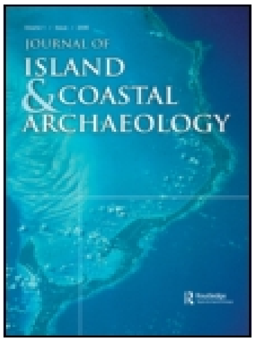

Routledge
Taylor & Francis Group

The Journal of Island and Coastal Archaeology

ISSN: 1556-4894 (Print) 1556-1828 (Online) Journal homepage: http://www.tandfonline.com/loi/uica20

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To cite this article: Amanda K. Taylor , Julie K. Stein & Stephanie A. E. Jolivette (2011) Big Sites, Small Sites, and Coastal Settlement Patterns in the San Juan Islands, Washington, USA, The Journal of Island and Coastal Archaeology, 6:2, 287-313, DOI: 10.1080/15564894.2010.504614

To link to this article: http://dx.doi.org/10.1080/15564894.2010.504614

Published online: 02 Aug 2011.

Journal of Island & Coastal Archaeology, 6:287–313, 2011

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2010.504614

Big Sites, Small Sites, and Coastal Settlement Patterns in the San Juan Islands, Washington, USA

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ABSTRACT

In this article we examine prehistoric coastal settlement patterns in the San Juan Islands, Washington by integrating dating work with erosion studies, accumulation rate analysis, and paleoenvironmental data. Dating work draws on previously published radiocarbon dates from big sites and new radiocarbon dates from both big and small sites. We find that an increase in abundance of sites at 650–300 cal BP is amplified but not created by site destruction caused by coastal erosion. We hypothesize that prehistoric peoples established more permanent settlements on the San Juan Islands after 650 cal BP during a wetter climate regime. By calculating accumulation rates for shell midden sites and considering climate change and access to freshwater, we test this hypothesis and discuss differences between temporal patterns in the San Juan Islands and southwestern British Columbia.

Keywords shell midden, settlement patterns, Coast Salish, Gulf of Georgia, coastal erosion

INTRODUCTION

Coastal shell middens present both great potential and profound challenges in reconstructing prehistoric regional settlement patterns. The presence and extent of shell middens can be determined through minimally invasive testing, and shells allow direct dating of archaeological deposits; however, sea level shifts, stratigraphic complexity,

Received 7 April 2010; accepted 24 June 2010.
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and vulnerability to erosion and residential and commercial development complicate investigations of these sites. Regional chronologies often focus on big sites with visible and intact stratigraphy and do not include dates from small sites. In this paper, we discuss our efforts to overcome these issues in establishing settlement patterns for the San Juan Islands, Washington. This study includes published data on big shell middens and new data on both big and small shell middens obtained through survey and testing by the San Juan Islands Archaeological Project (SJIAP) from 2005 to 2009. Here we define "small" shell middens as those smaller than 3,000 square meters, and "big" shell middens as those larger than 3,000 square meters.

Dating work completed at 50 sites in the San Juan Islands indicate the highest frequency of dates occurred at 650–300 cal BP. We hypothesize that this peak reflects an increase in permanent settlement on the islands, potentially a consequence of a shift to a cooler and wetter climate at the end of the Fraser Valley Fire Period and subsequent Medieval Warm Period. We systematically consider the effect of erosion on this temporal pattern and examine several lines of evidence to address the hypothesis, including accumulation rates of shell middens and paleoenvironmental data.

Several Gulf of Georgia studies suggest an increase in population density or sedentism during the Marpole phase at ca. 2500–1500 cal BP (e.g., Croes and Hackenberger 1988; Lepofsky et al. 2005; Matson 1983, 1985; Matson and Coupland 1995) but do not emphasize empirical evaluation of settlement pattern shifts. Our finding that the number of sites on the San Juan Islands increases after the Marpole phase and our focus on temporal and spatial patterns at a landscape scale represent a departure from this research. By considering accumulation rates and environmental data specific to the San Juan Islands environment, we address the significance of differences between the San Juan Islands record and settlement pattern research in southwestern British Columbia.

STUDY AREA

The San Juan and Gulf Islands are part of an archipelago of over 400 islands in the Salish Sea between Vancouver Island and the Washington and British Columbia coasts. They lie within the Gulf of Georgia culture area which also encompasses the Lower Fraser River, the Strait of Georgia, northern Puget Sound and southeastern Vancouver Island (Stein 2000; Suttles 1990). The San Juan Islands lie within the traditional territories of Native communities of Coast Salish speaking groups including the Lummi Nation, the Samish Indian Nation, the Swinomish Nation, the Songhees Nation, and the Saanich Nation (Figure 1).

Today, the Northwest Coast is characterized by a mild maritime climate with cool summers and wet and mild winters due to the ocean to the west and prevailing westerly winds; however, the San Juan Islands have drier summers than the mainland due to the rain shadow effect of the Olympic Mountains. The island landscape is characterized by mixed coniferous forests, open prairies, and rocky and sandy beaches. Mixing of cold ocean waters of high salinity with brackish surface waters supports a productive and diverse marine environment with rich kelp forests and eelgrass beds. During prehistoric times, inhabitants hunted terrestrial and sea mammals and relied heavily on abundant fish and shellfish (Stein 2000; Suttles 1990; Wessen 1986). Shell middens are typically dominated by littleneck clam (*Protothaca staminea*), butter clam (*Saxidomus giganteus*), and blue mussel (*Mytilus trossulus*). The San Juan Islands offer a fishing advantage in that salmon (*Oncorhynchus* spp.) returning to the Fraser River to spawn must pass through narrow passages between the islands. The lack of freshwater, however, presented a challenge to long-term human occupations.

COASTAL SETTLEMENT PATTERN RESEARCH

Settlement pattern research no longer drives American archaeology as it did in the 1960s

