PaleoAmerica

A journal of early human migration and dispersal

ISSN: 2055-5563 (Print) 2055-5571 (Online) Journal homepage: https://www.tandfonline.com/loi/ypal20

Late Pleistocene Archaeological Discovery Models on the Pacific Coast of North America

Duncan McLaren, Daryl Fedje, Quentin Mackie, Loren G. Davis, Jon Erlandson, Alisha Gauvreau & Colton Vogelaar

PALEOAMERICA
https://doi.org/10.1080/20555563.2019.1670512

Center for the Study of the First Americans
Texas A&M University

Routledge
Taylor & Francis Group

REVIEW ARTICLE

Late Pleistocene Archaeological Discovery Models on the Pacific Coast of North America

Duncan McLaren [a,b], Daryl Fedje[a,b], Quentin Mackie [b], Loren G. Davis[c], Jon Erlandson[d], Alisha Gauvreau[a,b] and Colton Vogelaar[a,b]

[a]Hakai Institute, Victoria, Canada; [b]University of Victoria, Victoria, Canada; [c]Oregon State University, Corvallis, OR, USA; [d]Museum of Natural & Cultural History and Department of Anthropology, University of Oregon, Eugene, OR, USA

ABSTRACT

The Pacific coast of North America is a hypothesized route by which the earliest inhabitants of the Americas moved southwards around the western margin of the Cordilleran Ice Sheet just after the last glacial maximum. To test this hypothesis, we have been using a stepwise process to aid in late Pleistocene archaeological site discovery along the coast. The steps involved include: (1) creating localized sea level curves; (2) generating detailed bare earth digital elevation models; (3) creating archaeological predictive models; (4) ground truthing these models using archaeological prospection; and (5) demonstrating that archaeological materials found date to the late Pleistocene. Here, we consider the use of these steps and how they have been employed to find late Pleistocene archaeological sites along the Pacific Coast of North America.

KEYWORDS
Peopling of the Americas; coastal entry theory; paleo-coastline reconstruction; stemmed projectile points

1. Introduction

A growing body of archaeological evidence from the Americas reveals that humans were on the landscape earlier than 14,000 calendar years before present (cal yr BP) (Davis et al. 2019; Dillehay et al. 2015; Halligan et al. 2016; Hirasawa and Holmes 2017; Jenkins et al. 2012; Waters et al. 2011; Waters et al. 2018; Williams et al. 2018). Genetic evidence reveals that late Pleistocene Americans came from Beringia and Northeast Asia (Graf and Buvit 2017; Raghavan et al. 2015; Waters 2019). Stemmed points have been found in several late Pleistocene contexts in both northeastern Asia and northwestern North America; these archaeological findings have been advanced as providing further evidence for a link between these two geographic regions (Dikov 1979; Dixon 2000; Erlandson and Braje 2011; Mandryk et al. 2001).

The route(s) people followed from Beringia to the Americas south of the late Wisconsin ice sheets has yet to be fully resolved (Braje et al. 2017; Potter et al. 2018). The western margin of the Cordilleran Ice Sheet has been hypothesized as an early route which people followed from Asia into the Americas south of the ice sheets (Davis et al. 2009, 2011; Dixon 2000; Erlandson 2002; Erlandson et al. 2007; Fladmark 1978, 1979, 1983, 1986; Heusser 1960; Mandryk et al. 2001). Non-glaciated conditions on the outer coastal islands west of the Cordilleran Ice Sheet, going back at least 16,000 years, are a key factor supporting the coastal corridor hypothesis (e.g., Al-Suwaidi et al. 2006; Blaise, Clague, and Mathewes 1990; Darvill et al. 2018; Lesnek et al. 2018; Misarti et al. 2012; Shaw et al. 2019). In this paper, we test the coastal corridor hypothesis by focusing on various approaches to locating evidence of early use of and movement along the Pacific coast of North America.

Sea level changes and the resulting absence of archaeological visibility have made it challenging to discover evidence for early use of and movement along this proposed route (Mackie, Fedje, and McLaren 2018). Changes in relative sea level through time have obscured the vast majority of continental shelf coastlines along which these populations would have lived. These changes in shoreline position are sub-regionally specific (ca. 17,000–12,000 cal yr BP), ranging from 150 m below to over 200 m above present-day sea level (Figure 1: A-D), with considerable variation within relatively small distances. However, it is exactly along these paleoshorelines that archaeologists would expect to find the most evidence for late Pleistocene archaeological sites created by maritime-adapted people. In order to explore the potential of early habitation and movement along the Pacific coast during the late Pleistocene, we have employed site discovery models to locate potential archaeological sites dating to this early period. While this research is still in its infancy, some enticing discoveries have been made.

CONTACT Duncan McLaren dsmclaren@gmail.com

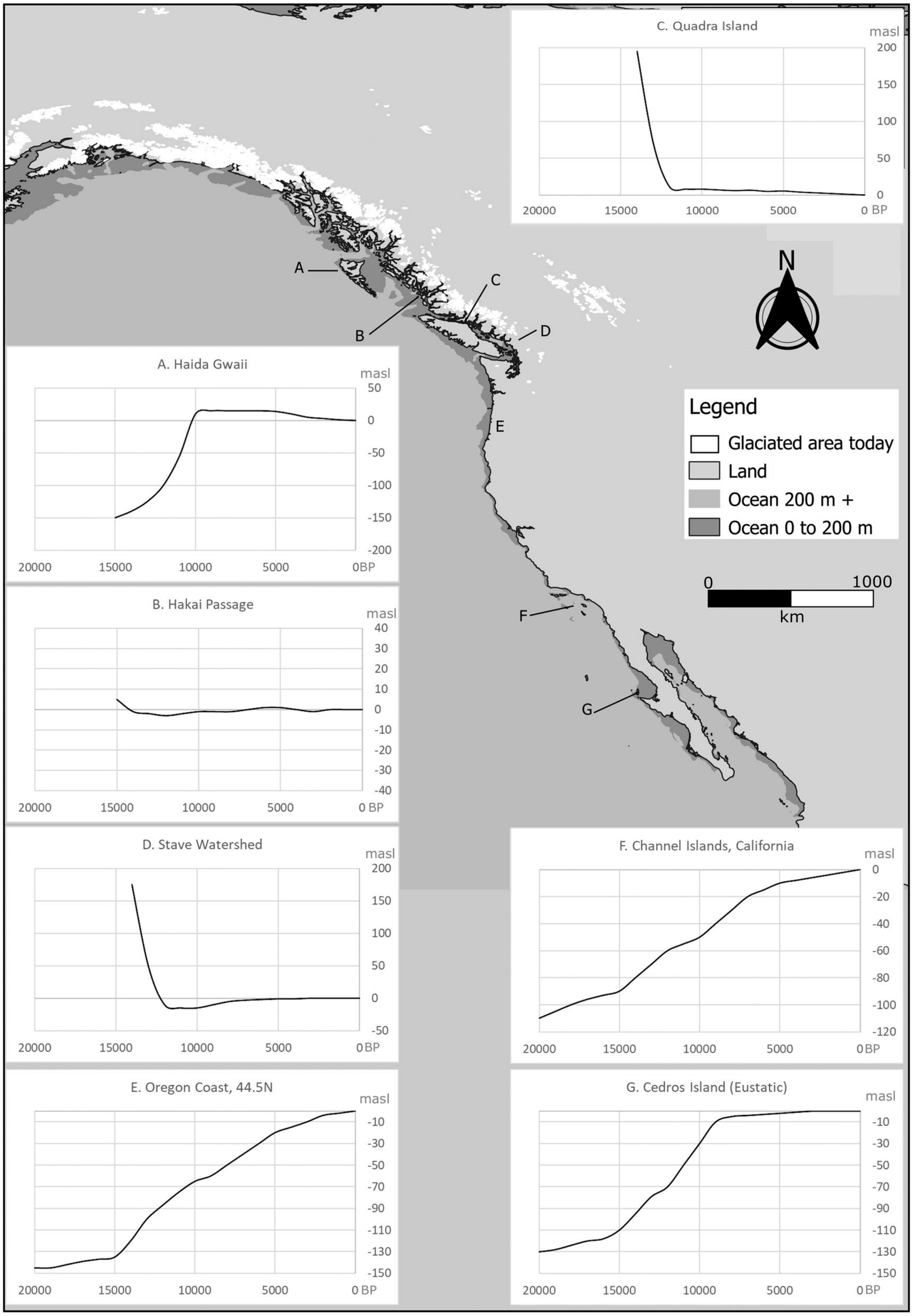

Figure 1 Map showing locations of case studies and associated sea level curves. Sea level curves have been generalized from: (A) Fedje et al. (2005a); (B) McLaren et al. (2014); (C) Fedje et al. (2018a); (D) Shugar et al. (2014); (E, F) Clark, Mitrovica, and Alder (2014); (G) Peltier and Fairbanks (2006).

For regions situated away from large glaciers or ice sheets, eustatic sea level was the primary factor in determining where the shoreline was situated, although tectonic, minor isostatic and other factors have to be considered as well (Clark, Mitrovica, and Alder 2014; Clark, Mitrovica, and Latychev 2019; Reeder-Myers et al. 2015; Shugar et al. 2014). Along the coasts of California, Oregon, and Washington, paleoshorelines dating to the time of the last glacial maximum (LGM) were in the order of 100–140 m below present sea level (Figure 1: E-G) (Clark, Mitrovica, and Alder 2014). As a result of this, archaeologists looking for evidence of late Pleistocene coastal occupation in these areas must either conduct underwater investigations or examine inland targets that would have attracted coastal peoples, e.g., caves, springs, toolstone outcrops, and resource-rich areas (Davis et al. 2009; Dixon 1979; Erlandson, Rick, and Jew 2011; Rick et al. 2013).

In areas glaciated now or in the past, isostatic, eustatic, and tectonic factors need to be considered when estimating the position of late Pleistocene shorelines (Clark, Mitrovica, and Alder 2014; Clark, Mitrovica, and Latychev 2019; Shugar et al. 2014). Evidence that parts of the coastal margin were directly overrun by outlet, valley, and piedmont glaciers issuing from the Cordilleran Ice Sheet is also relevant (Ryder, Fulton, and Clague 1991; Shaw et al. 2019). In these glacial proximal regions, determining the position of ancient shorelines is highly complex due to localized variation in relative sea level, both spatially and temporally (Shugar et al. 2014). In general, areas closer to large masses of ice were more isostatically depressed, and as a result, paleoshorelines are higher, in some cases up to 200 m or more above modern levels (Fedje et al. 2018a; Kovanen and Slaymaker 2015). With greater distance from the ice, isostatic effects lessened and the associated ancient shorelines are less elevated. The weight of this ice on the earth's crust also displaced the underlying magma laterally towards the edge of the continental margin, resulting in what has been referred to as the "forebulge effect" (Clague et al. 1982), which describes the raising of landforms along the edge of the coastal margin. As a result, relative sea level positions in some cases are even lower than those affected by eustatic factors alone (Josenhans et al. 1997). Further complicating matters in glacial regions is the fact that glacial, eustatic, and isostatic processes vary through time. Major fluctuations in these patterns appear to have had some association with known stadial, interstadial, and meltwater pulse events occurring in the late Pleistocene (Fedje et al. 2018a). For all these reasons, pinning down past sea level elevations can be like playing a game with ever-changing goal posts.

In some instances, late Pleistocene archaeological deposits have been discovered accidentally, as in the case of the Manis Mastodon site (Waters et al. 2011). The methods described in this paper represent an attempt to search for late Pleistocene sites along the coast through a systematic, stepwise process (Mackie, Fedje, and McLaren 2018). These steps form an ideal trajectory, building on one another. Some steps in the process constitute large projects in their own right. Unfortunately, only a few studies so far have been well enough funded and given enough time to actually reach the final step.

2. A methology for discovery of coastal sites dating to the late Pleistocene

2.1. Step 1: Creating local sea level curves

The first step in late Pleistocene coastal archaeology site discovery requires the identification of ancient shoreline locations through the employment of methods associated with developing of local relative sea level histories. In glacial areas, understanding the local glacial history and where glacial refugia are more likely to have been present is essential (Carrara, Ager, and Baichtal 2007; Mathewes et al. 2015; Shaw et al. 2019). Often these two goals can be achieved using the same methods. In some cases, the relative sea level history of a particular place may have already been worked out in sufficient detail (e.g., Clague and James 2002; Fedje et al. 2005a; James, Clague, and Hutchinson 2002). In non-glacial proximal areas, there are also deviations from eustatic factors, primarily due to tectonics, which need to be understood at a regional level (Clark, Mitrovica, and Alder 2014; Reeder-Myers et al. 2015).

In recent years, a number of coastal archaeological projects have adopted sea level studies at a localized level to help identify late Pleistocene and early Holocene archaeological sites (Carlson and Baichtal 2015; Erlandson 2016; Erlandson et al. 2011; Fedje and Christensen 1999; Fedje and Josenhans 2000; Fedje et al. 2018a; Josenhans et al. 1995, 1997; Letham et al. 2016; Mackie, Fedje, and McLaren 2018; McLaren et al. 2014; Reeder-Myers et al. 2015; Rick et al. 2013). This is generally undertaken by employing paleo-environmental field methods. Practice has demonstrated that isolation basin coring combined with microfossil analyses and radiocarbon dating is the most effective approach. However, we have also drawn upon other methods, including radiocarbon dating geomorphic features (such as raised beach deposits), sediment sections and basal archaeological components of known elevation (Carlson and Baichtal 2015; Fedje et al. 2018a; Letham et al. 2016; McLaren et al. 2014). The most robust data points used to create sea level curves are radiocarbon ages from precise elevations where proxy indicators demonstrate the depositional context was either marine, brackish, freshwater, or terrestrial (McLaren et al. 2014). Each date and elevation pair allows for a single point on a sea level diagram to be entered. With a detailed sea level curve including many data points, archaeologists can begin to make decisions about where and how to find archaeological sites of a given age by focusing attention on the corresponding specific elevation ranges. However, distinguishing relict shoreline features in the field can be difficult, in particular in areas that are now heavily forested, with thick soils and underbrush. To help visualize these areas, we have been turning to remote sensing and digital elevation models.

