



# The coastal migration theory: Formulation and testable hypotheses

Loren G. Davis <sup>a,\*</sup>, David B. Madsen <sup>b,1</sup>

<sup>a</sup> Oregon State University, Department of Anthropology, 203 Waldo Hall, Corvallis, OR, 97331, USA

<sup>b</sup> University of Nevada-Reno, Department of Anthropology, 512 Ansari, Reno, NV, 89557, USA

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## ABSTRACT

The presence of well-documented sites in the Americas predating and south of the opening of an ice-free corridor in the North American ice sheets lends credence to a Pacific coastal migration theory (CMT) explaining the route for the initial peopling of the Americas. This theory has been informally discussed for more than 50 years, but until recently, has been largely ignored and never properly defined as a result. We provide a formal definition of the CMT which, briefly stated, is that Upper Paleolithic populations moved from Asia to coastal regions along the northwestern Pacific Rim between ~45–30 ka. By ~30 ka these coastal populations developed a mixed maritime, nearshore, and terrestrial adaptation involving the use of boats, shell fishhooks for deep-water fishing, and a stemmed point and macroblade core technology. About 25–24 ka a subset of these coastal populations became isolated somewhere in the vicinity of the Japan/Paleo-Hokkaido, Sakhalin, Kuril (PSHK) region, developing genetically into the ancient Native American (ANA) populations that eventually settled the Americas. Between ~22–16 ka these ANA people began migrating by foot and boat along the southern Beringian coast and down the Alaskan and Canadian coastline into the Americas south of the continental ice sheets before eventually expanding inland. We develop a series of testable hypotheses through which the CMT can be examined.

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## 1. Introduction

The archaeological discovery of repeated instances of human occupation south of the North American continental ice sheets predating the appearance of fluted projectile points and before any possible opening of an ice-free corridor (IFC) between the Laurentide and Cordilleran ice sheets has essentially falsified the long held Clovis-first hypothesis (CFH). This array of data is now sufficiently large that it requires an organizational framework within which to consider the processes and chronology underlying the only reasonable alternative for the initial Pleistocene peopling of the Americas: A Pacific coastal entry way into the New World.

While this is a view that has deep roots in Americanist archaeology as a hypothesis about the process of how the Americas were initially settled by humans, it has been largely discounted until the last decade or so. For more than 400 years (Acosta, 1604) the notion that the earliest Native Americans arrived in the New World via a Beringian overland route has dominated archaeological thought. Despite that dominance, the possibility of a coastal route

has long been held out as a viable alternative by a small minority, and while "... most anthropologists believe(d) that man first entered the Western Hemisphere by a land bridge ...," others thought entry was "... perhaps by a short trip across the water in the region of the Bering Straits land route (Jarcho, 1959)." The concept of a coastal route remained poorly developed, however, being briefly mentioned from time to time but never fully formed (e.g., Heusser, 1960; Macgowan and Hester, 1962; Laughlin, 1967; Bryan, 1978). It was not until the late 1970s when Knut Fladmark (1978, 1979) published his landmark papers outlining a coastal alternative to an IFC model that the idea began to be taken seriously. Now, more than 40 years later, and after the excavation and reporting of a series of sites in both North and South America dating to before the Clovis period, Fladmark's "alternative" is now the most widely accepted model for the peopling of the Americas. As a recent review in *Science* suggests "... current evidence favors the Pacific coast as the route taken by the first Americans" (Waters, 2019).

By the end of the twentieth century a number of scholars, in the face of overwhelming opposition from many CFH proponents, even began to describe a possible Pacific coastal entry route as the "Coastal Migration Theory" (e.g., Easton, 1992; Busch, 1994), although the phrase was used primarily as a descriptive label for an

\* Corresponding author.

E-mail address: [loren.davis@oregonstate.edu](mailto:loren.davis@oregonstate.edu) (L.G. Davis).

<sup>1</sup> Contributed equally to this work.

idea rather than as a well-formulated theory. As increasing numbers of sites dating to before the Clovis era were discovered and reported, specific hypotheses about how, when, and where people may have reached the Americas via a coastal route began to be promulgated (e.g., Dixon, 1993, 1999; Gruhn, 1994; Mandryk et al., 2001; Erlandson, 2002). This growing interest in the early coastal record was accompanied by an increased focus on the human ecology of ancient marine environments (Erlandson, 1994; Erlandson and Colten, 1994). One of the most well-formulated of these ecological hypotheses was the notion of a “kelp highway” first described by Jon Erlandson and colleagues (Erlandson et al., 2007). They even suggested this hypothesis was connected to an overarching “Coastal Migration Theory,” although the theory itself was not fully defined, nor the linkage between hypothesis and theory clearly described. Most recently, Braje et al. (2017, 2020) argue that although the growing record of early First Americans sites dating to before the Clovis period underscores the importance of considering a Pleistocene coastal migration, understanding the specifics of that migration will require multiple working hypotheses.

Building on these groundbreaking works we here review the evidence that informs an explicit Coastal Migration Theory (CMT) for when, how, and from where Upper Paleolithic populations first reached the Americas. By “theory” we mean a broad framework or model, devised to help explain an array of data on a particular topic, and whose explanatory viability can be examined via a variety of testable hypotheses. We then describe a series of such hypotheses, of which the Kelp Highway hypothesis is but one, and identify a number of tests of these hypotheses that could help resolve their relative viability.

## 2. A brief review of the Clovis-first hypothesis and data requiring its rejection

*The Clovis First Hypothesis* – The Clovis Paleoindian Tradition (CPT) is radiocarbon dated between 13,125 and 12,925 cal yr BP (Waters and Stafford, 2007) or 13,350–12,870 cal yr BP (Haynes, 1980, 1982, 1987; 1992; Haynes et al., 1984). The CPT is characterized by the presence of Upper Paleolithic-type lithic technology manufactured from high quality lithic materials, and includes diagnostic fluted lanceolate projectile points, prismatic blade cores, discoidal cores, end scrapers, graters, and the manufacture of osseous rod tools (Stanford, 1991). Clovis peoples pursued a terrestrial subsistence economy and hunted extinct megafauna, including proboscideans and bison, as well as a variety of smaller animals.

The CFH seeks to explain the initial peopling of the Americas as the result of humans bearing the CPT cultural pattern (e.g., Haynes, 1964, 1980; 1987; Haynes, 2002). Clovis progenitors are assumed to have entered North America following an occupation of western Beringia and then Alaska and Yukon (eastern Beringia) during or prior to the last glacial maximum (LGM) (Haynes, 1982). These eastern Beringians migrated south through an IFC shortly before 13 ka, coinciding with the appearance of the CPT in the Great Plains and American Southwest, or perhaps as early as ~14.8 ka (Haynes, 1982; Potter et al., 2018). These initial migrants emerged from the IFC bearing the CPT fluted point technology (or developed it soon afterwards in areas south of the ice sheets [e.g., Mason, 1962]) and spread rapidly throughout the Americas. According to the CFH, most regional archaeological sequences in the Americas have some ancestral version of the CPT as their technological antecedent (Willig and Aikens, 1988).