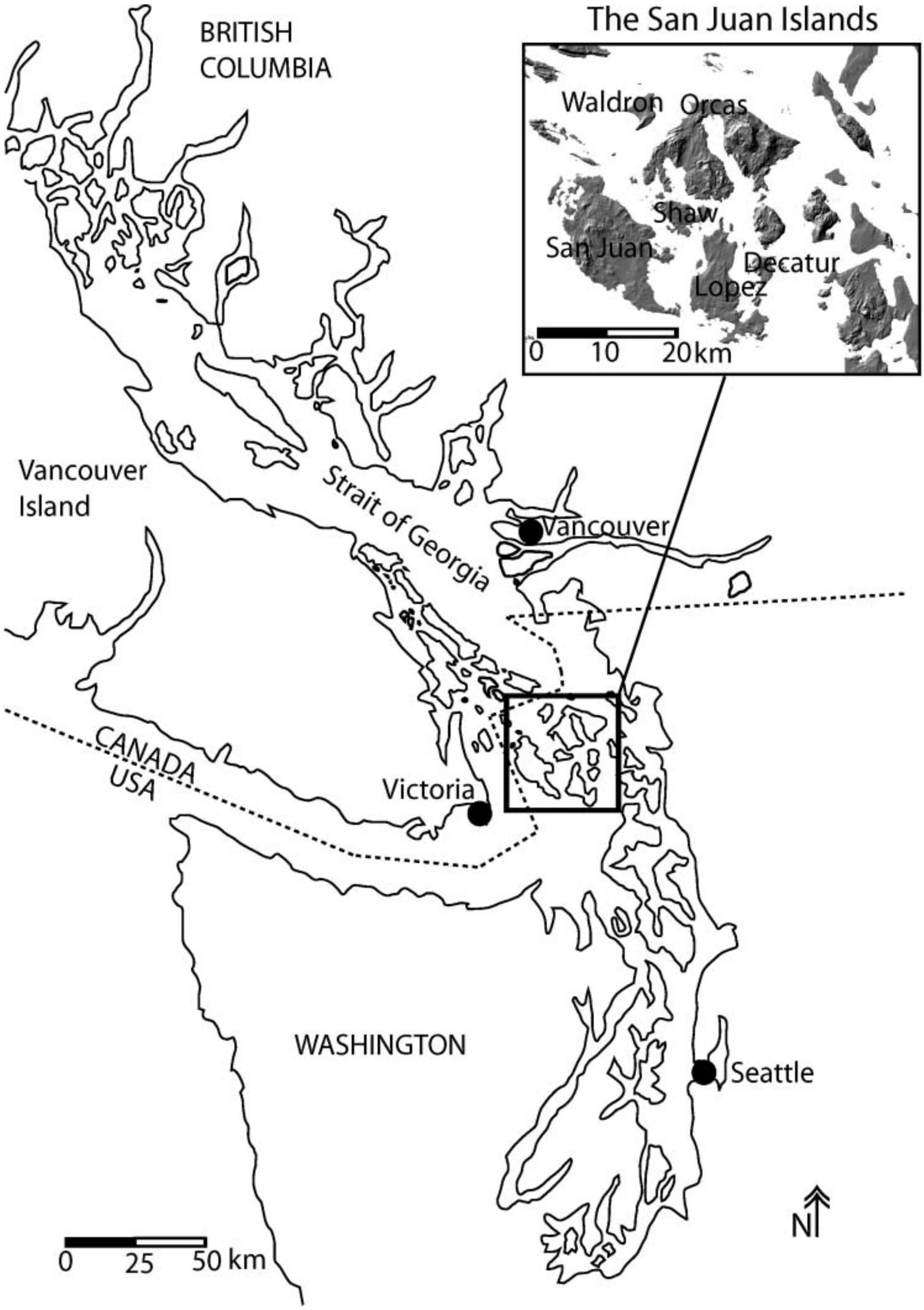

Figure 1. *Map of the San Juan Islands, Washington with the Gulf of Georgia region as defined by Lepofsky et al. (2005:269).*

and 1970s, but it continues to encompass a diverse and productive subset of projects that range from cultural resource databases to investigations of urbanism and demographic change (Kowalewski 2008). Coastal settlement pattern studies all over the world establish baseline information about spatial and temporal patterns in human occupation that are essential to addressing more specific questions related to subsistence strategies, the development of social complexity, territoriality, and other topics.

Studies within the last decade show coastal archaeologists focusing on small sub-regions and examining chronological data in the context of environmental, geomorphological, and archaeological data. Detailed work in California investigating site size, type, and distribution relative to resources has been undertaken on the central coast (Byrd and Reddy 1999), the Channel Islands (Kennett 2005; Rick et al. 2005), and the San Francisco Bay area (Luby et al. 2006). Arctic researchers address sea level change and human-environment interactions on Newfoundland (Bell and Renouf 2003; Renouf 1999;), the Kuril Islands (Fitzhugh et al. 2002), and the Kodiak Archipelago (Fitzhugh 2003). Many of the chapters in a recent edited volume on shell middens by Milner et al. (2007) demonstrate the potential of a poorly preserved archaeological record when considered alongside other landscape-scale datasets within sub-regions of Atlantic Europe (Anderson 2007; Bjerck 2007; Fano 2007; Milner and Woodman 2007; Wickham-Jones 2007). On the other side of the Atlantic, Bernstein (2006) analyzes long-term continuity in settlement patterns in coastal New York and New England.

Several Northwest Coast settlement studies focus on sub-regions and emphasize innovative approaches to settlement pattern research. Using the Oregon Coast as a case study, Erlandson and Moss (1999) advocate radiocarbon dating samples from eroding banks to manage sites, salvage information, and investigate temporal trends in settlement, environment, and technology. Fedje and Christensen (1999) survey for sites on ancient shorelines in southern Haida Gwaii allow for a better understanding of the relationship between site location and sea level change. Cannon (2000a, 2000b) uses auger testing to investigate temporal patterns in site use and fishing in the vicinity of the Namu site in British Columbia. Bathurst (2005) demonstrates the potential of paleoparasites as an index of high population density on the central coast of British Columbia.

In the northern Gulf of Georgia, Lepofsky et al. (2005) present a new perspective on Gulf of Georgia dates and settlement patterns by considering paleoenvironmental research. By summing the probability plots of 345 Gulf of Georgia radiocarbon dates from the Canadian Archaeological Radiocarbon Database, the authors find a peak in date frequency at 2400–1200 cal BP. Hypothesizing that this peak indicates an increase in population or increased dispersal of the population across the landscape, they suggest that settlement patterns changed in large part due to climate. During a drier climate regime at 2400–1200 cal BP, the Fraser Valley may have become a center of social and economic networks due to better access to freshwater and food resources than surrounding areas. Prior to dating work by the SJIAP in 2005, no intensive dating or settlement pattern studies had been applied in the San Juan Islands sub-region of the Gulf of Georgia. In our research, we incorporate Erlandson and Moss's (1999) focus on dating eroding sites, Cannon's (2000a, 2000b) auguring techniques, and Lepofsky et al.'s (2005) focus on paleoenvironmental data.

THE SAN JUAN ISLANDS ARCHAEOLOGICAL PROJECT

Beginning in 2005, the San Juan Islands Archaeological Project (SJIAP) began a shell midden survey, sampling shell midden sites to investigate settlement patterns in the San Juan Islands, conduct erosion studies, and engage in public outreach. The survey area included San Juan County, Washington and a single site from western Skagit County, Washington. In total we investigated 58 sites and dated 41 sites on the islands. Most of this work took place on private land, but some sites were on land managed by Washington State Parks, the Washington State Department of Natural Resources, land trusts, nature preserves, and San Juan Island National Historical Park. Previously recorded and unrecorded sites were chosen for sampling largely based on ability to gain landowner permission to access the property. Despite an unconventional sampling strategy, we obtained a relatively even distribution of sites across the four larger islands, San Juan, Orcas, Lopez, and Shaw, as well as samples from several of the smaller islands (Figure 2).

The goal of sampling at each site was to obtain as much information as possible about the duration of site occupation. Because shell middens accumulate by the basket load and the entire site may not have been occupied simultaneously (Carlson 1983:30; Stein et al. 2003), sampling in just one area may not be sufficient to date the site. To address this issue, we sampled from several areas across most sites. We also sampled from throughout the stratigraphic profile to determine the accumulation rate of the shell deposits. Number and locations of samples collected at each site was determined by site size, configuration, and stratigraphy. At small sites where no shell deposits extended beyond the eroding bank, samples were taken directly from the bank where stratigraphy was visible. Such a strategy is time-effective and minimizes impact to the site. Each sample consisted of approximately a one liter bag of sediment and shell. We recorded sample locations using survey grade GPS units and created site maps on file at the Burke Museum of Natural History and Culture and the Washington State Department of Archaeology and Historic Preservation.