2.2. Step 2: Generating detailed digital elevation models

Digital elevation models derived through remote sensing are extremely important in the search for late Pleistocene archaeological sites along the Pacific coast, and constitute the second step in the methodical process outlined in this paper. Modeling past shorelines and areas of archaeological site potential has been aided in recent times by the use of high-density digital elevation models generated through remote sensing techniques such as LiDAR (Lausanne et al. 2019; Letham et al. 2018; Vogelaar 2017), photogrammetry (Fedje and Christensen 1999; McLaren et al. 2011), swath bathymetry (Fedje and Josenhans 2000; Gusick and Faught 2011; Mackie, Fedje, and McLaren 2018; Monteleone, Dixon, and Wickert 2012) and subbottom seismic profiling data (Davis, Cantelas, and Valette-Silver 2018; Josenhans et al. 1997). It is our experience that LiDAR provides more accurate land-based bare earth elevation models where there is significant forest cover as compared to digital photogrammetry. High-density bathymetric models are critical for mapping relict shorelines and paleo-terrestrial landforms now drowned by sea level transgression.

An important aspect of digital elevation models is that they can provide means of visualizing geomorphic features associated with past shorelines that are now stranded either below or above high tide: for instance, deltas, islands, exposed shoreline, protected coves, bays, and tombolos (Lausanne 2018). Underwater geomorphic features can include the same features but also those that were slightly above the coast, including rivers and lakes (Fedje and Josenhans 2000). While digital elevation models can help determine the types of coastal geomorphic features at different elevations, they are not necessarily useful in identifying where archaeological sites will be located. To help pinpoint where archaeological sites may be situated along, or above, the shoreline, archaeological site predictive models are used.

2.3. Step 3: Generating predictive models for late Pleistocene archaeological site discovery

The third step in the investigative process involves generating predictive models to aid in archaeological site discovery for both drowned (Davis et al. 2009; Dixon 1979; Erlandson 2016; Gusick and Davis 2010; ICF International et al. 2013; Jenevein 2010; Monteleone, Dixon, and Wickert 2012; Punke 2001) and raised paleoshorelines (Carlson and Baichtal 2015; Laussanne 2018; Vogelaar 2017). In general, these build on digital elevation models, employing criteria in a GIS system to predict where archaeological sites are most likely to be found. The types of criteria include various aspects of shoreline morphology such as aspect, exposure, sinuosity, and grade. Near-coastal geomorphic features may also be factored in, including the presence of karst cave features, lakes, and river systems. The general output of such modeling exercises is map-based predictions that indicate where archaeological sites dating to a particular time period are likely to have been formed and also where they are likely to have been preserved (Mackie et al. 2013). These predictive models provide the starting point for archaeological prospection.

2.4. Step 4: Ground truthing predictive models

Searching for late Pleistocene archaeological deposits can be a complex and difficult task, even with the aid of relative sea level curves, remote sensing data, digital elevation models, and predictive models. Working underwater is expensive, it requires equipment with which most archaeologists are unfamiliar, and in many places on the outer Pacific coast of North America, late Pleistocene shorelines are well below the depths at which most divers are typically comfortable working (Davis et al. 2009; Gusick and Faught 2011). For these reasons, there has been relatively little effort in the way of underwater archaeological prospection for late Pleistocene archaeological sites along the Pacific coast. One exception to this was work carried out in Haida Gwaii; in this case a clamshell grab dredger was employed from a ship-based platform (Fedje and Josenhans 2000). In other cases, investigations have been limited to the use of remotely operated vehicles that provide a means of conducting surveys on the surface of the submerged landscape (Mackie, Fedje, and McLaren 2018).

Archaeologists looking for late Pleistocene archaeological sites on raised marine landforms in areas influenced by glacial isostatic processes are typically surveying

Figure 2 Bifacial knife from relict beach sediments on 50-m terrace on Quadra Island, found in borrow pit (photos by P. Bishop).

landforms in dense forests with underbrush, thick organic soils, and limited ground exposure. Often these forests can foster the growth of large conifers. In some cases, these trees are felled by windstorms, resulting in large scale bioturbation as root wads are heaved upwards bringing mineral sediments to the surface. While this can obscure archaeological stratigraphy, the root balls of wind-thrown trees often expose artifacts or faunal remains, providing a first glimpse of what may be below the surface. In the absence of tree throws, fortuitously situated exposures created by roads or erosion may facilitate the discovery of archaeological materials (Figure 2). In the absence of such exposures, archaeologists must resort to shovel and auger testing through the thick organic soils and extensive root systems. In karst caves and rock shelters, surface scattered bone samples can provide an initial means of understanding the age of the materials through radiocarbon dating (Fedje et al. 2011a); even surficial bones in karst contexts can be Pleistocene in age. Otherwise, trowel tests or other excavation units are used to sample sediments in caves.

When testing for archaeological deposits along ancient shorelines, we have found that particular beach-oriented geomorphic features hold the best potential for preserved archaeological remains in primary context. For example, high tide beach berms are often flat-topped and well-drained near shore features that were especially attractive to coastal people looking to land a boat and form a camp (McLaren et al. 2018; Smith 2004). These berms accumulate sediment, in particular during transgressive episodes, such as storms and extreme high tide events. As a result, berms formed through multiple transgressive events can be several meters thick. We have found that they can contain multiple living surfaces, each capped by sediments dumped by wave action. In fortuitous cases, these types of berms can help preserve deeper lying sediments.

2.5. Step 5: Demonstrating that archaeological materials are late Pleistocene in age

The final step of the process involves establishing that archaeological materials discovered using the techniques oultined above actually date from the late Pleistocene era. The elevation of archaeological deposits or materials can provide an initial indication of the potential age of the site, especially where sea level was higher or lower than today (Fedje et al. 2018a). However, it is also possible that some higher elevation archaeological deposits represent Holocene inland occupation of Pleistocene paleo-coastal features (McLaren et al. 2015). For this reason, it is desirable to find archaeological deposits in primary context with clear stratigraphic relationships. Ideally, archaeological deposits can be dated using conventional methods, most typically radiocarbon dating (Erlandson et al. 1996; Fedje et al. 2011a; McLaren et al. 2018; Waters, Stafford, et al. 2011), although luminescence dating has also been used (Davis 2006; Waters et al. 2018). Recovery of micro-fossils of pollen, diatoms, dinoflagellates, and amoebas can help support the dating of sites by providing environmental proxies that match the expected late Pleistocene conditions – for example, when artifacts are found in sediments identified as brackish paleo-estuarine deposits (Fedje et al. 2011a; Fedje et al. 2018a; McLaren et al. 2018).

In some cases, secondary deposits can be important. For instance, when submerged or intertidal artifacts have been colonized by barnacles, dating the barnacles can establish how much time has passed since these artifacts were last in the intertidal zone (Fedje, McSporran, and Mason 1996; Mackie, Fedje, and McLaren 2018).

3. Case studies

The following case studies provide insights into the processes we have used to search for late Pleistocene archaeological sites in several areas along the Pacific coast of North America. In some cases, not all of the steps described above have been undertaken or followed in sequence. The case studies described below include locations ranging from British Columbia south to Baja California. While early Holocene archaeological deposits are known from the Pacific coast of Alaska (Ackerman 1996; Carlson and Baichtal 2015; Davis 1996; Dixon 2008; McCartney and Veltre 1996), late Pleistocene-aged deposits have not been reported. However, with the creation of local sea level curves (Carlson and Baichtal 2015; Jordan 2001) and the identification of glacial refugia (Lesnek et al. 2018; Misarti et al. 2012), and with techniques like LiDAR becoming increasing available, it is likely that the search for earlier sites will soon begin in a methodical and earnest manner along the Pacific coast of Alaska.

3.1. Haida Gwaii forebulge

Much of Haida Gwaii was ice-free by 18,000 calendar years ago (cal yr BP) (Lacourse et al. 2005; Ramsey et al. 2004; Shaw et al. 2019) and there are indications of a full glacial biotic refugium on the now-drowned Hecate Plain immediately east of the archipelago (Mathewes and Clague 2017). The shoreline history of the archipelago is complex. Earliest post-glacial (ca. 18,000–15,000 cal yr BP) relative sea level histories are poorly constrained. Well-constrained sea level histories extend from ca. 14,500 cal yr BP to the present. Shorelines dating to 14,500 cal yr BP are 150 m below modern level. Subsequently, relative sea level rose rapidly, passing modern level at 10,700 cal yr BP and reaching 15 m above modern level by 10,000 cal yr BP (Fedje 1993; Fedje et al. 2005a). Paleoshorelines dating to the early Holocene (10,000–6000 cal yr BP) stabilized 15 m above modern level, when local tectonic uplift was balanced by eustatic sea level rise. Relative sea level then fell to modern level during the late Holocene due to ongoing tectonic uplift.

Starting in the mid-1990s, this sea level history was used to focus archaeological research on stranded coastlines, especially the +15-m high stand dating from ca. 10,000–6000 cal yr BP. One-meter contours were derived from photogrammetry, on which paleo-coastlines and paleo-intertidal zones were highlighted. An initial targeted survey of these identified 17 raised beach sites, with several dated to between 10,300 and 6500 cal yr BP (Fedje and Christensen 1999). Several more were subsequently found on the same raised marine terrace elsewhere on Haida Gwaii (Fedje et al. 2005b). Early Holocene components dating from 10,300 to 9800 cal yr BP show bifacial technology (leaf-shaped points and knives) and Levallois-like and unidirectional blade-like core reduction. These assemblages, in which microblades are absent, are known as the Kinggi Complex (Fedje and Christensen 1999). At Richardson Island, a mixed bifacial and microblade occupation (the Early Moresby tradition) started at ca. 9800 cal yr BP (Waber 2011) and lasted for several centuries, after which bifaces disappear completely from the record.

Following the raised beach surveys, research focused on the 10,700-year-old shoreline, which is when rising sea level coincided with the modern shoreline (Fedje et al. 2005a; Mackie and Sumpter 2005). During intertidal investigations at Kilgii Gwaay in southernmost Haida Gwaii, well-preserved *in situ* cultural deposits dating between 11,000 and 10,500 cal yr BP were sampled. Abundant faunal and floral remains were recovered in these intertidal zone excavations. The archaeological assemblage provided strong evidence for a well-developed maritime adaptation and exhibits similar core reduction technology to that seen in slightly later raised beach components (Cohen 2015; Fedje et al. 2001, 2005c). Notably, Kilgii Gwaay was submerged up to 15 m deep for most of the past 10,000 years, only recently re-emerging into the intertidal zone with local tectonic uplift.

Investigating the archaeological record prior to approximately 10,700 cal yr BP has involved underwater archaeology on drowned terrain associated with lower sea level, and higher elevation karst cave research. In Haida Gwaii, sea level history was combined with high-resolution swath bathymetry of waters adjacent to the east coast of Haida Gwaii in a collaborative offshore testing program involving Parks Canada and the Geological Survey of Canada (Fedje and Josenhans 2000). This program identified a number of paleoshoreline and drowned landscape features, including river terraces, lakes, and areas with intact forest soils to 150-m ocean depth. It also identified an archaeological site at a depth of 53 m (Fedje and Josenhans 2000; Lacourse, Mathewes, and Fedje 2005). Subsequent work incorporating sidescan sonar mounted on an Autonomous Underwater Vehicle identified a number of deeply drowned, possibly archaeological features yet to be fully investigated (Fedje, Mackie, and McLaren 2018b; Mackie et al. 2015, 2018).

In the early 2000s, we undertook karst cave investigations at elevations above the early to mid-Holocene +15-m high stand (Fedje, McLaren, and Wigen 2004,

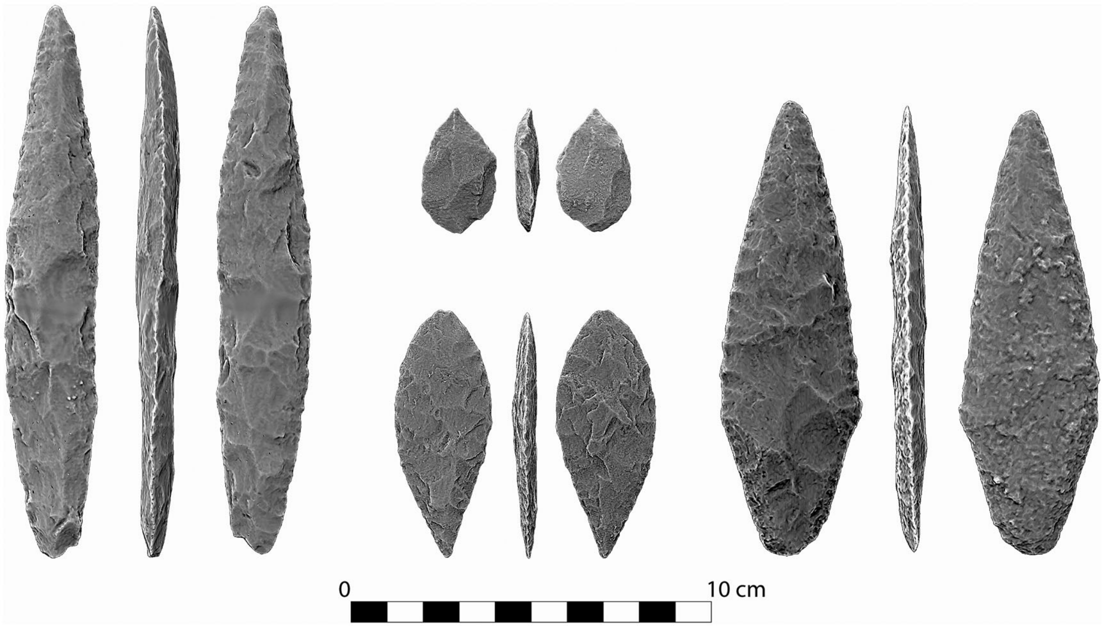

Figure 3 Images produced by 3D scanning of stemmed and foliate spear points found in late Pleistocene and early Holocene archaeological sites on the Pacific Coast of North America (image provided by Loren Davis). Left: Taan spear point 12,700–12,400 cal yr BP; center top and center bottom: Xil point 10,600–10,000 cal yr BP; right: Taan spear point 12,075–11,819 cal yr BP (Fedje et al. 2008).

