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Introduction

1.1. Introduction

How people migrated to the Americas is still a complicated issue. Much of the current debate revolves around the lack of evidence along the Northwest Coast of the American continent. Though the 'Clovis first' model has officially been put to rest (Erlandson 2013; Ives et al. 2013; Mulligan and Kitchen 2013; D. G. Anderson, Bissett, and Yerka 2013), others are still sceptical of the coastal migration theory (Potter et al. 2017, 2018). Where are the sites? Underwater; now we just have to prove that. The Hakai Research Institute in partnership with the University of Victoria has focused on finding sites in areas where the sea level change would have been minimal, a hinge point. They have been able to locate two sites that have sensationalized this research in the last few years with dates older than 13,000 cal BP (McLaren et al. 2018; Muckle and Gauvreau 2017; McLaren et al. 2015; Letham et al. 2016). In Oregon, on the southern Northwest Coast (NWC) researchers unearth coprolites with human DNA that date to 14,000 to 14,270 cal BP[1] (12,300 ^{14}C years) at Paisley Caves (Gilbert et al. 2008). However, these recently uncovered archaeological sites are still not early enough for people to travel from Siberia to Chile at Monte Verde by 13,900 to 14,220 cal BP (Dillehay et al. 2008). We know that early people on the NWC are maritime adapted (Lindo et al. 2017; Erlandson et al. 2015; Braje et al. 2017; Sandweiss et al. 1998; Balter 2008; Q. Mackie, Fedje, and McLaren 2018). Therefore, the earliest sites should be along the coastline as it was when people migrated to the Americas. That coastline can be as much as -165 meters below modern sea levels in southeast Alaska.

1.2. Project Background

The Gateways to the Americas I and II projects, of which this research was a part of, aims to develop reliable methods to identify preserved archaeological sites on the continental shelf, supporting the coastal migration theory. Gateway to the Americas I was funded by the United States National Science Foundation (NSF)-Office of Polar Programs (OPP) (project number 0703980) to investigate the feasibility of testing the continental shelf in southeast Alaska for archaeological sites including one year of field research (Dixon and Monteleone 2011). Fieldwork was conducted in June 2010. Gateway to the Americas II was a multi-year project also funded by the US NSF-OPP (project number 1108367) including three years of fieldwork from 2012 through 2014 (Monteleone and Dixon 2018). The area covered by the Gateway to the Americas project encompassed the southern part of the Alexandra Archipelago from Prince of Wales Island west to the Pacific Ocean. This area is referred to as the 'study region' (figure 1-1).

The research presented here was originally the author's dissertation, a small part of the Gateway to the Americas projects. Here the focus is on Shakan Bay. Shakan Bay is one of nine identified sub-regions within the study region. Shakan Bay is identified as the 'study area' (figure 1-1). This research has continued to evolve since the completion of the author's PhD in 2013 (Monteleone 2013). What is presented, is an update including new analyses are more refined scales and using new and better technology.

The primary objectives of this research are to develop and test an archaeological predictive model designed to identify areas of high archaeological potential on the continental shelf of southeast Alaska. Sea level history and glacial geology suggest that the archaeological record prior to 10,600 cal BP (9,400 ^{14}C years) is submerged on the continental shelf in this region. To locate and test for sites older than 10,600 cal BP, it is essential to extend the archaeological record to the continental shelf in areas that were either unglaciated refugia or areas that were deglaciated during the interval between 16,000 and 10,500 cal BP. This research facilitates the exploration and the interpretation of the origins and character of early maritime adaptations along the NWC.