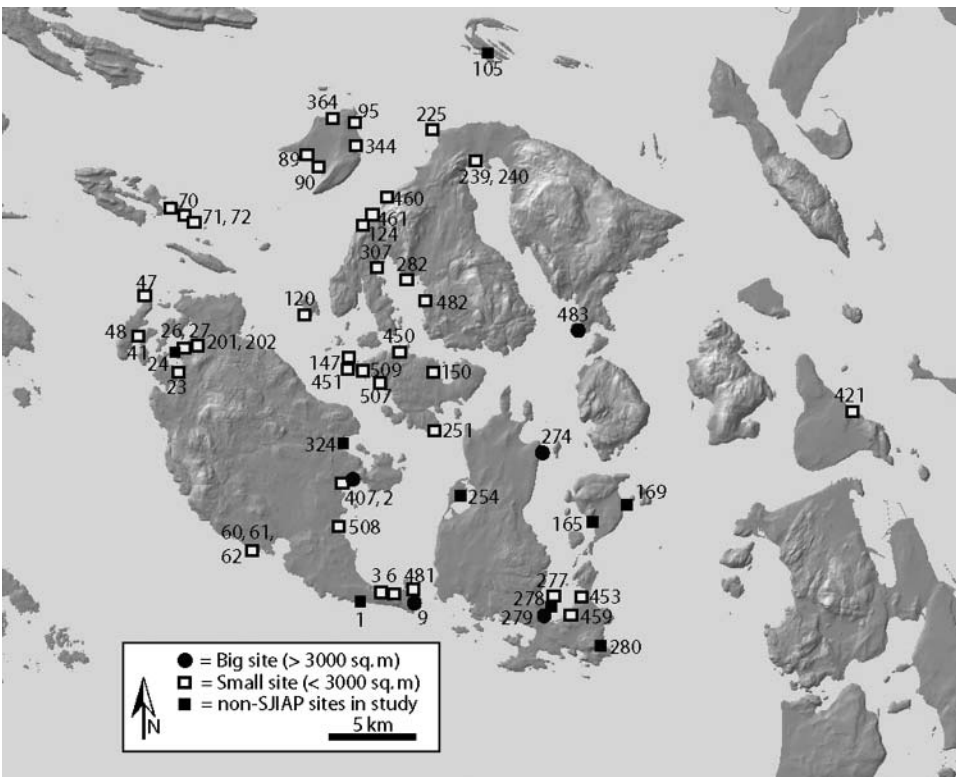

__Figure 2.__ Map showing sites (with site numbers) included in the SJIAP survey.

(a) (b)

Figure 3. *Augering technique. (Color figure available online.)*

At larger sites with substantial midden areas that extended beyond the eroding bank, we used an auger to take additional samples (Figure 3). There are several advantages to augering. As noted by Stein (1986:523), coring and augering are effective, nondestructive, and inexpensive means to determine the stratigraphic context, depth, and volumetric and areal extent of subsurface archaeological deposits. Augering allows for quick collection of bulk samples of shell, sediment, and charcoal for dating purposes and impacts a smaller portion of the site than shovel testing. We used a Dutch (Eijkelkamp) open-sided auger that works effectively in shell middens. It is a portable rod with a 4-inch diameter bit that is manually twisted into the ground in approximately 20 cm intervals. Midden material caught in the bit is only minimally damaged and mixed as the auger is twisted and extracted. Material that fell to the bottom of the auger hole during extraction was removed from the hole before taking the next sample to avoid mixing shell deposits of different ages. Because some middens may have accumulated shoreward over time, using previously published dates from excavations and dating shell from auger samples ensured that temporal patterns were not skewed by sample location.

DATING RESULTS

From 2005 to 2009 the SJIAP obtained a total of 84 dates from 41 sites (Table 1). These dates were added to a database of 145 previously published dates from excavations at eight sites on the San Juan Islands from Bovy (2005), Daniels (2009), Deo et al. (2004), Stein et al. (2003), and Walker (2003). Three dates were also contributed by Drayton Archaeological Research (Baldwin, personal communication 2007), bringing the total to 50 dated sites in the San Juan Islands. Dating work for the SJIAP was conducted by Beta Analytic. The marine reservoir correction used for the shell follows values established by Deo et al. (2004) and refined by Daniels (2009). At 0–600 cal BP and 1000–3000 cal BP, the regional correction value (ΔR) was 400 years. At 600–1000 cal BP the ΔR was 0 years, likely due to a decrease in upwelling offshore. Unless otherwise noted, dates are presented in calibrated years before present (cal BP).

That there are no sites in the San Juan Islands older than 4000 cal BP indicates that inundation and erosion associated with sea level change has destroyed a large part of the record. At 11,700 radiocarbon years before present (RCYBP), sea level was over six meters below its modern level. It dropped to 30 meters below modern sea level by 11,000 RCYBP, possibly reaching 60 meters below sea level by 10,000 RCYBP due to isostatic movement (Clague 1981; Dethier et al. 1996; Mosher and Hewitt 2004; Wilson et al. 2009). At 5000 RCYBP, relative sea level was within a few meters of modern sea level, and may have been within a meter of its present

Table 1. **Marine shell dates obtained by the SJIAP (2005–2009). Standard radiometric dates are marked with an asterisk in the Beta analytic # column, all others are AMS dates.**

Site	Sample ID	Beta Analytic #	Material	Measured C-14 age (RCYBP)	$^{13}C/^{12}C$ ratio	Conventional age	2σ Calibrated results (cal BP)	Depth (cm below surface)	Core #
45-SJ-2	2.3.10–20.S	210403	Shell	2270 ± 40	−2.4 o/oo	2640 ± 40	1720–1950	10–20	3
45-SJ-2	2.3.40–50.S	210404	Shell	2180 ± 40	−2.3 o/oo	2550 ± 40	1620–1850	40–50	3
45-SJ-3	3A.1.40–50.S	223234	Shell	2280 ± 40	−2.6 o/oo	2650 ± 40	1740–1960	40–50	1
45-SJ-3	3A.1.0–20.S	223235	Shell	2250 ± 40	+0.5 o/oo	2670 ± 40	1770–1990	0–20	1
45-SJ-3	3C.4.0–20.S	223236	Shell	820 ± 40	−2.2 o/oo	1190 ± 40	320–500	0–20	4
45-SJ-3	3C.4.50–70.S	223237	Shell	820 ± 40	−2.6 o/oo	1190 ± 40	320–500	50–70	4
45-SJ-6	6A.1.10–20.S	234093	Shell	810 ± 40	−2.8 o/oo	1170 ± 40	310–480	10–20	1
45-SJ-9	9.1.40–50.S	259811	Shell	910 ± 40	−1.3 o/oo	1300 ± 40	450–600	40–50	1
45-SJ-23	23.2.20–40.S	234094	Shell	1580 ± 40	−2.3 o/oo	1950 ± 40	1000–1220	20–40	2
45-SJ-26	26.1.0–10.S	234095	Shell	580 ± 40	−2.3 o/oo	950 ± 40	490–630	0–10	1
45-SJ-27	27.1.20–40.S	223238	Shell	930 ± 40	−1.5 o/oo	1320 ± 40	470–610	20–40	1
45-SJ-27	27.1.110–130.S	223239	Shell	1140 ± 40	−0.9 o/oo	1540 ± 40	630–770	110–130	1
45-SJ-47	47.1.20–30.S	259803	Shell	700 ± 40	−1.0 o/oo	1090 ± 40	260–480	20–30	1
45-SJ-60	60.2.90.S	267091	Shell	720 ± 40	−0.7 o/oo	1120 ± 40	280—450	90	2
45-SJ-61	61.4.0–10.S	259815	Shell	730 ± 40	−0.2 o/oo	1140 ± 40	290–470	0–10	4
45-SJ-70	70.3.50–60.S	259816	Shell	1030 ± 40	−0.6 o/oo	1430 ± 40	530–660	50–60	3
45-SJ-70	70.4.30–45.s	267092	Shell	2160 ± 40	−1.3 o/oo	2550 ± 40	1620–1850	30–45	4
45-SJ-71	71.1.45–50.S	259814	Shell	980 ± 40	−0.9 o/oo	1380 ± 40	510–640	45–50	1
45-SJ-72	72.2.65–85.S	259807	Shell	1030 ± 40	−1.1 o/oo	1420 ± 40	530–660	65–85	2
45-SJ-89	89.2.20–40.S	259810	Shell	770 ± 40	−0.6 o/oo	1170 ± 40	310–480	20–40	2
45-SJ-95	95.1.20–40.S	267089	Shell	620 ± 40	−1.0 o/oo	1010 ± 40	130–360	20–40	1
45-SJ-120	120.1.0–10.S	259802	Shell	520 ± 40	−1.9 o/oo	900 ± 40	450–600	0–10	1
45-SJ-124	124.1.0–20.S	223240	Shell	650 ± 40	−1.3 o/oo	1040 ± 40	150–160, 190–410	0–20	1

