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Mid to Late Holocene Population Trends, Culture Change and Marine Resource Intensification in Western Alaska

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ABSTRACT. The goal of this project is to understand the influence of population size on human adaptation processes and culture change during the Mid to Late Holocene in Western Alaska. We use a database of 1180 radiocarbon dates ranging from 6000 to 1000 ^{14}C years BP and drawn from 805 archaeological components in Alaska to construct a proxy record for relative change in regional and Alaskan metapopulation sizes over time. Our analysis indicates that a major population crash coincided with the disappearance of the Arctic Small Tool tradition (ASTt) and the subsequent emergence of the Norton tradition. The ASTt population began to decline around 3600 cal BP, and by 3500 cal BP it had disappeared almost completely from northern tundra habitats, though it persisted in coastal areas in Northwest and Southwest Alaska for another 500 years. The reduction in human population across Alaska after 3600 cal BP appears linked to a reduced carrying capacity that was perhaps driven by a caribou population crash. Such a shock would have increased population pressure and fostered increased reliance on marine resources, precipitating cultural changes associated with an increasingly complex maritime economy. The sharp decline in ASTt population size reduced the number of cultural role models for this population, resulting in the loss of some of the tradition's characteristic cultural traits, while the influence of neighboring populations in southern Alaska and across the Bering Strait apparently increased, counteracting this attrition of cultural traits. Holistic explanations of the ASTt-Norton transition must take into account population size, ecological adaptation, and cultural transmission processes, as is true for cultural change more generally.

Key words: Alaska prehistory; radiocarbon dating; archaeological demography; population ecology; culture change; maritime adaptations; human migration; Arctic Small Tool tradition; Norton tradition

RÉSUMÉ. L'objectif de ce projet est de comprendre l'influence de la taille de la population sur les processus d'adaptation et le changement culturel des humains de l'Holocène moyen à l'Holocène supérieur dans l'ouest de l'Alaska. Nous nous appuyons sur une base de données contenant 1 180 datations par radiocarbone allant de 6000 à 1000 années radiocarbones BP et nous avons puisé parmi 805 composantes archéologiques en Alaska pour établir un relevé indirect des changements relatifs dans les métapopulations des régions et de l'Alaska au fil du temps. Notre analyse indique qu'un effondrement majeur de la population coïncide avec la disparition de la tradition microlithique de l'Arctique et avec l'émergence subséquente de la tradition nortonienne. La population de la tradition microlithique de l'Arctique a commencé à s'éteindre vers les années 3600 cal BP, et vers 3500 ans cal BP, elle avait presque complètement disparu des habitats de la toundra arctique, bien qu'elle ait survécu pendant encore 500 ans dans les zones côtières nord-ouest et sud-ouest de l'Alaska. Après 3600 cal BP, la diminution de la population humaine en Alaska semble avoir un lien avec la capacité de charge réduite probablement engendrée par un effondrement de la population de caribous. Un tel choc aurait contribué à augmenter la pression démographique et à favoriser la dépendance aux ressources marines, précipitant ainsi les changements culturels liés à une économie maritime de plus en plus complexe. La forte baisse de la taille de la population partageant la tradition microlithique de l'Arctique a réduit le nombre de modèles culturels de cette population, résultant ainsi en la perte de certains des traits culturels caractéristiques à cette tradition. Cependant, l'augmentation apparente de l'influence des populations avoisinantes du sud de l'Alaska et au-delà du détroit de Béring a compensé l'attrition des traits culturels. Les explications holistiques de la transition de la tradition microlithique de l'Arctique à la tradition nortonienne doivent tenir compte de la taille de la population, de l'adaptation écologique et des processus de la transmission culturelle, comme c'est le cas pour tout changement culturel en général.

Mots clés : préhistoire de l'Alaska; datation par radiocarbone; démographie archéologique; écologie des populations; changement culturel; adaptations en milieu marin; migration humaine; tradition microlithique de l'Arctique; tradition nortonienne

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INTRODUCTION

A primary challenge of archaeology is to explain why cultures persist, evolve, and disappear (Shennan, 2000; Kintigh et al., 2014). Researchers have long recognized demographic shifts and population size fluctuations as major forces promoting economic and technological change (Malthus, 1798; Boserup, 1965; Cohen, 1977; Wood, 1998), which they promote both through adaptation processes driven by competition for resources in density-dependent habitats (Binford, 1968; Kennett et al., 2009; Morgan, 2015) and through variability in the rate and fidelity of cultural transmission (Neiman, 1995; Shennan, 2000; Henrich, 2004; Kline and Boyd, 2010). Many studies demonstrate that human population pressure promotes settlement of lower-ranked habitats (Winterhalder et al., 2010; Codding and Jones, 2013; Williams et al., 2015; Tremayne and Winterhalder, 2017), resource intensification, increased diet-breadth (Broughton, 1999; Nagaoka, 2001), technological innovations (Boserup, 1965; Morgan, 2015), increased social inequality, and reduced mobility in hunter-gatherer societies (Keeley, 1988; Fitzhugh, 2003; Sassaman, 2004; Kelly, 2007). Furthermore, some researchers argue that larger population sizes stimulate the gradual accumulation of cultural knowledge, while decreases in population size often lead to reductions in technological and socio-ecological complexity through cultural drift (Shennan, 2000:815; Henrich, 2004; Kline and Boyd, 2010; but see Vaesen et al., 2016 and Collard et al., 2016). Application of these explanatory lenses to the interpretation of particular cultural changes in the archaeological record hinges upon our ability to reconstruct prehistoric population sizes and growth trends accurately.

Two related, longstanding questions in Alaskan archaeology concern the timing and cause of the cultural transition from the Arctic Small Tool tradition (ASTt) to the Norton tradition that transpired around 3000 years ago—a “significant reorientation” (Dumond, 2000:1) marked not only by technological change, but also by marine resource intensification and profound changes in settlement regimes (Anderson, 1979; Clark, 1982; Dumond, 1982, 1987, 2016; Tremayne, 2017). What makes this transition particularly puzzling is the proposition that these changes occurred during an episode of population decline rather than one of growth (Dumond, 1975, 2000). Our study thus aims to further evaluate the influence of population change on this transition and ultimately to resolve this apparent explanatory paradox.

To estimate relative changes in paleopopulation size, researchers have traditionally relied on diachronic changes in site size and density, as well as changes in the numbers and sizes of house features (e.g., Dumond, 1972b; Savelle and Dyke, 2002, 2014; Fitzhugh, 2003; cf. Chamberlain, 2006:126–128). Some have also cited evidence of resource depression as an indicator of population growth (e.g., Broughton, 1999; Klein and Steele, 2013). Over the last three decades, archaeologists have increasingly used temporal frequency distribution **(**tfd**)** plots as a further means of modeling changes in regional occupation intensity and population growth trends (Rick, 1987; Glassow, 1999; Buchanan et al., 2008; Potter, 2008; Collard et al., 2010; Steele, 2010; Mullen, 2012; Williams, 2012; Kelly et al., 2013; Shennan et al., 2013; Timpson et al., 2014; Brown, 2015, 2017; Zahid et al., 2016). Such analyses have relied primarily on radiocarbon (^{14}C) age estimates to provide chronometric control for site occupation events, which researchers often use as a proxy for regional population size. Our study uses ^{14}C datasets associated with Mid to Late Holocene contexts in Alaska to test the hypothesis that a population crash accompanied the demise of the ASTt and preceded the development of the Norton tradition. We also revisit the explanatory paradox that such a hypothesis would raise.

