

# Temporal and Dietary Reconstruction of Past Aleut Populations: Stable- and Radio-Isotope Evidence Revisited

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**ABSTRACT.** A recent accelerator radiocarbon study of Eastern Aleutian human remains that Ales Hrdlicka collected in the 1930s contradicts his long-standing assertion that brachycranic Neo-Aleut people, moving west along the island chain at ca. 1000 BP, replaced the dolichocranic Paleo-Aleut population. Radiocarbon dates for Paleo-Aleut individuals ranged from ca. 3400 to 400 cal BP, covering the entire temporal span of the study and indicating that Paleo-Aleuts coexisted in the study area with Neo-Aleuts from ca. AD 1000 until well into the 16th century. Shortly after publication of that study, the curating institution informed the authors that a small number of cataloguing errors with respect to cranial category had come to their attention. Subsequent corrections made to cranial categories have strengthened temporal patterning characteristic of this data set. Mortuary practices and genetic and dietary patterning also distinguish Paleo-Aleut from Neo-Aleut groups. The stable isotope chemistry of their diets indicates that Neo-Aleuts relied on higher-trophic-level marine taxa than Paleo-Aleuts and, within that category of taxa, on more offshore rather than nearshore-feeding pinnipeds.

**Key words:** Paleo-Aleut, Neo-Aleut, Hrdlicka, Kagamil burial cave, Ship Rock burial cave, Chaluka midden, Umnak Island, Eastern Aleutians, stable carbon isotope chemistry, stable nitrogen isotope chemistry, bone collagen

**RÉSUMÉ.** Une étude récente réalisée au moyen d'un accélérateur pour la datation par le carbone 14 visant des dépouilles mortelles d'Aléoutes de l'Est recueillies par Ales Hrdlicka dans les années 1930 vient contredire son affirmation de longue date selon laquelle le peuple néo-aléoute brachycrâne, se déplaçant vers l'ouest le long de l'arc insulaire vers l'an 1000 BP, a remplacé la population paléo-aléoute dolichocrâne. La datation par le carbone 14 pour les individus paléo-aléoutes variait environ entre 3400 et 400 cal. BP, ce qui recouvrait toute la durée temporelle de l'étude et indiquait que les Paléo-Aléoutes ont coexisté avec les Néo-Aléoutes dans la région visée par l'étude d'environ 1000 AD jusqu'au XVI<sup>e</sup> siècle avancé. Peu après la publication de cette étude, l'établissement responsable de la conservation a signalé aux auteurs qu'un petit nombre d'erreurs de catalogage avaient été décelées relativement à la catégorie crânienne. Les corrections qui ont été subséquentement apportées aux catégories crâniennes se sont trouvées à renforcer les caractéristiques de typification temporelle de cet ensemble de données. Les pratiques mortuaires de même que les caractéristiques génétiques et alimentaires ont également permis de distinguer les Paléo-Aléoutes des Néo-Aléoutes. La chimie des isotopes stables de leurs alimentations indique que les Néo-Aléoutes dépendaient de taxons marins de niveau trophique plus élevé que les Paléo-Aléoutes et, au sein de cette catégorie de taxon, qu'ils dépendaient davantage de pinnipèdes extracôtiers que côtiers.

**Mots clés :** Paléo-Aléoutes, Néo-Aléoutes, Hrdlicka, caverne d'inhumation de Kagamil, caverne d'inhumation de Ship Rock, tertre de Chaluka, île Umnak, Aléoutes de l'Est, chimie des isotopes stables du carbone, chimie des isotopes stables de l'azote, collagène osseux

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## INTRODUCTION

In the late 1930s, Ales Hrdlicka collected human remains from several sites in the Eastern Aleutians with the intent to use craniometric patterning to investigate Aleut origins. In the course of his research, Hrdlicka (1945:575) defined two cranial categories. "The essential differences are those in the vault of the skull. The pre-Aleuts [Paleo-Aleuts] had a decidedly higher and more oblong vault. They also had a[n] appreciably higher face, giving higher facial indices, a longer base and less prognathism." Hrdlicka (1945)

reported that Paleo-Aleuts were dolichocranic in form, with a high-vaulted, more oblong cranium, whereas Neo-Aleuts were brachycranic, with a low-vaulted, wider, and rounder cranium. He further argued that Neo-Aleut people, moving west along the island chain, replaced Paleo-Aleuts around 1000 BP. This inference was based primarily on the apparent superposition of Neo-Aleut remains in the Chaluka midden deposits on Umnak Island (cf. Laughlin and Marsh, 1951).