*Ice-Free Corridor chronology* – Although the IFC features prominently in the CFH as the only possible migration route between high and middle latitude areas of North America, until relatively recently there were few high-resolution studies clarifying the

timing of glacial ice position and the paleoenvironmental conditions present in the IFC. Potter et al. (2018) argue that the IFC could have been open for human migration south from eastern Beringia along its entire north-south extent as early as 14.8 ka. Margold et al. (2019) studied cosmogenic nuclide exposure dating of glacial erratic boulders distributed along the eastern front of southern Alberta's Rocky Mountains and found that the Laurentide and Cordilleran glacial ice sheets detached from each other along the southern ICF by ~14.9 ka. Since the timing of Late Wisconsinan deglaciation that led to the opening of the IFC is modeled to have begun first in the southern end of the corridor (Dyke, 2004), Margold et al. (2019) stress that more research is needed to confirm the timing of when the IFC opened in more northern areas. Pedersen et al. (2016) examined environmental DNA (eDNA) signatures from sedimentary sequences within Alberta's Charlie and Spring lakes and conclude that the IFC was only ecologically viable enough to support hare and bison after ~12.6 ka, and lacked environmental conditions required to support earlier human migration. Genetic studies of Pleistocene fossil bison skeletal remains found to the north and south of the IFC reveal that gene flow between the two populations was delayed until 13.4 ka to 12 ka (Heintzman et al., 2016), supporting the ecological viability interpretations of Pedersen et al. (2016).

*Sites dating to and prior to the Clovis period* – Several archaeological sites suggest people were present in areas south of the glacial margin during a window of time after a possible opening of the IFC at ~14.8 ka, but before the IFC became biologically viable between ~13.4–12.6 ka. These sites include Monte Verde II (~14.2 ka; Dillehay, 1997; Dillehay et al., 2008), Paisley Cave (~14.2 ka; Gilbert et al., 2009; Jenkins et al., 2012), Page-Ladson (~14.5 ka; Halligan et al., 2016) (Fig. 1), and a number of others more often disputed by CFH adherents (Williams and Madsen, 2019).

*Sites predating the earliest possible opening of the IFC before ~15 ka* – A smaller set of sites south of the continental ice sheets bear evidence of cultural occupation predating 15 ka, before the earliest hypothesized opening of the IFC at ~14.8 ka (Potter et al., 2018). These sites include Huaca Prieta (Dillehay et al., 2012, 2017), Gault/Friedkin (Waters et al., 2018; Williams et al., 2018), and Cooper's Ferry (Davis et al., 2019), as well as several more whose validity is often disputed (Williams and Madsen, 2019) (Fig. 1). An example of the latter set is the underwater Cinmar site located off the coast of Virginia at a depth of ~74 m (Stanford et al., 2014). A large ~190 mm long biface and the partial skull of a mastodon were recovered by fishermen in a single scallop dredge in 1974, with the location and depth of the find carefully recorded. The mastodon was subsequently dated to ~22.8 ka (Stanford et al., 2014). While it seems possible that the biface and skull are associated, and represent evidence of the human occupation of now flooded coastal margins on the continental shelf during the LGM, the lack of a scientific investigation of the site together with the alternative possibilities (among others) that the finds are contextually unrelated or a product of ice-rafted debris, precludes widespread acceptance of the site's validity.

The dating of these pre-Clovis-aged sites south of the continental ice sheets, combined with recognition that Clovis sites date oldest in the U.S. Plains/Southwest region and youngest in Alaska (Goebel et al., 2013; Buvit et al., 2018), have finally laid the CFH to rest.

## 3. The coastal migration theory

Our formal CMT is:

- 1 The progenitors of the First Americans were Early Upper Paleolithic (EUP) foragers who originated in interior northeast



**Fig. 1.** Location map showing key regions, features, archaeological sites, and potential migration routes.

Asia and made their way by various land and sea routes, including a northern route, possibly down the Amur River valley (Izhuho et al., 2020; Jeong et al., 2016; Nakazawa, 2017) and through northern China, and a southern route, possibly through southern China and Taiwan (Gakuhari et al., 2019; Izhuho et al., 2020; Nakazawa, 2017), to coastal Pacific areas ranging from South Korea to the Japanese archipelago and to its extension in the convergent island area that emerged during late Pleistocene marine regression known as the Paleo-Sahkalin-Hokkaido-Kuril (PSHK) area. These populations merged prior to LGM, giving rise to daughter populations in the PSHK area which eventually evolved into such diverse groups as the Jomon in more southerly Japan, northeastern Siberians such as the Itelmen and Chukchi, and ancient Native Americans (Jeong et al., 2016).

2 Between ~40–30 ka these foragers adopted mixed and variable terrestrial, near shore, and maritime subsistence adaptations along this northwestern Pacific coastal margin, with the degree of specialization differing from area to area.

3 Starting in the EUP period, they developed both a stone tool technology characterized by unifacially and bifacially-worked stemmed projectile points and sea-going vessels capable of reaching pelagic fishing grounds and obsidian source areas scores of kilometers from the coast. A number of these populations may have become isolated in the PSHK region, allowing for genetic bottlenecks to develop via genetic drift.

4 By about 20 ka, sea levels as much as 130 m lower than modern, and correspondingly shorter travel distances between islands and refugia, allowed ocean-going coastal foragers in the PSHK to begin to expand along the Kamchatka peninsula to the southern margin of the Bering Land Bridge and Aleutian Islands to the coastlines of southern Alaska and British Columbia.

5 Sometime between ~20–16 ka these gradually expanding Late Upper Paleolithic populations reached coastal margins south of the Cordilleran glaciation. Once there, they applied generalized coastal fishing/foraging adaptations to wetland, terrestrial, near-shore, and maritime resources, which allowed more specialized

daughter populations to expand rapidly inland, along major waterways and onto lake-margin habitats, and down the coast to South America through a variety of differing coastal habitats. Over the course of the next 3000–5000 years these populations expanded inland from the coast, developing specialized terrestrial hunting and gather adaptations which eventually led to later Clovis and other Paleoindian complexes.

#### 4. Paleogenetics

The genetic composition and distribution of ancient East Asian populations dating to before ~30 ka, as well as the relationships between these ancient populations and those of the earliest Americans, are complex and incomplete (e.g., [Sikora et al., 2019](#)). At least part of the genome of the founding ancient Native American (ANA) population is derived from populations in western Siberia. The ~24 ka “Mal’ta boy” from the Lake Baikal–Altai Mountains region shares ~40% of his genome with Native American populations ([Raghavan et al., 2015](#)), but that gene flow appears to have occurred after the split between early West Eurasians (EWE) and early East Asians (EEA) ~33–49 ka ([Fig. 2](#)).