2011a, 2011b; McLaren et al. 2005; Ramsey et al. 2004). Part of the rationale for these investigations was to avoid the challenges associated with researching deeply submerged landscapes. The premise was that these stable features with good preservation would have offered special resources such as hibernating bears in prehistoric times, which could have drawn people inland from ancient coasts. These investigations produced data on the early post-glacial paleontology of Haida Gwaii, when the endemic terrestrial fauna was more diverse than in historic times (Wigen 2005). Small archaeological assemblages were also recovered from three caves, including stemmed points (Figure 3), butchering tools, tool maintenance debitage, and hearth features. These sites likely represent winter bear hunting activities at cave hibernacula (Fedje et al. 2011a; McLaren et al. 2005). The cave archaeological components date from ca. 12,800 to 10,000 cal yr BP. The paleontological record from these caves is dominated by brown bear, black bear, and salmon bones dating between 12,000 and 14,000 cal yr BP (Fedje et al. 2011a) and a single brown bear bone dating to ~17,500 cal yr BP (Ramsey et al. 2004).

3.2. Hakai Passage sea level hinge

Hakai Passage is located on the Central Coast of British Columbia. The area comprises a large archipelago, with exposed shorelines, productive intertidal and estuarine areas, sheltered bays, tombolos, and moderately flat to uneven, rocky, and steeply sided forested terrain, with peaks over 1000 m in elevation. The Cordilleran Ice Sheet began retreating from the Central Coast, including the Hakai Passage area, by 18,100 cal yr BP (Darvill et al. 2018). The relative sea level history between 18,100 and 14,500 is not well constrained. After 14,500 cal yr BP only minimal relative sea-level fluctuation (2–3 m) occurred as a result of a balance between localized isostatic rebound and eustatic sea level rise. This phenomenon is referred to as a sea level hinge (McLaren et al. 2014).

Archaeological work in the Hakai Passage area was initiated in 2014, with the aim of locating terminal Pleistocene sites (14,000–11,500 cal yr BP) and targeting relict shorelines. The investigations were premised on the relatively stable sea level history of the area. We began by examining deposits stratigraphically below and adjacent to Holocene archaeology sites. Field research employed the use of an environmental soil probe, auger and shovel testing, karst cave survey, and archaeological excavation. Archaeological materials and features associated with late Pleistocene radiocarbon dates were encountered on Calvert Island (EjTa-4) and Triquet Island (EkTb-9). These deposits were found near the modern shoreline, as predicted. Use of watercraft would have been required to access these islands during the late Pleistocene.

Twenty-nine human footprints, impressed into a 13,000 cal yr BP paleosol, were discovered amid the intertidal deposits in front of a large archaeological site located west of Meay Channel on Calvert Island (EjTa-4) (McLaren et al. 2018). A small sample of flakes, cores, pebble tools, flake tools, and a spall tool were recovered from the same stratigraphic unit. Northwest of Calvert Island, in a sheltered northeastern bay on Triquet Island, we encountered a stone tool cache within a paleosol, stratigraphically contiguous with a hearth feature, charcoal from which provided us with a date of 14,086–13,613 cal yr BP (Gavreau and McLaren 2017). Analysis of this site (EkTb-9) is ongoing, and provides the focus of Gauvreau's PhD thesis (expected August 2020). To date, late Pleistocene projectile points have not been found in the Hakai region. Early Holocene projectile points found in the area include stemmed (Mackie, Fedje, and McLaren 2018; McLaren et al. 2015) and foliate forms (Carlson 2008).

3.3. Quadra Island higher sea level terraces

Quadra Island is the largest of the Discovery Islands archipelago, located along the Inside Passage between north-central Vancouver Island and mainland British Columbia. It was ice-free by 14,300 cal yr BP (Fedje et al. 2018a). Sea level research shows that shorelines of that age are at least 200 m above modern level (Figure 4). After that time, relative sea level fell rapidly, reaching elevations ca. 4 m above modern by ~12,000 cal yr BP. During this period of marine regression there appear to have been at least three brief intervals of relatively stable sea level (slowstands or stillstands) and, possibly, minor transgressive events. These events resulted in the development of a number of well-defined marine terraces, including ones at ca. 4, 10, and 30 m above the modern tidal limit (Fedje et al. 2018a, 2018b).

LiDAR was flown in two areas of Quadra Island to develop a bare earth elevation model as a base for paleoshoreline archaeological survey (Lausanne 2018; Lausanne et al. 2019). The LiDAR elevation models were used by Lausanne (2018) and Vogelaar (2017) to produce predictive models. Elevation, slope, shoreline complexity, wind/wave fetch, and other environmental variables were used to identify high potential paleoshoreline survey targets and to interpret archaeological sites located on raised shorelines. Ten raised beach sites were identified in 2015 based on Lausanne's (2018) focus on the 10-m and 30-m paleoshorelines. An additional 14 upland sites were located in 2016 using a predictive model refined by Vogelaar (2017).

Test excavations at several sites associated with raised beaches identified artifact-rich components dating as early as ca. 11,000 cal yr BP. A few artifacts associated with sediments dating to ca. 12,900-12,700 cal yr BP (Fedje et al. 2018a) were also found. The early Holocene (ca. 11,000–10,000 cal yr BP) components contain stemmed and leaf-shaped points and knives, as well as a rich assemblage of Levallois-like and unidirectional blade-like core reduction artifacts.

3.4. Stave river watershed projectile points

The Stave River Watershed is situated in southwestern British Columbia. The river flows out of the Coast Mountain Range on the north side of the lower Fraser River Valley, 75 km east of the city of Vancouver. Parts of the Stave River area were ice-free by at least 14,500 cal yr BP (Mathewes 1973) and appear to have remained so even though glacial re-advances into the lower Fraser Valley occurred during the Younger Dryas interval (~13,000–11,700 cal yr BP) (Kovanen and Slaymaker 2015). This area was isostatically depressed during the early deglacial period, with sea level being on the order of 175 m above present between 14,500 and 14,000 cal yr BP (James, Clague, and Hutchinson 2002). Stave Lake, where the majority of late Pleistocene archaeological sites have been found in the watershed, is now between 70 and 80 m above sea level; however, it was under the sea until 13,500–13,000 cal yr BP. With regressing sea level after this period, the Stave fjord become a lake and river system (Mackie et al. 2011; McLaren 2003).

The lower Stave River and Stave Lake were transformed into a hydroelectric reservoir in AD 1910. Archaeological work in the draw down zone of the reservoir began in the late 1990s as part of an inventory and impact assessment project for BC Hydro. Prior to field research, a predictive model was generated from a photogrammetrically-derived digital elevation model enabling the generation of 1-m contours (McLaren et al. 1997). Bay mouth bars, terraces, and levees were easily identified from these data and highlighted for archaeological inventory. Survey work in the draw down zone of the reservoir found extensive surface scatters of stone artifacts left as lag deposits resulting from reservoir related erosion. Many of these were collaterally flaked spear points of various forms. These styles were not known to be found in any of the well-documented Holocene archaeological sites in the region, except for those with early Holocene components (McLaren and Steffen 2008).

In recent years, subsurface testing has been undertaken to determine where intact archaeological deposits remain, and to date these where found (McLaren 2017). Archaeological materials have been found associated with late Pleistocene radiocarbon dates at five archaeological sites (DhRo-11, DhRo-16, DhRn-14, DhRn-18 and DhRn-29). In most cases, occupation at these sites continued into the Holocene. While fairly common on the surface, spearpoints and bifaces have rarely been found *in situ*. There are a few exceptions to

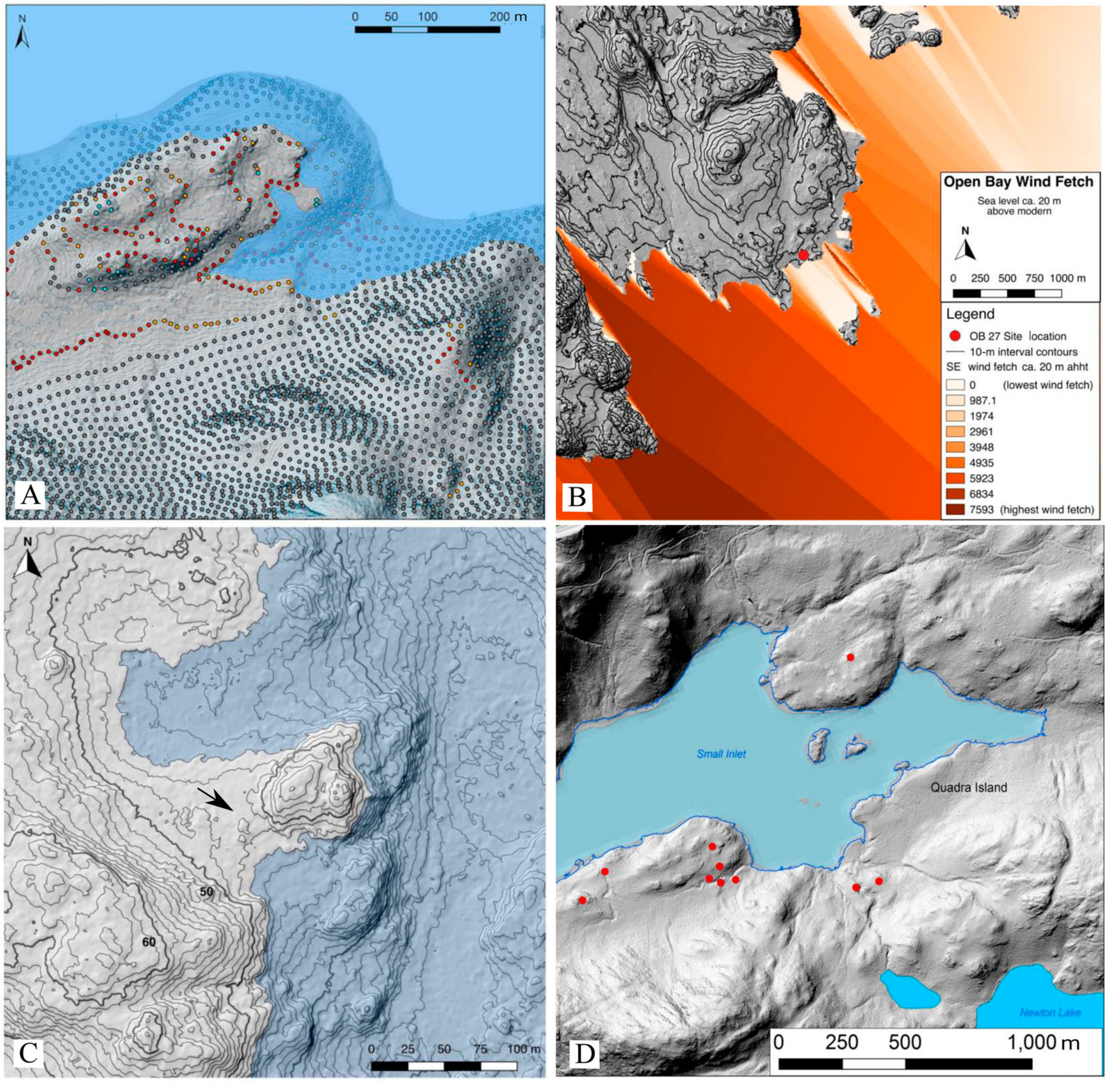

Figure 4 Modeling paleoshorelines and late Pleistocene archaeological site potential on Quadra Island, BC, using a LiDAR-based digital elevation model. (A) Coastline complexity in the area around small inlet flooded to 30 m above high tide (~13,000 cal yr BP); (B) an area of Open Bay flooded to 20 m above high tide (~12,900 cal yr BP) and the location of an archaeological site found in an area protected from southeasterly wind fetch; (C) a paleo-tombolo feature when the DEM is flooded to 48 m above high tide (~13,100 cal yr BP, contours in meters); (D) map of archaeology sites found while surveying and shovel testing paleoshorelines in Small Inlet between 44 and 14 m above high tide. All images modified from Vogelaar (2017).

this (Figure 5): at DhRo-11, a concave-based lanceolate spear point finished with collateral flake scars was found associated with charcoal dated between 12,382 and 11,975 cal yr BP; at DhRn-29, a biface preform was found with two samples of associated charcoal dating between 12,460–12,020 cal yr BP and 12,021–11,621 cal yr BP; and finally, at DhRn-18, a tool cache was excavated, including two collaterally flaked spearpoints, two biface preforms, and scraper tools, with an associated fragment of charcoal dated to 11,698–11,290 cal yr BP (McLaren in prep).

A single fluted point fragment was found on the surface of archaeological site DhRn-20. If this artifact dates to the time period generally associated with Clovis, 13,000–12,700 cal yr BP (Waters and Stafford 2007), then it is possible that this site was occupied when sea level was high enough to fill the basin of Stave Lake. To the best of our knowledge, fluted points have not been found along the Pacific Coast of North America north of this point. They are known from scattered surface finds to the south in the Puget Sound region of Washington State (Croes et al. 2008) and rare finds in coastal Oregon and California.