In Coltrain et al. (2006), we reported accelerator radiocarbon dates on purified bone collagen from 80 burials

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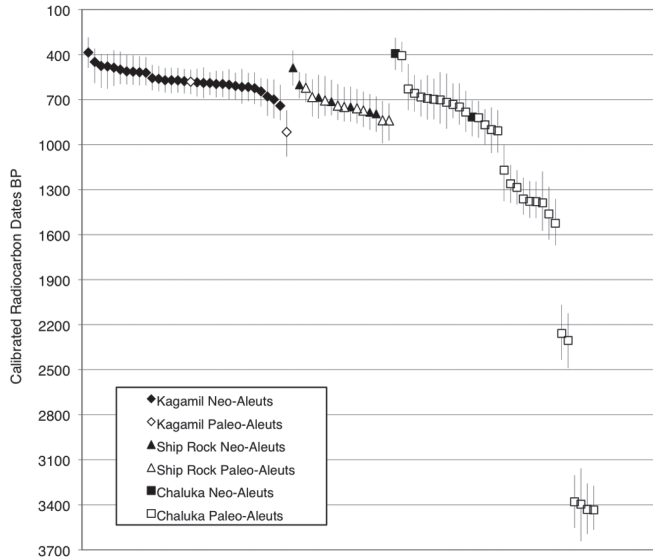


FIG. 1. Calibrated radiocarbon intercept dates before present (BP) with two-sigma ranges graphed by site and cranial category.

analyzed by Hrdlicka. Our study population comprised remains that Hrdlicka collected from both the Chaluka midden ( $n = 32$ ) and the Kagamil ( $n = 32$ ) and Ship Rock ( $n = 16$ ) burial caves offshore of Umnak Island. Several significant findings were presented based on calibrated accelerator radiocarbon dates, corrected for both global and local marine reservoir effect with directly measured  $\delta^{13}\text{C}$  values. 1) Dates for Paleo-Aleut remains ranged from ca. 3400 to 400 cal BP and covered the entire temporal span of the study (Fig. 1; Coltrain et al., 2006: Table 1). 2) All burials older than ca. cal 1000 BP were Paleo-Aleuts and most were Chaluka midden inhumations. 3) Dates for Neo-Aleut remains ranged from ca. 800 to 400 cal BP and were collected by Hrdlicka, primarily as mummified remains, from the Kagamil and Ship Rock burial caves. 4) Paleo- and Neo-Aleut groups coexisted on Umnak Island from ca. AD 1000 until well into the 16th century (Fig. 2).

These findings clearly contradict Hrdlicka's (1945) long-standing assertion that Neo-Aleut people from the Alaska Peninsula replaced Paleo-Aleuts at 1000 BP. Nonetheless, Hrdlicka's cranial categories exhibit temporal patterning that correlates with distinct mortuary practices, subsistence behavior, and genetic patterning. Most Paleo-Aleuts were recovered from Chaluka midden as inhumations, whereas Neo-Aleuts were interred in burial caves as mummified remains, in accord with their tradition: "[t]he Unangan [Neo-Aleuts] preserved all deceased members of their community from new-born to elderly and of both sexes" (Frohlich and Laughlin, 2002:92). Differences in resource acquisition are documented by bone collagen stable isotope chemistry, discussed below. Finally, Smith et al. (2009) report a shift at approximately 1000 BP in Eastern Aleutian mtDNA haplogroup frequencies coincident with the appearance of Neo-Aleuts in the archaeological record.

As Coltrain et al. (2006) was going to press, the Smithsonian Institution Repatriation Office notified us that after

TABLE 1. Corrections to Coltrain et al. (2006) cranial category, by site.

Site	Curation Number	New Affiliation
Kagamil	377913	Paleo-Aleut
Kagamil	377915	Paleo-Aleut
Ship Rock	378470	Paleo-Aleut
Ship Rock	378473	Paleo-Aleut
Ship Rock	378474	Paleo-Aleut
Ship Rock	378542	Paleo-Aleut
Ship Rock	378543	Paleo-Aleut
Ship Rock	378544	Paleo-Aleut
Chaluka	378606	Neo-Aleut

a thorough review of Aleut collections, nine cataloguing errors had been identified in our study population (S. Ousley, pers. comm. 2006). These errors were in the form of discrepancies between Hrdlicka's cranial notations and the cataloguing of that information. Here I report corrections to the cranial affiliation of dated burials and evaluate their implications for the findings discussed above. I also make available stable carbon and nitrogen isotope values and discuss broad dietary patterning evident in the stable isotope chemistry of the study population.