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Table 1. **Marine shell dates obtained by the SJIAP (2005–2009). Standard radiometric dates are marked with an asterisk in the Beta analytic # column, all others are AMS dates. *(Continued)***

Site	Sample ID	Beta Analytic #	Material	Measured C-14 age (RCYBP)	$^{13}C/^{12}C$ ratio	Conventional age	2σ Calibrated results (cal BP)	Depth (cm below surface)	Core #
45-SJ-147	147.1.10–25.S	218138	Shell	980 ± 50	−1.2 o/oo	1370 ± 50	490–640	10–25	1
45-SJ-147	147.1.50–60.S	218139	Shell	930 ± 40	−0.7 o/oo	1330 ± 40	480–620	50–60	1
45-SJ-147	147.3.0–20.S	218140	Shell	810 ± 60	−1.2 o/oo	1200 ± 60	300–520	0–20	3
45-SJ-147	147.4.0–20.S	210407	Shell	870 ± 40	−2.3 o/oo	1240 ± 40	400–540	0–20	4
45-SJ-147	147.4.50–70.S	218141	Shell	890 ± 40	+0.4 o/oo	1310 ± 40	460–610	50–70	4
45-SJ-147	147.4.75–87.S	210408	Shell	680 ± 40	−0.1 o/oo	1090 ± 40	260–430	75–87	4
45-SJ-147	147.7.5–20.S	218142	Shell	610 ± 50	−1.4 o/oo	1000 ± 50	80–370	5–20	7
45-SJ-147	147.7.65–78.S	218143	Shell	1000 ± 60	−3.7 o/oo	1350 ± 60	470–650	65–78	7
45-SJ-147	147.7.95–117.S	218144	Shell	880 ± 40	−0.6 o/oo	1280 ± 40	430–560	95–117	7
45-SJ-147	147.12.0–14.S	218145	Shell	890 ± 40	−0.5 o/oo	1290 ± 40	440–570, 580–600	0–14	12
45-SJ-147	147.12.50–65.S	218146	Shell	970 ± 40	−1.7 o/oo	1350 ± 40	490–630	50–65	12
45-SJ-147	147.13.20–35.S	218147	Shell	940 ± 40	−1.5 o/oo	1330 ± 40	480–620	20–35	13
45-SJ-150	150.1.10–20.S	223241*	Shell	670 ± 30	−2.8 o/oo	1030 ± 30	150–160, 200–380	10–20	1
45-SJ-150	150.1.70–85.S	223242	Shell	710 ± 50	−1.0 o/oo	1100 ± 50	260–450	70–85	1
45-SJ-201	201.2.0–20.S	223243	Shell	1040 ± 40	−0.4 o/oo	1440 ± 40	540–670	0–20	2
45-SJ-201	201.2.60–80.S	223244*	Shell	1180 ± 60	−1.4 o/oo	1570 ± 60	630–870	60–80	2
45-SJ-202	202.1.0–20.S	234092	Shell	1180 ± 40	−24.0 o/oo	1200 ± 40	330–500	0–20	1
45-SJ-225	225.2.10–20.S	259812	Shell	730 ± 40	−1.0 o/oo	1120 ± 40	280–450	10–20	2
45-SJ-239	239.1.20–30.S	259813	Shell	1950 ± 40	−1.2 o/oo	2340 ± 40	1380–1600	20–30	1
45-SJ-251	251.3.0–20.S	210409	Shell	790 ± 40	−1.2 o/oo	1180 ± 40	320–490	0–20	3
45-SJ-251	251.3.40–60.S	210410	Shell	790 ± 40	−2.1 o/oo	1170 ± 40	310–480	40–60	3
45-SJ-251	251.5.0–22.S	216372*	Shell	710 ± 40	0 o/oo	1120 ± 40	280–450	0–22	5

45-SJ-251	251.5.20–37.S	216328	Shell	1140 ± 40	−0.9 o/oo	1540 ± 40	630–770	20–37	5
45-SJ-274	274.105N/10W.10NW	223248*	Shell	1280 ± 70	−1.0 o/oo	1670 ± 70	670–940	10	NA
45-SJ-274	274.105N/10W.30NW	223245	Shell	1470 ± 40	−1.5 o/oo	1860 ± 40	920-1110	30	NA
45-SJ-274	274.65N/12W.100NW	223247*	Shell	1330 ± 40	−4.0 o/oo	1670 ± 40	720—910	10	NA
45-SJ-274	274.65N/12W.10NW	223246*	Shell	1140 ± 70	−1.8 o/oo	1530 ± 70	550—830	10	NA
45-SJ-277	277.1.50–60.S	223249	Shell	540 ± 40	−1.4 o/oo	930 ± 40	480–620	50–60	1
45-SJ-279	279.1.50–60.*S*	223250	Shell	700 ± 40	−1.1*o/oo*	1090 ± 40	260–430	50–60	1
45-SJ-279	279.1.130–150.*S*	223251	Shell	960 ± 40	−1.2*o/oo*	1350 ± 40	490–630	130–150	1
45-SJ-279	279.1.220–240.*S*	223252	Shell	1700 ± 40	−0.9*o/oo*	2100 ± 40	1170–1330	220–240	1
45-SJ-279	279*M*.1.20–40.*S*	223258	Shell	700 ± 40	−0.3*o/oo*	1110 ± 40	280–440	20–40	1
45-SJ-279	279H.4.50–75.S	223253	Shell	1340 ± 40	−1.2 o/oo	1730 ± 40	770–960	50–75	4
45-SJ-282	282.1.0–20.S	223254	Shell	770 ± 40	−0.5 o/oo	1170 ± 40	310–480	0–20	1
45-SJ-282	282.1.80–100.S	223255*	Shell	2020 ± 50	−1.9 o/oo	2400 ± 50	1420–1690	80–100	1
45-SJ-307	307.1.5–15.S	259808	Shell	1120 ± 40	−0.6 o/oo	1520 ± 40	610–760	5–15	1
45-SJ-364	364.1.20–40.S	267090	Shell	940 ± 40	−0.7 o/oo	1340 ± 40	490—620	20–40	1
45-SJ-407	407.1.10–20.S	210405	Shell	2650 ± 40	−1.1 o/oo	3040 ± 40	2190–2450	10–20	1
45-SJ-407	407.1.30–40.S	216329*	Shell	2570 ± 40	−1.2 o/oo	2960 ± 40	2130–2330	30–40	1
45-SJ-407	407.1.40–50.S	210406	Shell	2680 ± 40	−2.0 o/oo	3060 ± 40	2250–2490	40–50	1
45-SJ-450	450.5.0–20.S	210411	Shell	1110 ± 40	−2.1 o/oo	1490 ± 40	560–720	0–20	5
45-SJ-450	450.5.45–70.S	218148	Shell	1890 ± 60	−0.9 o/oo	2290 ± 60	1300–1570	45–70	5
45-SJ-450	450.5.70–91.S	210412	Shell	2130 ± 40	−1.4 o/oo	2520 ± 40	1580–1820	70–91	5
45-SJ-450	450.7.10–20.S	218151	Shell	900 ± 40	−0.5 o/oo	1300 ± 40	450–600	10–20	7
45-SJ-450	450.7.40–50.S	218150	Shell	670 ± 40	−1.4 o/oo	1060 ± 40	240–420	40–50	7
45-SJ-450	450.7.67–84.S	218149	Shell	1760 ± 40	−1.9 o/oo	2140 ± 40	1210–1380	67–84	7