3.5. Oregon coast

The Oregon coast does not share the same degree of glacioisostatic effects seen farther north in Washington,

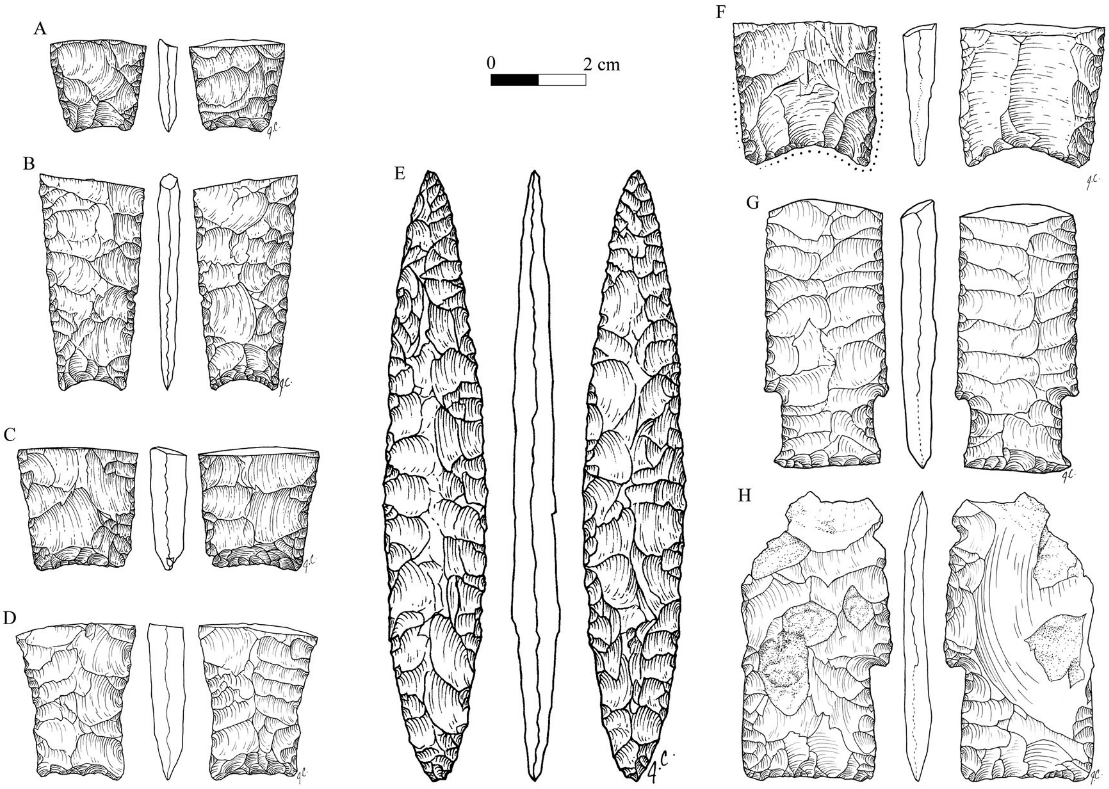

Figure 5 Examples of late Pleistocene spear points from the Stave Watershed (illustration by Jenny Cohen). All are surface finds except A and B, which are associated with an age range of 12,380–11,975 cal yr BP. (A–D) Concave-based lanceolate spear point fragments; (E) large lanceolate spear point; (F) fluted point base. (G–H) stemmed points.

British Columbia, and Alaska (Clark, Mitrovica, and Alder 2014). However, its coastal landscape experienced significant neotectonic deformation due to its proximity to the Cascadia Subduction Zone, which lies offshore of the outer continental shelf. The effects of this subduction are seen not only in the gradual uplift of Oregon's coastal margin but also in the presence of local-scale upper crustal faults that run perpendicular to Oregon's coast.

The search for late Pleistocene-aged sites along Oregon's coast began in earnest in the late 1990s and began to bear fruit a few years later, as seen in the work of Punke (2001), Punke and Davis (2003, 2006), Davis et al. (2004), Hall et al. (2005), and Davis (2006). Research into coastal Oregon's earliest archaeological record has often employed geoarchaeological perspectives, particularly in efforts to model late Quaternary paleo-landscape changes and their effects on the preservation and visibility of late Pleistocene-aged archaeological sites. Efforts to model Oregon's changing coastal landscape initially began with global eustatic-based reconstructions of sea level (Davis et al. 2009; ICF International 2013; Jenevein 2010; Punke 2001), but now incorporate newly available glacioisostatic adjustment models (Clark, Mitrovica, and Alder 2014) to calculate local relative sea level histories for parts of Oregon's continental shelf. These relative sea level curves are combined with GIS-based landscape models that first model the probable distribution of coastal stream networks based on publicly available bathymetric datasets, and then add gridded data layers that calculate relative environmental productivity values and heuristic grid values to model the potential attractiveness of different parts of the coastal landscape.

Archaeological evidence for late Pleistocene-aged occupation of coastal Oregon is currently limited to two sites: Indian Sands and Devil's Kitchen. Indian Sands is located on Oregon's southern coast near the town of Brookings. It contains a stratified series of repeated cultural occupations in a cumulic soil developed at the top of a late Pleistocene-aged sand dune (Davis 2006, 2008; Davis et al. 2004). The earliest component at Indian Sands consisted of 808 pieces of debitage and 12 tools, including cores, utilitarian biface fragments, lanceolate projectile-point base fragments, unifaces, and modified flakes (Davis and Willis 2011). The site's earliest component also included 56 pieces of fire-cracked rock, to one of which adhered a piece of wood charcoal that returned a radiocarbon age of 12,312 cal yr BP (Davis et al. 2004). Undisturbed aeolian sediments accumulated throughout the early to middle Holocene and buried this late Pleistocene occupation. Excavations conducted at the Devil's Kitchen site, located near the town of Bandon, revealed a record of repeated cultural occupation along an inland coastal stream and dunefield. Hall et al. (2005) and Curteman (2015) report evidence that humans occupied the site sometime between ca. 12,800 and 6700 cal yr BP. More recent excavations at the site uncovered lithic debitage and wood charcoal in an alluvial floodplain deposit that aggraded between ca. 13,440 and 12,630 cal yr BP (Curteman 2015).

Geoarchaeological and archaeological approaches are jointly applied to understand the late Quaternary history of landscape evolution and site formation along Oregon's coast. Studies by Hall and Radosevich (1995), Punke (2001), and Punke and Davis (2006) employed mechanical coring and trenching techniques that showed how Oregon's coastal environments often experienced rapid sedimentation in response to post-glacial marine transgression, burying terminal Pleistocene-aged terrestrial deposits to depths up to 30 m below the modern surface. A large number of Oregon's late Pleistocene to early Holocene-aged sites are known from uplifted headlands that received far less sedimentation over time; at some localities, these headlands retain intact archaeological components within paleosols.

Since 2016, with funds provided by the Bureau of Ocean Energy Management (BOEM) and the National Oceanographic and Atmospheric Administration, Davis has collaborated with archaeologists Todd Braje, Jon Erlandson, Amy Gusick, and Alexander Nyers, marine geologists Jillian Maloney and Neal Driscoll, and others to conduct a more intensive evaluation of a GIS-based site location model. Multiple geophysical surveys conducted by this team led to the discovery of an extensive network of submerged alluvial channel and floodplain features buried beneath a thin mantle of marine sediments offshore Oregon's central coast (Davis, Cantelas, and Valette-Silver 2018). In the summer of 2018, the team collected multiple marine cores from key localities. Analysis and interpretation of these cores is forthcoming.

3.6. California Channel Islands

California's Northern Channel Islands have been the focus of research on maritime Paleocoastal peoples for more than two decades (Erlandson et al. 1996, 2011; Rick et al. 2013). This research includes detailed paleogeographic reconstructions (Erlandson 2016; Reeder-Myers et al. 2015) and extensive terrestrial surveys (Erlandson et al. 2016; Gusick and Erlandson 2019), combined with mapping, remote sensing, and coring work on the submerged landscapes that surround the islands (Watts, Fulfrost, and Erlandson 2011). Although they have been separated from the mainland throughout the Quaternary, San Miguel, Santa Rosa, Santa Cruz, and Anacapa islands were connected as one large island known as Santarosae during the LGM and up until ~10,000–9000 cal yr BP (Figure 6). Sea level was a maximum of ~100–110 m below present at the LGM, and since that time the islands have lost as much as 75 per cent of their area to rising post-glacial seas (Reeder-Myers et al. 2015).

On land, more than 90 Paleocoastal sites dating between ~13,000 and 8200 cal yr BP have been documented on the islands (Gusick and Erlandson 2019). Erlandson et al. (1996) reported on an earlier component with two chert flakes and a bone bead found in charcoal lenses dated to ca. 18,800–18,500 cal yr BP at Daisy Cave on San Miguel Island, but the age and context of these finds have yet to be presented in detail. Elsewhere, terrestrial surveys have focused on landforms and features that would have drawn Paleocoastal peoples away from now-submerged shorelines and into the interior: caves and rockshelters, springs, stream courses and wetlands, toolstone sources, and bluff-top "overlook" sites with broad viewsheds. The large number of Paleocoastal sites found so far, the knowledge that vast coastal lowland and wetland areas are submerged offshore, and the fact that Holocene dunes and alluvium obscure large areas on land, all suggest that the islands were settled very early and supported substantial human populations during later Paleocoastal times.

Paleocoastal sites include shell middens, bone middens, lithic scatters, and quarry workshops, with hints of some sedentary occupations as much as 11,700 cal yr BP. Faunal remains from several sites dating between 12,200 and 11,100 cal yr BP document a heavy reliance on shellfish, with varying intensities of fishing, and hunting of marine mammals, seabirds, and waterfowl. Archaeobotanical data are still limited from these sites, but so far have produced evidence for the use of geophytes and other plant foods (Braje and Erlandson 2019; Gill 2015, 2016; Reddy and Erlandson 2012), suggesting that productive patches of edible terrestrial plant foods may also have drawn Paleocoastal people into the interior of the islands. The faunal and floral data available so far suggest a heavy reliance on rocky shore, kelp forest, wetland, and grassland habitats (Gusick and Erlandson 2019).

Some of the earliest dated human skeletal remains found in the Americas are from the Channel Islands. A number of attempts have been made to secure an accurate age of these remains of a single individual (Johnson et al. 2002). Agenbroad et al. (2005) report that charcoal found above and below the remains point to an age span

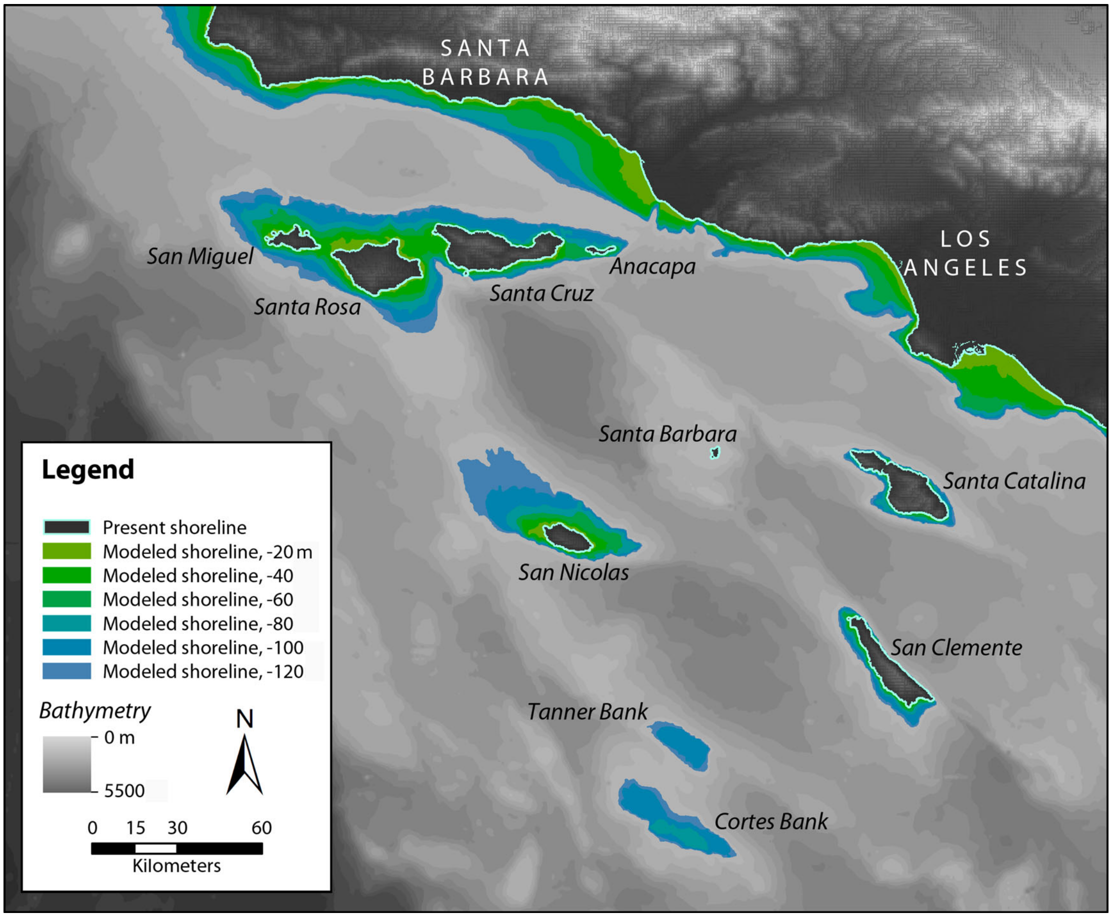

Figure 6 Map showing how the California Channel Islands have shrunken in size since late Pleistocene time as a result of sea level rise (image provided by Jon Erlandson, courtesy of Doug Kennett).

of 13,500–13,000 cal yr BP. Attempts to directly date the remains place them slightly later, between 13,020 and 12,700 cal yr BP (Johnson et al. 2002). However, no $\delta^{13}C$ ratio has been reported, thus making a correction for potential marine reservoir effect difficult. Charcoal reported as being directly associated with the stratum from which the remains were found returned an age of 12,000–11,350 cal yr BP (Johnson et al. 2002). As currently reported, a more precise age of the remains is difficult to pin down with certainty.