#### *Revised Cranial Affiliations*

Table 1 shows corrections to the cranial affiliations reported in Coltrain et al. (2006: Table 1). In all but one case, they constitute a change from Neo-Aleut to Paleo-Aleut, and six of nine corrections were to individuals from the Ship Rock burial cave. Cranial affiliation for this site is now nearly evenly divided between nine Paleo- and seven Neo-Aleut burials. Two individuals from Kagamil, including the oldest Kagamil burial in the study population (377913), were also reclassified as Paleo-Aleut. Finally, the youngest individual from the Chaluka midden on Umnak Island (378606) was reclassified as Neo-Aleut.

Although these corrections do not alter the findings discussed above, they do affect the intra-site distribution of burial categories. Importantly, Kagamil burial 377913, now classified as Paleo-Aleut, was previously thought to be the oldest Neo-Aleut burial in the study, with a calibrated intercept date of AD 1034 (two-sigma range, AD 890–1198). This correction is in keeping with the antiquity of this burial, as well as with the general temporal trends characteristic of the data set. Chaluka midden burial 378606, now classified as Neo-Aleut, was previously thought to be the youngest Paleo-Aleut individual in the data set, with a calibrated intercept date of AD 1557 (two-sigma range, AD 1452–1666). The revision places it well within the upper range of Neo-Aleut remains from both Kagamil and Ship Rock. The near-equal distribution of burials from Ship Rock assigned to each cranial category is consistent with the temporal range of the Ship Rock assemblage relative to the data set as a whole. Most Ship Rock burials are older than those from Kagamil, but the Ship Rock collection contains no remains as old as the oldest Chaluka midden inhumations (Fig. 1). Finally, as reported previously, all burials with two-sigma

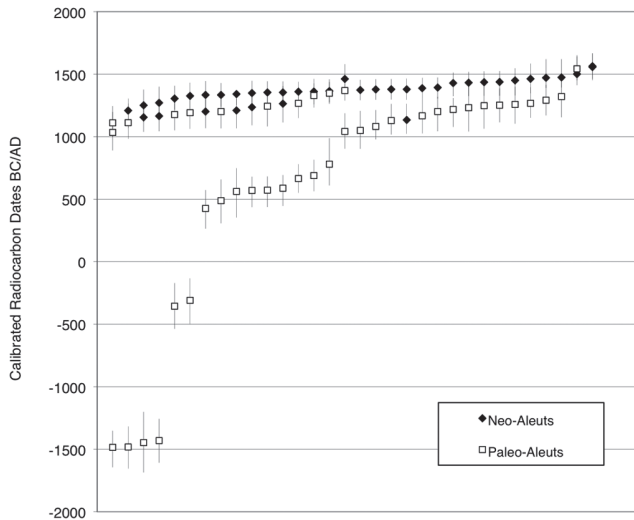


FIG. 2. Calibrated radiocarbon intercept dates with two-sigma ranges graphed by cranial category.

ranges older than ca. cal 1000 BP are classified as Paleo-Aleut, and all but one are Chaluka midden inhumations.

#### *Eastern Aleutian Stable Isotope Chemistry*

Stable carbon isotope ratios ( $\delta^{13}\text{C}$ ) have frequently been used to address the importance of marine resources in forager diets lacking a  $\text{C}_4$  component. The technique was introduced by Tauber (1981) to demonstrate a reduction in dependency on marine resources at the Mesolithic to Neolithic transition in coastal Denmark (see also Chisholm et al., 1982). Since then, a number of studies have employed stable carbon isotope analysis to reconstruct mixed marine/terrestrial diets (e.g., Sealy and van der Merwe, 1985; Lovell et al., 1986; Sealy, 1986; Walker and DeNiro, 1986; Parkington, 1991; McGovern-Wilson and Quinn, 1996 [cf. Ambrose et al., 1997]; Richards and Hedges, 1999; Coltrain et al., 2004a; Eriksson et al., 2008; Coltrain, 2009; Jones and Quinn, 2009; Szapak et al., 2009). The technique is also commonly used to reconstruct marine food webs (e.g., Hobson, 1987; Bunn et al., 1989; Wada et al., 1991; Kling et al., 1992; Hobson and Welch, 1995; Burton and Koch, 1999; Tamelander et al., 2006; Caraveo-Patiño et al., 2007; Dehn et al., 2007) and as a device for tracking migration patterns of human populations and an array of Arctic species, including bowhead whale, anadromous fish, and migratory waterfowl (e.g., Schell, 1983; Schell et al., 1988; Kurle and Worthy, 2001; Phillips et al., 2009).