Archaeological evidence suggests seafaring EEA populations appeared in Japan and (probably) the PSHK by at least ~38 ka ([Gakuhari et al., 2019](#); [Izuho and Kaifu, 2015](#)), but the genetic composition of these groups remains largely unknown. By ~32 ka, a foraging population had also reached the Arctic coast in far western Beringia at the Yana Rhino Horn site (RHS) ([Sikora et al., 2019](#)), but ANA populations are not apparently derived from this Ancient Northern Siberian group. Rather, Native Americans are genetically more closely related to an EEA population that returned to the lower Yana River region between 20–11 ka after an occupational gap during the LGM ([Sikora et al., 2019](#)). Since the earliest ancient Native American populations split from Siberians and East Asian

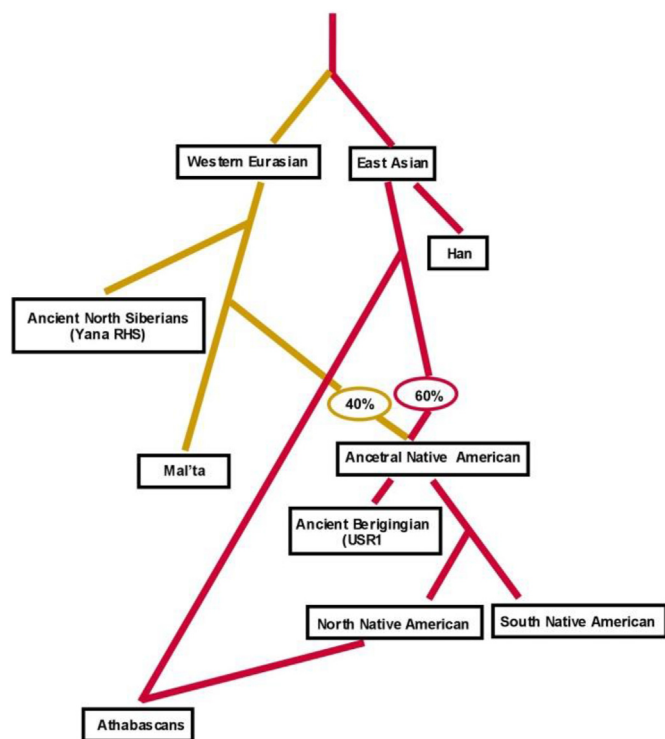
groups ~36 ka, with gene flow between the groups continuing until ~25 ka ([Moreno-Mayar et al., 2018](#); [Raghavan et al., 2015](#)), they appear to be unrelated to this pre-LGM population in western Beringia. The split is thus more likely to have occurred somewhere along the northwestern Pacific coast in the Japan/PSHK region and/or in southeastern Siberia rather than farther north in interior or coastal western Beringia. We hypothesize this founding ANA population arose from a merger of East Asian populations entering the Japan/PSHK region from Korea and Taiwan to the south and a population related to the Mal’ta child moving down the Amur River valley to the Japan/PSHK archipelago.

After this final ~25 ka split, the founding population remained isolated from other Asian populations for a period of 4000–8000 years ([Moreno-Mayar et al., 2018](#); [Raghavan et al., 2015](#)) before expanding into the Americas sometime after ~19.5 ka ([Llamas et al., 2016](#); [Pinotti et al., 2019](#)). Where this population resided during that standstill is generally thought to have been in interior central and eastern Beringia. However, that notion is not derived from archaeological data since there is no evidence of people in Beringia during the LGM (e.g., [Faught, 2017](#)), but is based largely on the idea that there was a possible LGM refugium in that area that could have supported human populations (e.g., [Hoffecker et al., 2016](#)). A population represented by the Upward Sun River 1 burial was in east-central Beringia by at least ~11.5 ka ([Potter et al., 2014](#)), but this Ancient Beringian (AB) population apparently split off from the founding ANA population sometime ~21 ka ([Moreno-Mayar et al., 2018](#)). Where that split happened remains unknown, but we hypothesize that the most plausible location for the isolated region where the 4000–8000 year standstill occurred was on one or more of the islands in the PSHK.

In the Ryukyu Islands of southern Japan genetic differentiation among Holocene age groups apparently resulted from genetic drift ([Sato et al., 2014](#)). A similar process among PSHK islands seems plausible, since Pleistocene age populations there were likely smaller and more isolated than their Ryukyu Islands Holocene counterparts. It remains to be seen if the Upper Paleolithic populations of Japan are also related to the same isolated populations that gave rise to the founding American populations, but Jeong et al. (2016:261) indicate “... the Ainu [of the northernmost Japanese islands] have a closer genetic relationship with northeast Siberians than with central Siberians, suggesting ancient connections among populations around the Sea of Okhotsk.” They also suggest (2016:268) there is “... evidence for extra genetic affinity between the Ainu and northeast Siberians (Itelmen and Chukchi), who share ancestry with Native Americans. This finding coupled with the ancient origin of the Ainu raises the possibility that the same migration event led to the settlement of Jomon hunter-gatherers and to the initial dispersal of Native American ancestors. If this is the case, this first northward migration took place before the LGM.”

#### 5. Distribution of people in northeast Asia during the LGM

Far western Beringia was initially occupied by at least ~32 ka, as reflected in the occupation of Yana RHS in the lower reach of the Yana River near the Arctic Ocean ([Pitulko et al., 2004](#); [Goebel et al., 2013, Fig. 1](#)). Yana RHS and the rest of northern Siberia and Beringia were abandoned during the LGM ([Goebel et al., 2000a, 2000b](#); [Graf and Buvit, 2017](#)) but reoccupied during the deglacial period. Genetic data suggest the lower Yana River region was reoccupied between 20–11 ka by EEA peoples ([Sikora et al., 2019](#)), while archaeological data suggest the rest of Beringia was abandoned between 31–14.5 ka ([Graf and Buvit, 2017](#)). The earliest archaeological evidence of human presence in the northern Pacific Rim region comes from South Korea and Japan where Upper Paleolithic sites date as early as 40–35 ka and 38 ka, respectively ([Izuho, 2013](#);



**Fig. 2.** A simplified model for the formation of Native American populations (modified from [Moreno-Mayar et al., 2018](#)).

Kaifu et al., 2015; Morisaki et al., 2019). Unlike northern Siberia and (probably) Beringia, which was largely abandoned during the LGM, these regions show continuous human occupation predating the LGM and extending through the Holocene. Elsewhere in the northern Pacific Rim region, only three archaeological sites predate ~15 ka, including: the Ustinovka complex (first occupied at ~18.5 ka; Tabarev, 2013) in the Russian Far East maritime region west of Hokkaido and the Bol'shoi Iakor' I (~15.5 ka; Pratt et al., 2020) and Diuktai Cave (~17 ka; Mochonov and Fedoseeva, 1996a) sites, both located in Siberia but west of Beringia. Humans initially expand into Beringia during the Bølling-Allerød warm interval, appearing first in western Beringia at the Berelekh site (~13.8 ka; Mochonov and Fedoseeva, 1996b) and soon after in eastern Beringia in the Nenana River valley by ~14.1 ka at Swan Point (Goebel et al., 1991, 1996; Graf and Bigelow, 2011; Graf and Buvit, 2017; Graf et al., 2015; Pearson, 1999; Powers and Hoffecker, 1989).