Archaeological sites document continuous occupation of southeast Alaska following sea level rise above modern levels around 10,600 cal BP. In southeast Alaska, a parallel study has been conducted by Carlson and Baichtal (2015; Baichtal and Carlson 2010) to investigate sites on raised marine terraces. This project has been extremely successful locating numerous sites between 6,000 and 10,600 cal BP. These early sites, which date between 13,300 and 10,000 cal BP, demonstrate that the region was occupied at times of lower sea level (Dixon 1999; R. J. Carlson and Baichtal 2015; R. J. Carlson 2007; Moss 2011, 2004; Wang et al. 2017). Coastal sites on the British Columbia, Canada (BC) mainland north of Vancouver Island have been identified dating to greater than 13,300 cal BP (Muckle and Gauvreau 2017). The expanding archaeological literature for pre-10,000 cal BP sites along the northern NWC supports the possibility of submerged coastal sites located on the continental shelf where maritime subsistence resources were abundant.

[1] cal BP = calibrated using Calib 6.0 (http://calib.qub.ac.uk/calib/calib.html) IntCal 09 (Reimer et al. 2009)

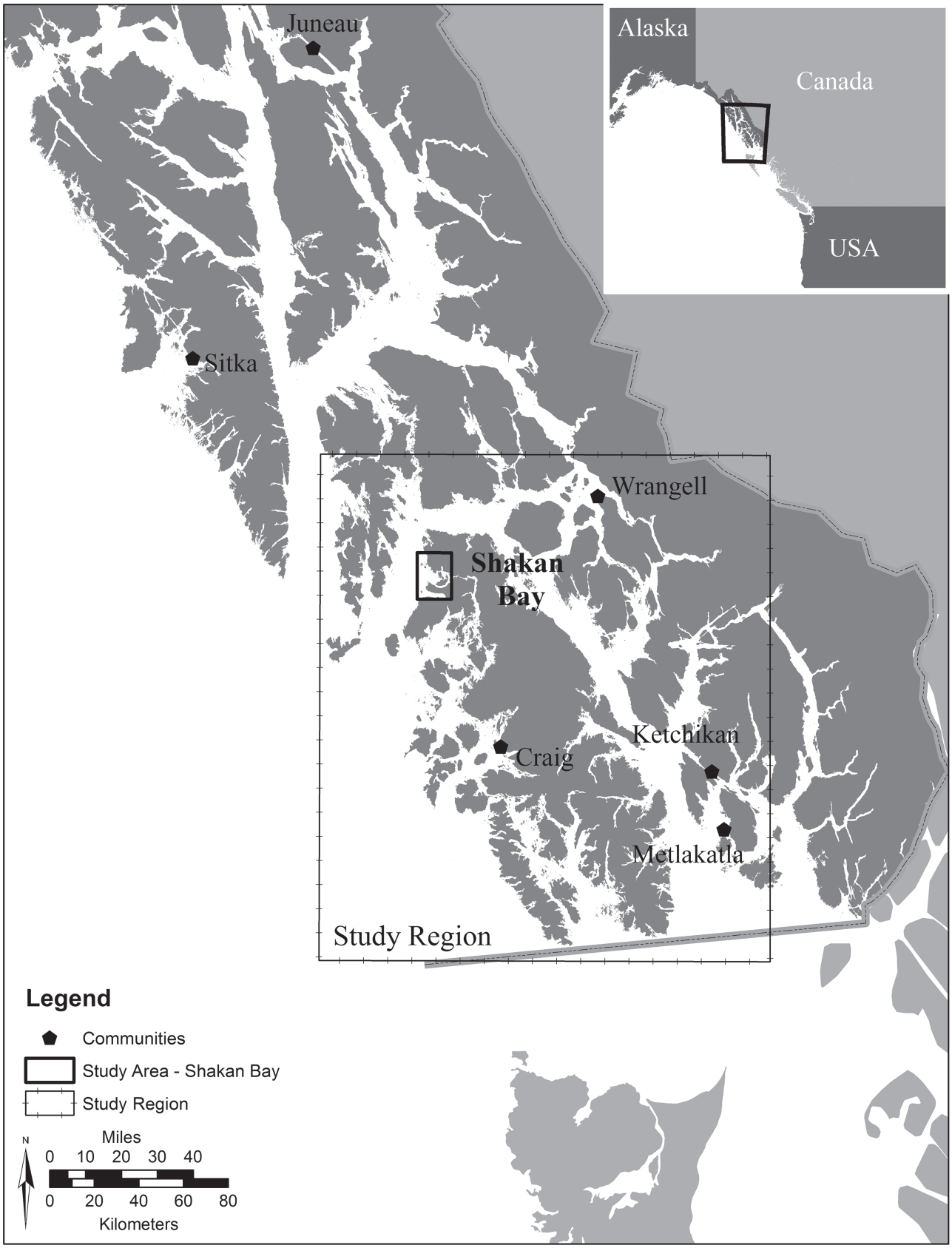

Figure 1-1. Map of study region and area.

The hypothesis this research is testing is that the archaeological record of Southeast Alaska extends to areas of the continental shelf that were submerged by post-Pleistocene sea level rise from 16,000 to 10,500 cal BP. People chose to live along the coast to exploit marine resources; they would have moved progressively landwards as sea level rose. An important goal for this project is to limit the area of the continental shelf for marine archaeological survey to increase the likelihood of

locating a submerged archaeological site. An archaeological land-use or high potential model was developed using the geographic information system (GIS) function of weighted overlay in ESRI's ArcGIS. The variables incorporated are slope, aspect, sinuosity, and distance from streams, lakes, tributary junctions, the coast, and known archaeological sites. The model was produced at 500 cal BP intervals. For the study region, the model was 10-meter resolution and spanned 10,500 to 16,000 cal BP. For the study area, a two-meter resolution model was developed from 11,000 to 16,000 cal BP.