Carbon occurs naturally in two stable forms or isotopes. Carbon-12 is the most common, making up approximately 98.89% of global carbon; carbon-13, with an extra neutron, comprises approximately 1.11% of the earth's carbon. When atmospheric carbon ( $\text{CO}_2$ ), dissolved  $\text{CO}_2$ , or marine bicarbonates ( $\text{HCO}_3^-$ ) are incorporated into plant tissues, physical and metabolic processes alter or fractionate the ratio of  $^{13}\text{C}$  to  $^{12}\text{C}$  relative to the substrate from which it was taken. This ratio is expressed in delta ( $\delta^{13}\text{C}$ ) notation as parts per mil

(‰) difference from an internationally recognized standard (Craig, 1957).

The degree of discrimination against  $^{13}\text{C}$  during photosynthesis covaries with the photosynthetic pathway type (Farquhar et al., 1989). Lichens, cool season grasses, trees, and most bushy plants employ  $\text{C}_3$  photosynthetic mechanisms that discriminate heavily against  $^{13}\text{C}$ . Thus modern  $\text{C}_3$  plants express a mean  $\delta^{13}\text{C}$  value of  $-26.7 \pm 2.7\text{‰}$  ( $n = 370$ ) (Cerling et al., 1998). Alternatively, warm-season grasses, those growing in regions where daytime growing-season temperature exceeds  $22^\circ\text{C}$  and precipitation exceeds 25 mm (Ehleringer et al., 1997), use a  $\text{C}_4$  pathway, resulting in less discrimination against  $^{13}\text{C}$  and an average  $\delta^{13}\text{C}$  value of  $-12.5 \pm 1.1\text{‰}$  ( $n = 455$ ) (Cerling et al., 1998). Plants grown before fossil fuel depletion of atmospheric  $\text{CO}_2$  are enriched by 1–2‰ relative to these averages (Tieszen and Fagre, 1993).

Kinetic processes governing bicarbonate ( $\text{HCO}_3^-$ ) formation enrich marine bicarbonates by approximately 7‰ relative to atmosphere, placing seawater  $\delta^{13}\text{C}$  values near 0‰ (Tauber, 1981; Chisholm et al., 1982). Submerged marine plants employ a  $\text{C}_3$  photosynthetic pathway with its associated heavy discrimination against  $^{13}\text{C}$ , yielding mean  $\delta^{13}\text{C}$  values of  $-16\text{‰}$  to  $-18\text{‰}$ , approximately 7‰ more positive than terrestrial  $\text{C}_3$  plants. This characteristic gives marine plants a distinctive carbon isotopic label, which is passed up the food web. However, in the Aleutians and other marine environments, additional factors influence plant  $\delta^{13}\text{C}$  values. Ocean upwelling can create areas of high productivity, drawing down nutrients and enriching phytoplankton  $\delta^{13}\text{C}$ . Conversely, upwelling can recycle old carbon depleted in  $^{13}\text{C}$  (Schell et al., 1988), or eroding peat depleted in  $^{13}\text{C}$  may enter the marine food web at the deltas of large drainages (Peterson et al., 1986; Nelson et al., 1988; Bunn et al., 1989; Oechel et al., 1993). For example, zooplankton from bowhead whale summer feeding grounds off the MacKenzie River delta produced  $\delta^{13}\text{C}$  values 8‰ more negative than those of zooplankton collected in the Bering-Chukchi seas, the whales' winter range (Schell et al., 1988; also see Peterson et al., 1986). However, sections of baleen laid down during summer (as opposed to winter) feeding episodes exhibit only a 3‰ difference, illustrating that the isotope chemistry of baleen represents a weighted average of intraspecific variation in lower-order diets. The  $\delta^{13}\text{C}$  values of eastern Aleutian foragers subsisting high in the marine food web represent a further averaging of intraspecific variation, since in both human and ingested prey tissues (unlike baleen, a keratinous protein metabolically inactive after formation) carbon is subject to continuous turnover. Thus, human bone collagen from individuals with diets high in marine foods typically ranges from  $-13\text{‰}$  to  $-11\text{‰}$ .

