano, or because this short river drainage and coastline were quick to recover from them are open questions. We do, however note that the area was not occupied from ca. 3600–2900 cal BP and suggest this likely reflects the disturbance associated with the Aniakchak II eruption of 3700 BP. If so, it would suggest that people avoided the region for 800 years after the eruption, which was a little more than 100 km away. That people were living at both Wildman Lake and the lower end of Chignik Lake at approximately the same time (within ~150 yr of each other) may point to cultural, or at least adaptive, similarities among people that re-colonized the area. This issue is quite testable as the settlements in both areas are stratified, reasonably well-preserved, and rich in material remains (compare CHK-125 at Wildman Lake and CHK-031 at Chignik Lake).

[4]Age estimates for the Aniakchak II eruption vary from approximately 3500–3700 cal BP, depending on the priorities different researchers give to ages based on ^{14}C dates on charcoal beneath Aniakchak tephra, and proxies extracted from both high latitude lake cores and Greenland ice (see Davies et al. 2016 and VanderHoek 2009 for reviews of the evidence). For comparative discussion, we simplify this body of evidence to a single point estimate of 3700 cal BP based on medians of calibrated ^{14}C age estimates published in Beget et al. (1992) and Miller and Smith (1987).

[5]The median of three dates for the Veniaminof eruption provided in Miller and Smith (1987) calibrates to 3996 ± 206; the mean calibrates to 4023 ± 200. Here we simply express this as 4000 cal BP.

Table 3 A comparison of the age of first evidence for human activity in each analytical area, and the age when the density of ^{14}C data increases markedly for each area, along with the amount of time elapsed for each since the caldera-forming eruption of the Aniakchak volcano (ANIA II eruption).

Analytical unit	Age of 1st evidence	Time after ANIA II eruption	Age of increasing density	Time after ANIA II eruption
Meshik River drainage	1700	2000	1500	2200
King & Dog Salmon Rivers drainage	1950	1750	1650	2050
Pacific Coast	2200	1500	1700	2000
Chignik River drainage	3000	700	2300	1400
Ocean River drainage	2900	800	2000	1700

Archaeological evidence from the Pacific Coast also informs the relationship between volcanic succession and human occupation. Though we recorded settlements along the Pacific Coast, we did not study them on the ground. The bulk of the work in this area was conducted in the process of a cultural resource survey of the Aniakchak National Monument and Preserve (VanderHoek and Myron 2004). Perhaps the most interesting observation of the Pacific coastal data is that there is no evidence for human activity prior to ca. 2200 cal BP. We find it unlikely that nobody occupied these resource-rich, and often sheltered marine habitats, particularly since we have ample evidence for marine-adapted coastal foragers in the eastern Aleutians by 9000 cal BP (Knecht and Davis 2001; Rogers et al. 2009), by at least 5000 cal BP on the Bering Sea side of the peninsula (Maschner 1999; Maschner 2004a, 2004b), and by 7700 cal BP on the Pacific side only 300 km farther up the peninsula (Schaaf 2008; Tennessen 2009).

More likely is that the earliest parts of the Pacific sequence have escaped detection because site locations have been obscured through the combined effects of isostatic, eustatic, and tectonic influence on relative sea level (Jordan and Maschner 2000; Jordan 2001): we may simply be looking in the wrong places. However, we also find it unlikely that the entire record prior to 2200 cal BP, or our ability to detect that record, was affected by sea level change in exactly the same way. One expects the pre- and early post-volcanism records found at Chignik and Wildman Lakes to appear on the Pacific coast as well. However, there is no evidence for human activity on the coast until ca. 2200 cal BP. Though it is tempting to use these data to suggest that coastal and nearshore resources were insufficient to support human occupation for another 1500 years after the Aniakchak II eruption, this seems unlikely. If anything, one expects marine habitats to rebound much more rapidly than the terrestrial, riverine, and lacustrine habitats, which should be disproportionately impacted by volcanic deposition and chemical alteration. This assumption may be incorrect. More focused research on the Pacific coast of the central Alaska Peninsula should help to resolve these issues.

As with most of these analytical areas, the evidence from the King Salmon and Dog Salmon Rivers (which both join the Ugashik River at the head of Ugashik Bay) does not reveal anything about human habitation prior to the volcanism of the mid-Holocene. In part this may reflect the difficulty of finding the material remains of small numbers of mobile hunter-gatherers underneath the constantly accreting volcanic sediments, but it also might simply be that big portions of this vast coastal plain were submerged under higher sea-levels or simply so water-logged that they were uninhabitable. However, we do not expect sea level in this area to vary in the same way that it did farther south (cf. Jordan 2001), as the oldest evidence for human occupation at

https://doi.org/10.1017/RDC.2018.2 Published online by Cambridge University Press

Ugashik Narrows (Henn 1978), which is ~50 km northeast of the outlet of the King and Dog Salmon Rivers and today's coastline, comes from a landform only ~10 m above contemporary sea level; ca. 10,100 cal BP, relative sea level might have been nearly 10 m higher than it is today in the area, but there is no geomorphic evidence that it has been higher than that since. Though the geohydrology of these rivers during the early Holocene was almost certainly different than today, (which might explain why no early Holocene human evidence has been found) we do see that people only started to settle the banks of the rivers after 1950 cal BP, some 1750 years after the Aniakchak II eruption. We suggest this delay was directly related to the timing of ecological recovery in Bering Sea river systems in the aftermath of the Aniakchak II eruption.