Investigations at several Paleocoastal sites – including a large quarry/workshop/shell midden complex (CA-SMI-678, -679, -680, and -701) at Cardwell Bluffs on San Miguel Island – have produced substantial assemblages of artifacts, including more than a thousand chipped-stone bifaces, numerous cores and flake tools, occasional ground-stone artifacts (e.g., pitted stones), bone gorges, *Olivella* shell beads, woven sea grass cordage, and red ochre. Among the chipped-stone tools are stemmed Channel Island Barbed (CIB) and Amol (CIA) points, crescents that appear to have been used as transverse points for hunting birds, leaf-shaped bifaces, and biface preforms (Erlandson 2013; Erlandson et al. 2011; Glassow, Erlandson, and Braje 2013; Gusick and Erlandson 2019; Rick et al. 2013).

The stemmed points and crescents appear to link the Channel Island Paleocoastal assemblages to broadly similar Western Stemmed Tradition sites found across the American Far West, from the Columbia Plateau and Great Basin, to California's Central Valley and the Baja California Peninsula (Moss and Erlandson 2013; Sanchez, Erlandson, and Tripcevich 2016). Although the Northern Channel Islands appear to have been occupied at least since Clovis times (~13,000 cal yr BP), and a few fluted points have been found along California's mainland coast, no fluted points have been found on the islands.

Research on the submerged landscapes surrounding the Channel Islands is in its infancy (Watts, Fulfrost, and Erlandson 2011). Currently, with support from the Bureau of Ocean Energy Management and other sources, predictive modeling and the mapping and sub-bottom profiling of offshore landforms is being combined with analysis of the location of Paleocoastal sites on land and paleogeographic reconstructions with a view to identifying submerged landforms and features of high probability that may have survived post-glacial sea level rise in an area of relatively exposed and erosive coast. With the predominant wind and swell direction coming from the northwest, a former south-facing embayment dubbed Crescent Bay would have provided Paleocoastal people with relatively protected lowland, wetland, estuarine, and marine habitats (Erlandson 2016). More than 25 Paleocoastal sites have been identified on land inland from the margins of this bay. Erlandson conducted a submersible reconnaissance of a portion of the seafloor in this area, finding it mantled in sand except for the rocky walls of a submarine canyon. Sub-bottom profiling has identified submerged and buried drainage channels, transgressive surface features, and potential estuarine sediments (Gusick and Erlandson 2019). Coring of bottom sediments has occurred but these cores have not yet been analyzed.

3.7. Baja California Peninsula, Mexico

Late Pleistocene to early Holocene-aged coastal sites are known from three areas in the Baja California Peninsula: in the northern state of Baja California at Cueva Escorpiones and in multiple areas on Cedros Island, as well as on Espíritu Santo Island in Baja California Sur (Fujita and Ainis 2018). Sea level reconstructions and coastal paleo-landscape reconstructions are few; they are based primarily on global eustatic history models (e.g., Des Lauriers 2010; Gusick and Davis 2010; Gusick and Faught 2011). While glacioisostatic adjustments are likely to be greatly diminished and of little effect around the Baja California Peninsula, regional neotectonic effects are expected to have some effect on relative sea level. For example, Cueva Escorpiones is an ancient sea cave that was lifted 14 m above sea level by long-term tectonic activity; the remains of *Equus* and *Tetrameryx* were found in the bottommost stratum of the cave (Gruhn and Bryan 2009).

The earliest projectile points discovered along the coastal zones of the Baja California peninsula include lanceolate and stemmed forms made on local cherts, metavolcanics, rhyolites, and quartzite (Davis 2007; Des Lauriers 2010; Fujita 2010; Fujita and Ainis 2018; Gruhn and Bryan 2009). All these projectile points have been dated (12,500–11,600 cal yr BP) based upon their buried context. Des Lauriers (2010) also reported the undated surficial discovery of a fluted point from Cedros Island. It appears that the subsistence economy of late Pleistocene-aged and early Holocene-aged Cedros Islanders was remarkably diverse and included the use of 25 different marine fishes, pinnipeds, sea turtles, birds, small mammals, crustaceans, and artiodactyls. While projectile points are thought to have been used along the Baja California Peninsula's coastline to take marine mammals, sea turtles, and artiodactyls (Des Lauriers 2010; Des Lauriers et al. 2017; Fujita 2010), weapon systems incorporating hafted lithic tips may not have been as critical to early coastal peoples in the region. Instead, late Pleistocene and early Holocene early coastal foragers on Cedros Island in Baja California and Espíritu Santo Island in Baja California Sur employed shell fishhooks to exploit a wide range of marine fishes, including large offshore game species, providing the earliest evidence for deep-sea fishing in the New World (Des Lauriers et al. 2017; Fujita 2014).

4. Implications of coastal finds for the late Pleistocene archaeology of the Americas

In recent years, an increasing number of archaeological components that predate 14,000 cal yr BP have been investigated from interior regions in the Americas (Dillehay et al. 2015; Jenkins et al. 2012; Waters et al. 2018; Waters, Forman, et al. 2011; Williams et al. 2018). These sites are older than most of the earliest sites found along the Pacific margin of North America (Table 1) and appear to be variable in their lithic assemblages, projectile point types, and resource use strategies (Williams and Madsen 2019). In North America, as described here, evidence for late Pleistocene Pacific coastal occupation appears by at least ca. 14,000–13,700 cal yr BP, with a possible earlier component at Daisy Cave (18,810–18,530 cal yr BP). However, radiocarbon dated late Pleistocene sites are relatively few and far between until ~12,500 cal yr BP (Table 1). If Pacific coastal archaeologists working in North America are going to help address questions regarding the earliest human populations in the Americas, we need to start targeting pre-14,000-year-old shorelines wherever they are found, above or below the sea.

There is more evidence of early Pacific coast archaeology sites from South America. The clearest indication of a coastal affiliation in the pre-Clovis time period comes from radiocarbon dates on nine species of seaweed found at the Monte Verde wet site, in Chile, with calibrated ages between ~14,220 and 13,980 cal yr BP (Davis et al. 2019; Dillehay et al. 2008). Huaca Prieta, in Peru, has a long-term sequence of occupation with earliest evidence dating to ~15,000 cal yr BP (Dillehay 2017). Also, from the Monte Verde sites, ephemeral occupations are reported between 18,500 and 14,500 cal yr BP (Dillehay et al. 2015). In this context, the 18,800–18,500 cal yr BP component from Daisy Cave (Erlandson et al. 1996) may not be out of order. Clearly, however, better quality evidence is needed to make the case for a pre-16,000 cal yr BP human presence in the Americas.

Table 1 Archaeological sites on the outer Pacific Coast of North America with dated components in the late Pleistocene (prior to 11,500 cal yr BP). Where multiple ages have been reported only the earliest and latest late Pleistocene dates are listed. Calibrations are as listed by authors. Where marine carbon corrections are necessary an asterisk (*) appears beside the original radiocarbon date. Where dates have been acquired but not fully published and peer reviewed, only an age range is given.

Site name	Location	Radiocarbon date	Calibration (cal yr BP)	Source	Cultural materials
K1 Cave	Haida Gwaii	10,960 ± 35 to 10,510 ± 35	12,897–12,730 to 12,543–12,442	Fedje et al. (2011a)	Bear bones below and above spear fragments
Gaadu Din 1	Haida Gwaii	10,615 ± 30, 10,550 ± 25	12,604–12,548, 12,568–12,432	Fedje et al. (2011a)	Charcoal associated with stone tools
Gaadu Din 2	Haida Gwaii	10,530 ± 20 to 10,025 ± 45	12,551–12,428 to 11,690–11,394	Fedje et al. (2011)	Charcoal associated with spearpoint, bifaces, hearth
EkTb-9	Triquet Island		14,000–13,700	Gavreau and McLaren (2017)	Charcoal associated with flake cache, cobble core, anvil stone, hearth
EjTa-4	Calvert Island	11,440 ± 25 to 10,720 ± 60	13,316–13,255 to 12,715–12,633	McLaren et al. (2018)	Wood found at base of human footprint impression
EaSh-81	Quadra Island		13,000-12,900	Fedje et al. (2018a)	28 m above high tide deltaic deposits and flakes
EbSh-1	Quadra Island	10,740 ± 70	12,744–12,566	Fedje et al. 2018a	Charcoal associated with deltaic deposits and flakes
EbSh-98	Quadra Island	10,940 ± 60	12,970-12718	Fedje et al. (2018a)	Charcoal associated with raised beach deposits with associated flakes
DhRo-11	Stave Watershed		12,380–12,000	McLaren in prep.	Charcoal associated with concave base, collaterally flaked spear points, flakes
DhRo-16	Stave Watershed	10,290 ± 50 10,210 ± 40	12,381–11,829 12,086–11,760	McLaren (2017)	Charcoal associated with large flake tool
DhRn-13	Stave Watershed		12,380–12,070	McLaren in prep.	Charocal associated with blade
DhRn-18	Stave Watershed	10,353 ± 33 to 10,001 ± 34	12,389–12,037 to 11,698–11,290	McLaren (2017); McLaren in prep.	Charcoal associated with tool kit cache: collaterally flaked foliate spearpoints, bifaces, scrapers, flakes
DhRn-29	Stave Watershed	10,370 ± 40, 10,150 ± 40	12,460–11,290, 12,021–11,621	McLaren (2017)	Charcoal associated with biface preform, flakes
Manis	Salish Sea	11,960 ± 17	13,860–13,763	Waters, Stafford, et al. 2011	Bone point in mastodon rib
Bear Creek	Puget Sound	10,489 ± 29 to 9033 ± 52	12,670–12,370 to 10,277–9938	Kopperl (2016)	Charcoal from stratum with concave base spear points, flakes, cores
Indian Sands	Oregon Coast	10,430 ± 150	12,930–11,690	Davis (2008)	Charcoal adhering to fire cracked rock and associated with retouched flakes and debitage
Devil's Kitchen	Oregon Coast	11,596 ± 37 to 10,638 ± 35	13,440–12,630	Curteman (2015)	Charcoal associated with lithic debitage
CA-SRI-173 Arlington Springs	Channel Islands	10,960 ± 80*, 11,250 ± 50 to 11,580 ± 45	13,020–12,700 ($\delta^{13}C$ not reported) 13,500–13,000	Johnson et al. (2002), Agenbroad et al. (2005)	Human remains, charcoal above and below remains
CA-SMI-261 Daisy Cave	Channel Islands	15,780 ± 120 and 10,390 ± 130 to 11,100 ± 100*	18,810–18,530 and 12,800–10,840	Erlandson et al. (1996)	Charcoal associated with hearths, flakes and bone bead; twig associated with stemmed and leaf points, crescent, shellfish
CA-SMI-678	Channel Islands	10,500 ± 50 to 10,950 ± 45	12,200–11,400	Erlandson et al. (2011)	Stemmed points, crescents, shellfish
CA-SMI-679	Channel Islands	10,750 ± 55 to 10,800 ± 45	12,200–11,710	Erlandson et al. (2011)	Stemmed points, crescents, shellfish
CA-SMI-701	Channel Islands	10,700 ± 40	11,730–11,410	Erlandson (2013)	Stemmed points, crescents, bifaces, shellfish
CA-SRI-26	Channel Islands	10,070 ± 30 to 10,700 ± 37	11,980–11,410	Erlandson, Rick, and Jew (2011)	Crescents, stemmed points, shellfish, bird, fish and sea mammal
CA-SRI-512	Channel Islands	10,000 ± 30 to 10,200 ± 45	12,000–11,410	Erlandson, Rick et al. (2011)	Stemmed points, crescents, red ochre, bird, fish, sea mammal
CA-SRI-706	Channel Islands	10,600 ± 65*	11,620–11,240	Rick et al. (2013)	Shell midden associated with four crescents
CA-SRI-708	Channel Islands	10,255 ± 40 to 10,400 ± 47*	11,250–10,790	Rick et al. (2013)	Stemmed points, crescents, shellfish
CA-SRI-723	Channel Islands	10,940 ± 47*	12,170–11,930	Rick et al. (2013)	Stemmed points, crescents, shellfish
CA-SRI-725	Channel Islands	10,585 ± 50*	11,360–11,220	Rick et al. (2013)	Stemmed points, crescents, shellfish
PAIC-49 Richard's Ridge	Cedros Island, Baja	10,380 ± 60 to 10,745 ± 25*	12,429–12,038 to 12,103–11,616	Des Lauriers et al. (2017)	Lithics, shellfish, fish

Regardless of whether one interprets the initial peopling of the Americas as an overland entry through an "ice-free corridor" or as a seaborne entry along the northern Pacific margin, what is clear is that both coastal and inland-adapted populations thrived in the Americas during the late Pleistocene period. Most likely these groups interacted and shared information. It makes sense that both routes would have been used when they were passable. Direct paleo-environmental evidence reveals that the western margin was far more viable than the interior ice-free corridor as a habitat for plants and animals to thrive in between 20,000 and 14,000 cal yr BP (Al-Suwaidi et al. 2006; Blaise et al. 1990; Clague, Mathewes, and Ager 2004; Darvill et al. 2018; Heintzman et al. 2016; Pedersen et al. 2016; Ramsey et al. 2004; Shaw et al. 2019; Steffen and Fulton 2018; Ward et al. 2003). Furthermore, it seems unlikely that the founding Beringian lineages that moved into the Americas had no knowledge of watercraft and seafaring and only mastered these skills after they had passed through the ice-free corridor on foot. This is particularly the case given the pre-last glacial maximum evidence for boat usage and seafaring in eastern Asia (Erlandson and Braje 2011).