BACKGROUND

The Arctic Small Tool tradition (ASTt), first defined by Irving (1957, 1964), represents a geographically widespread stone tool technological tradition that originated in northeastern Asia and spread into northern North America around 5000 cal BP (Dumond, 1987; Powers and Jordan, 1990; McGhee, 1996; Slaughter, 2005; Tremayne, 2015a). Arctic archaeologists recognize people of the ASTt as the first humans to colonize the Canadian High Arctic and Greenland (McGhee, 1996). Diagnostic artifacts of the ASTt include tiny endblades and sideblades exhibiting intricate parallel oblique pressure flaking, microblade technology, and distinctive burins made on high-quality raw materials (Giddings, 1964; Irving, 1964; McGhee, 1996). In Alaska, regional representations of the ASTt include the Denbigh Flint Complex in the Northwest (Giddings, 1964; Tremayne and Rasic, 2016) and the Brooks River phase of the Southwest (Dumond, 2005) (Fig. 1). The Alaskan ASTt economy is typically characterized as dependent on terrestrial resources, primarily caribou, with a secondary emphasis on hunting of small marine mammals (e.g., Giddings and Anderson, 1986), though recent studies have placed greater subsistence and economic importance on maritime resources (Buonasera et al., 2015; Tremayne and Winterhalder, 2017).

By 3200 years ago, many of the distinctive traits and tool forms of the ASTt had disappeared, and over the succeeding centuries, this culture evolved into, or contributed to, the emergence of the Norton tradition (Fig. 1). The Norton tradition, which existed between about 3000 and 1000 cal BP, is distinguishable from the ASTt by the lack of microblade and burin technologies and by a greater variety of stone tool forms (Giddings, 1964). Additionally, we find the appearance of new technologies, including decorated pottery, polished slate blades, increased use of lower-quality raw materials, and less-refined stone tool manufacture (Anderson, 1979; Clark, 1982; Dumond, 1982, 2000; Tremayne, 2017).

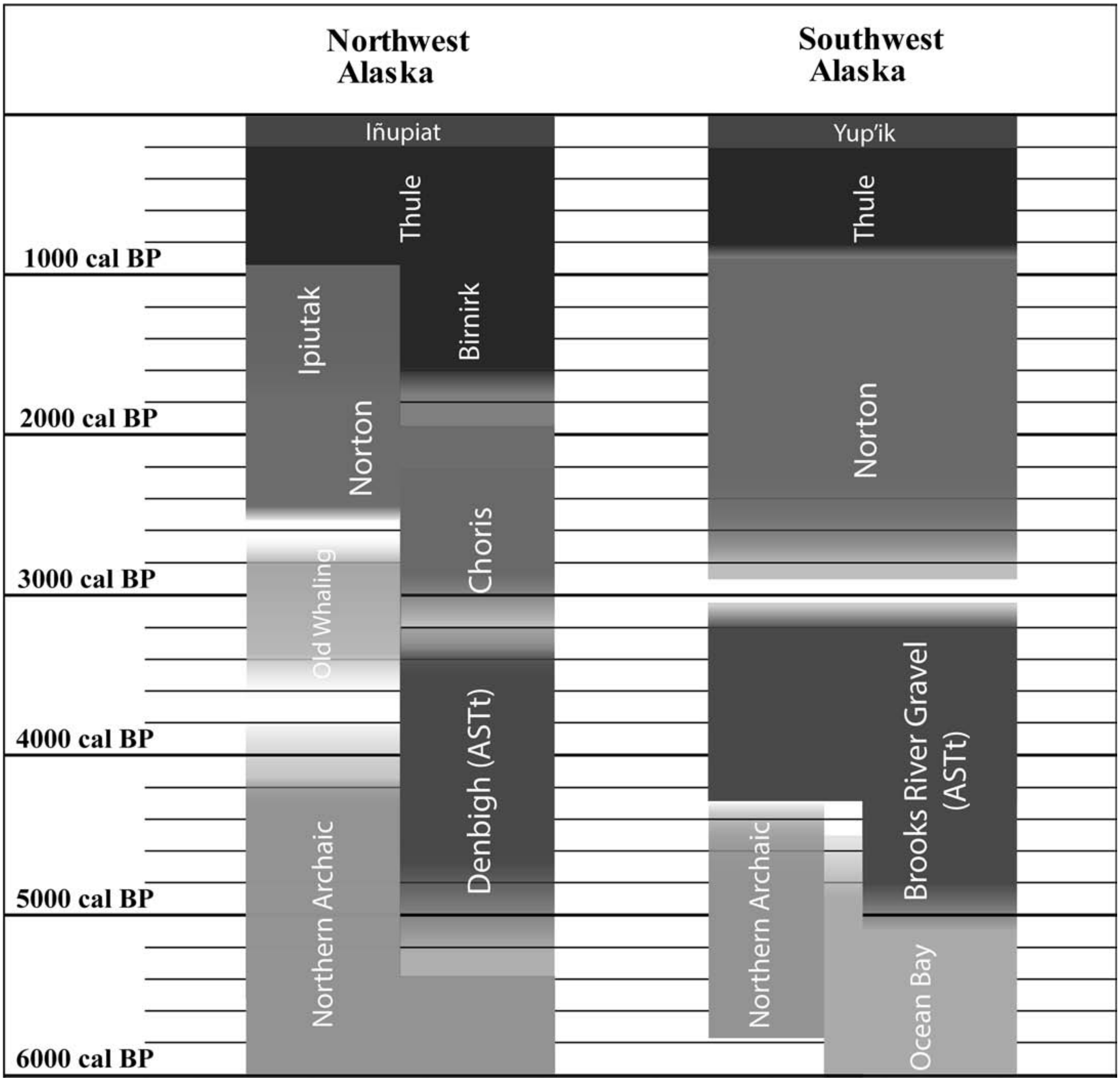

FIG. 1. A cultural chronology of Northwest and Southwest Alaska. Note that the zones with graduated shading indicate uncertainty in the radiocarbon date record. The ASTt period is represented from about 5000 to 3200 cal BP, and the Norton tradition period, from about 3000 to 1000 cal BP.

While recognition of technocomplexes representing the Norton tradition eludes full consensus among Alaskan archaeologists, this set typically includes the regionally specific Choris, Norton, Near-Ipiutak, and Ipiutak phases (Larsen and Rainey, 1948; Darwent and Darwent, 2016; Dumond, 2016; Fig. 1). Culture histories of Northwest and Southwest Alaska do not correspond precisely (Fig. 1), and indeed this fact has contributed to disagreements about ASTt, Choris, and Norton affiliations (Anderson, 1979; Dumond, 1982). In Northwest Alaska, researchers see continuity and gradual evolution from ASTt to Choris to Norton to Ipiutak (Giddings and Anderson, 1986; Anderson, 1988), while in Southwest Alaska, Dumond (1987:106) sees a sharp distinction and regional hiatus preceding the appearance of Norton material culture. Most recently, Dumond (2016) has suggested that the southern phases of the Norton tradition evolved from Choris and spread southward, though others point out that the Choris phase is not well defined or securely dated (Darwent and Darwent, 2016). Additionally, most secure Choris dates are contemporaneous with early Norton dates in Southwest Alaska (Tremayne, 2015b).

While some researchers subsume the entire Norton tradition under the ASTt heading (Anderson, 1979; Lutz, 1982), we accept an ancestor-descendant relationship between the two constructs but follow Dumond (1982, 2000) in treating them as separate traditions because the technological differences standing between the two appear to correspond with marked socio-ecological change. While ASTt hunter-gatherers used marine resources, a major share of their subsistence activities focused on the pursuit of terrestrial game, necessitating a highly mobile settlement regime. ASTt sites in Northwest Alaska are typically small, ephemeral camps, with a few hearth features and occasional evidence of semi-subterranean houses (Anderson, 1988), whereas ASTt sites in the Southwest exhibit semi-subterranean houses, and seasonal fishing is inferred (Dumond, 2005). As of yet no ASTt houses are known from coastal contexts, which suggests that exploitation of maritime resources was only seasonal. In contrast, Norton people of Southwest Alaska resided in large coastal villages with numerous semi-subterranean house features, suggesting increased group sizes, greater sedentism, and heavy reliance on fish (Maxwell, 1980:175; Dumond, 2016; Tremayne, 2017). In Northwest Alaska, archaeological assemblages attributed to the Choris and Norton likewise suggest an increased reliance on marine mammals, and by the appearance of the Ipiutak phase in this region, we also see the appearance of large coastal villages (Larsen and Rainey, 1948).