## 6. Circum-north Pacific coastal refugium during the LGM

Across Beringia and farther southward along the western Pacific coast into PSHK and the Japanese Archipelago, glacial ice was limited to high elevation mountain areas and lowland areas remained ice free throughout the late Pleistocene (Sato et al., 2014; Sawagaki et al., 2004; Elias and Brigham-Grette, 2013). In southwestern Alaska, glacial ice expanded to its maximum extent across the Alaskan Archipelago to ground on the Pacific continental shelf by ~27.3 ka (Mann and Peteet, 1994) and had begun to retreat by ~17.9–17 ka (Mann and Hamilton, 1995; Misarti et al., 2012). At their maximum extents, southern Alaskan mountain glacier complexes presented a discontinuous ice front along the northeastern Pacific coastline where ice lobes separated large unglaciated areas (Kaufman and Manley, 2004) that supported ecological refugia (Heaton et al., 1996). In general, coastal glaciers had undergone significant recession by 18 ka (Briner et al., 2017). Paleontological remains from caves in the Alexander Archipelago suggest that glacial ice advanced and retreated there between 19.5–17 ka (Heaton and Grady, 2003). On the basis of cosmogenic exposure chronology and radiocarbon dated paleontological remains from caves in southeastern Alaska's Prince of Wales Island archipelago, Lesnek et al. (2018) show that the Cordilleran Ice Sheet expanded to its maximum extent in southeastern Alaska between ~20–17 ka and retreated thereafter.

Global eustatic sea level was lowered by ~130 m at the height of the LGM between ~26–20 ka (Lambeck et al., 2002; Clark et al., 2009), exposing continental shelf areas, merging islands together and with mainland regions, and generally shortening travel routes along coastal margins. Areas more proximal to continental glacial ice experienced different changes in relative sea level during the late Pleistocene due to glacioisostatic adjustments (e.g., Clark et al., 2014). In the northern Pacific Rim region, eustatic lowering of sea level notably led to the emergence of the Bering Land Bridge, which connected Russia and Alaska before the LGM until submergence beneath rising sea levels after ~11 ka (Clark et al., 2014). During the onset of the Bølling-Allerød warming period, global eustatic sea levels rose 14–18 m from 14,650–14,310 cal yr BP (Deschamps et al., 2012). Under these conditions, accelerated deglaciation of the Cordilleran ice sheet would have increased meltwater input to the northeastern Pacific and greatly strengthened the westerly gyre of the Alaska current, probably making boat travel from Asia more difficult during this period (Royer and Finney, 2020). Thus, marine conditions for a Pacific coastal migration appear to have been most ideal during the period of transition from glacial to postglacial environments at ~17–15 ka.

Migrating from Japan/PSHK to North America along the northern Pacific coast could have been possible with oceangoing

watercraft and pedestrian travel. Departing from the eastern end of Hokkaido and navigating along the Kuril Island chain to the northeast and then to southern Kamchatka, maritime coastal travelers could reach Umnak Island (the southernmost point of the Bering Land Bridge; Laughlin, 1967) in southwestern Alaska's Aleutian Archipelago along a 4300 km archipelago route (Fig. 1). Alternatively, they could have taken a slightly longer route of ~4600 km to Umnak Island via the southern edge of Beringia. Over a seven-month period, two modern adventurers successfully traveled a similar route via kayak where they paddled from northern Hokkaido, along the Kuril Island chain, up the western edge of the Bering Strait, to ultimately reach Alaska's St. Lawrence Island (Turk, 2006). Initial coastal migrants may have also traveled by boat eastward from southern Kamchatka along the Aleutian Islands. Starting from the western edge of the Aleutian Island chain (i.e., Commander Island) and moving eastward, distances between some islands are great (~280–120 km) even during lower sea level conditions at the LGM. It is worth noting that humans settled the 1200 km-long chain of Japan's Ryukyu Islands by 36 ka (Kaifu et al., 2015) along a route that includes several significant deep 220–130 km-wide ocean gaps never connected during LGM sea levels. Travelling along the southern coast of the Bering Land Bridge to the same point may have been easier than island hopping along the southern Aleutian Archipelago and probably provided more access to necessary resources along the way.

## 7. Circum-north Pacific similarities in lithic technology

Comparing similarities in the design, manufacture, and use of stone tools as a way to examine patterns of human migration or cultural transmission of knowledge is a fundamental aspect of archaeological practice and represents the primary means by which Clovis First advocates originally argued that the spread of fluted point technology reflected the initial peopling of the Americas (e.g., Haynes, 1960, 1964, 1969, 1980, 1987; Morrow and Morrow, 1999; Haynes, 2002). During the twentieth century, archaeologists sought to identify a technological progenitor for the CPT among late Pleistocene-aged Beringian and Northeast Asian sites (Bonnichsen and Schneider, 1999; Goebel, 2004) and the report of a potential (but later dismissed) fluted point in western Beringia sparked great interest within the First American studies community (King and Slobodin, 1996). The later discovery that Alaskan fluted points post-dated fluted point technology south of the North American continental ice sheets (Goebel et al., 2013; Buvit et al., 2018) was perhaps the last straw and confirmed that Clovis fluted points were not the earliest lithic technology of the Americas. Given these developments, most archaeologists appear to consider the CPT as a North American innovation and interest has shifted to uncovering details about the "Proto-Clovis" ancestor to the CPT (e.g., Ferring, 2012; Haynes, 2002, 2015; Jennings and Waters, 2014).

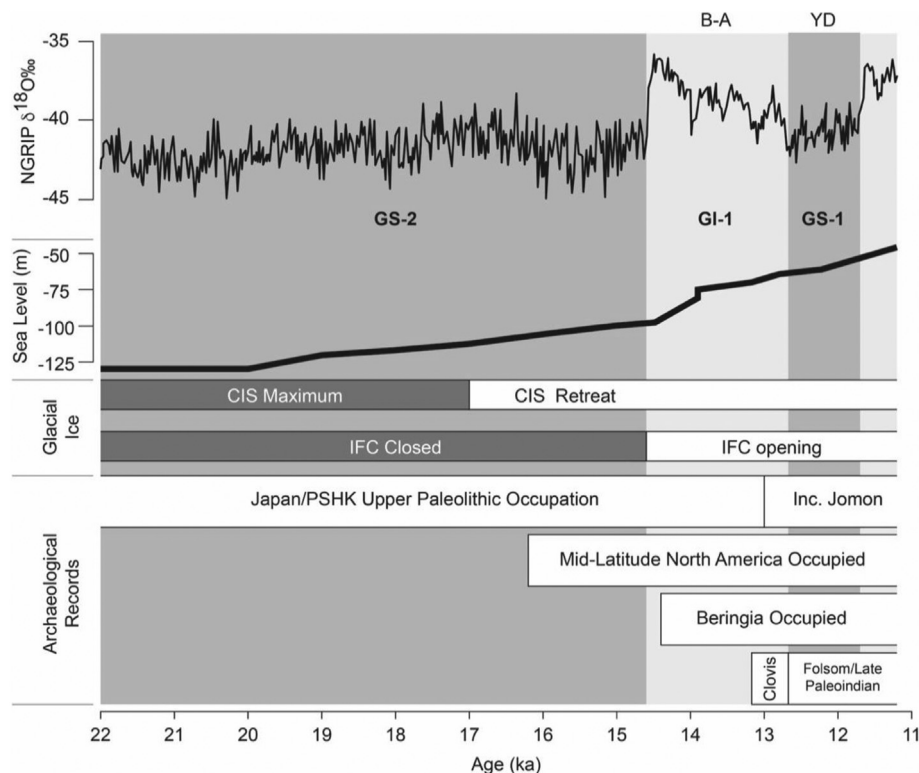
The discovery that nonfluted stemmed projectile points predate the CPT in North America requires us to adjust our expectations for what a technological progenitor for the First Americans might look like. Microblade and microcore technology appears in China and Korea by ~30–25 ka (Bae, 2017; Coutouly, 2018), reaching Japan by way of diffusion from Korea shortly thereafter (Sato et al., 2014), but possibly reaching the PSHK by other routes as early as ~27 ka (Coutouly, 2018). This technology spreads into Beringia after 14.5 ka (Graf and Buvit, 2017). These particular late Pleistocene microblade and microcore production patterns (e.g., Yubetsu microblade/microcore type; Andrefsky, 1987; Hirasawa and Holmes, 2017; Holmes, 2001; Morlan, 1978; Nakazawa et al., 2005) have origins that can be traced back to Upper Paleolithic Japan but are not found in late Pleistocene-aged sites in the Americas south of Beringia, indicating that it remained in high latitude regions. Microblade