Only a small number of pre-Clovis-aged archaeological sites have been found along the Pacific Coast of the Americas, and fewer still along the western margin of the area covered by the Cordilleran Ice Sheet. This has been used to imply that the hypothesis of a coastal dispersal corridor has less plausibility than that of the ice-free corridor (Potter et al. 2018). Yet an argument based solely on the lack of sufficient evidence could also be used to argue against a pedestrian dispersal across the Bering Land Bridge, seeing as no pre-Clovis sites have been found at the bottom of Bering Strait (Madsen 2015). The same line of argument would apply, however, with even more force, to the fact that no pre-13,000-year-old sites have been found in the 2000-km-long ice-free corridor gap between the Little John Site (~14,000 cal yr BP) in the western Yukon and Wally's Beach in southern Alberta (~13,300 cal yr BP) (Easton et al. 2011; Waters et al. 2015).

Our case studies demonstrate the value of an investigative approach to late Pleistocene coastal archaeology that gives careful consideration to creating maps of local and regional sea level curves, reconstructing the paleogeography of the locality, using predictive modeling to identify where early sites might best be preserved, and employing appropriate testing methods on land or beneath the sea. As our case studies show, the relatively limited preliminary work that has been conducted to date has already led to the discovery of several late Pleistocene sites along the Pacific Coast, sometimes in large enough numbers (e.g., in British Columbia and the Northern Channel Islands) to suggest relatively dense populations and the possibility of an even deeper demographic history in the region. These case studies should encourage further research along the Pacific Coast of North America, on land and beneath the sea.

Acknowledgements

We are grateful to the Wilson Fund at the Center for the Study of the First Americans, Tula Foundation, and Hakai Institute for organizing and supporting the Stemmed Point Workshop and putting us all in the same room to talk about our research and compare results. Many archaeologists, First Nations members, students, and scientists have worked in the field and laboratory to help pull together the results we present here. We are grateful to them all.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

Funding for the Stemmed Point Workshop, during which the writing of the paper was planned, was provided by the provided by the Wilson Seminar Series (Center for the Study of the First Americas at Texas A&M University) and the Hakai Institute.

Notes on contributors

Duncan McLaren is affiliated with the Hakai Institute, the University of Victoria, and Cordillera Archaeology. Recently his work has focused on patterns of long-term land use and occupation on the central coast of British Columbia, northern Vancouver Island, and Stave Watershed.

Daryl Fedje is affiliated with the Hakai Institute and the University of Victoria. His work has focused on late Pleistocene environments and archaeology on Haida Gwaii, Banff National Park, and most recently Quadra Island.

Quentin Mackie is an associate professor at the University of Victoria. He is a specialist in the archaeology of the Northwest Coast culture area with a particular interest in late Pleistocene and early Holocene time periods.

Loren Davis is a professor in the Department of Anthropology at Oregon State University. His research focuses on early archaeological occupations in Idaho, the Oregon coast, and Baja California.

Jon Erlandson is the director of the Museum of Natural and Cultural History and professor emeritus at the University of Oregon. He has conducted research in California, Oregon, Alaska, and Iceland.

Alisha Gauvreau is a PhD student at the University of Victoria. Her dissertation research is focused on investigations at the Triquet Island site (EkTb-9) on the central British Columbia coast.

Colton Vogelaar recently completed his MA at the University of Victoria in the Department of Anthropology. His research focused on site discovery models on Quadra Island, British Columbia.

ORCID

Duncan McLaren http://orcid.org/0000-0001-8319-8881
Quentin Mackie http://orcid.org/0000-0002-4231-0678

References

Ackerman, R. 1996. "Ground Hog Bay, Site 2." In *American Beginnings: The Prehistory and Palaeoecology of Beringia*, edited by F. West, 424–430. Chicago: The University of Chicago Press.

Agenbroad, L., J. Johnson, D. Morris, and T. Stafford. 2005. "Mammoths and Humans as Late Pleistocene Contemporaries on Santa Rosa Island." Paper presented at the Sixth California Islands Symposium, Ventura, CA, December 1–3.

Al-Suwaidi, M., B. Ward, M. Wilson, R. Hebda, D. Nagorsen, D. Marshall, B. Ghaleb, R. Wigen, and R. Enkin. 2006. "Late Wisconsinan Port Eliza Cave Deposits and their Implications for Human Coastal Migration, Vancouver Island, Canada." *Geoarchaeology* 21: 307–332.

Blaise, B., J. Clague, and R. Mathewes. 1990. "Time of Maximum Late Wisconsin Glaciation, West Coast of Canada." *Quaternary Research* 34: 282–295.

Braje, T., T. Dillehay, J. Erlandson, R. Klein, and T. Rick. 2017. "Finding the First Americans." *Science* 358: 592–594.

Braje, T., and J. Erlandson. 2019. *From Paleoindians to Pioneers: Archaeological Data Recovery Excavations at CA-SRI-997/H, the Vail & Vickers Ranch House Site, Santa Rosa Island, California*. Report submitted to Channel Islands National Park.

Carlson, R. 2008. "Projectile Points from the Central and Northern Mainland Coast of British Columbia." In *Projectile Point Sequences in Northwestern North America*, edited by R. Carlson and M. Magne, 61–78. Burnaby: Archaeology Press, Simon Fraser University.

Carlson, R., and J. Baichtal. 2015. "A Predictive Model for Locating Early Holocene Archaeological Sites Based on Raised Shell-Bearing Strata in Southeast Alaska, USA." *Geoarchaeology* 30: 120–138.

Carrara, P., T. Ager, and J. Baichtal. 2007. "Possible Refugia in the Alexander Archipelago of Southeastern Alaska during the Late Wisconsin Glaciation." *Canadian Journal of Earth Sciences* 44: 229–244.

Clague, J., J. Harper, R. Hebda, and D. Howes. 1982. "Late Quaternary Sea Levels and Crustal Movements, Coastal British Columbia." *Canadian Journal of Earth Sciences* 19: 597–618.

Clague, J., and T. James. 2002. "History and Isostatic Effects of the Last Ice Sheet in Southern British Columbia." *Quaternary Science Reviews* 21: 71–87.

Clague, J., R. Mathewes, and T. Ager. 2004. "Environments of Northwestern North America before the Last Glacial Maximum." In *Entering America: Northeast Asia and Beringia before the Last Glacial Maximum*, edited by D. B. Madsen, 63–96. Salt Lake City: The University of Utah Press.

Clark, J., J. Mitrovica, and J. Alder. 2014. "Coastal Paleogeography of the California–Oregon–Washington and Bering Sea Continental Shelves during the Latest Pleistocene and Holocene: Implications for the Archaeological Record." *Journal of Archaeological Science* 52: 12–23.

Clark, J., J. Mitrovica, and K. Latychev. 2019. "Glacial Isostatic Adjustment in Central Cascadia: Insights from Three-Dimensional Earth Modeling." *Geology* 47: 295–298.

Cohen, J. 2015. "Paleoethnobotany of Kilgii Gwaay, a 10,700-Year-Old Ancestral Haida Archaeological Wet Site." MA thesis, Department of Anthropology, University of Victoria, Victoria, BC.

Croes, D., S. Williams, L. Ross, M. Collard, C. Dennler, and B. Vargo. 2008. "The Projectile Point Sequences in the Puget Sound Region." In *Projectile Point Sequences in Northwestern North America*, edited by R. Carlson and M. Magne, 105–130. Burnaby: Archaeology Press, Simon Fraser University.

Curteman, J. 2015. "Geoarchaeological Investigations at the Devils Kitchen Site (35CS9), Southern Oregon Coast." MA thesis, Department of Anthropology, Oregon State University, Corvallis OR.

Darvill, C., B. Menounos, B. Goehring, O. Lian, and M. Caffee. 2018. "Retreat of the Western Cordilleran Ice Sheet Margin during the Last Glaciation." *Geophysical Research Letters* 45: 9710–9720.

Davis, S. 1996. "Hidden Falls." In *American Beginnings: The Prehistory and Palaeoecology of Beringia*, edited by F. West, 413–424. Chicago: The University of Chicago Press.

Davis, L. 2006. "Geoarchaeological Insights from Indian Sands, a Late Pleistocene Site on the Southern Northwest Coast." *Geoarchaeology* 21: 351–361.

Davis, L. 2007. "Dating of the Bahía La Ballena Site (J69E): A Possible Terminal Pleistocene Occupation in Baja California Sur, Mexico." *Current Research in the Pleistocene* 24: 53–55.

Davis, L. 2008. "New Support for a Late Pleistocene-Aged Coastal Occupation at the Indian Sands Site, Oregon." *Current Research in the Pleistocene* 25: 74–76.

Davis, L., F. Cantelas, and N. Valette-Silver. 2018. "Discovering Oregon's Lost Coast: Finding and Studying Submerged Archaeological Sites and Landscapes on the Pacific Continental Shelf." *Oceanography* 31 (1): 38.

Davis, L., S. Jenevein, M. Punke, J. Noller, J. Jones, and S. Willis. 2009. "Geoarchaeological Themes in a Dynamic Coastal Environment, Lincoln and Lane Counties, Oregon." In *Volcanoes to Vineyards: Geologic Field Trips through the Dynamic Landscape of the Pacific Northwest*, edited by J. O'Connor, R. Dorsey and I. Madin, 319–336. Geological Society of America Field Trip Guide 15. Boulder: Geological Society of America.

Davis, L. G., D. B. Madsen, L. Becerra-Valdivia, T. Higham, D. A. Sisson, S. M. Skinner, D. Stueber, et al. 2019. "Late Upper Paleolithic Occupation at Cooper's Ferry, Idaho, USA, ~16,000 Years Ago." *Science* 365: 891–897.

Davis, L., M. Punke, R. Hall, M. Fillmore, and S. Willis. 2004. "A Late Pleistocene Occupation on the Southern Coast of Oregon." *Journal of Field Archaeology* 29: 7–16.

Davis, L., and S. Willis. 2011. "Technology, Mobility, and Adaptation among Early Foragers of the Southern Northwest Coast: The View from Indian Sands, Southern Oregon Coast, USA." In *Trekking the Shore: Changing Coastlines and the Antiquity of Coastal Settlement*, edited by N. Bicho, J. Haws, and L. G. Davis, 137–160. New York: Springer Publishing Company.

Des Lauriers, M. 2010. *Island of Fogs: Archaeological and Ethnohistorical Investigations of Isla Cedros, Baja California*. Salt Lake City: University of Utah Press.

Des Lauriers, M., L. Davis, J. Turnbull, J. Southon, and R. Taylor. 2017. "The Earliest Shell Fishhooks from the Americas Reveal Fishing Technology of Pleistocene Maritime Foragers." *American Antiquity* 82: 498–516.

Dikov, N. 1979. *Early Cultures of Northeastern Asia*. Originally published in Russian as *Drevnie Kul'tury Severo-Vostochnoi Azii (Aziia na Styke s Amerikoi v Drevnosti)* by N. N. Dikov (Moscow: Nauka, 1979) and translated into English by Richard L. Bland of the Museum of Natural and Cultural History, University of Oregon, Eugene, OR, and published by the US Department of the Interior, National Park Service, Shared Beringian Heritage Program, Anchorage, Alaska, 2004.

Dillehay, T. 2017. *Where the Land Meets the Sea: Fourteen Millennia of Human History at Huaca Prieta, Peru*. Austin: University of Texas Press.

Dillehay, T., C. Ocampo, J. Saavedra, A. Sawakuchi, R. Vega, M. Pino, M. Collins, et al. 2015. "New Archaeological Evidence for an Early Human Presence at Monte Verde, Chile." *PLOS ONE* 10: e0141923. doi:10.1371/journal.pone.0141923.

Dillehay, T., C. Ramírez, M. Pino, M. Collins, J. Rossen, and J. Pino-Navarro. 2008. "Monte Verde: Seaweed, Food, Medicine, and the Peopling of South America." *Science* 320: 784–786.

Dixon, E. 1979. "A Predictive Model for the Distribution of Archeological Sites on the Bering Continental Shelf." PhD diss., Department of Anthropology, Brown University, Providence, RI.

Dixon, E. 2000. *Bones, Boats and Bison: Archaeology and the First Colonization of Western North America*. Albuquerque: University of New Mexico Press.

Dixon, E. 2008. "Bifaces from On Your Knees Cave, Southeast Alaska." In *Projectile Point Sequences in Northwestern North America*, edited by R. Carlson and M. Magne, 11–18. Burnaby: Archaeology Press, Simon Fraser University.

Easton, N., G. Mackay, P. Young, P. Schnurr, and D. Yesner. 2011. "Chindadn in Canada? Emergent Evidence of the Pleistocene Transition in Southeast Beringia as Revealed by the Little John Site, Yukon." In *From the Yenisei to the Yukon: Interpreting Lithic Assemblage Variability in Late Pleistocene/Early Holocene Beringia*, edited by T. Goebel and I. Buvit, 289–307. College Station: Texas A&M University Press.

Erlandson, J. M. 2002. "Anatomically Modern Humans, Maritime Voyaging, and the Pleistocene Colonization of the Americas." In *The First Americans: The Pleistocene Colonization of the New World*, edited by N. Jablonski, 59–92. San Francisco: Memoirs of the California Academy of Sciences.

Erlandson, J. 2013. Channel Island Amol Points: A Stemmed Paleocoastal Type from Santarosae Island, Alta California. *California Archaeology* 5: 105–121.

Erlandson, J. 2016. "Seascapes of Santarosae: Paleocoastal Seafaring on California's Channel Islands." In *Marine Ventures: Archaeological Perspectives on Human-Sea Relations*, edited by H. Bjerck, H. Breivik, S. Fretheim, E. Piana, B. Skar, A. Tivoli, and J. Zangrando, 317–327. Sheffield: Equinox Publishing.

Erlandson, J., and T. Braje. 2011. "From Asia to the Americas by Boat? Paleogeography, Paleoecology, and Stemmed Points of the Northwest Pacific." *Quaternary International* 239: 28–37.

Erlandson, J., K. Gill, M. Glassow, and A. Gusick. 2016. "Three Paleocoastal Lithic Sites on Santa Cruz Island, California." *PaleoAmerica* 2 (1): 52–55.