Taken together, these observations suggest a long process of marine resource intensification and culture change related to these economic changes. We use resource intensification here descriptively to indicate an increase in economic productivity (Morgan, 2015:165), but we make no claims that these efforts were in any way more efficient than previous systems of production.

DATA COLLECTION AND ANALYTICAL METHODS

Our analysis uses a database of 1180 radiocarbon dates taken from 805 components defined at 366 sites in Alaska. These dates range from 6000 and 1000 ^{14}C years BP. Most of the previously published dates included in our analysis are found in the Canadian Archaeological Radiocarbon Database (CARD; Gajewski et al., 2011), with additional dates gathered from the Alaska Historic Resources Survey (AHRS) database, National Park Service reports, master's theses, and dissertations (Tremayne, 2015b). We use only dates assayed from terrestrial organic materials, primarily charcoal, culturally modified wood, and terrestrial mammal bone from anthropogenic contexts. We exclude dates that are paleontological, geoarchaeological, or lacking information on the type of material dated, as well as those derived from marine environments (e.g., sea mammal bone, ivory, shells, and human bone or tissue from coastal contexts).

We plotted all dated components in ARCGIS 10.3 against an Alaska ecoregion base layer (Nowaki et al., 2002) to determine geographical region, habitat, and site setting (Fig. 2). We designated sites within 10 km of modern shoreline as coastal, assuming that this represents the maximum distance that a forager could walk from camp to coastline in a day while leaving enough time to gainfully exploit coastal resources (Tremayne and Winterhalder, 2017:83). We also recorded cultural affiliation for each component if reported by the primary investigator, assuming that the researcher based such designations on associations with diagnostic artifacts. Finally, we disaggregate the database into subsets to evaluate the geographical and ecological settings of ASTt and Norton population dynamics against a backdrop of pan-Alaskan populations and cultures more generally.

Temporal Frequency Analysis

Treating tfd plots based on time-stamped site components or occupation episodes as proxy census records assumes that larger populations create a greater abundance of datable deposits than do smaller ones and, by implication, that the probability of recovering deposits left by larger populations is greater than that of recovering those left by smaller populations, all else being equal (Rick, 1987).

Researchers use both histograms and summed probability distributions (spds) of calibrated ^{14}C dates to express the temporal distributions of such site occupation episodes. The histogram method relies on a count of calibrated median dates that fall within a pre-specified age range, typically 100- or 200-year bins. This approach is constrained by the fact that the uncertainty characterizing ^{14}C age estimates (Bronk Ramsey, 2009:353–354) may lead to their assignment to incorrect histogram bins (Glassow, 1999), and low-precision age estimates are especially prone to this problem. A better way to address uncertainty in ^{14}C age estimation is to use spds, which incorporate information on lab error into the tfd plots. Specifically, most radiocarbon calibration programs express calendric age estimates probabilistically (usually implementing Bayesian methods) and produce spds by summing these probabilistic expressions across the timeline. In short, in the presence of lab error, this method provides a best estimate regarding the temporal distribution of observations in the sample (Bronk Ramsey, 2001:361).

To test the hypothesis that a population crash accompanied the demise of the ASTt and preceded the development of the Norton tradition, we have constructed spds for both the full supra-regional (hereafter "pan-Alaskan") aggregate and for the various regional and cultural subsets it comprises. Because researchers often regard low-precision ^{14}C ages as confounders of spd-based temporal frequency analysis (Culleton, 2008; Kelly et al., 2013), we have also constructed an spd from a high-precision subset of the pan-Alaskan sample, omitting those

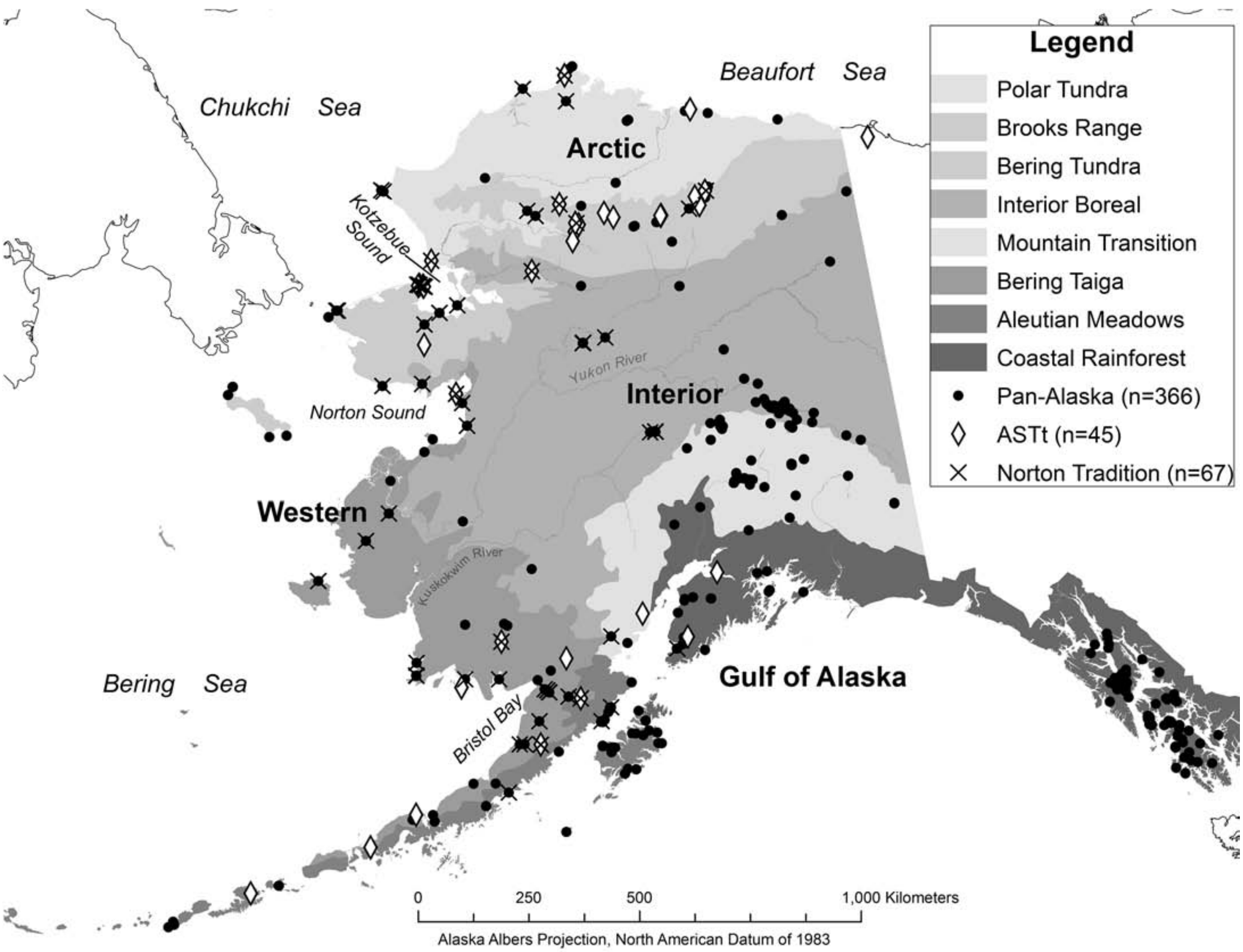

FIG. 2. Map of Alaska generalized ecoregions (Nowacki et al., 2002) showing locations of sites with radiocarbon-dated components. Subsets of radiocarbon dates were divided between Arctic, Western, Interior, and the Gulf of Alaska. ASTt and Norton tradition sites are indicated.