This is the first project to explore the continental shelf in southeast Alaska and one of a few in North America (see chapter two: underwater archaeology). It was an exploratory project with a low probability of locating archaeological sites in the limited time available. This is partially due to:

1. The need to refine methods for survey and excavation,
2. The large expanse of the continental shelf within the study region,
3. The scarcity of early hunter-gather archaeological sites globally,
4. The probable small size of possible sites, and
5. The expanses of time since these sites were deposited into the archaeological record.

Though the underwater environment can provide excellent preservation for organic and lithic artefacts, taphonomic processes will limit the length of time an archaeological site will remain in an identifiable state on the seafloor. The predictive model is intended to focus the survey areas to high potential locations. These high potential areas can be generalised as 'flat areas near freshwater and the coast'; or, areas where past people would have used the landscape for resource extraction. Potential problems include the scarcity of available input information (more detailed bathymetry and topography would produce a more precise model), changes in the environment over the last 16,000 years (including storms and tectonic events which may have destroyed or moved possible archaeological sites), difficulties during marine geophysical surveys and sampling, and the vast area to be surveyed and sampled. The study region is over 45,000 km^2; the study area is 1100 km^2.

A quick note about tectonic processes: though southeast Alaska has two major faults, the Queen Charlotte-Fairweather fault and the Chatham Strait fault, tectonic processes are not incorporated into the model. Tectonic events can cause several meters change in elevation over local areas; these are not predictable. However, as these changes in elevation would be reflected in the sea level, tectonic changes are incorporated as part of the overall land-sea level reconstruction.