technologies do not appear in the earliest lithic technological assemblages from the earliest components at the Gault, Friedkin, and Cooper's Ferry sites, nor are they a part of the pre-Clovis-aged Nenana Complex (Graf and Buvit, 2017) or the younger CPT lithic technology. A well-developed Upper Paleolithic biface and core technological system is present in Japan/PSHK during the LGM, continues through the Pleistocene, and may be the source of the ANA traditional technological knowledge (Fig. 3). Davis et al. (2019) point out that pre-Clovis-aged stemmed projectile point technology from the Cooper's Ferry site is similar in both design and manufacture (i.e., made on linear macroflakes) to Upper Paleolithic stemmed bifaces in Hokkaido. These Japanese sites arguably include the most abundant, earliest, and most technologically similar examples of late Pleistocene lithic technology in the northern Pacific Rim region. Stemmed projectile points made on macroblades are present in South Korea between 40–14 ka (Lee and Sano, 2019) and are similar to Hakuhen-Sentoki stemmed projectile points that appear in Japan between 30–23 ka (Morisaki et al., 2019). By 16 ka, more complex bifacial stemmed projectile point, core, and blade technologies are widespread in Japan (Sato et al., 2014; Lee and Sano, 2019; Kudo, 2006; Nagai, 2007; Natsuki, 2018). This period also includes the proliferation of stemmed (or “tanged”) projectile point forms throughout Japan and include the Tachikawa type on Hokkaido, the Kosegawasa type in northern Honshu near the Sea of Japan, and the Yanagimata type in central and western Honshu (Sato et al., 2014; Nagai, 2007; Natsuki, 2018; Befu and Chard, 1960). The younger lithic technologies of Beringia that postdate human presence south of North American ice sheets include different, generally smaller stemmed, lanceolate, and teardrop-shaped projectile point forms in western Beringia at Ushki (~13 ka; Goebel et al., 2003; Slobodin, 2011) and

Berelekh (~13.9 ka; Mochanov and Fedoseeva, 1996a), and in eastern Beringia in sites bearing the Nenana (~13.6 ka), Denali (~12.8 ka), and Mesa (~13 ka) technological complexes (Graf and Buvit, 2017). Based on their age and inherent technological attributes, the Upper Paleolithic stemmed point industries of Hokkaido and North America may derive from the same common source, signalling a shared cultural link in Northeast Asia.

## 8. Circum-north Pacific adaptive strategies

A clear pattern of generalized coastal foraging, involving the use of littoral and near shore marine species, along with other terrestrial coastal and riverine resources, appears by 35 ka in the Ryukyu Islands of southern Japan (Fujita et al., 2016), in the Russian Far East from 28 to 14 ka at multiple sites in the Amur River basin (Tabarev, 2013), during the terminal Pleistocene to early Holocene period at sites in southern Alaska (Dixon, 1999, 2008, 2013), British Columbia (Fedje et al., 2005, 2008, 2011), the Northern Channel Islands of California (Braje et al., 2017, 2020) and in the Baja California peninsula (Des Lauriers, 2010; Des Lauriers et al., 2017; Fujita, 2014). Thus, use of marine resources by the peoples of NE Asia predates human arrival in the Americas and is seen in the earliest late Pleistocene-aged coastal sites of the Americas. Specialized maritime subsistence patterns appear first on Okinawa Island where shell hooks were used to exploit fishes beyond the nearshore zone at 35–30 ka (Fujita et al., 2016), with the use of boats further confirmed by the conveyance of obsidian from offshore islands by ~38 ka (Ikeya et al., 2015). A similar fishing pattern appears first in the Americas on Cedros Island in northwestern Mexico where single piece shell hooks—remarkably similar in form to those from Okinawa—were used to catch large deep-sea fishes during the



**Fig. 3.** Multiproxy record showing the timing and conditions of environmental and archaeological events relative to the CMT. North Greenland Ice Core Project (NGRIP) isotopic data and Greenlandic stadial (GS) and interstadial (GI) timing adapted from North Greenland Ice Core Project members (2004). Global eustatic sea level data adapted from Clark et al. (2014). Cordilleran ice sheet (CIS) and ice-free corridor (IFC) conditions adapted from Lesnek et al. (2018) and Margold et al. (2019). Timing of archaeological records are cited in text. B-A = Bølling-Allerød. YD = Younger Dryas. Inc. Jomon = incipient Jomon.

terminal Pleistocene (Des Lauriers et al., 2017). Throughout the period between ~35–15 ka, Japan/PSHK sites show patterns of nearshore and deep-sea fishing complemented by the use of Upper Paleolithic stemmed and lanceolate projectile points, biface, and flake/blade core technology in the pursuit of a wide range of terrestrial resources (e.g., Morlan, 1967; Pearson, 2006; Yamaoka, 2014; Sato et al., 2011).

## 9. Testable hypotheses

Determining whether or not this Coastal Migration Theory is viable requires, as with any theory, explicit tests of its various implications. In the case of the CMT, most of the testable hypotheses involve the discovery and exploration of geological deposits and archaeological sites around the northern Pacific Rim dating to the LGM. Here we outline several possible hypotheses and develop a number of tests which could falsify them.

**Hypothesis 1.** – This hypothesis is actually composed of two related, but competitive, hypotheses: **1A**–*The earliest genetic antecedents of the founding Ancient Native American population will be found in the Upper Paleolithic populations of the PSHK region;* Or **1B**–*Its earliest genetic antecedents will be found in the Upper Paleolithic populations of Beringia and can be traced southward along the northeastern Pacific coastline.*

Since the pre-LGM populations of western Beringia, as represented by DNA recovered from the Yana RHS site, were unrelated to the ANA population(s) that settled the Americas, then the likeliest locations of the standstill and associated genetic bottleneck are either immediately south of Beringia in the PSHK region or in a hypothetical interior eastern Beringian refugium. Of these two possibilities, an interior Beringian standstill seem less parsimonious 1) because of the likelihood Beringian populations withdrew from the region during the LGM, as did their Siberian neighbors (Graf and Buvit, 2017), and 2) because the limited gene flow between ANA and AB populations that occurred after their ~21 ka split (Moreno-Mayar et al., 2018a) is more readily explained by isolation on separate islands rather than in highly mobile foraging populations living in the same small refugium.