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Table 1. **Marine shell dates obtained by the SJIAP (2005–2009). Standard radiometric dates are marked with an asterisk in the Beta analytic # column, all others are AMS dates. *(Continued)***

Site	Sample ID	Beta Analytic #	Material	Measured C-14 age (RCYBP)	$^{13}C/^{12}C$ ratio	Conventional age	2σ Calibrated results (cal BP)	Depth (cm below surface)	Core #
45-SJ-450	450.9.0–25.S	218152	Shell	840 ± 60	−0.8 o/oo	1240 ± 60	320–550	0–25	9
45-SJ-450	450.9.20–45.S	218153**	Shell	830 ± 60	−1.0 o/oo	1230 ± 60	310–540	20–45	9
45-SJ-450	450.9.50–68.S	218154	Shell	1600 ± 40	−1.3 o/oo	1990 ± 40	1050–1250	50–68	9
45-SJ-451	451.2.0–20.S	210413	Shell	610 ± 40	−0.7 o/oo	1010 ± 40	130–360	0–20	2
45-SJ-451	451.2.20–40.S	210414	Shell	820 ± 40	−1.5 o/oo	1210 ± 40	330–350, 350–510	20–40	2
45-SJ-451	451.3.0–31.S.M	218156	Shell	750 ± 40	+0.3 o/oo	1160 ± 40	300–480	0–31	3
45-SJ-451	451.3.0–31.S.S	218155*	Shell	750 ± 40	−3.1 o/oo	1110 ± 50	270–460	0–31	3
45-SJ-453	453.1.0–10.S	223256	Shell	760 ± 40	−0.8 o/oo	1160 ± 40	300–480	0–10	1
45-SJ-460	460.1.220–260.S	223257	Shell	910 ± 40	−0.4 o/oo	1310 ± 40	460–610	220–260	1
45-SJ-461	461.1.S	223259*	Shell	700 ± 40	−1.8 o/oo	1090 ± 50	250–450	0–10	1
45-SJ-481	481.2.80–100.S	259806	Shell	600 ± 40	−1.2 o/oo	990 ± 40	510–640	80–100	2
45-SJ-483	483.2.10–25.S	259809	Shell	720 ± 40	−0.5 o/oo	1120 ± 40	280–450	10–25	2
45-SJ-507	507.1.S	259805	Shell	470 ± 40	+0.2 o/oo	880 ± 40	430–560	0–10	1
45-SJ-509	509.1.15–25.S	267088	Shell	960 ± 40	−0.6 o/oo	1360 ± 40	500–630	15–25	1
45-SK-421	SK421.1.S	259804	Shell	1490 ± 40	−1.2 o/oo	1880 ± 40	930–1130	0–10	1

position within the last 2,000 years (Whittaker and Stein 1992). Although one meter of sea level rise over 2,000 years is minimal on a geological scale, on an archaeological scale, it is enough to erode older shell deposits near the shoreline where people were fishing and shellfishing. Underwater excavation for early sites has been attempted in the Gulf Islands (Easton and Moore1991), but this avenue is unexplored in the San Juan Islands.

Recent megafauna discoveries in inland areas of Orcas Island (Kenady et al. 2011; Wilson et al. 2009) suggest that people may have been on the islands by the Terminal Pleistocene/Early Holocene. Evidence of early human occupation on the coast may have eroded away, and convincing evidence of early occupation in inland areas is difficult to find due to thick vegetation. One of us (Jolivette) is conducting inland surveys as part of her dissertation research. Her preliminary results confirm that projectile points with attributes similar to Cascade/Olcott points have been discovered by private landowners while farming and gardening their inland properties. These points date to approximately 9000–5000 cal BP elsewhere on the Northwest Coast but have not been found in buried context in the San Juan Islands (Bense 1972; Butler 1961; Carlson 1990, 2008; Kidd 1964). Based on current information, we assume that the paucity of Middle and Early Holocene coastal sites in the San Juan Islands is attributable to erosion associated with sea level rise.

The earliest published date on archaeological material in the San Juan Islands is from the Mud Bay site (45-SJ-278), a big site on Lopez Island that dates to 3690–3080 cal BP (Stein et al. 2003). Only three other sites, all big, date prior to 2500 cal BP (Figure 4). The total number of sites in the islands and proportion of smaller to larger sites increases slightly at 2000–1500 cal BP. Six big sites are located in the southern part of the islands and one big site (45-SJ-105) is in the northern region on Sucia Island. Four small sites are located in the northern region of the islands with one to the south at Argyle Lagoon on San Juan Island (45-SJ-3). At 1500–1000 cal BP, this trend continues with several big sites to the south on Lopez and San Juan Islands and smaller sites on northern islands, with the exception of 45-SJ-105, which was inhabited continuously through late prehistory (Figure 4).

The number of all sites, especially small sites, increases dramatically during the 1000–500 cal BP and 500–0 cal BP time periods with larger sites generally to the south and smaller sites to the north (Figure 4). A majority of these dates fall between 650 and 300 cal BP (Figure 5). Site size differs significantly before and after 650 cal BP ($\chi^2 = 16.931$; $p < .001$), with more big sites occurring during the earlier period and more small sites occurring during the later period. In general, more big sites in the San Juan Islands have been intensively dated than small sites. To ensure that the regional chronology is not predominantly based on big site chronology, we follow Lepofsky et al. (2005) in creating a summed probability plot that incorporates only one date per 200-year interval per archaeological site. This figure also shows a peak in radiocarbon dates at 650–300 cal BP (Figure 6).