1.3. Study Region and Study Area

The study region is the southwestern Alexander Archipelago in southeast Alaska (figure 1-1) in the northern NWC of North America. Recent research indicates southeast Alaska and western British Columbia were largely glaciated beginning around 21,000 to 17,000 cal BP (18,000 to14,000 ^{14}C years) albeit with refugia (unglaciated areas capable of supporting humans) existing along the coast (Carrara et al. 2003; Carrara, Ager, and Baichtal 2007; Clague, Mathewes, and Ager 2004; Shugar et al. 2014). By 16,000 cal BP (13,500 ^{14}C years), much of the region was deglaciated and ecologically viable for human habitation, although a few valley glaciers from the Coast Mountain Range still extended to the coast (Carrara, Ager, and Baichtal 2007; Clague, Mathewes, and Ager 2004, 94; Mathews 1979; Shafer et al. 2010). Sea level reconstructions for Haida Gwaii, formerly named the Queen Charlotte Islands (Q. Mackie, Fedje, and McLaren 2018; Fedje et al. 2018) and southeast Alaska (Dixon and Monteleone 2014; R. J. Carlson and Baichtal 2015; Monteleone 2013) indicate sea level has risen approximately 165 m since the last glacial maximum, briefly rising above modern sea level in many areas around 10,600 cal BP. Although the character of the NWC continental shelf within the study area varies, it extended from three to 50 km (one to 30 mi) seaward from the mainland coast prior to 10,600 cal BP.

Within the study region, Shakan Bay was identified as a high potential location for archaeological sites. The larger Gateway to the Americas projects has identified several study areas for survey. These include Keku Strait, the Gulf of Esquibel, and Suemez Island. Keku Strait was selected based on a report from a local fisherman of an artefact recovered from the seafloor. Suemez Island was selected based on its proximity to a known obsidian source and palaeoenvironmental reconstructions that indicate that the southern cove may have been part of larger ice-free refugium during the LGM (Carrara et al. 2003; Carrara, Ager, and Baichtal 2007; Moss and Erlandson 2001). Shakan Bay was identified because it would have been an intertidal estuary from at least 12,000 to 13,000 cal BP and a series of connected lakes from 13,000 cal BP. If the area were not covered in glaciers during the LGM, the connected lakes would have remained as the seafloor drops quickly and steeply into Sumner Strait. These past environments would have been highly productive for past peoples similar to the Ertebølle culture in northern Europe. In addition, Shakan Bay is sheltered by Baranof Island to the west and does not receive the full fetch of the Pacific Ocean, but Sumner Strait, to the west, is deep and would have support diverse marine resources. Because there are elevation changes within the bay that allows for hills, valley, and depressions to form, Shakan Bay would have been an excellent place to live at all sea levels.

1.4. The GIS Model

High potential areas are defined based on the synthesis and interpretation of archaeologically and ethnographically documented land-use patterns applied to reconstructions of the submerged landscape. The model incorporates both inductive, utilising known archaeological site data,

and deductive, utilising anthropological theory and the ethnographic record, types of modelling (Verhagen and Whitley 2012). The scale of measurement for this analysis are interval or ratio, and both the analytic (archaeological) and the systemic (dynamic living system) contexts were analysed to develop the model (Kohler 1988, 35–37; Schiffer 1972).

The analytic units are the ranked valued for each of the model variables. The synthetic units are the larger groupings of the variables. These are slope, aspect, water variables, and sites. Slope and aspect defined as specific location properties, based on rank. Water variables include distance from streams, lakes, the coast, and tributary junctions. This variable type not only provides access to freshwater but also is the main location for dietary resources and for transportation. Sinuosity is incorporated into the synthetic unit because it is combined with distance from the coast. Sinuosity reflects the amount of coastline available from a location. Increased sinuosity often indicates more resources available (A. P. Mackie and Sumpter 2005). The last synthetic unit sites and incorporates distance from known archaeological sites. This increase the potential for archaeological sites near known sites Binford's (1980) logistical collectors, whereby people move to nearby camps, stations, and caches. People exploit resources near each of these site types. Camps, stations, and caches then become sites and new sites will be 'near' other sites or camps. This is also referred to as clustering.