Nonetheless, it is possible that the initial human migrants came from interior Beringia, rather than from the PSHK, and ultimately traveled south of the North American ice sheets via a coastal route in a way that might have resembled the “three stage model” proposed by Mulligan and Kitchen (2013). If a human population migrated overland through western Beringia, over the Bering Land Bridge, and into eastern Beringia before 16 ka, they would encounter a *cul de sac* at the northern margin of the Cordilleran Ice Sheet. While some people may have stayed and settled eastern Beringia, later creating the occupation layers at Swan Point (Holmes, 2001, 2011) and in the sites bearing the Nenana Complex, it is also possible that some humans traveled on to the Pacific coast and continued moving southward around the Cordilleran Ice Sheet through a combination of walking and paddling. These ancient Beringian peoples could have brought the Upper Paleolithic biface, core, and small projectile point technologies that are hallmarks of ancient Beringian culture to mid-latitude North America—providing the cultural transmission mechanism for the long-hypothesized technological link between Nenana and the CPT (Goebel et al., 1991; Meltzer, 2009). Considering that there are no known Beringian or Pacific coastal sites that contain human skeletal remains or artifacts that predate 16 ka, these related, but competitive, hypotheses remain speculative.

**H1 Test** – Finding genetic evidence of ancestral ANA populations either in central Beringia or in locations outside the PSHK region would falsify hypothesis 1A, just as finding evidence that ANA

populations are more closely related to populations from Japan/PSHK or in other locations outside of Beringia (e.g., Russian Far East) would falsify hypothesis 1B. Such genetic tests may be even more difficult to achieve than other hypotheses suggested here. Not only do they involve finding sites of the right age in the right spots, many of which are likely now underwater, but they also involve finding preserved human DNA. Human skeletal material is rare even in early Holocene sites in areas now above sea level; in sites around the northern Pacific Rim dating to 25–15 ka, finding and extracting ancient DNA (aDNA) from human skeletal remains may be even more problematic. However, recent advancements in extracting aDNA from soils in high latitude and altitude locations where colder temperatures can preserve readable human DNA for tens of thousands of years (e.g., Willerslev et al., 2003; Slon et al., 2017; Zhang et al., 2020) provides some promise for testing these H1 hypotheses. In cold climate localities stretching from the Hokkaido/Sakhalin/Karil islands to the Kamchatka peninsula to the Aleutian islands chain to the coastal margins of southern Alaska and British Columbia, where sites dating to the LGM may occur above modern sea levels (see below), there is a good chance aDNA can also be recovered.

**Hypothesis 2.** – *Only lithic technologies in East Asia in the Japan/PSHK region are old enough and similar enough to be the logical progenitor(s) of the earliest stemmed projectile point traditions in the Americas.*

This is the archaeological expression of **Hypothesis 1**, added here because finding human remains of the appropriate age in the right places may be difficult. Stemmed and lanceolate projectile points appear as the earliest weaponry forms in the Americas between ~16–13.4 ka at sites like Monte Verde, Gault, Friedkin, Paisley Caves, and Cooper's Ferry. Similar point forms do not occur in western and east-central Beringia until well after their appearance in the Americas. These earliest points are accompanied by core, blade, and biface technologies that, like the point styles, appear to share strong similarities with Upper Paleolithic lithic technologies of Japan/PSHK (Davis et al., 2019). Correlations between archaeological patterns in North America and the Japanese Islands have been made before. Most recently, Erlandson and Braje (2011) correlate small, triangular bladed, contracting stemmed points (called Channel Island Barbed) found on the northern Channel Islands (dating between ~12.2–11.2 ka; Erlandson et al., 2011) with other incipient Jomon-era projectile points from Japan, arguing that these artifacts provide potential evidence of a Pacific coastal migration. This claim is problematic as these particular projectile point forms occur in sites on Paleo-Honshu Island only after 14.5 ka (Sato et al., 2011) and are thus younger than the earliest North American sites. Therefore, the Channel Island Barbed-Incipient Jomon projectile point connection either represents an example of evolutionary convergence or some unclarified mechanism of cultural transmission that significantly postdates the initial peopling of the Americas. That said, the fact that the earliest projectile point form found so far on the Channel Islands bears a stemmed hafting element is consistent with the emerging pattern from other North American pre-Clovis sites. Thus, the initial presence of stemmed point forms on the Channel Islands may be a signal of continued cultural transmission among North American peoples from an early pattern of northern Pacific Rim stemmed point technology and only coincidentally similar to Japanese styles.

**H2 Test** – Archaeological excavations that produce evidence showing humans were in interior Beringia prior to 16 ka and possessed lithic technological patterns similar to those present at the earliest sites in the Americas will falsify this hypothesis. Although numerous archaeological surveys and excavations have

been conducted by a variety of research teams over recent decades, evidence people were in Beringia during the LGM or earlier has yet to emerge. While this absence of evidence cannot be definitive, and there is always the possibility that a technological complex dating to this early period may be found, the probability this hypothesis will be falsified appears to be limited.

Importantly, this test will require the application of archaeological methods that can identify the links between the design, manufacture, and uses of technologies found in late Pleistocene-aged sites around the northern Pacific Rim region. Comparative artifact assemblage studies do not highlight this issue appropriately, since humans in nearly all Upper Paleolithic societies knew how to make bifaces, blades, unifaces, and cores. What is important to establish is how specific patterns of technological production were created and used across time and space. In essence, we want to measure and compare the patterns of how technological concepts were put into action through the design, manufacture, and use of artifacts among the earliest peoples of the northern Pacific Rim. We anticipate that a deeper integration of three-dimensional digital artifact model analysis can play an important role in tracing the connections between NE Asia and the Americas.

**Hypothesis 3.** — *Late Pleistocene northern Pacific Rim marine ecosystems could not adequately support initial human migrants during a journey from Northeastern Asia to mid-latitude North America.*

Paleoenvironmental records show that many areas of the northern Pacific Rim region were ecologically rich, complex in operation, and exhibited dynamic changes throughout the late Pleistocene period (e.g., Mandryk et al., 2001; Heaton et al., 1996; Clark et al., 2014; Dixon, 2013; Fedje and Christensen, 1999; Fedje et al., 2018). The combined influences of continental glaciation, lower sea levels, and colder climates produced non-analogous environmental conditions. For example, marine core records obtained from multiple localities along the northeastern Pacific margin appear to show lower-than-modern marine productivity associated with cold periods during the LGM and the Younger Dryas periods (Davis, 2011). How this variation in marine productivity translated to changes in foraged resource return rates along the northern Pacific Rim is unknown, but because of the inherent difficulty of quantifying paleoecological productivity at landscape scales, it may be necessary to accept presence/absence information about species availability as indicators of environmental resource availability (e.g., Pedersen et al., 2016).