168 dates with measurement errors exceeding 100 ^{14}C years. With the R programming language, we calibrated all ^{14}C timestamps using the IntCal13 calibration curve (Reimer et al., 2013), following the standard Bayesian method and assuming uniform prior distributions truncated at 0 and 50 000 cal BP (Bronk Ramsey, 2009: Eqs. 9–11).

Researchers recognize multiple issues, falling broadly under the headings of investigation, preservation, and creation errors, that can muddle efforts to discern paleodemographic trends in tfd plots (Rick, 1987). Investigation error subsumes a number of distinct confounders. For example, over- or underrepresentation of various time intervals may result from the disproportionately intensive dating of certain sites relative to others. Conversely, palimpsests of multiple occupations at a single location may be difficult if not impossible to distinguish for the sake of separate counting (Jochim, 1991). To reduce the risk of double-counting individual occupation episodes while also attempting to disentangle multiple-occupation palimpsests, we used Ward and Wilson's (1978) procedure to identify and collapse clusters of internally consistent dates into pooled age estimates. Application of this pooled date clustering protocol resulted in the reduction of 1180 ^{14}C dates from 366 sites to 805 timestamps for distinguishable site occupation events.

Preservation error alludes to the fact that not all cultural deposits survive to the time of potential archaeological detection. One of the salient dimensions of preservation error is taphonomic bias, which refers to the fact that deposits created long ago are likely to have been exposed to a greater cumulative hazard of destruction than younger deposits (Surovell and Brantingham, 2007; Surovell et al., 2009; Surovell and Pelton, 2016). The systematic under-counting that taphonomic bias drives is further exacerbated by detection bias (another component of investigation error), which refers to the fact that older deposits are likely to be more deeply buried than younger ones (Ballenger and Mabry, 2011). Surovell and colleagues have recommended applying correction factors to mitigate the influence of these time-transgressive geological forces on tfd morphology through the application of correction factors (Surovell et al., 2009; Surovell and Pelton, 2016; Williams, 2012). To assess the degree to which such geological forces have interfered with our ability to evaluate the population crash hypothesis, we have applied Surovell and colleagues' model correction factors to spds generated from our data sets.

Recent simulation studies indicate that a large sample size is necessary to mitigate another component of investigation error: the influence of random sampling error on tfd plot structure (Williams, 2012; Brown, 2015). Because the sample size for most ecoregions in our study is small ($n < 100$), we combined these subsamples into four larger regional subsamples: (1) the Arctic, which comprises all sites north of the Arctic Circle (including the Chukchi and Beaufort coasts, the Brooks Range, and Polar tundra zones); (2) subarctic Western Alaska, including all sites along the Bering Sea, inland Seward Peninsula (Bering tundra), Bering taiga, Alaska Peninsula, and Aleutian Islands; (3) the Interior, including all sites in the interior boreal forest and the mountain transition; and (4) the Gulf of Alaska, including the Pacific side of the Alaska Peninsula, the Kodiak Archipelago, and the coastal rainforests of south-central and southeastern Alaska (see Fig. 2). We also stratified the sample into coastal and interior settings, the latter of which we further divided into forest and tundra subsamples. Finally, we stratified and analyzed the ASTt and Norton subsamples by regional and ecological divisions to explore in greater detail the temporal dynamics of populations associated with these cultural traditions. To estimate start and end dates for both traditions, we drew on a phase model previously presented by the first author (Tremayne and Winterhalder, 2017:86), implemented using Oxcal 4.2 (Bronk Ramsey, 2009:343 – 352; Bronk Ramsey and Lee, 2013).

RESULTS

Pan-Alaskan Population Trends

Evaluation of an spd constructed for Alaska as a whole suggests that the greater Alaskan paleopopulation experienced two discernible pulses of growth over the course of the Mid to Late Holocene (Fig. 3). Our results suggest that with a large enough dataset, there is no discernable difference between the shapes of the high-precision and inclusive spds (Fig. 3). The taphonomy-corrected spd differs little in shape from the uncorrected version, but it does dampen the signal for pronounced population growth after 2500 years ago (Fig. 3). This result suggests that the pan-Alaskan population recovered to levels rivaling those achieved during the first pulse, though not much higher—an interesting observation to explore in the future. Because our goal is not to compare population size between the pulses, but instead to identify the general course of population dynamics over the ASTt-Norton transition, we forgo interpreting the corrected spd in the remainder of the paper.

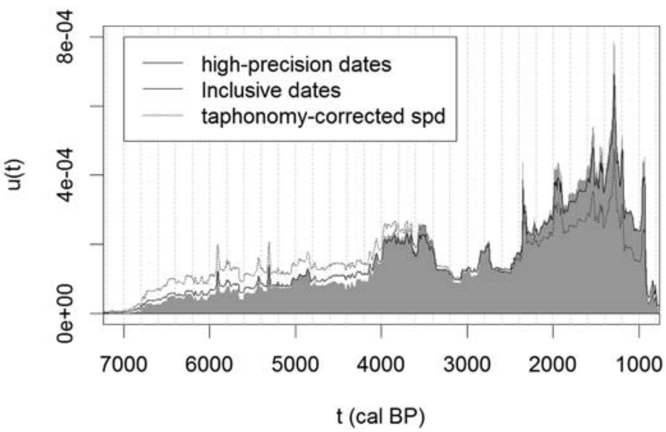

FIG. 3. Graph showing three spds based on Alaska radiocarbon dates: 805 dated archaeological components in Alaska (black line); a high-resolution subset (n = 637; grey), excluding 168 dates with standard deviations greater than 100 years; and a taphonomic correction of the inclusive subset, following Surovell et al. (2009) (dotted line).

The pan-Alaskan spd shows that the first population growth pulse began a century or two before 4000 cal BP, plateauing for approximately six centuries after 4000 cal BP (Fig. 3). This pulse ended with a brief but dramatic episode of decline beginning around 3700 cal BP, and the population remained low until the second pulse began with renewed growth around 2500 – 2400 cal BP (Fig. 3). A minor peak structure between 3000 and 2750 cal BP suggests a short-lived episode of recovery, followed by decline once again for another 300 years. The second period of major growth shows a nearly continuous increase for at least 1000 years before leveling off at the end of our study window (Fig. 3). Other regional population studies suggest that this increase continued to the historic period, though regional declines and recoveries are recognized (Potter, 2008; Anderson and Freeburg, 2014; Brown, 2015).

ASTt components in Alaska apparently largely account for the mesa-like structure defining the first population pulse in the pan-Alaskan spd: when disaggregated by culture (Fig. 4), the temporal distribution of non-ASTt components holds constant throughout this pulse, while the central mass of the ASTt subsample is isolated to this pulse alone. Consequently, we propose that as the ASTt population expanded and contracted over time, other populations occupying neighboring ecoregions (e.g., Northern Archaic, Ocean Bay, and Paleo-Aleut populations) maintained relatively stable sizes (see also Tremayne and Winterhalder, 2017).

While both the oldest and youngest purported ASTt dates are disputed (Harritt, 1998; Slaughter, 2005; Tremayne and Rasic, 2016), Raghavan et al. (2014) argue that this tradition must have emerged sometime between 6000 and 5000 cal BP, this timing being required to explain the patterns of Arctic genetic diversity and the earliest ASTt dates in Canada (Savelle and Dyke, 2002). Bayesian analysis of Alaskan ASTt dates using Oxcal 4.2's phase model functionality shows a modeled age range of approximately 2000 years spanning an interval between 4950 ± 50 and

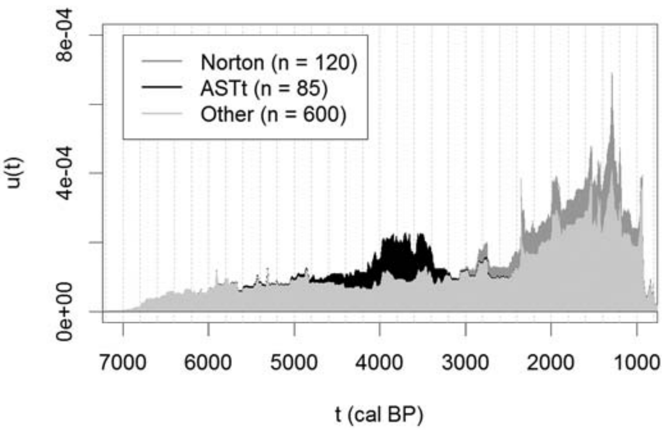

FIG. 4. Stacked polygon graph of spds for ASTt (black), Norton (dark gray), and all other cultures (light gray). All regions of Alaska are included (n = 805 dated components).