Summary statistical are a means to estimate appropriate weights for theoretically derived variables (Kvamme 2006, 12). Statistics were generated from known archaeological site locations. These statistics were then qualitatively compared to ethnographic accounts and general anthropological theory. For example, a theory such as 'people live near freshwater' was compared to the median distance from streams, lakes, and tributary junctions. Because the median values for lakes and streams were closer to 500 m than 100m, the highest rank was assigned to the 500 m buffer for these variables. This means that people still live near water, but more often, they were a short distance from these sources of freshwater. Based on these qualitative assessments, the variables in the model were ranked and were weighted out of 100 per cent. This model uses inductive modelling techniques to derive deductive variables (Kvamme 2006, 12).

1.5. Peopling of the Americas

This model has the potential to test and provide evidence for the coastal migration theory. This theory postulates that the NWC of the Americas was a possible route that the first Americas took when migrating to the New World (Dixon 1993, 1999, 2011a, 2013a, Fladmark 1975, 1979; Gruhn 1994; Heusser 1960; Braje et al. 2017; Erlandson et al. 2015). It is hypothesised that these migrants would have used watercraft to travel along the coastal areas of the north Pacific Rim that are now submerged by post-Pleistocene sea level rise. This means the continental shelf of southeast Alaska may contain archaeological sites from the earliest settlers in the Americas.

The 'ice-free corridor' proposed between the continental glaciers was not viable for human occupation until 13,000 cal BP (11,000 ^{14}C years). This has been corroborated by several independent researchers from different disciplines including archaeology, geology, and palaeontology (Arnold 2006; Dixon 2011a; Mandryk et al. 2001; Wilson 1996; Potter et al. 2018, 2017; Freeman 2016). As Freeman (2016) points out, this late date does not mean that the deglaciated corridor should not be investigated as a migration route. Evidence for the Atlantic coastal migration is still lacking genetic and linguistic support (Stanford and Bradley 2012; Collins et al. 2013). This leaves the coastal migration theory as a leading theory in explaining the first colonisation of the Americas. This is supported by Wheat's (2012) survey of scholars researching the peopling of the Americas where 86 per cent favoured the coastal migration theory contributing to the initial peopling of the Americas. All major areas along the Pacific Coast of the Americas were occupied by at least 13,000 and 11,500 cal BP. These occupations are contemporary with Folsom and Clovis sites in the continental interior (Erlandson, Moss, and Des Lauriers 2008; Dixon 2011a).

1.6. Northwest Coast Maritime Adaptations

Along the NWC, the timing of intensification of maritime adaptation is an ongoing discussion, specifically if the early inhabitants were full maritime adapted and exploiting a maritime culture, or if they developed these technologies after moving to the coast. A maritime culture is adapted to the sea and acquires the majority of its dietary and economic needs from the sea (McCartney 1974, 158–59). The non-maritime adapted theory assumes that people moved into the NWC from riverine environments and then later developed technology for salmon harvesting and deep-sea fishing. This maritime culture was then only fully developed by approximately 5800 calendar years ago (Borden 1950, 1951; Fladmark 1979; Kroeber 1939; Potter et al. 2017; Moreno-Mayar et al. 2018).

The fully adapted maritime view assumes the cultures that migrated into the NWC were already utilising the sea (Borden 1975; A. Cannon 1998; Drucker 1955; Q. Mackie, Fedje, and McLaren 2018; Fedje et al. 2001). This theory is synergistic with the coastal migration theory. Early evidence for maritime adapted cultures along the Pacific Coast can be found in the Channel Islands by 13,000 cal BP (Moss 2011; Rick et al. 2005; Erlandson et al. 2011). Similar to some of the Channel Island evidence, there is overwhelming evidence on the Northern NWC of travel by boat. On Haida Gwaii, there are several sites dating to 12-13,000 cal BP when Haida Gwaii would have been an island chain. Obsidian recovered from OYKC dating to older than 10,000 cal BP is sourced to Suemez Island, a distance that could not have been travelled by land 10,000 cal years ago (Dixon 1999, 2013a; Dixon et al. 1997; Lee 2007). Early maritime adaptation is supported by recent

evidence including site location models on Haida Gwaii (A. P. Mackie and Sumpter 2005), human remains from On Your Knees Cave with an isotopic signature of a marine carnivore (Lindo et al. 2017; Barrie and Conway 1999), and consistency in salmon harvesting since at least 7000 cal BP at Namu (A. Cannon and Yang 2011).