These  $\delta^{13}\text{C}$  values are passed up the food web, leaving a diagnostic signature in the tissue of consumers that does not covary with the skeletal element analyzed or with the sex of the sample independently of gender-based differences in feeding ecology (Hobson and Schwarcz, 1986; Lovell et al., 1986). Fractionation between primary producers and consumers approximates 5‰, and enrichment at higher trophic

TABLE 2. Stable isotope values with preservation criteria.

Curation Number	Cranial Category	$\delta^{13}\text{C}$ ‰	$\delta^{15}\text{N}$ ‰	Atomic C:N	Wt % Collagen	Curation Number	Cranial Category	$\delta^{13}\text{C}$ ‰	$\delta^{15}\text{N}$ ‰	Atomic C:N	Wt % Collagen
<b>Kagamil</b>						<b>Ship Rock – continued:</b>					
17459	NA	-13.1	19.7	3.3	16.7	378471	NA	-12.4	20.0	3.1	14.7
17485	NA	-12.9	19.0	3.2	20.7	378472	NA	-11.9	21.9	3.1	22.1
377807	NA	-12.9	20.4	3.2	22.2	378473 <sup>1</sup>	PA	-12.6	19.7	3.1	21.2
377808	NA	-12.7	20.4	3.2	23.2	378474 <sup>1</sup>	PA	-11.8	21.5	3.1	21.0
377809	NA	-13.0	20.2	3.2	21.5	378541	NA	-12.9	19.6	3.2	24.0
377810	NA	-12.8	20.5	3.2	20.1	378542 <sup>1</sup>	PA	-12.4	19.8	3.3	21.4
377811	NA	-12.2	19.8	3.2	22.1	378543 <sup>1</sup>	PA	-11.6	21.7	3.2	22.4
377812	NA	-13.0	20.1	3.2	23.1	378544 <sup>1</sup>	PA	-12.2	21.2	3.2	21.3
377813	NA	-13.1	20.3	3.2	21.6	<b>Chaluka</b>					
377814	NA	-13.0	20.3	3.2	21.8	378601	PA	-12.4	19.3	3.1	16.4
377815	NA	-12.8	20.0	3.3	19.5	378602	PA	-11.9	19.2	3.2	14.2
377816	NA	-13.1	20.0	3.2	19.3	378603	PA	-12.1	19.6	3.2	9.1
377817	NA	-12.5	21.2	3.3	22.7	378604	PA	-11.9	19.3	3.2	15.6
377818	NA	-12.5	20.8	3.3	21.9	378605	PA	-12.2	19.5	3.2	19.7
377819	NA	-13.0	20.0	3.2	21.1	378606 <sup>1</sup>	NA	-11.9	20.2	3.2	23.7
377821	NA	-12.9	20.7	3.3	24.1	378607	PA	-11.4	19.8	3.2	14.5
377900	NA	-13.0	21.1	3.2	22.4	378608	PA	-12.0	19.4	3.2	8.4
377901	NA	-12.9	20.5	3.4	22.4	378609	PA	-11.6	20.1	3.1	22.7
377902	NA	-12.8	20.1	3.1	16.8	378610	PA	-12.3	19.9	3.3	18.1
377903	NA	-12.6	20.4	3.3	21.8	378611	NA	-12.2	19.1	3.3	15.6
377904	NA	-12.9	20.0	3.3	21.7	378612	PA	-11.3	20.0	3.3	16.2
377906	NA	-13.0	21.0	3.2	21.8	378613	PA	-12.3	19.3	3.3	9.6
377910	NA	-12.9	20.7	3.2	22.5	378614	PA	-12.1	19.7	3.2	
377911	NA	-12.2	21.5	3.3	21.0	378615	PA	-11.9	18.3	3.3	10.2
377913 <sup>1</sup>	PA	-12.6	19.5	3.3	20.8	378616	PA	-12.0	19.3	3.2	12.1
377914	NA	-12.5	21.2	3.4	21.9	378619	PA	-12.1	19.4	3.3	17.8
377915 <sup>1</sup>	PA	-13.2	20.5	3.3	22.7	378620	PA	-12.5	19.1	3.3	21.5
377916	NA	-12.4	21.0	3.2	22.3	378621	PA	-12.9	18.5	3.2	16.0
377917	NA	-12.9	19.5	3.2		378622	PA	-12.0	18.7	3.2	10.0
377918	NA	-12.4	20.1	3.3	21.9	378623	PA	-12.0	19.3	3.2	18.5
377919	NA	-11.9	20.4	3.3	22.9	378624	PA	-13.1	19.3	3.3	17.0
377920	NA	-12.3	19.6	3.2	22.2	378625	PA	-13.1	20.1	3.2	19.1
<b>Ship Rock</b>						378626	PA	-13.2	19.5	3.3	15.0
378461	NA	-12.6	20.2	3.1	18.9	378627	PA	-12.0	19.8	3.3	12.8
378462	NA	-12.1	21.2	3.1	21.3	378628	PA	-12.4	18.3	3.2	15.8
378463	PA	-12.8	19.6	3.2	20.6	378629	PA	-12.5	17.6	3.3	11.9
378464	NA	-13.7	17.9	3.1	23.5	378630	PA	-13.6	19.4	3.3	16.9
378467	PA	-12.0	20.7	3.3	20.9	378633	PA	-11.9	19.0	3.2	9.7
378468	PA	-12.2	20.7	3.1	21.8	378639	PA	-12.6	18.8	3.2	21.3
378469	NA	-12.2	20.8	3.1	15.0	378646	PA	-12.9	18.0	3.2	18.7
378470 <sup>1</sup>	PA	-12.5	19.9	3.1	17.7	378663	PA	-12.0	19.0	3.2	20.9