3200 ± 80 cal BP (Tremayne and Winterhalder, 2017). This phase model suggests that it is unlikely that ASTt was present in Alaska in large enough numbers to be archaeologically visible much earlier than 5000 cal BP, or that it persisted in its classic form beyond 3000 years BP (Table 1). As suggested above, the ASTt disappearance coincides with the tumultuous decline marking the end of the first population pulse, by 3400–3200 cal BP (Fig. 4).

A phase model based on all Norton tradition dates suggests a start date of 2900 ± 50 cal BP and a terminal date of approximately 990 ± 50 cal BP (Tremayne, 2015a), though Norton components became widespread only after 2700 cal BP. Similarly, a phase model of 29 probable Choris phase dates indicates a start date of 3080 ± 90 cal BP, though the model includes an anomalously old date from Onion Portage (see Table 2). The earliest known evidence for the Norton tradition in Southwest Alaska comes from sites dating to approximately 2850 cal BP (Ackerman, 1988) (Table 2). A phase model for the southern Norton tradition suggests a start date of 2900 ± 50 cal BP. By 2700 cal BP, Norton and Choris populations were present along the shores of Kotzebue Sound in Northwest Alaska (Giddings and Anderson, 1986), as far north as the Beaufort Sea at the Coffin site (Stanford, 1971; Tremayne and Rasic, 2016), and in Southwest Alaska at the Chagvan Beach site (Ackerman, 1988), Raleigh Knoll (Shaw, 1989), and Summit Island in Bristol Bay (M. Casperson, pers. comm. 2017).

Regional Population Trends

Analysis of regional subsets of our data provides a more nuanced perspective on pan-Alaskan population growth trends, as regional and local populations responded differently to various internal and external forces. Analyses of tfd plots based on the Arctic, Western, Interior, and Gulf of Alaska subsets indicate that widespread trends of population increase, stationarity, and decline frequently occurred over slightly different intervals within each region. For example, the period of dearth evident in the pan-Alaskan tfd plot between approximately 3600 and 2500 cal BP is strongly pronounced in the Arctic tfd plot, but in Western Alaska we find a more complex dynamic of initial decline, recovery, and crash beginning a century later (Fig. 5). Focusing specifically on the ASTt subsample, we also observe a significant increase in frequency in Western Alaska and a decrease in Arctic Alaska at 3600 cal BP (Fig. 5), which may signal a rather sudden and decisive shift in ASTt population to Western Alaska at this time. Conversely, while a pattern of decline is also evident in the Gulf of Alaska tfd plot after 3400 cal BP (Fig. 5), a brief episode of recovery may have occurred between 3000 and 2800 cal BP (c.f. also Brown, 2015: Fig. 3). Finally, the Interior Alaskan tfd plot suggests that population size was relatively stable throughout the Mid to Late Holocene, with a minor episode of decline from about 2700 to 2500 cal BP (Fig. 5).

Comparisons between coastal and interior ^{14}C subsets further support the hypothesis that population decline began around 3600 cal BP and suggest that this effect was more pronounced in interior settings than in coastal ones. Occupation intensity in coastal settings continued to increase for nearly two centuries after that date, then declined somewhat to a moderate stand over the following millennium (Fig. 6). Further stratification of the interior habitat into forest and tundra ecoregions suggests abandonment of tundra habitat shortly after 3600 cal BP, while coastal and forested ecoregions remained populated (Fig. 6). The Arctic subsample demonstrates total collapse of interior populations from 3600 to 2700 cal BP, while the signal for coastal occupations first increases then gradually declines during this same period (Fig. 7). After 3400 cal BP, coastal occupations in this region increasingly outnumber interior ones.

In Western Alaska, the tfd indicates greater fluctuations between coastal and interior populations than observed in the Arctic (Fig. 7), though small sample size should prompt caution in interpreting this pattern as wholly demographic. We tentatively suggest that occupation intensity repeatedly increased and declined in Western Alaska, in both coastal and interior settings, between 4500 and 3300 cal BP. Subsequently, the interior tfd shows a dramatic increase in occupation intensity beginning around 3500 cal BP, only to decline again a few centuries later. Such patterns suggest a volatile ecosystem and frequent movement of groups between coastal and adjacent inland habitats. After 3600 cal BP, coastal occupations in Western Alaska increasingly outnumber inland ones.

Focusing on the ASTt and Norton subsamples, our analyses demonstrate that the ASTt people occupied both coastal and interior habitats throughout the duration of their existence (Fig. 8), though coastal occupations slightly outnumber interior ones following initial appearance (ca. 5000–4400 cal BP) and initial decline (ca. 3600–3200 cal BP). The long younger tail of the interior ASTt distribution (Fig. 8) results from the inclusion of one questionably young date from Mosquito Lake in the

TABLE 1. Youngest ASTt sites in Alaska by region and coastal versus interior contexts. Sites with ambiguous cultural affiliation or anomalous dates are noted.

Site	Lab number	^{14}C Date	σ	cal BP	σ	Reference
Northwest Alaska Interior:						
Mosquito Lake	Beta-319842	3310	30	3530	40	Tremayne and Rasic, 2016
Mosquito Lake[1]	GX-5075	2705	160	2830	210	Kunz, 1977
Punyik Point	Beta-193795	3300	40	3530	50	Kunz, 2005
Imageinik	Beta-235373	3300	40	3530	50	Tremayne and Rasic, 2016
Gallagher Flint St.[2]	SI-973	3280	155	3520	190	Dixon, 1975
Onion Portage[3]	P-1110	3200	60	3430	70	Anderson, 1988
Lake Selby[2]	Beta-288559	3190	40	3410	40	NPS records
Kuzitrin Lake	Beta-422595	3290	30	3520	40	Tremayne, 2015b
Northwest Alaska Coast:						
Iyatayet	P-102a	3290	290	3560	380	Giddings, 1964
Iyatayet	Beta-319843	3300	40	3520	40	Tremayne, 2015b
Cape Espenberg	AA102999	3190	40	3410	40	Tremayne, 2015a
Cape Espenberg	AA102997	3153	41	3370	50	Tremayne, 2015a
Cape Krusenstern[2]	OS-81651	3090	35	3300	50	Anderson and Freeburg, 2014
Southwest Alaska Interior:						
Igiugig	Beta-76533	3350	60	3590	80	AHRS records
Lake Beverley	Beta-34417	3220	80	3450	90	DePew and Biddle, 2006
Brooks River BR16	SI-1860	3280	60	3510	70	Dumond, 1981
Brooks River BR4	I-1159	3052	250	3250	300	Buckley and Willis, 1970
Southwest Alaska Coast:						
Magnetic Island	UGAMS-12486	3270	25	3500	40	Rogers et al., 2013
Russell Creek	CAMS-41415	3110	50	3310	60	Maschner and Jordan, 2001
Margaret Bay	Beta-107806	3110	60	3310	70	Davis and Knecht, 2005
Round Island	Beta-406789	3070	30	3280	50	Schaaf, 2015

[1] Date is suspect.
[2] Cultural affiliation is undetermined.
[3] Young Northern Archaic.