DATING RESULTS AND EROSION

Erosion likely destroyed evidence of a pre-Middle Holocene archaeological record and continued to impact coastal shell midden sites after sea level reached its present levels. To determine the extent to which this has skewed our results towards a younger distribution of dates requires a systematic understanding of site vulnerability to erosion (e.g., Kellog 1995; Luby et al. 2006). On beaches in the Puget Sound and Gulf of Georgia, typical erosion is characterized by long periods of stability with sudden mass wasting events every few decades, often caused by high-tide storms. Storms are the most powerful transport agents in this region; they occur frequently and dominate other events (Finlayson 2006). Based on Canning and Shipman's (1995:10) analysis of Puget Sound erosion, areas highly vulnerable to erosion should be found in long-fetch wave environments with steep nearshore bathymetry. Fetch length

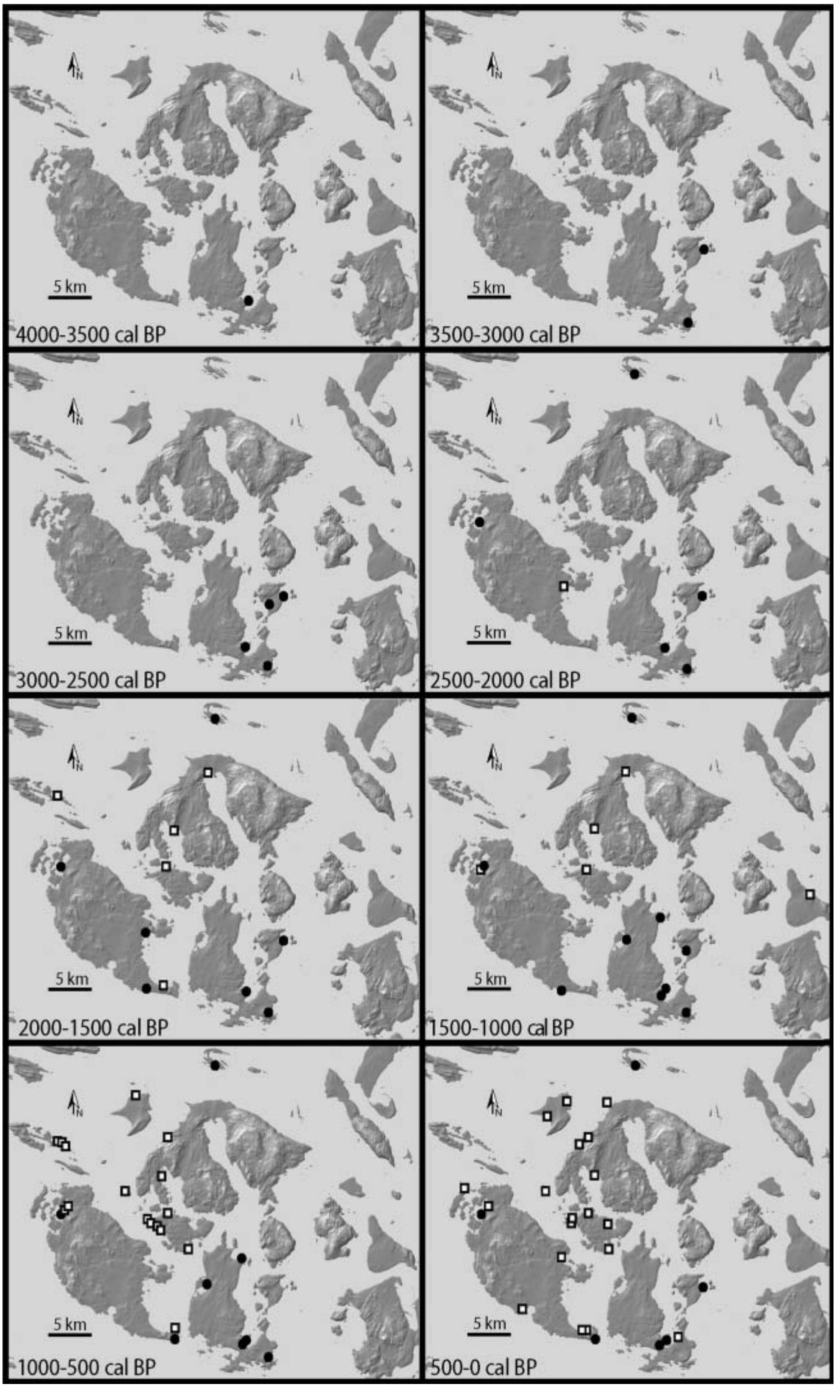

Figure 4. *Change over time in the spatial distribution of big and small sites on the San Juan Islands shown in 500-year increments based on SJIAP (2005–2009) dates and previously published dates. Big sites are indicated by black circles and small sites are indicated by white squares.*

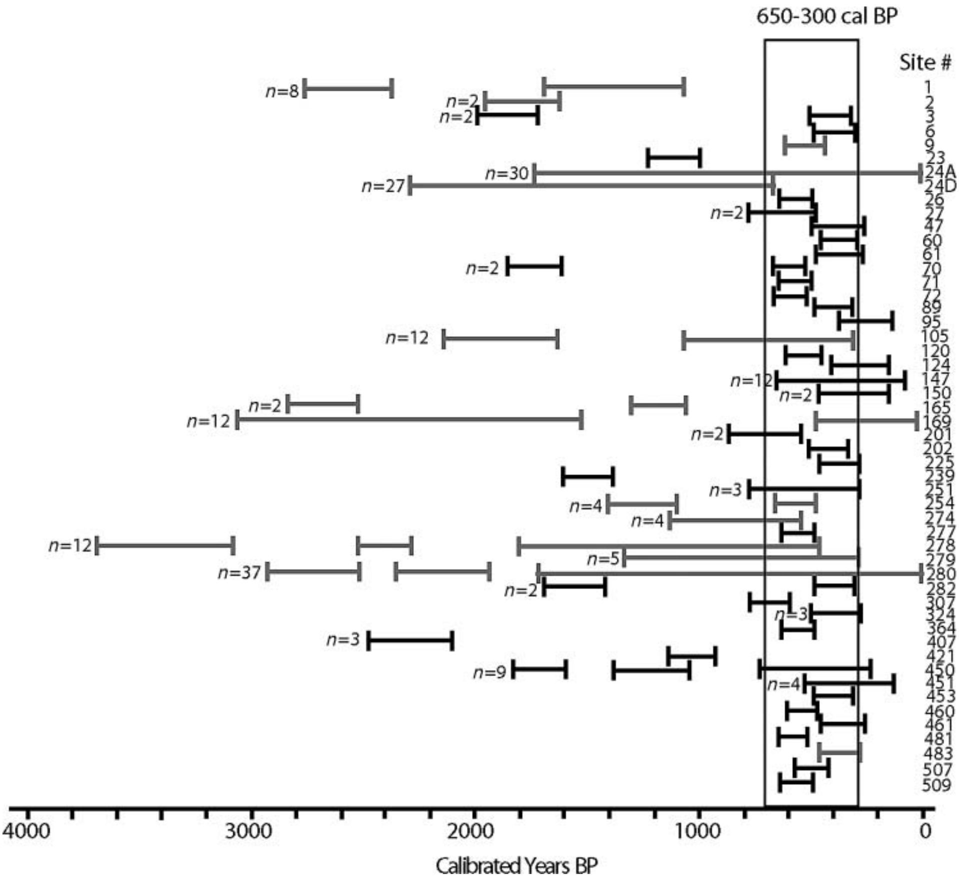

Figure 5. *Plot showing 2σ calibrated radiocarbon dates for each site from SJIAP 2005–2009 dates and previously published dates. Each line represents the range of all calibrated radiocarbon dates for each site. Black lines represent small sites; gray lines represent big sites. For sites with more than one date, the number of dates are listed next to each line (and see Table 1).*

is defined as length of unobstructed water distance leading up to a beach (often used as a proxy for wave energy). Finlayson (2006) provides fetch length for every water pixel in a 90 m DEM of the greater Puget Sound area. He provides GIS raster data on his website that can be used to generate a map of fetch length (http://sites.google.com/site/davidpfinlayson/Home/programming/fetch). The southern shore of San Juan Island is the longest continuous high-fetch wave environment. Data on bathymetry for the San Juan Archipelago comes from the Puget Sound Digital Elevation Model Project (PRISM) and Don (2002). The area of steepest bathymetry on the San Juan Islands is on the northern shore of Orcas Island (Figure 7).