<sup>1</sup> Corrected cranial affiliations (cf. Coltrain et al., 2006).

levels approaches 1‰ (Katzenberg, 1993; Burton and Koch, 1999). Human adult bone collagen  $\delta^{13}\text{C}$  values represent a weighted average of long-term dietary intake since the carbon in bone collagen turns over slowly, requiring ca. 30 years to replace existing carbon with an equivalent amount of carbon (Libby et al., 1964; Harkness and Walton, 1972; Stenhouse and Baxter, 1977, 1979).

Nitrogen isotope ratios ( $\delta^{15}\text{N}$ ) monitor the trophic level of sampled diets. This function follows from the understanding that  $^{15}\text{N}/^{14}\text{N}$  increases by approximately 2–4‰ with each increase in trophic level associated in part with discrimination against isotopically heavy urea at renal membrane boundaries, enriching the isotope signature of endogenous nitrogen (Ambrose and DeNiro, 1986; Schoeller, 1999). Most terrestrial plant taxa obtain nitrogen from soil ammonium ( $\text{NH}_4^+$ ) or nitrate ( $\text{NO}_3^-$ ), and those in temperate ecosystems have mean  $\delta^{15}\text{N}$  values of 3–6‰ (range

= 0–9‰) contingent on temperature, salinity, and water stress (Pate, 1994; Bocherens and Drucker, 2003; Coltrain et al., 2004b). Accordingly, herbivores in such ecosystems typically exhibit  $\delta^{15}\text{N}$  values of 6–9‰ (Heaton et al., 1986; Ambrose, 1991; Schwarcz et al., 1999). Conversely, plants that fix atmospheric nitrogen, (e.g., legumes, mosses, and lichens) have mean  $\delta^{15}\text{N}$  values of approximately 1‰, with a -2‰ to 2‰ range (Evans and Ehleringer, 1994; Pate, 1994). Phytoplanktons, primary producers in marine ecosystems, exhibit nitrogen isotope ratios in the 4–9‰ range with an open ocean mean of ca. 6‰ (Fry, 1988; Tamelander et al., 2006; Misarti et al., 2009).

#### *Aleut Isotope Chemistry*

All Aleut bone collagen met established preservation criteria (Table 2), with atomic C:N ratios falling between 2.9

TABLE 3. Stable isotope means and standard deviations by site, age, and cranial category.