Brooks Range (2705 ± 160 ^{14}C years; Kunz, 1977) (Table 1). Similarly, while the earliest known Norton occupations come from interior settings (Table 2), the coastal subsample dominates the interior between approximately 2900 and 1500 cal BP (Fig. 8).

DISCUSSION

The Demise of the Alaskan Arctic Small Tool Tradition

Dumond (1975, 1987, 2000) has noted that the Norton tradition appeared in Southwest Alaska after an apparent hiatus in the archaeological record, whereas others have implied a gradual, uninterrupted cultural evolution from ASTt to Norton in Northwest Alaska (Giddings and Anderson, 1986; Anderson, 1988). Our analysis supports the hypothesis that the cultural transition from ASTt to Norton corresponds with a pan-Alaska human population crash that disproportionately affected people of the ASTt in both Northwest and Southwest Alaska. Our study indicates that this population decline had begun by 3600 cal BP, while the Bayesian phase model suggests a terminal ASTt date of 3200 ± 80 cal BP. The youngest ASTt dates in Alaska also indicate that distinctively ASTt populations persisted latest in coastal areas (Table 1, Fig. 8).

The cause of this apparent ASTt population decline and habitat shift remains uncertain, though we tentatively attribute both to a hypothetical crash of the caribou population, in line with previous accounts offered by Dumond (1987) and VanderHoek (2009), who have tied such demise to environmental perturbations. VanderHoek (2009) went farther, arguing that the caldera-forming Aniakchak II eruption (Begét et al., 1992; Blackford et al., 2014) wrought an ecological catastrophe severe enough to decimate western Alaskan caribou populations and blanket the region with highly toxic volcanic ash. While other factors such as climate change and extreme weather may also be to blame (Tyler, 2010), the close coincidence in time between the Aniakchak II eruption and the initial decline and geographic reorganization of the ASTt population (Fig. 5), particularly in northern Alaska (Fig. 7), is provocative.

Our analysis suggests a somewhat more complicated population history in Southwest Alaska in the wake of the Aniakchak II eruption, as parts of the Alaska Peninsula and the Aleutians were peripheral to the plume of ash fallout. For example, while the occupation of inland settings in this region temporarily declined during the period surrounding the eruption, a short-lived (bicentennial) occupation pulse followed it. Coastal settings in Western Alaska show a similar peak in occupation intensity for about three centuries after 3600 cal BP. It is only after this peak that the occupation histories of these two ecoregions diverge, with coastal settings showing a sustained foothold thereafter, while interior settings indicate a millennium-long lowstand (Fig. 7). Consequently, it appears increasingly plausible that the Aniakchak II eruption triggered environmental

TABLE 2. Compilation of the oldest Norton tradition radiocarbon dates in Alaska sorted by region and coastal versus interior settings.

Site	Lab number	^{14}C Date	σ	cal BP	σ	Reference
Northwest Alaska Interior:						
Onion Portage[1]	K-835	3170	120	3380	150	Anderson, 1988
Onion Portage	GX-1505	2780	100	2920	120	Anderson, 1988
Trail Creek Caves	K-979	2890	110	3040	140	Tauber, 1968
Northwest Alaska Coast:						
Cape Espenberg	Beta -33759	2790	80	2920	100	Harritt, 1994
Choris Site	P-203	2646	177	2740	230	Giddings and Anderson, 1986
Coffin Site	Beta-197900	2630	60	2740	80	Tremayne and Rasic, 2016
Southwest Alaska Interior:						
Lake Beverley	Beta-34422	2470	90	2550	120	DePew and Biddle, 2006
Curtis Site	N/A	2540	75	2600	110	Shaw, 1989
Raleigh Knoll[2]	N/A	2700	105	2830	130	Shaw, 1989
Southwest Alaska Coast:						
Chagvan Bay Beach	WSU-3215	2720	80	2850	80	Ackerman, 1988
Chagvan Bay Beach	WSU-3216	2710	60	2830	50	Ackerman, 1988
Summit Island[3]	D-AMS-014568	2540	30	2640	80	M. Casperson, 2017, pers. comm.

[1] Context of this early Choris date is mixed, and the material dated is undetermined.

[2] Assemblage has shared ASTt and Norton characteristics. Shaw (1989) considers the component Norton, but Dumond (2005) calls it ASTt.

[3] We did not include the unpublished Summit Island dates in the spd analysis, as we await a final report.

perturbations that ultimately led to the coastal reorientation of remnant ASTt populations in Western Alaska. However, the brief post-eruption recovery in both interior and coastal settings suggests that more work is needed to understand the extent and the ecological and subsistence-economic ramifications of the Aniakchak II volcanic tephra plume (R. VanderHoek, pers. comm. 2016).

The Origins of the Norton Tradition

Four and a half decades ago, Dumond (1972a) proposed that early Norton populations originated from late ASTt in both Northwest and Southwest Alaska, basing this two-center model on the regionally separated appearance of classic Norton traits in both regions. In the Northwest, Norton ceramics originating in Asia appeared and spread southward and eastward from there (Griffin, 1960; Dumond, 2000; Anderson et al., 2011), while ground slate technology, pecked stone lamps, and lip adornment with labrets originated in southern Alaska and spread northward from there (Clark, 1982; Dumond, 2000). Our analysis lends support to this model, indicating that late ASTt remnant populations persisted in both Northwest and Southwest Alaska, independently evolving to produce the distinct material cultures of the Choris and southern Norton phases, respectively.

The earliest known Norton tradition components belong to the Choris, appearing perhaps some time before 3000 cal BP, though contextual uncertainty surrounds the earliest dates for these components (Tauber, 1968; Anderson, 1988; Darwent and Darwent, 2016). As noted, analysis of the Choris dates indicates a probable start date of 3080 ± 90 cal BP, while the phase model for the Southwest Alaska Norton is 2900 ± 50 cal BP, implying a difference in start dates of 180 ± 103 years. Note that Dumond (2016:401) does not seem to accept such an early start date for the Norton in Southwest Alaska; instead, he places the start date at about 2500 cal BP there and closer to 2300 cal BP on the Alaska Peninsula. However, early Norton dates ranging from 2800 to 2600 cal BP (Table 2)—contemporaneous with those from the Choris type site and Onion Portage (Giddings and Anderson, 1986; Anderson, 1988)—are also found at the interior lake sites of the Raleigh Knoll and Curtis sites (Shaw, 1989) and at Summit Island in Bristol Bay (M. Casperson, pers. comm. 2017). In part, this difference of interpretation owes to the fact that the principal investigator of the Raleigh Knoll site considers the assemblage Norton (Shaw, 1989), while Dumond (2005:71) attributes it to the ASTt, but acknowledges that this date is a few centuries younger than any other ASTt deposit in the region. In our view, the Raleigh Knoll materials represent a transitional ASTt/Norton assemblage, exhibiting traits suggestive of both traditions, which further supports a two-center model for the origin of the Norton tradition.