**H3 Test** — If paleoenvironmental and paleoecological proxy records from northern Pacific Rim coastal environments show the presence of marine resources that are known to support later period coastal foragers then this hypothesis will be falsified. The complex interplay between advancing and retreating glacial ice lobes, neotectonic deformation of coastal landscapes under glacioisostatic stresses, and the history of landform emergence and submergence driven by relative sea level trends produced a highly dynamic environment for the northern Pacific Rim's earliest foraging peoples. While we often assume that a coastal migration would require boat travel around glacial ice or between islands, there may have been times when paleoenvironmental conditions produced more extensive terrestrial passages than others. Expanding the search for ice-free terrestrial paleolandscape features along the northern Pacific Rim both above and below sea level will improve our understanding of regional Pleistocene paleoenvironmental contexts and can aid in identifying stratigraphic units that hold important proxy paleoecological and archaeological records. Thus, the search for and study of late Pleistocene terrestrial landscape features and the stratigraphic records they hold is fundamental to the study of the CMT. Suitable paleoecological tests

could involve the study of eDNA records, micro/macrofossil assemblages, isotopic, biochemical, and other suitable proxy indicators obtained from late Pleistocene-aged sediments cored from submerged terrestrial landforms or, alternatively, extracted from nearshore lakes and ponds that remained above sea level since the LGM.

**Hypothesis 4.** — *Archaeological sites predating the earliest sites south of North America's continental ice sheets will not be located along the coastlines of southern Alaska and British Columbia.*

If the initial migrants into the Americas followed a Pacific coastal route of entry, then we should find archaeological evidence of this journey and subsequent settlement. Finding archaeological evidence along the northeastern Pacific coastline is extremely challenging due to the effects that postglacial marine transgression and deglaciation had on landscapes and any sites they might have held. In many parts of the coast, early sites will likely be deeply submerged and probably buried beneath thick deposits of marine and terrigenous sediments. In other areas where glacioisostatic-driven crustal uplift closely tracked rising sea levels, late Pleistocene-aged coastal sites may exist at or above the modern shoreline (Fedje et al., 2015; Fedje and Christensen, 1999; Fedje et al., 2018; McLaren et al., 2020). Searching for archaeological evidence in this dynamic glacially active coastal environment will be challenging and will require robust multidisciplinary efforts to find, characterize, and sample buried and submerged deposits that contain archaeological evidence older than ~16 ka. Given that submerged late Pleistocene-aged and Holocene-aged sites have been found previously on continental shelf zones in the Americas and elsewhere (e.g., Stanford et al., 2014; Faught and Gusick, 2011; Peeters et al., 2019) we have reasons to expect that continued search efforts will lead to discoveries of submerged precontact sites along the northeastern Pacific rim. Two research projects funded by the U.S. Bureau of Ocean Energy Management and the U.S. National Oceanic and Atmospheric Administration are currently underway in California and Oregon (Braje et al., 2019; Klotsko et al., 2020) that are focused on modeling submerged coastal landscapes, coring potential submerged paleolandforms, and recovering associated archaeological evidence—precisely the kinds of approaches needed to find evidence of an initial human migration along the Pacific coast.

North and South American LGM coastal sites may also be found inland where critical resources were located. For example, on Cedros Island in Baja California, archaeological evidence of late Pleistocene offshore deep-sea fishing was found concentrated at freshwater spring sources located many kilometers inland from the ancient shoreline (Des Lauriers et al., 2018). At the Indian Sands site on the southern Oregon coast late Pleistocene foragers appear to have ventured inland to exploit local chert toolstone in order to repair hunting equipment (Davis, 2006, 2008; Davis et al., 2004; Davis and Willis, 2011). Finally, marine resources found at Monte Verde and Huaca Prieta suggest coastal foragers included inland sites as part of a generalized coastal/terrestrial foraging adaptation (Dillehay et al., 2008, 2017).

**H4 Test** — Discovering northeastern Pacific coastal sites that predate archaeological evidence found south of North American ice sheets will falsify this hypothesis. So far, systematic efforts to find Pleistocene-aged archaeological sites along the northeastern Pacific Rim region have led to the discovery of sites ranging in age from ~13 to 12 ka at several locations (Fig. 1). Intensive geoarchaeological and archaeological investigations to locate and test late Pleistocene-aged deposits along the Alaskan and British Columbian coastlines have focused thus far on relatively small areas within an otherwise large geographic region. Research efforts must be significantly expanded here to provide a meaningful test of this hypothesis.

**Hypothesis 5.** — *Initial human migrants employed true maritime technological adaptations during their journey to the Americas.*

If the First Americans employed a comprehensive adaptation to coastal environments as they followed a route of initial entry into North America along the northern Pacific Rim, we should see archaeological evidence of an expansive maritime adaptation to a broad range of Pleistocene coastal resources that demonstrates an ability to forage beyond the limits of the littoral/nearshore zone. Such an archaeological signature of this *maritime maximization adaptation* may be seen in the presence of specialized tools used to extract marine resources from ocean environments that extend well beyond the shoreline and should differ, perhaps in an additive fashion, from the archaeological signature of subsistence activities related to nearshore adaptations. A true maritime maximization adaptation should be reflected in an archaeological assemblage that contains specialized tools, such as shell/bone hooks and harpoons that significantly extend the foraging reach beyond the shoreline, and most importantly, the associated remains of marine animals that live in ocean habitats that cannot be accessed from littoral/nearshore zones.

**H5 Test** — Excavation of northeastern Pacific coastal archaeological sites that reveal cultural components that predate 16 ka but consistently lack evidence of maritime maximization adaptations, will falsify this hypothesis. Here again, tests of this hypothesis are dependent on an intensified search for early coastal sites as noted for H4.

**Hypothesis 6.** — *Initial human migrants lacked true maritime adaptations during their journey to the Americas but developed them after arrival.*

If the First Americans did not bring a deep adaptation to marine ecosystems with them during their initial migration into the Americas, but instead possessed a more generalized terrestrial and nearshore orientation to subsistence pursuits, then we should see a more restricted adaptation to a limited range of Pleistocene coastal environments that are limited to the nearshore zone. Such an archaeological signature of this *maritime minimization adaptation* should be seen in the presence of generalized tools that can be used to extract a broad-based economy that includes both terrestrial and marine resources from coastal environments that are easily accessed along the littoral/nearshore zone. The development of more complex, specialized approaches to marine resource extraction, like those seen in the manufacture and use of shell fishhooks to capture deep sea fishes offshore of Cedros Island in Baja California, will be absent because they represent later developments within coastal communities after the initial period of entry into the Americas. Under this hypothesis, the similarities seen between shell fishhooks found in southern Japan and northwestern Mexico can be explained merely as the result of evolutionary convergence working to produce similar technological solutions to similar marine resource opportunities.

**H6 Test** — Finding evidence of maritime maximization adaptations in northeastern Pacific coastal sites predating 16 ka will falsify this hypothesis. Like H4 and H5, falsification is dependent on an increase in archaeological explorations focused on the coastal margins of the northern Pacific Rim.

**Hypothesis 7.** — *Kelp forest productivity increased significantly during the late Pleistocene under glacial conditions, enabling migration along the northern Pacific Rim and into the Americas by foragers focused primarily on the exploitation of resources in that ecosystem.*

This hypothesis focuses on the role of kelp forest ecosystems from four related perspectives. According to Erlandson (2013), the central premise of the Kelp Highway hypothesis (KHH) is: "The

ecologically based Kelp Highway Hypothesis proposes that coastal peoples may have followed the shorelines of the Pacific Rim from northeast Asia into the Americas, migrating along a linear route with no major obstacles after about 16,000 years ago, through productive coastal habitats that offered a variety of very similar marine species (e.g., seals, sea otters, cetaceans, shellfish, seaweeds, etc.) along the way (Erlandson et al., 2007)." While the idea that coastal environments could have supported early migrants had been stated earlier (e.g., Fladmark, 1978), the concern with the productivity of Pleistocene coastal environments is important (see Hypothesis 3) and published discussion of the KHH presents key arguments that coastal ecosystems are resource rich, present a relatively predictable environmental structure through a wide range of latitudes, and as such are expected to have sufficiently supported human migration into the Americas during the late Pleistocene.