The kelp highway is a ring around the northern Pacific, from Japan through California/Mexico, where similar resources could be exploited (Erlandson et al. 2015, 2007; Erlandson 2013; Braje et al. 2017). Coastal migration theory along the kelp highway would have provided a linear migration corridor with few barriers to maritime peoples. This path would have had abundant resources in the nearshore, estuarine, riverine, and terrestrial ecosystems that would have allowed populations to rapid grow and provide demographic pressures to fuelled exploration and colonisation (Erlandson et al. 2015, 408). This route would have been open through to northern Vancouver Island by 16,000 cal BP, where a 400 km stretch of coast was still glaciated (Dixon 2013b). Based on the available evidence, the coastal migration theory is the reasonable choice; but Potter and colleagues (2017, 2018) still need more evidence that early people along the NWC were maritime adapted. This research aims to gather more data about the early NWC and maritime adaptations.

1.7. How Does This Relate to Other Projects?

Chapter two reviews the history and other projects where predictive models are utilised and where underwater archaeology is employed. This research is rare that it utilises both a formalized predictive model and underwater archaeological methods to locate submerged archaeological sites. Other underwater archaeological predictive modelling projects that have developed interval/ratio scale measurements using inductive and/or deductive methods include Barbra and Roberts in 1979 for the northeast United States and Muche's 1981 model for Santa Monica Bay, California. Many underwater archaeology projects include aspects of predictive modelling including mapping specific environmental/geologic variables and sea level changes. Numerous projects reconstruct paleoenvironments to identify locations of high probability for archaeological sites. However, these projects are infrequently or discretely using the predictive modelling literature as a source to narrow the search for sites on the seafloor, i.e. they are using inductive or deductive reasoning but not developing interval or ratio scale measurements.

Archaeological predictive modelling is an extensive sub-field within archaeology. The methods and theory behind archaeological predictive modelling have expanded extensively with the ready availability of GIS. Options and possibilities of open source GIS software make spatial analysis available to everyone, not just funded projects. With the introduction of ArcPro, an ESRI product for analysis and mapping, processing times are getting even shorter allowing for analyses that are more complex. ArcPro is the first ERSI tool to utilise 64-bit technology and multiple computer cores. This project is somewhat unique in the resolution and scale of analysis. Most analyses at two-, five- or 10-meter resolution are not at the scale of 45,000 km^2. In an earlier iteration of the model, the 10-meter resolution was actually too large for several analyses (Monteleone 2013). Some steps in this analysis took weeks to complete because of the computational limits during the first production prior to ArcPro.

1.8. Structure of This Book

Chapter two presents the theoretical background underlying this research. It overviews landscape theory as high-level theory, archaeological land-use or high potential modelling as middle-range theory, and GIS (geographic information systems) and underwater archaeology as low-level theory. Chapter three reviews the geographic and geologic background for southeast Alaska, the Alexander Archipelago, and Shakan Bay. Chapter four discusses the archaeological and ethnographic literature for southeast Alaska and the northern Northwest Coast (NWC) in terms of research questions. The region's three Native American ethnographic groups each are reviewed in relation to traditional land-use, seasonal round, social structure, and economic orientations. Chapters five, six, and seven, present the high potential model, and its statistical and geophysical testing. The results of two field seasons of marine geophysical survey and subsurface testing are reported in chapter seven. Chapter eight summarises archaeological sites that are older than 9,000 cal BP on the northern NWC, their relevance to this research, and how these sites are located in relation to the land-use model. Finally, chapter nine discusses the geologic history of Shakan Bay based on the multibeam and ROV results, the implications of model resolution on the results, the survey results and future directions.