The apparent geographic isolation of early Norton components between northern and southern manifestations makes a single-center origin account evidentially tenuous, particularly since these groups retained different configurations of ancestral ASTt traits within their respective cultural repertoires. For example, the northern Choris phase preserved such ASTt traits as the parallel oblique flaking of stone tools and use of burin technology, while the people of the southern Norton culture produced endblades and sideblades very similar to those of their progenitors. However, Dumond (2016) has recently argued that the Norton tradition emerged from the Choris phase in Northwest Alaska. In his view, first the Choris culture spread from the northwest to the south, where it evolved into the early southern manifestation of the Norton tradition, which later spread back to the north to replace its parent Choris culture. We argue that while

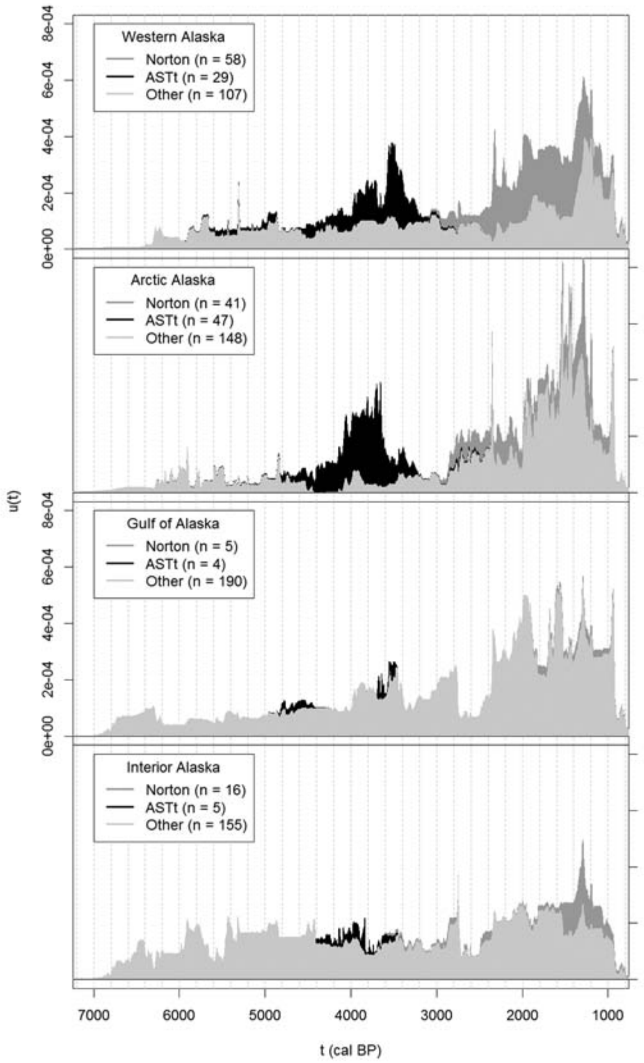

FIG. 5. Spds for major regions of Alaska. Compared to the pan-Alaska sample, population decline is variable across major regions.

genetic and cultural transmission occurred between these geographically separated late ASTt/early Norton groups, such contact must have been occasional and perhaps interrupted for multiple centuries, particularly given the sparseness of the latest ASTt and the earliest Choris and Norton sites between 3200 and 2700 cal BP. In short, we find the spatial and temporal distribution of the latest ASTt and earliest Norton assemblages to fit Dumond's (1972a) two-center model more convincingly than his more recent one-center model. Ultimately, the classic Norton tradition emerged through the coalescence of the northern Choris and southern Norton cultures after the northward expansion of the southern Norton population, which was supported by the increased exploitation of anadromous fish and marine mammals.

Population Trends, Maritime Adaptation, Cultural Transmission, and Culture Change

The economic transition from ASTt to Norton includes an apparent increased reliance on marine resources, and

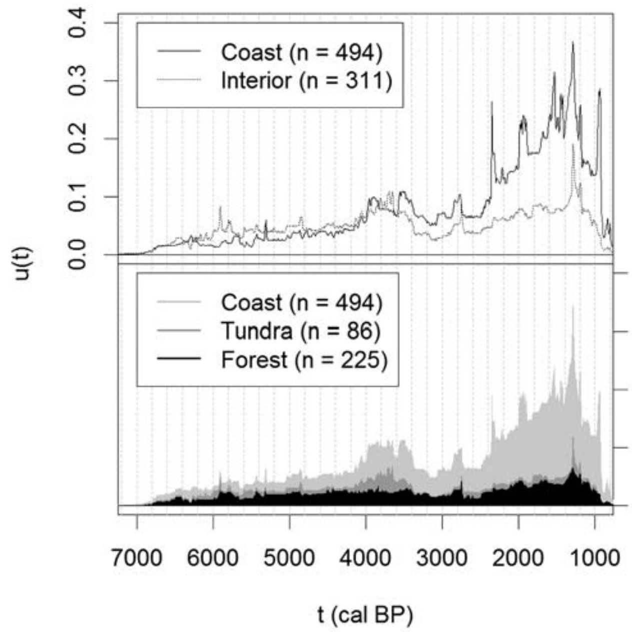

FIG. 6. Upper panel: superimposed spds of the pan-Alaskan dated components divided between coast and interior settings. Lower panel: a stacked spd showing the relative abundance of components from coast, tundra, and forest ecoregions.

particularly fish south of the Bering Strait, accompanied by increased social and technological complexity (Lutz, 1982; Dumond, 2016; Tremayne, 2017). While it now seems that the ASTt economy was more reliant on marine resources than once believed (Seersholm et al., 2016; Tremayne and Winterhalder, 2017), it is also true that ASTt settlements were most abundant in the tundra zones of Alaska (Dumond, 1987), where caribou was a key food and raw material resource (Dumond, 2005; Tremayne, 2011). The results of our analysis support the hypothesis that the ASTt terrestrial resource base collapsed around 3600 cal BP, leading to the total abandonment of tundra ecoregions at that time (Fig. 6). In response, late ASTt groups appear to have taken refuge in coastal habitats (Fig. 8) in both Northwest and Southwest Alaska, which implies that coastal habitats provided a stable resource base. A compilation of terminal ASTt dates across Alaska shows that the latest ASTt components were predominantly located in coastal contexts (Table 1), though interior lake regions of Southwest Alaska where anadromous fish are found were not ignored (Dumond, 2005; DePew and Biddle, 2006).

Multiple lines of evidence support an increased reliance on marine resources by Norton populations, but perhaps no evidence is as telling as their permanent semi-subterranean houses located in large coastal settlements, which suggest both increased residential group size and longer occupation spans (Lutz, 1972; Harritt, 2010). Technologically, Norton assemblages exhibit a greater number of tool forms (Dumond, 1982; Tremayne, 2017), including adoption of ceramic technology (Anderson et al., 2011). Ritualistic objects and decorative adornments that

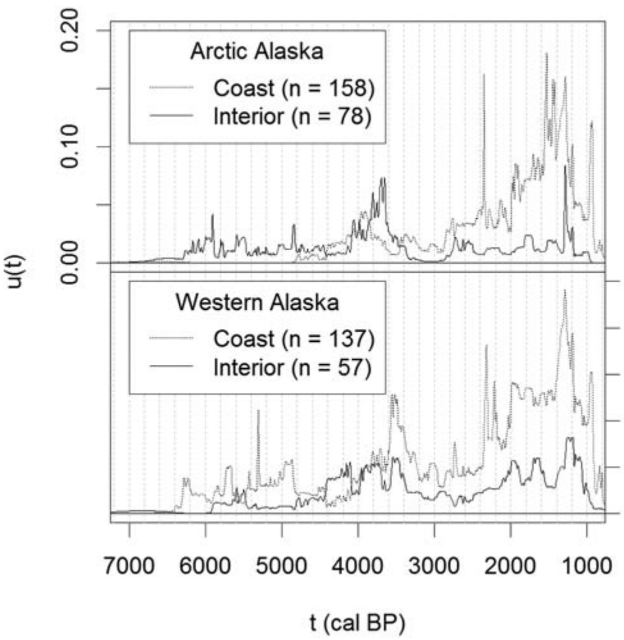

FIG. 7. Upper panel: spd plots of the Arctic subsample divided between coast and interior settings. Lower panel: spd plots of the Western Alaska subsample divided between coast and interior settings.