Empirical observation suggests that site vulnerability should also be directly affected by landform and vegetation. Sites were given ordinal values based on degree of landform protection with open coast considered least protected, sites with islands or spits blocking wave energy considered somewhat protected, and sites on enclosed

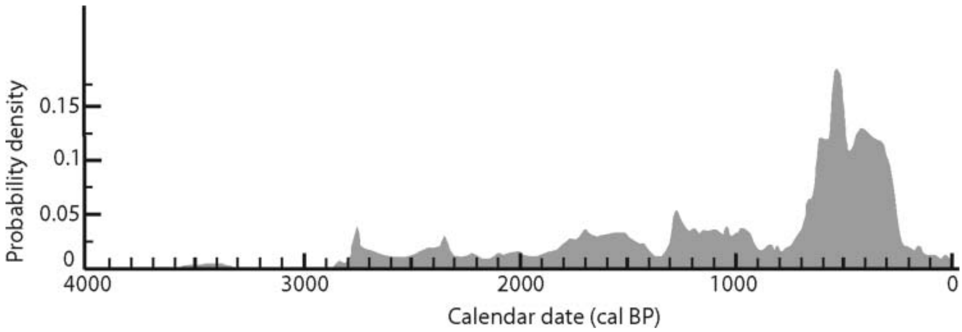

Figure 6. *A summed probability plot of calibrated radiocarbon dates from the San Juan Islands generated with OxCal 4.1 using one date per site per 200-year interval. This plot includes SJIAP (2005–2009) dates and previously published dates.*

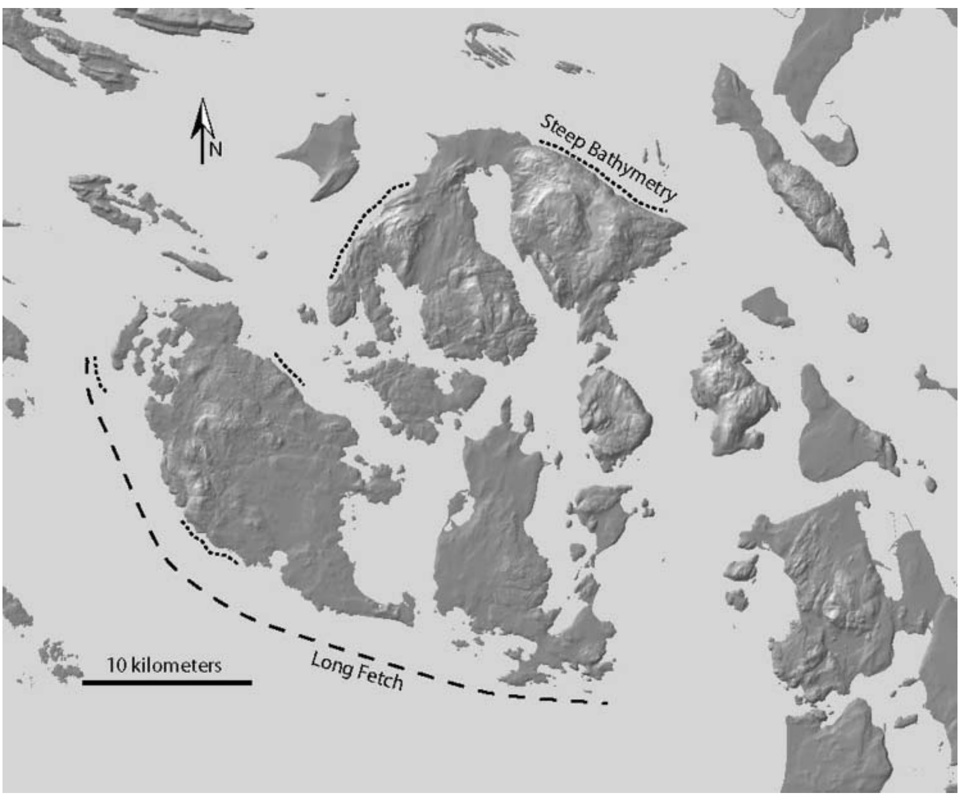

Figure 7. *Map of the San Juan Islands showing areas of long fetch and steep nearshore bathymetry.*

bays considered most protected. Amount and type of vegetation is also a factor because shrub and tree roots create a fibrous web that helps reinforce the bank. Plant litter acts as a sponge for water in the soil and allows water to evaporate instead of washing down the bank (MacDonald and Witek 1994). Sites were given ordinal values based on whether trees and shrubs were present, shrubs and grasses were present, only grasses were present, or only lawn was present.

To assess whether older sites are more likely to have been destroyed by erosion than younger sites, we investigate the distribution of older sites relative to erosion vulnerability based on values for fetch length, bathymetry, landform, and vegetation. If older sites are only found in the least vulnerable areas, this would suggest that erosion has biased the archaeological record towards younger sites. Of the three oldest sites in the San Juan Islands, two are among the best protected from erosion. Both 45-SJ-278 and 45-SJ-280 are located in short-fetch wave environments, shallow bathymetry, are on bays, and have trees, shrubs, and grasses. The site 45-SJ-169 is located in an area more vulnerable to erosion. Fetch is slightly longer than at 45-SJ-278 and 45-SJ-280, bathymetry is shallow, it is not on a bay, and vegetation mainly consists of grasses. It should also be noted that some older sites may be protected by the deposition of material from younger sites on prograding shorelines.

Quantitative analyses comparing the distribution of ordinal values for fetch, bathymetry, landform, and vegetation relative to time period provide further insights on the impact of erosion on dating results (Table 2). Sites were divided into two groups: those present at 1000–500 cal BP and those present only after 500 cal BP. Results of chi-square tests indicate that the number of sites located on steep-bathymetry beaches before and after 500 cal BP is significantly different. At 1000–500 cal BP, only a single site of a total of 27 sites was recorded in a steep nearshore bathymetry area. At 500–0 cal BP, 4 of 12 sites were found in steeper areas. For fetch, differences between the early and later periods are not statistically significant at a .05 level. In the earlier period, no sites are found on long-fetch beaches while in the later period, 4 sites are found on long-fetch beaches. These results indicate that sites in areas highly vulnerable to erosion are more abundant the more recently they were deposited, but some older sites remain in these areas. The dramatic peak in radiocarbon dates at this time cannot be explained entirely by post-depositional processes. Likewise, the increase in small sites later in prehistory is to some extent the result of the partial loss of big sites, but some of these sites were small to begin with.

HYPOTHESES AND EXPLANATIONS

We hypothesize that (a) the peak in radiocarbon dates at 650–300 cal BP indicates more permanent settlements on the islands, and (b) this settlement shift is attributable to a climate shift towards wetter and cooler conditions resulting in greater availability in freshwater and other resources. We test this hypothesis using accumulation rate and paleoenvironmental data.