Erlandson, J., M. Graham, B. Bourque, D. Corbett, J. Estes, and R. Steneck. 2007. "The Kelp Highway Hypothesis: Marine Ecology, the Coastal Migration Theory, and the Peopling of the Americas." *The Journal of Island and Coastal Archaeology* 2: 161–174.

Erlandson, J., D. Kennett, B. Ingram, D. Guthrie, D. Morris, M. Tveskov, G. West, and P. Walker. 1996. "An Archaeological and Paleontological Chronology for Daisy Cave (CA-SMI-261), San Miguel Island, California." *Radiocarbon* 38: 355–373.

Erlandson, J., T. Rick, T. Braje, M. Casperson, B. Culleton, B. Fulfrost, T. Garcia, et al. 2011. "Paleoindian Seafaring, Maritime Technologies, and Coastal Foraging on California's Channel Islands." *Science* 441: 1181–1185.

Erlandson, J., T. Rick, and N. Jew. 2011. "CA-SRI-26: A Terminal Pleistocene Site on Santa Rosa Island, California." *Current Research in the Pleistocene* 28: 35–37.

Fedje, D. 1993. "Sea Levels and Prehistory in Gwaii Haanas." MA thesis, University of Calgary, Calgary.

Fedje, D., and T. Christensen. 1999. "Modeling Paleoshorelines and Locating Early Holocene Coastal Sites in Haida Gwaii." *American Antiquity* 64: 635–652.

Fedje, D., T. Christensen, H. Josenhans, J. Strang, and J. B. McSporran. 2005b. "Millennial Tides and Shifting Shores: Archaeology on a Dynamic Landscape." In *Haida Gwaii: Human History and Environment from the Time of Loon to the Time of the Iron People*, edited by D. W. Fedje and R. W. Mathewes, 163–186. Vancouver: UBC Press.

Fedje, D., and H. Josenhans. 2000. "Drowned Forests and Archaeology on the Continental Shelf of British Columbia, Canada." *Geology* 28: 99–102.

Fedje, D., H. Josenhans, J. J. Clague, J. V. Barrie, D. J. Archer, and J. R. Southon. 2005a. "Hecate Strait Paleoshorelines." In *Haida Gwaii: Human History and Environment from the Time of Loon to the Time of the Iron People*, edited by D. W. Fedje and R. W. Mathewes, 21–37. Vancouver: UBC Press.

Fedje, D., Q. Mackie, D. McLaren, and T. Christensen. 2008. "A Projectile Point Sequence for Haida Gwaii." In *Projectile Point Sequences in Northwestern North America*, edited by R. Carlson and M. Magne, 19–40. Burnaby: Archaeology Press, Simon Fraser University.

Fedje, D., Q. Mackie, T. Lacourse, and D. McLaren. 2011a. "Younger Dryas Environments and Archaeology on the Northwest Coast of North America." *Quaternary International* 242: 452–462.

Fedje, D., Q. Mackie, and D. McLaren. 2018b. "Deeply Drowned and Highly Stranded: Investigating High Latitude Early Post-Glacial Coastal Landscapes on the

British Columbia Coast." Paper presented at the 18th World UISPP Congress, Paris, June 4–9.

Fedje, D., Q. Mackie, N. Smith, and D. McLaren. 2011b. "Function, Visibility, and Interpretation of Archaeological Assemblages at the Pleistocene/Holocene Transition in Haida Gwaii." In *From the Yenisei to the Yukon: Interpreting Lithic Assemblage Variability in Late Pleistocene/Early Holocene Beringia*, edited by T. Goebel and I. Buvit, 408. College Station: Texas A&M University Press.

Fedje, D., A. Mackie, R. Wigen, Q. Mackie, and C. Lake. 2005c. "Kilgii Gwaay: An Early Maritime Site in the South of Haida Gwaii." In *Haida Gwaii, Human History and Environment from the Time of Loon to the Time of the Iron People*, edited by D. W. Fedje and R. W. Mathewes, 187–203. Vancouver: UBC Press.

Fedje, D., D. McLaren, T. James, Q. Mackie, N. Smith, J. Southon, and A. Mackie. 2018a. "A Revised Sea Level History for the Northern Strait of Georgia, British Columbia, Canada." *Quaternary Science Reviews* 192: 300–316.

Fedje, D., D. McLaren, and R. Wigen. 2004. *Preliminary Archaeological and Paleoecological Investigations of Late Glacial to Early Holocene Landscapes of Haida Gwaii, Hecate Strait and Environs (2001-172)*. Report on file at the BC Archaeology Branch.

Fedje, D., J. McSporran, and A. Mason. 1996. "Early Holocene Archaeology and Paleoecology at the Arrow Creek Sites in Gwaii Haanas." *Arctic Anthropology* 33: 116–142.

Fedje, D., R. J. Wigen, Q. Mackie, C. R. Lake, and I. D. Sumpter. 2001. "Preliminary Results from Investigations at Kilgii Gwaay: An Early Holocene Archaeological Site on Ellen Island, Haida Gwaii, British Columbia." *Canadian Journal of Archaeology* 25: 98–120.

Fladmark, K. 1978. "The Feasibility of the Northwest Coast Route as a Migration Route for Early Man." In *Early Man in America from a Circum-Pacific Perspective*, edited by A. Bryan, 119–128. Occasional Papers No. 1. Edmonton: University of Alberta.

Fladmark, K. 1979. "Routes: Alternate Migration Corridors for Early Man in North America." *American Antiquity* 44: 55–69.

Fladmark, K. 1983. "Times and Places: Environmental Correlates of Mid-to-Late Wisconsinan Human Population Expansion in North America." In *Early Man in the New World*, edited by R. Shulter, 13–41. Beverly Hills, CA: Sage Publications.

Fladmark, K. 1986. "Getting One's Berings." *Natural History* 95: 8–17.

Fujita, H. 2010. "Prehistoric Occupation of Espíritu Santo Island, Baja California Sur, Mexico: Update and Synthesis." *Journal of California and Great Basin Anthropology* 30: 17–33.

Fujita, H. 2014. "Early Holocene Pearl Oyster Circular Fishhooks and Ornaments on Espíritu Santo Island, Baja California Sur." *Monographs of the Western North American Naturalist* 7: 129–134.

Fujita, H., and A. Ainis. 2018. "Traditions of Early Human Groups in Baja California and Possible Routes for the Peopling of the Peninsula." *Western North American Naturalist* 78: 285–301.

Gavreau, A., and D. McLaren. 2017. "Long-term Culture Landscape Development at (EkTb-9) Triquet Island, British Columbia, Canada." Paper presented at the 50th Annual Meeting of the Canadian Archaeological Association, Ottawa, Ontario, May 10–13.

Gill, K. 2015. "Ancient Plant Use and the Importance of Geophytes among the Island Chumash of Santa Cruz Island, California." PhD diss., University of California, Santa Barbara, CA.

Gill, K. 2016. "10,000 Years of Geophyte Use among the Island Chumash of the Northern Channel Islands." *Fremontia* 44: 34–38.

Glassow, M., J. Erlandson, and T. Braje. 2013. "Channel Island Barbed Points: Shape and Size Variation within a Paleocoastal Projectile Type." *Journal of California and Great Basin Anthropology* 33: 185–195.

Graf, K., and I. Buvit. 2017. "Human Dispersal from Siberia to Beringia: Assessing a Beringian Standstill in Light of the Archaeological Evidence." *Current Anthropology* 58 (Supplement 17): S583–S603.

Gruhn, R., and A. Bryan. 2009. "An Interim Report on Two Rockshelter Sites with Early Holocene Occupation in the Northern Baja California Peninsula." *Pacific Coast Archaeological Society Quarterly* 42: 1–16.

Gusick, A., and L. Davis. 2010. "Exploring Baja California's Submerged Landscapes." *Journal of California and Great Basin Anthropology* 30: 35–49.

Gusick, A., and J. Erlandson. 2019. "Paleocoastal Landscapes, Marginality, and Early Human Settlement of the California Islands." In *An Archaeology of Abundance: Re-Evaluating the Marginality of California's Islands*, 77–115. Gainesville: University of Florida Press.

Gusick, A., and M. Faught. 2011. "Prehistoric Archaeology Underwater: A Nascent Subdiscipline Critical to Understanding Early Coastal Occupations and Migration Routes." In *Trekking the Shore: Changing Coastlines and the Antiquity of Coastal Settlement*, edited by N. Bicho, J. Haws, and L. Davis, 27–50. New York: Springer.

Hall, R., L. Davis, S. Willis, and M. Fillmore. 2005. "Radiocarbon, Soil, and Artifact Chronologies for an Early Southern Oregon Coastal Site." *Radiocarbon* 47: 1–11.

Hall, R., and S. Radosevich. 1995. "Geoarchaeological Analysis of a Site in the Cascadia Subduction Zone on the Southern Oregon Coast." *Northwest Archaeological Research Notes* 29: 123–140.

Halligan, J., M. Waters, A. Perrotti, I. Owens, J. Feinberg, M. Bourne, B. Fenerty, et al. 2016. "Pre-Clovis Occupation 14,550 Years Ago at the Page-Ladson Site, Florida, and the Peopling of the Americas." *Science Advances* 2 (5): e1600375. doi:10.1126/sciadv.1600375.

Heintzman, P., D. Froese, J. Ives, A. Soares, G. Zazula, B. Letts, T. Andrews, et al. 2016. "Bison Phylogeography Constrains Dispersal and Viability of the Ice Free Corridor in Western Canada." *Proceeding of the National Academy of Sciences* 113: 8057–8063.

Heusser, C. 1960. *Late-Pleistocene Environments of North Pacific North America: An Elaboration of Late-Glacial and Post-Glacial Climatic, Physiographic, and Biotic Changes*. Special Publication No. 35. New York: American Geographical Society.

Hirasawa, Y., and C. Holmes. 2017. "The Relationship between Microblade Morphology and Production Technology in Alaska from the Perspective of the Swan Point Site." *Quaternary International* 442: 104–117.

ICF International, Davis Geoarchaeological Research, and Southeastern Archaeological Research. 2013. *Inventory and Analysis of Coastal and Submerged Archaeological Site Occurrence on the Pacific Outer Continental Shelf*. Report on file at the U.S. Department of the Interior, Bureau of Ocean Energy Management, Pacific OCS Region, Camarillo, CA. OCS Study BOEM 2013-0115.

James, T., J. Clague, and I. Hutchinson. 2002. *Improved Relative Sea-Level Histories for Victoria and Vancouver, British Columbia, from Isolation-Basin Coring*. Current Research 2002-A16. Ottawa: Natural Resources Canada, Geological Survey of Canada.

Jenevein, S. 2010. "Searching for Early Archaeological Sites along the Central Oregon Coast: A Case Study from Neptune State Park (35LA3), Lane County, Oregon." MA thesis, Department of Anthropology, Oregon State University, Corvallis.

Jenkins, D., L. Davis, T. Stafford, P. Campos, B. Hockett, G. Jones, L. Cummings, et al. 2012. "Clovis Age Western Stemmed Projectile Points and Human Coprolites at the Paisley Caves." *Science* 337: 223–228.

Johnson, J., T. Stafford Jr, H. Ajie, and D. Morris. 2002. "Arlington Springs Revisited." In *Proceedings of the Fifth California Islands Symposium*, edited by D. Browne, K. Mitchell, and H. Chaney, 541–545. Santa Barbara, CA: Santa Barbara Museum of Natural History.

Jordan, J. 2001. "Late Quaternary Sea Level Change in Southern Beringia: Postglacial Emergence of the Western Alaska Peninsula." *Quaternary Science Reviews* 20: 509–523.

Josenhans, H., D. Fedje, K. Conway, and J. Barrie. 1995. "Post Glacial Sea Levels on the Western Canadian Continental Shelf: Evidence for Rapid Change, Extensive Subaerial Exposure, and Early Human Habitation." *Marine Geology* 125: 73–94.

Josenhans, H., D. Fedje, R. Pienitz, and J. Southon. 1997. "Early Humans and Rapidly Changing Holocene Sea Levels in the Queen Charlotte Islands-Hecate Strait, British Columbia, Canada." *Science* 277: 71–74.

Kopperl, R. 2016. *Results of Data Recovery at the Bear Creek Site (45K1839) King County, Washington*. 27287. Seattle: SWCA Environmental Consultants.

Kovanen, D., and O. Slaymaker. 2015. "The Paraglacial Geomorphology of the Fraser Lowland, Southwest British Columbia and Northwest Washington." *Geomorphology* 232: 78–93.

Lacourse, T., R. Mathewes, and D. Fedje. 2005. "Late-Glacial Vegetation Dynamics of the Queen Charlotte Islands and Adjacent Continental Shelf, British Columbia, Canada." *Palaeogeography, Palaeoclimatology, Palaeoecology* 226: 36–57.

Lausanne, A. 2018. "Identifying and Interpreting Geoarchaeological Sites with High Prospecting Potential Using Aerial LIDAR, GIS and Sedimentological Analysis." MA thesis, University of Victoria, Victoria, BC.

Lausanne, A., D. Fedje, Q. Mackie, and I. Walker. 2019. "Identifying Potential Geoarchaeological Sites with High Prospecting Potential Using Aerial LIDAR Imaging and GIS on Quadra Island, Canada." *Journal of Island & Coastal Archaeology* 14. Manuscript ID UICA-2018-0042.

Lesnek, A., J. Briner, C. Lindqvist, J. Baichtal, and T. Heaton. 2018. "Deglaciation of the Pacific Coastal Corridor Directly Preceded the Human Colonization of the Americas." *Scientific Advances* 4: eaar5040.

Letham, B., A. Martindale, R. Macdonald, E. Guiry, J. Jones, and K. Ames. 2016. "Postglacial Relative Sea-Level History of the Prince Rupert Area, British Columbia, Canada." *Quaternary Science Reviews* 153: 156–191.