	n	$\delta^{13}\text{C} \text{ ‰}$	$\delta^{15}\text{N} \text{ ‰}$
<b>Affiliation:</b>			
Paleo-Aleut	41	$-12.3 \pm 0.5$	$19.5 \pm 0.9$
Neo-Aleut	39	$-12.7 \pm 0.4$	$20.3 \pm 0.7$
<b>Paleo-Aleut:</b>			
Pre 1000 BP	15	$-12.5 \pm 0.6$	$19.1 \pm 0.6$
Post 1000 BP	26	$-12.2 \pm 0.4$	$19.8 \pm 0.9$
<b>Site:</b>			
Chaluka	32	$-12.3 \pm 0.5$	$19.2 \pm 0.6$
Kagamil	32	$-12.7 \pm 0.3$	$20.3 \pm 0.6$
Ship Rock	16	$-12.4 \pm 0.5$	$20.4 \pm 1.0$

and 3.6 and weight percent collagen yields ranging from 9.1% to 24.1% of whole bone (Ambrose, 1990). Uniformly enriched  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values indicate heavy reliance on high-trophic-level marine foods (Tables 2 and 3, Fig. 3). Yet significant differences exist in the mean isotope chemistry of Paleo- and Neo-Aleuts, in the mean  $\delta^{15}\text{N}$  values of pre- and post-1000 BP Paleo-Aleuts, and in four of six between-site comparisons (Table 4). These differences suggest dietary regimes weighted by reliance on high- versus lower-trophic-level marine foods, or intake of inshore versus offshore pinnipeds, or both. Although mean differences with significant “p” values are in most cases less than 1‰, they exceed experimental uncertainty for mass spectrometric analyses (carbon = 0.1‰, nitrogen = 0.2‰).

Four general patterns are evident: 1) Neo-Aleuts have significantly enriched mean  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values, which indicate that they were reliant on higher-trophic-level marine foods than both pre- and post-1000 BP Paleo-Aleuts. 2) Post-1000 BP Paleo-Aleut diets are significantly higher in trophic level ( $\delta^{15}\text{N}$ ) than those of pre-1000 BP Aleuts. 3) Between-site differences are largely driven by the inter-site distribution of Paleo- versus Neo-Aleut burials. 4) No significant differences exist between male and female diets either within a single site or in the whole study population.

## DISCUSSION

Both Paleo-Aleut and Neo-Aleut groups subsisted on marine diets. Their stable isotope chemistry indicates that ca. 95% of their protein and lipid intake derived from marine resources, an estimate well supported by the ethnographic literature, which reports diets high in marine foods and virtually devoid of carbohydrate intake (e.g., Laughlin, 1980). Significant differences appear to reflect the type and trophic level of marine intake rather than a marine ecosystem shift in food-web isotope chemistry (e.g., Misarti et al., 2009) coincident with the arrival of Neo-Aleuts. Sixty-three percent of the Paleo-Aleuts under study date after 1000 BP, and were therefore fully contemporary with Neo-Aleuts, but the diets of the Neo-Aleuts are significantly enriched in  $\delta^{15}\text{N}$  relative to both pre- and post-1000 BP Paleo-Aleuts (Table 4), suggesting that enrichment in Neo-Aleut  $\delta^{15}\text{N}$  derives primarily from behavioral rather than ecosystem

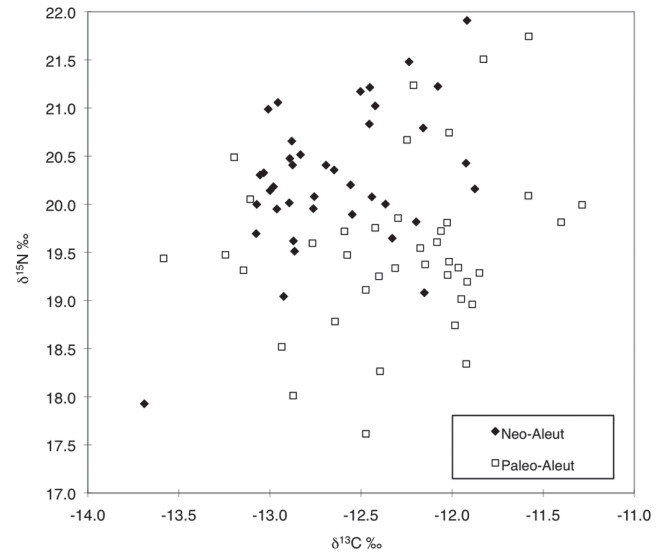


FIG. 3. Paleo-Aleut (n = 41) and Neo-Aleut (n = 39) bone collagen stable carbon and nitrogen isotope values in per mil (‰) units.

TABLE 4. Probability (p) values for significant differences in mean isotope values by site, age, and cranial category.