Erlandson et al. (2007; see also Erlandson et al., 2015) also suggest that kelp forests of the North Pacific expanded significantly beyond their modern extents under the glacial conditions of the late Pleistocene to create a continuous nearshore marine ecozone along the northern Pacific Rim that provided an enhanced resource corridor (a "kelp highway") that attracted and supported human migrants into the Americas. If this is true, then we should expect that the archaeological record of an initial coastal migration will reflect a foraging specialization on kelp forest exploitation. Devising a test for resource productivity aspects of the KHH requires care since many of the animals found within kelp forests do not exclusively live in these environments. For example, kelp bass (*Paralabrax clathratus*), despite their common name, are not definitive indicators of a kelp forest since they will "... congregate around any type of structure, like shipwrecks, rocks, pipes and pilings" (Monterey Bay Aquarium, 2020). Modern northern Pacific sea otters (*Enhydra lutris lutris*, *E. lutris kenyoni*, *E. lutris nereis*) favor outer coast kelp forests but do not forage there exclusively and are also seen to live in inner coast seagrass and saltmarsh habitats (Johnson et al., 1994; Allen and Hovey, 2001; Tinker et al., 2017; Lowe et al., 2003). As a result, finding the remains of otters and kelp bass in an archaeological site might suggest support for the KHH, but could also signal other kinds of habitats; thus, these faunas are equivocal proxy indicators for kelp forests. That said, some kelp obligate species do exist (Graham, 2004:Fig. 2B), including kelp crabs (*Pugettia producta*), umbrella crabs (*Cryptolithodes sitchensis*), certain hydroids (e.g., *Sertularella* sp.), and a variety of macroalgae and sponges that could be found in late Pleistocene sites. For example, at the Monte Verde site in Chile, Dillehay et al. (2008) report the discovery of nine species of marine algae from cultural features directly radiocarbon dated between 14.2–13.9 ka, which support interpretations about Pleistocene marine environments in nearby coastal areas. A broader array of marine floral and faunal species prefer to exploit (but are not obligate to) the trophic framework that kelp forests provide (Graham, 2004:Table 1). These nonobligate kelp forest associated taxa include even more marine mammals, fishes, crustaceans, mollusks, algae, and other invertebrates (Graham, 2004:Table 1A); however, the list of ubiquitous marine species that show no clear preference to kelp forests is even longer (Graham, 2004:Table 1B). Thus, except in cases where kelp-obligate species are found, it will be challenging to quantify the degree to which kelp forests were present along Pleistocene coastlines in the past and how they were used by early coastal foragers.

Questions about the KHH can thus be posed in a variety of ways: 1) were kelp forests more continuously present around the northern Pacific Rim during the LGM than they are today; 2) were northern Pacific Rim marine resources significantly more productive immediately prior to the appearance of people in sub-glacial

North America; 3) were coastal foragers focused primarily on other offshore, littoral, and nearshore zone resources; or 4) did coastal foragers focus on kelp forests because they provide a more productive (i.e., have a higher return rate per work unit) resource patch than do other coastal resource patches? If kelp forests were neither more plentiful nor more productive in the Pleistocene and/or were merely one of many resource patches exploited by early coastal peoples then kelp ecosystems may not have played an oversized role in promoting an initial migration into the Americas. These and other more readily testable questions help focus the larger question of whether or not and to what degree early peoples specifically used kelp forest resources as they migrated into the Americas.

**H7 Tests** - Finding that kelp forest ecosystems were geospatially and temporally discontinuous over large stretches of the northern Pacific Rim before ~16 ka will falsify this hypothesis. Finding that the productivity of the kelp forest ecosystems during the LGM was the same as, or lower than, modern conditions will also falsify this hypothesis. Finally, finding that early ANA populations were not significantly focused on kelp forest resources but rather foraged more broadly for resources above and below sea level within the littoral and nearshore zones as a whole would falsify this hypothesis. Measuring the presence and relative distribution of kelp forests along Pleistocene shorelines could be achieved through the study of fossil remnants or proxy indicators of kelp forest obligates (e.g., eDNA, isotopic signatures, biochemical markers) held in cored sediments sampled from dated coastal stratigraphic sequences. Building on these proxy studies, the intensity of subsistence focus that early coastal foragers directed toward kelp forest ecosystems could be achieved by devising microeconomic analyses of the relative presence of kelp obligate and kelp-nonobligate faunal and floral remains preserved in archaeological sites.

## 10. Summary and conclusions

Based on the overwhelming genetic evidence that the indigenous peoples of the Americas share ancestral origins in Northeast Asia, coupled with the recent discovery of multiple archaeological occurrences of humans south of North American continental ice sheets prior to an opening of an ice-free corridor, we logically conclude that the First Americans initially migrated from Asia via a coastal route of entry before ~16 ka. While our understanding of the paleoenvironmental context of the northern Pacific coastline is imperfect, the current state of knowledge about this region indicates that Pleistocene peoples had many opportunities to travel along lowered shorelines into the Americas.

Given the timing and technological nature of the earliest archaeological evidence in North America, we argue that the closest archaeological ancestor can be seen in the Japan/PSHK archipelago and not in Beringia. Currently there is no evidence suggesting Beringia was occupied during the time when humans were initially present south of the continental ice sheets, casting doubt that Beringia was the location of any “genetic standstill” that happened during the late Pleistocene. While the absence of evidence is not definitive, the failure of archaeological research in the Beringian region to uncover any such evidence may be telling. While there are no known Pacific coastal sites in North America predating ~16 ka, we hypothesize that because of inland North American sites such as Cooper’s Ferry (Davis et al., 2019) dating to ~16 ka and near coastal sites with evidence of marine resource acquisition in South America dating to as early as ~15 ka, such as Huaca Prieta (Dillehay et al., 2017), archaeological evidence will be found for an initial migration along the northeastern Pacific coastline.

Although many people have written about the role a Pacific coastal migration may have had in explaining the initial peopling of

the Americas, these ideas have not yet been framed in terms of falsifiable hypotheses; nor has the evidence against an interior route of migration been so strong. In light of these developments, we articulate an overarching Coastal Migration Theory and offer a series of working hypotheses that, in their pursuit, can provide a scientific approach to evaluating various elements of the CMT. As research moves forward in the search for archaeological sites containing evidence for human occupation on the northeastern Pacific coast that is at least coeval with known pre-Clovis-aged sites in mid-latitude North America, it is imperative that research includes a focus on retrieving information about the past that can help to address the hypotheses we present here. By articulating a Coastal Migration Theory, we hope it will stimulate a new generation of sustained, focused multidisciplinary research projects that contribute critical information to the themes we describe.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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