Letham, B., A. Martindale, N. Waber, and K. Ames. 2018. "Archaeological Survey of Dynamic Coastal Landscapes and Paleoshorelines: Locating Early Holocene Sites in the Prince Rupert Harbour Area, British Columbia, Canada." *Journal of Field Archaeology* 43: 181–199.

Mackie, Q., L. Davis, D. Fedje, D. McLaren, and A. Gusick. 2013. "Locating Pleistocene-Age Submerged Archaeological Sites on the Northwest Coast: Current Status of Research and Future Directions." In *Paleoamerican Odyssey*, edited by K. Graf, C. Ketron, and M. Waters, 133–147. College Station: Center for the Study of the First Americans, Texas A&M University.

Mackie, Q., D. Fedje, and D. McLaren. 2018. "Archaeology and Sea Level Change on the British Columbia Coast." *Canadian Journal of Archaeology* 42: 74–91.

Mackie, Q., D. Fedje, D. McLaren, N. Smith, and I. McKechnie. 2011. "Early Environments and Archaeology of Coastal British Columbia." In *Trekking the Shore: Changing Coastlines and the Antiquity of Coastal Settlement*, edited by N. Bicho, J. Hawes, and L. Davis, 51–103. New York: Springer.

Mackie, Q., A. Proctor, D. Fedje, and C. Bradley. 2015. "Survey for Stone Wall Fish Weirs on the Continental Shelf near Haida Gwaii, British Columbia Using an Autonomous Underwater Vehicle (AUV)." Paper presented at the 80th Annual Meeting of the Society for American Archaeology, San Francisco, April 15–19.

Mackie, A. P., and I. Sumpter. 2005. "Shoreline Settlement Patterns in Gwaii Haanas during the Early and Late Holocene." In *Haida Gwaii: Human History and Environment from the Time of Loon to the Time of the Iron People*, edited by D. Fedje and R. W. Mathewes, 337–372. Vancouver: UBC Press.

Madsen, D. 2015. "A Framework for the Initial Occupation of the Americas." *PaleoAmerica* 1 (3): 217–250.

Mandryk, C., H. Josenhans, D. Fedje, and R. Mathewes. 2001. "Late Quaternary Paleoenvironments of Northwestern North America: Implications for Inland versus Coastal Migration Routes." *Quaternary Science Reviews* 20: 301–314.

Mathewes, R. 1973. "A Palynological Study of Postglacial Vegetation Changes in the University Research Forest, Southwestern British Columbia." *Canadian Journal of Botany* 51: 2085–2103.

Mathewes, R., and J. Clague. 2017. "Paleoecology and Ice Limits of the Early Fraser Glaciation (Marine Isotope Stage 2) on Haida Gwaii, British Columbia, Canada." *Quaternary Research* 88: 277–292.

Mathewes, R., O. Lian, J. Clague, and M. Huntley. 2015. "Early Wisconsinan (MIS 4) Glaciation on Haida Gwaii, British Columbia, and Implications for Biological Refugia." *Canadian Journal of Earth Sciences* 52: 939–951.

McCartney, A., and D. Veltre. 1996. "Anangula Core and Blade Site." In *American Beginnings: The Prehistory and Palaeoecology of Beringia*, edited by F. West, 443–450. Chicago: The University of Chicago Press.

McLaren, D. 2003. “Long Term Histories and Archaeology of the Stave Watershed Region of Southwestern British Columbia.” MA thesis, Department of Anthropology, University of Victoria, Victoria, BC.

McLaren, D. 2017. “The Occupational History of the Stave Watershed.” In *Archaeology of the Lower Fraser River Region*, edited by M. Rousseau, 149–158. Burnaby: Archaeology Press, Simon Fraser University.

McLaren, D., D. Fedje, A. Dyck, Q. Mackie, A. Gauvreau, and J. Cohen. 2018. “Terminal Pleistocene Epoch Human Footprints from the Pacific Coast of Canada.” *PloS ONE* 13 (3): e0193522.

McLaren, D., D. Fedje, M. Hay, Q. Mackie, I. Walker, D. Shugar, J. Eamer, O. Lian, and C. Neudorf. 2014. “A Post-Glacial Sea Level Hinge on the Central Pacific Coast of Canada.” *Quaternary Science Reviews* 97: 148–169.

McLaren, D., T. Gludo, M. Eldridge, T. Christensen, and D. Owens-Baird. 1997. *Report for the Stave Reservoir Archaeological Inventory and Impact Assessment Project*. Report submitted to BC Hydro, Kwantlen First Nation, Stó:lō Nation, and BC Archaeology Branch (Permit 1997-036).

McLaren, D., A. Martindale, D. Fedje, and Q. Mackie. 2011. “Relict Shorelines and Shell Middens of the Dundas Island Archipelago.” *Canadian Journal of Archaeology* 35: 86–116.

McLaren, D., F. Rahemtulla, (E. White) Gitla, and D. Fedje. 2015. “Prerogatives, Sea Level, and the Strength of Persistent Places: Archaeological Evidence for Long-Term Occupation of the Central Coast of British Columbia.” *BC Studies* 187: 155–191.

McLaren, D., and M. Steffen. 2008. “A Sequence of Formed Bifaces from the Fraser Valley Region.” In *Projectile Point Sequences in Northwestern North America*, edited by R. Carlson and M. Magne, 161–186. Burnaby: Simon Fraser University Archaeology Press.

McLaren, D., R. Wigen, Q. Mackie, and D. Fedje. 2005. “Bear Hunting and the Pleistocene/Holocene Transition on the Northern Northwest Coast of North America.” *Canadian Zooarchaeology* 22: 3–29.

Misarti, N., B. Finney, J. Jordan, H. Maschner, J. Addison, M. Shapley, A. Krumhardt, and J. Beget. 2012. “Early Retreat of the Alaska Peninsula Glacier Complex and the Implications for Coastal Migrations of First Americans.” *Quaternary Science Reviews* 48: 1–6.

Monteleone, K., E. Dixon, and A. Wickert. 2012. “Lost Worlds: A Predictive Model to Locate Submerged Archaeological Sites in SE Alaska, USA”. *Proceedings of the 40th Conference in Computer Applications and Quantitative Methods in Archaeology*. Southampton, UK, March 26–29.

Moss, M. L., and J. M. Erlandson. 2013. “Waterfowl and Lunate Crescents in Western North America: The Archaeology of the Pacific Flyway.” *Journal of World Prehistory* 26: 173–211.

Pedersen, M., A. Ruter, C. Schweger, H. Friebe, R. Staff, K. Kjeldsen, M. Mendoza, et al. 2016. “Postglacial Variability and Colonization in North America’s Ice-Free Corridor.” *Nature* 537, doi:10.1038/nature19085.

Peltier, W. R., and R. G. Fairbanks. 2006. “Global Glacial Ice Volume and Last Glacial Maximum Duration from an Extended Barbados Sea Level Record.” *Quaternary Science Reviews* 25: 3322–3337.

Potter, B., J. Baichtal, A. Beaudoin, L. Fehren-Schmitz, C. Haynes, V. Holliday, C. Holmes, et al. 2018. “Current Evidence Allows Multiple Models for the Peopling of the Americas.” *Science Advances* 4, doi:10.1126/sciadv.aat5473.

Punke, M. 2001. “Predictive Locational Modeling of Late Pleistocene Archaeological Sites on the Southern Oregon Coast Using a Geographic Information System (GIS).” MA thesis. Oregon State University, Corvallis.

Punke, M., and L. Davis. 2003. “Finding Late Pleistocene Sites in Coastal River Valleys: Geoarchaeological Insights from the Southern Oregon Coast.” *Current Research in the Pleistocene* 20: 66–88.

Punke, M., and L. Davis. 2006. “Problems and Prospects in the Preservation of Late Pleistocene Cultural Sites in Southern Oregon Coastal River Valleys: Implications for Evaluating Coastal Migration Routes.” *Geoarchaeology: An International Journal* 21 (4): 333–350.

Raghavan, M., M. Steinrucken, K. Harris, S. Schiffels, S. Rasmussen, M. DeGiorgio, A. Albrechtsen, et al. 2015. “Genomic Evidence for the Pleistocene and Recent Population History of Native Americans.” *Science* 349: aab3884.

Ramsey, C., P. Griffiths, D. Fedje, R. Wigen, and Q. Mackie. 2004. “Preliminary Investigation of a Late Wisconsinan Fauna from K1 Cave, Queen Charlotte Islands (Haida Gwaii), Canada.” *Quaternary Research* 62: 105–109.

Reddy, S., and J. Erlandson. 2012. “Macrobotanical Food Remains from a Trans-Holocene Sequence at Daisy Cave (CA-SMI-261), San Miguel Island, California.” *Journal of Archaeological Science* 39: 33–40.

Reeder-Myers, L., J. Erlandson, D. Muhs, and T. Rick. 2015. “Sea Level, Paleogeography, and Archeology on California’s Northern Channel Islands.” *Quaternary Research* 83: 263–272.

Rick, T., J. Erlandson, N. Jew, and L. Reeder-Myers. 2013. “Archaeological Survey, Paleogeography, and the Search for Late Pleistocene Paleocoastal Peoples of Santa Rosa Island, California.” *Journal of Field Archaeology* 38: 324–331.

Ryder, J., R. Fulton, and J. Clague. 1991. “The Cordilleran Ice Sheet and the Glacial Geomorphology of Southern and Central British Colombia.” *Géographie Physique et Quaternaire* 45 (3): 365–377.

Sanchez, G. M., J. M. Erlandson, and N. Tripcevich. 2016. “Quantifying the Association of Chipped Stone Crescents with Wetlands and Paleo-shorelines of Western North America.” *North American Archaeologist* 38: 107–137.

Shaw, J., J. V. Barrie, K. W. Conway, D. G. Lintern, and R. Kung. 2019. “Glaciation of the Northern British Columbia Continental Shelf: The Geomorphic Evidence Derived from Multibeam Bathymetric Data.” *Boreas* doi:10.1111/bor.12411.

Shugar, D., I. Walker, O. Lian, J. Eamer, C. Neudorf, D. McLaren, and D. Fedje. 2014. “Post-Glacial Sea-Level Change along the Pacific Coast of North America.” *Quaternary Science Reviews* 97: 170–192.

Smith, N. 2004. “A Geochemical Approach to Understanding Raw Material Use and Stone Tool Production at the Richardson Island Archaeological Site, Haida Gwaii, British Columbia.” MA thesis, Department of Anthropology, University of Victoria, Victoria BC.

Steffen, M., and T. Fulton. 2018. "On the Association of Giant Short-Faced Bear (*Arctodus simus*) and Brown Bear (*Ursus arctos*) in Late Pleistocene North America." *Geobios* 51 (1): 61–74.

Vogelaar, C. 2017. "Using GIS Modelling as a Tool to Search for Late Pleistocene and Early Holocene Archaeology on Quadra Island, British Columbia." MA thesis, University of Victoria, Victoria, BC.

Waber, N. 2011. "The Development of the Microblade Industry at the Richardson Island Site, Haida Gwaii, British Columbia." MA thesis, University of Victoria, Victoria, BC.

Ward, B., M. Wilson, D. Nagorsen, D. Nelson, J. Driver, and R. Wigen. 2003. "Port Eliza Cave: North American West Coast Interstadial Environment and Implications for Human Migrations." *Quaternary Science Reviews* 22: 1383–1388.

Waters, M. R. 2019. "Late Pleistocene Exploration and Settlement of the Americas by Modern Humans." *Science* 365: 138–138.

wWaters, M., S. Forman, T. Jennings, L. Nordt, S. Driese, J. Feinberg, J. Keene, et al. 2011. "The Buttermilk Creek Complex and the Origins of Clovis at the Debra L. Friedkin Site, Texas." *Science* 331: 1599–1603.

Waters, M., J. Keene, S. Forman, E. Prewitt, D. Carlson, and J. Wiederhold. 2018. "Pre-Clovis Projectile Points at the Debra L. Friedkin Site, Texas – Implications for the Late Pleistocene Peopling of the Americas." *Science Advances* 4: eaat4505.

Waters, M., and T. Stafford. 2007. "Redefining the Age of Clovis: Implications for the Peopling of the Americas." *Science* 315: 1122–1126.

Waters, M., T. Stafford, B. Kooyman, and L. Hills. 2015. "Late Pleistocene Horse and Camel Hunting at the Southern Margin of the Ice-Free Corridor: Reassessing the Age of Wally's Beach, Canada." *Proceedings of the National Academy of Sciences* 112: 4263–4267.

Waters, M., T. Stafford, H. McDonald, C. Gustafson, M. Rasmussen, E. Cappellini, J. Olsen, et al. 2011. "Pre-Clovis Mastodon Hunting 13,800 Years Ago at the Manis Site, Washington." *Science* 334: 351–353.

Watts, J., B. Fulfrost, and J. Erlandson. 2011. "Searching for Santarosae: Surveying Submerged Landscapes for Evidence of Paleocoastal Habitation off California's Northern Channel Islands." In *The Archaeology of Maritime Landscapes: When the Land Meets the Sea*, edited by B. Ford, 11–26. New York: Springer.

Wigen, R. 2005. "History of Vertebrate Fauna in Haida Gwaii." In *Haida Gwaii: Human History and Environment from the Time of Loon to the Time of the Iron People*, edited by D. Fedje and R. W. Mathewes, 77–95. Vancouver: UBC Press.

Williams, T. J., and D. B. Madsen. 2019. "The Upper Paleolithic of the Americas." *Paleoamerica* 5 (4): doi:10.1080/20555563.2019.1606668.

Williams, T., M. Collins, K. Rodrigues, W. Rink, N. Velchoff, A. Keen-Zebert, A. Gilmer, C. Frederick, S. Ayala, and E. Prewitt. 2018. "Evidence of an Early Projectile Point Technology in North America at the Gault Site, Texas, USA." *Science Advances* 4 (10): eaat4505.