The Meshik River drainage is the closest to the Aniakchak volcano, and likely subjected to the most intense ecological disturbance of all the regions evaluated here. Accordingly, the Meshik River drainage was the last to be inhabited after the 3700 cal BP eruption. Indeed, we have no evidence for human activity prior to 1700 cal BP, some 2000 years after the eruption!

It is tempting to attribute the settlement of some of these zones (namely, the rivers of the Meshik, King Salmon, and Dog Salmon drainages) to something other than volcanic disturbance. For example, the earliest evidence of activity in these areas coincides broadly with the expansion of a riverine fishing adaptation, and perhaps demographic expansion often associated with the Norton cultural tradition, which became widespread across the upper peninsula by at least 2200 cal BP (Dumond 1981, 2011; Bundy 2007). Certainly the number of settlements dating from 2000–1000 cal BP seems to spike along the rivers of the central peninsula (as they do in the upper peninsula), and many, if not most of these appear oriented towards riverine resources (likely salmon, given the abundance of net weights and storage features), but it is also important to note that this spike is also visible on the Pacific Coast, which may not be connected with the Norton tradition at all. Furthermore, there is ample evidence for human activity prior to the interval of Norton expansion, in both the lower and upper parts of the peninsula (Maschner 2004b; Dumond 2011), as well as at Chignik and Wildman Lakes (both within the central peninsula study area), and perhaps along the Pacific Coast. The SPD for all dates from the central and lower (see the bottom frame of Figure 2) illustrates that frontier colonists were already in the area. The point is that had these river systems recovered sufficiently to support large aggregations of people, they should have been occupied much earlier. We suggest the delay is a result of the devastating effects of the Aniakchak II eruption and the time these ecosystems required to recover fully from them.

A number of other interesting patterns are visible in this comparison of SPDs. First, the abundance of evidence for human occupation of the Chignik, King Salmon, Dog Salmon, and Meshik Rivers declines considerably (in many cases to zero) ca. 1000 cal BP. This may well be associated with the effects of an as-yet unidentified volcanic disturbance. One possibility is the somewhat poorly documented Aniakchak eruption of 900 ^{14}C yr BP or the 1000 ^{14}C yr BP eruption of Veniaminof (Neal et al. 2001; VanderHoek 2009)[6]. Along the King and Dog Salmon Rivers, this gap in the record lasts about 500 years; in the Chignik River drainage it lasts at least 300 years; and in the Meshik drainage this marks the end of human activity until the historic, Euroamerican period (which we did not attempt to date with ^{14}C).

Pulses in ^{14}C dates beginning after 500 cal BP seem to document re-colonization of the King Salmon and Dog Salmon Rivers, the Chignik River drainage, and the Wildman Lake–Ocean

[6]Though uncalibrated point-estimates for these eruptions are referenced in VanderHoek (2009), the original dates have not been published, and are therefore impossible to calibrate.

River district. Less pronounced clusters are also visible on the Pacific Coast. What unites each of these pulses in each of the different analysis areas is the appearance of multi-room houses (Hoffman and Smith 2007; Hoffman 2009a, 2009b; Saltonstall and Steffian 2009; Shirar et al. 2011, 2013 2011), perhaps documenting the spread of the Koniag architectural tradition (and perhaps colonists) from the Kodiak Archipelago (Barton et al. 2011).

CONCLUSION

This paper presents the results of one of the primary purposes of the Chignik-Meshik Rivers Region Cultural Resource Reconnaissance Project: to document where and specifically when people occupied different parts of the central Alaska Peninsula in the context of cultural and environmental change. Neither our sampling strategy nor our sample size permit quantitative assessments of the density or intensity of human activity in each area, nor do the summed probability distributions of ^{14}C data permit realistic demographic estimates. But the data do reveal differences in the timing of human activity in different ecological settings, each in varying proximity to the two volcanoes known to have erupted catastrophically during the middle to late Holocene.

This effort builds on an emerging, but still nascent body of work in the region (Yesner 1981; Dumond 1987, 1992; VanderHoek and Myron 2004) that attempts to understand the relationships between volcanic activity, landscape change, ecological succession, and human occupation.

Certainly for some periods of time, the central peninsula was an "ecological frontier" (Yesner 1985) but at other times the region boasted sufficient resources to support large village-level aggregations along all of its rivers, lakes, and coastal ecosystems. Ultimately, the data presented here will help us to evaluate the reasons why some areas remained uninhabited for centuries to millennia, while others recovered sufficiently to permit human occupation. Furthermore, these data (and the material remains collected during this and other research projects) will reveal the cultural (namely technological and social) adaptations that made it possible for some groups to thrive in some areas but not others, or why some groups were more able to manage this difficult landscape more effectively than others. Ultimately we expect these elements will help inform our understanding of the nature of cultural affinities that attended the various waves of environmental disturbance, and the contraction and expansion, aggregation and dispersal, abandonment and re-colonization of the central Alaska Peninsula.

ACKNOWLEDGMENTS

This research was supported by the National Park Service through Cooperative Ecosystem Studies Unit task agreements with the University of Alaska Museum of the North (#J9796100057) and Antioch University New England (#P11AC60559). Special thanks to Jeanne Schaaf, Dale Vinson, Jeff Rasic, and Lois Dalle-Molle of NPS for institutional support; to Fawn Carter, Devon Reid, Sam Coffman, Jillian Richie, Linda Chisholm, Stormy Fields, and Lori Hansen for help in the field; and to the people of Chignik Lake, Chignik Lagoon, and Port Heiden for entrusting us with their cultural heritage. We hope this research will enable future scholarship and stewardship.

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