	$\delta^{13}\text{C} \text{ ‰}$	$\delta^{15}\text{N} \text{ ‰}$
Paleo-Aleut/Neo-Aleut	< 0.001	< 0.001
Paleo-Aleut Pre/Post 1000 BP	n.s.	0.007
Neo-Aleut/Post 1000 BP Paleo-Aleut	< 0.001	0.022
Kagamil/Chaluka	< 0.001	< 0.001
Kagamil/Ship Rock	0.01	n.s.
Ship Rock/Chaluka	n.s.	< 0.001

causality. Thus, average values reflect general patterning in resource choice and identify broad temporal trends in subsistence practices.

The Paleo-Aleut mean  $\delta^{15}\text{N}$  value was significantly lower than that of Neo-Aleuts; thus, it appears that Paleo-Aleuts relied more heavily on lower-ranked, smaller-packaged resources such as sea otter (*Enhydra lutris*), sea urchin (Echinacea), and plankton-feeding sea birds such as short-tailed albatross (*Diomedea albatrus*), shearwaters (*Puffinus* spp.) and fulmars (*Fulmarus glacialis*). Paleo-Aleuts may also have included more harbor seal (*Phoca vitulina*) than other pinnipeds in their diets. Among the pinnipeds, the stellar sea lion (*Eumetopias jubatus*) and northern fur seal (*Callorhinus ursinus*) have high-trophic-level diets consisting primarily of small schooling fish (Burton and Koch, 1999; Kurle and Worthy, 2001; Newsome et al., 2007), whereas the harbor seal is more reliant on near-shore squid and invertebrates.

Conversely, the mean Paleo-Aleut  $\delta^{13}\text{C}$  value was enriched relative to that of Neo-Aleuts, suggesting again that Paleo-Aleuts may have been more reliant on harbor seal. Nearshore-feeding pinnipeds such as the harbor seal tend to have enriched  $\delta^{13}\text{C}$  values relative to offshore-feeding species like the fur seal (Burton and Koch, 1999: Table 1) because nutrient-rich upwelling near shore increases photosynthetic rates, drawing down aqueous  $\text{CO}_2$  concentrations.

This process decreases discrimination against  $^{13}\text{C}$  and increases the  $\delta^{13}\text{C}$  signature of phytoplankton at the base of nearshore pinniped food webs.

Pre- and post-1000 BP Paleo-Aleut mean  $\delta^{13}\text{C}$  values are not significantly different; but the post-1000 BP mean  $\delta^{15}\text{N}$  value is significantly more positive, suggesting a slight increase in reliance on higher-trophic-level foods after 1000 BP.

Significant differences in between-site comparisons are undoubtedly a function of the site-specific distribution of Paleo-Aleut versus Neo-Aleut burials. Differences in Chaluka (versus Kagamil) isotope values likely reach significance because 30 of 32 Chaluka burials are Paleo-Aleut, whereas 30 of 32 Kagamil burials are Neo-Aleut. Conversely, the Ship Rock sample, which represents Paleo-Aleuts and Neo-Aleuts nearly equally, is not significantly different in mean  $\delta^{15}\text{N}$  value from the Kagamil burials or in  $\delta^{13}\text{C}$  from the Chaluka midden remains.

### CONCLUSION

Temporal and genetic patterns, as well as differences in mortuary behavior and subsistence behavior, suggest that the Neo-Aleuts represent an influx of people migrating west along the island chain, perhaps closely related to the Paleo-Aleuts but characterized by greater social and technological complexity. This suggestion is supported by the post-1000 BP appearance of fortified refuge rocks and longhouses. The latter are not found west of the Islands of the Four Mountains, but they are reminiscent of large, multi-room, semi-subterranean residential structures on Kodiak Island and the Alaskan Peninsula (Johnson and Wilmerding, 2001).

Since my primary goal in presenting this material was to update the cranial information reported in Coltrain et al. (2006) and to make Aleut stable isotope data available to other researchers, many questions remain. The brief discussion of Aleutian isotope chemistry leaves pivotal issues unaddressed, and the conclusions above merely reiterate long-standing uncertainties surrounding Eastern Aleutian prehistory. Although it is apparent that features of the Eastern Aleutian prehistoric record change at ca. 1000 BP, the causal factors are not fully understood. Nonetheless, our understanding of Aleut diets can improve. A higher-resolution reconstruction of these diets requires the isotope signatures of common prey types from archaeological contexts, and such research is underway with prey taxa from the Chaluka midden and the Amaknak Bridge site. A better understanding of resource acquisition strategies will help to clarify the genetic, mortuary, and cranial patterning evident among Eastern Aleutian Aleut populations.

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