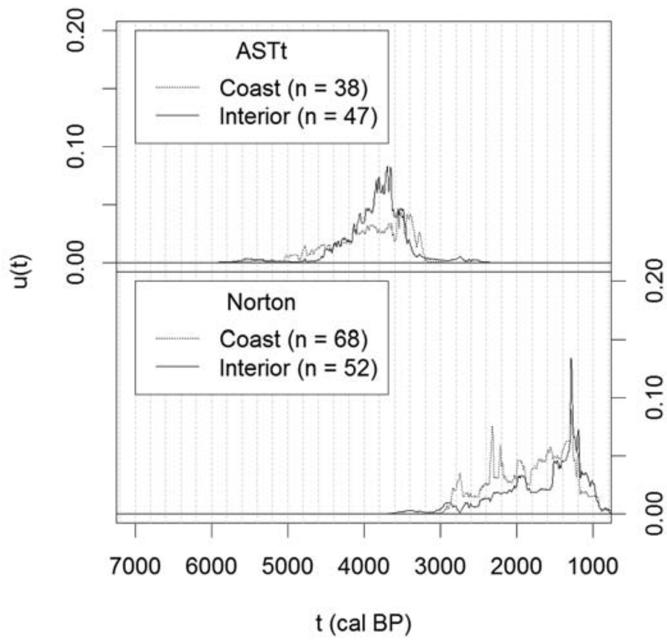

FIG. 8. Spds of ASTt components (upper panel) and Norton components (lower panel), divided by coast and interior settings.

were not observed in the ASTt record also became common in the Norton period. These included human figurines, labrets, possibly beads, and increasingly elaborate artistic carvings (Giddings, 1964; Clark, 1982; Tremayne, 2015b), all indications of increasing cultural complexity. Of course, the generally poor preservation of organic remains at ASTt sites in Alaska may bias our perceptions on this point.

Researchers often link evidence for resource intensification, larger residential group size, increased sedentism, and cultural complexity with population growth (e.g., Broughton, 1999; Sassaman, 2004; Kelly, 2007). In the case of the ASTt-Norton transition, however, such an explanation seems untenable, given the apparent episode of population decline that separates the two. We thus return to the paradox: if the ASTt population underwent such dramatic decline, why does the Norton record indicate increased cultural complexity customarily attributed to population growth? We argue that the answer lies in the shifting balance between regional population size, carrying capacity, intensified exploitation of previously under-used aquatic resources, and the dynamics of intra- and inter-group cultural transmission.

We propose that the late ASTt marine resource intensification entailed a further shift in the selective pressures acting on this remnant population's subsistence technology and economy, precipitating the adoption, if not the in-situ development, of novel techno-economic traits that came to characterize the Norton tradition. Vegvari and Foley (2014:1) assert that "high selection pressure in the form of resource pressure promotes the accumulation of adaptive culture in spite of small population sizes and high innovation costs." To cope with population pressure or resource shortfalls, hunter-gathers must relocate to new foraging patches or increase diet-breadth, which promotes reduced mobility and technological innovation to exploit resources more efficiently (Bettinger and Baumhoff, 1982; Williams et al., 2015). Following this reasoning, the subsistence hardships faced by late ASTt populations stemming from the conjectured collapse of western Alaskan caribou herds, and the increased reliance on a previously under-exploited marine habitat, may have been sufficient to precipitate the socio-technological changes observed in the Norton period in spite of the dramatic population decline characterizing the end of the ASTt in Alaska.

How, then, do we explain the loss of some technologies (e.g., microblades, burins, and parallel oblique flaking on stone tools) during this period of regional population decline? Reduced technological complexity may be a result of cultural drift due to diminished population size. Shennan (2000) argues that fluctuations in population size play a central role in promoting cultural change over time, with large populations tending to accumulate and maintain cultural traits. Others have noted that small populations tend to exhibit declining material-cultural diversity as stochastic processes in cultural transmission lead to the random loss of such traits (Henrich, 2004; Powell et al., 2009; Kline and Boyd, 2010). If remnant ASTt populations were isolated from other groups for an extended period, it stands to reason that some aspects of their material culture would have been lost as a result of cultural drift. Alternatively, the loss of some tool forms, such as microblade and burin technologies, might have resulted from changes in subsistence strategies as the tasks toward which these tool forms were applied became obsolete in the new economic order. We see no a priori reason to adopt a strict either/or approach to the explanation of these losses—a combination of cultural drift and changing selective pressures may account for the various losses characterizing the ASTt-Norton transition—but we do not believe that this matter has yet been settled.

While some tool forms disappeared over the ASTt-Norton transition, new technologies were also introduced. Once again, accounting for these innovations is an open matter. Explanations focusing on adaptation might suggest that it was necessary to develop and adopt new technologies to improve the success and efficiency of aquatic resource procurement activities. Alternatively, introduction of new technologies to late ASTt/proto-Norton populations may also have been due to increased contact with neighboring cultures. The latter scenario is consistent with the predominance of non-Norton components in the pan-Alaskan dataset (Fig. 4) and the prevalence of such components in the Western Alaskan subset (Fig. 5), even as Norton components increased in frequency primarily in Western Alaska. It is therefore likely that Norton communities had more opportunities for interaction with other culture groups than their ASTt forebears and thus a greater susceptibility to the diffusion of ideas across such lines. As pan-Alaska population size continued to expand after 2500 cal BP, these interactions would have increased in frequency.

Finally, we contend that general theoretical accounts that invoke population growth and decline to explain cultural evolution must be careful to distinguish between the separate effects of variability in regional population abundance and residential group size. Similarly, we distinguish between separate and potentially antagonistic influences of population size on cultural evolution: while variability in absolute population size may modulate a population's capacity to maintain knowledge of cultural traits, conversely variability in the relationship between realized population size and carrying capacity modulates the force of selective pressures acting on subsistence-economic organization. In the case of the ASTt-Norton transition, we find that the pan-Alaska population decreased, while group size (Dumond, 1982) and apparently population pressure both increased. We propose that both ecological and demographic processes account for the loss of some ASTt traits in the Norton tradition, while those traits that were maintained across the transition may be explained by appeal to continuing adaptive relevance or chance (or both). Late ASTt/early Norton people adopted new technologies to enhance the effectiveness of marine subsistence pursuits, and some of these traits were adopted from neighboring groups with a deeper history of maritime adaptation.

CONCLUSIONS

Our study implicates the ecological collapse of tundra habitats and human population decline in the demise of the Alaskan ASTt and the subsequent emergence of the Norton tradition. Two periods of population growth and one period of marked decline are identifiable in the temporal distribution of pan-Alaskan site occupation episodes during the Mid to Late Holocene. From a demographic standpoint, the ASTt florescence is noteworthy in that this subpopulation constituted nearly half of the pan-Alaskan population for the millennium spanning 4300 to 3300 cal BP. In areas where remnant ASTt populations took refuge in both Northwest and Southwest Alaska, the economic focus of these populations necessarily shifted to the exploitation of marine resources in response to a proposed collapse of terrestrial habitats, most likely involving a catastrophic decline in caribou herds. It is from these late coastal ASTt populations that the Choris developed in Northwest Alaska and the early Norton formed in Southwest Alaska. The eventual coalescence of these two groups led to the maturation of the widespread maritime Norton tradition (Dumond, 1972a:41).

The intensified reliance of remnant ASTt populations on coastal resources simultaneously facilitated renewed population growth, increased sedentism, year-round coastal occupation, and increased social and technological complexity. While maritime resource intensification during a period of depressed population size appears out of line with current theory regarding the relationship between hunter-gatherer population ecology and economic organization, we argue that the solution to this paradox lies in a dramatic reduction in carrying capacity wrought by ecological collapse. The resulting population-resource imbalance inevitably precipitated a compensatory downward adjustment to population, while the experience of such severe and sustained stress promoted more or less conscious efforts to develop novel means of mitigating such stress. Importantly, the proximity of other maritime-oriented populations in Southwest Alaska and Northeast Asia subsidized such efforts in the form of ready-made, transmissible technologies and practices for marine resource exploitation. While antecedent ASTt populations had themselves long engaged in casual maritime resource exploitation, it took a region-wide crash of terrestrial habitats and the severe subsistence stress that this crash induced to trigger a more decisive shift toward maritime resource intensification, setting remnant ASTt communities on an evolutionary path toward the development of the Norton tradition. Future work should focus on the proximate cause of the ecological catastrophe that precipitated the ASTt population collapse and on trade and interaction networks across the Bering Strait and into the Canadian Arctic.

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