Accumulation Rates

Accumulation rate data aid in interpreting the intensity of occupation at shell middens. Rapid midden accumulation rates correspond to more people or more permanent occupations; slow accumulation rates correspond to fewer people or less frequent visits. Pairwise accumulation rates are calculated for each auger or eroding bank "core" where we obtained two or more dates. The difference between the average depths of the two samples (thickness in cm) is divided by the difference in years between the average calibrated dates for the deposits. A problematic assumption inherent in this calculation is that deposits accumulate at a uniform rate. Linear regression analyses (Stein et al. 2003) and volumetric calculations (Ames 2005) have been used to calculate accumulation rates at a finer scale but require more stratigraphic information than could be obtained through the eroding bank and auger sampling undertaken in this research.

Table 2. **Results of chi-square tests to determine independence of site vulnerability characteristics, expressed as ordinal values, relative to time period (1000–500 or 500–0 cal BP).**

	1000–500 cal BP	500–0 cal BP	Total	Adjusted residuals	χ^2
Open coast	7	4	11	0.07	0.98
Protected by spit/island	5	5	10	−0.96	$p = .613$
Bay	15	7	22	0.75	
Total	27	16	43		
No vegetation	2	1	3	0.14	0.08
Beach grasses/ivy	10	6	16	−0.03	$p = .994$
Shrubs/grasses	4	2	6	0.21	
Trees/shrubs/grasses	11	7	18	−0.19	
Total	27	16	43		
Shallow bathymetry	26	12	38	**2.11**	4.434
Steep bathymetry	1	4	5	**−2.11**	$\boldsymbol{p = .035}$
Total	27	16	43		
Fetch 1 (longest)	0	2	2	−1.88	9.301
Fetch 2	0	2	2	−1.88	$p = .054$
Fetch 3	18	7	25	1.47	
Fetch 4	5	1	6	1.12	
Fetch 5 (shortest)	4	4	8	−0.83	
Total	27	16	43		

Pairwise accumulation rates provide a rough estimate that can be used to categorize cores as slow (<.02 cm/yr), intermediate (.02–.5 cm/yr), and rapid (>.5 cm/yr) (Stein et al. 2003). Pairs that provide negative accumulation rates are categorized as rapid if the ranges of the calibrated dates overlap and thus the two shells sampled were essentially deposited simultaneously. If the dates do not overlap, negative accumulation rates are attributed to post-depositional disturbance (Table 3, Figure 8).

Statistical analyses indicate significant differences in accumulation rate between sites occupied before and after 650 cal BP (Table 4). A chi-square test shows significantly more medium accumulation cores during the pre-650 cal BP time period and more rapid accumulation cores during the post-650 cal BP time period than would occur given a random distribution. Accumulation rate does not appear to be determined by site size ($\chi^2 = 1.319$; p = .517, $n = 90$). It is significantly faster after 650 cal BP when calculated either for big sites only or for small sites only (Table 4). A slight increase in fast accumulation rate cores occurs at 2000–1250 cal BP (Figure 8), but this peak is not statistically significant ($\chi^2 = 5.500$; $p = .231$, $n = 90$).

The small number of dates at some sites and the possibility of compaction of older deposits limit our confidence in accumulation rate results; however, the analysis supports the hypothesis that a settlement pattern shift coincides with the peak in radiocarbon dates at 650–300 cal BP. Though there may be other explanations for faster accumulation rates after 650 cal BP, we propose that the data are consistent with an increase in site permanence. Whether or not more people lived on the San Juan Islands at this time, it is likely that they inhabited large habitation

Table 3. **Accumulation rates for San Juan Islands sites from SJIAP 2005–2009 dates and previously published dates. Rates are marked in bold if they are the result of post-depositional disturbance.**

Site. core	Avg. depth	Avg. date	Accum. rate	Site. core	Avg. depth	Avg. date	Accum. rate	Site. core	Avg. depth	Avg. date	Accum. rate
2.3	15	1834.5		169.8S3E	834	2255		24D.TEF	184	1181	
2.3	45	1736	−0.3	169.8S3E	856	2783	0.04	24D.TEF	190	1403	0.03
3.1	15	1878.5		169.5S9E	623	2540		24D.TGH	123	1346	
3.1	45	1850.5	−1.07	169.5S9E	633	2625	0.12	24D.TGH	138	1718	0.04
3.4	10	409		169.5S7E	616	2542.5		24D.TGH	209	1111	−0.12
3.4	60	409	0	169.5S7E	642	2645	0.25	105.2.5-5	30	480.5	
27.1	30	541.5		1.1	68.58	1171		105.2.5-5	70	1888	0.03
27.1	120	700	0.57	1.1	129.54	1488.5	0.19	105.2.5-5	110	1827	−0.66
147.1	22.5	568.5		1.5	53.34	1161.5		105.7.5-7.5	35	807	
147.1	55	547.5	−1.55	1.5	99.06	1546	0.12	105.7.5-7.5	50	841.5	0.43
147.4	10	465		1.5	144.78	1437	−0.42	105.7.5-7.5	70	1778	0.02
147.4	60	534.5	0.72	1.5	175.26	2628.5	0.03	105.7.5-7.5	110	406	−0.03
147.4	81	347	**−0.11**	24A.310,300	18	1131.5		105.2.5-2.5	30	795.5	
147.7	12.5	227.5		24A.310,300	24	503	−0.01	105.2.5-2.5	50	634.5	−0.12
147.7	71.5	557.5	0.18	24A.310,300	36	808	0.04	105.2.5-2.5	110	794	0.38
147.7	106	494	−0.54	24A.310,300	54	984.5	0.1	105.2.5-2.5	130	927.5	0.15
147.12	7	516		24A.310,300	80	1070.5	0.3	105.2.5-2.5	170	903.5	−1.67
147.12	57.5	558.5	1.19	24A.310,300	106	1510	0.06	254.A	20.3	575	
150.1	15	261.5		24A.310,302	34	1571.5		254.A	55.9	1349	0.05
150.1	77.5	357	0.65	24A.310,302	48	1100	−0.03	254.A	66	1238	−0.09
201.2	10	607		24A.310,304	35	147.5		278.15-2	90	1120	
201.2	70	747.5	0.43	24A.310,304	43	409.5	0.03	278.15-2	110	1446	0.06
251.3	10	403		24A.310,304	53	405	−2.22	278.15-2	210	3386	0.05
251.3	50	396.5	−6.15	24A.310,304	72.5	974.5	0.03	278.21-2	70	989	
251.5	11	366.5		24A.310,304	78	467.5	−0.01	278.21-2	110	2411	0.03

(Continued on next page)

Table 3. **Accumulation rates for San Juan Islands sites from SJIAP 2005–2009 dates and previously published dates. Rates are marked in bold if they are the result of post-depositional disturbance. *(Continued)***

Site. core	Avg. depth	Avg. date	Accum. rate	Site. core	Avg. depth	Avg. date	Accum. rate	Site. core	Avg. depth	Avg. date	Accum. rate
251.5	28.5	700	0.05	24A.310,304	90	405	−0.19	278.21-2	130	1150	−0.02
274.105.10	10	807		24A.310,200	104	589		280.0-24	70	2443	
274.105.10	30	1015.5	0.1	24A.310,200	135	605	1.94	280.0-24	90	1261	−0.02
274.65.12	10	689		24A.306,300	32	431		280.0-24	110	1446	0.11
274.65.12	100	813.5	0.72	24A.306,300	52	746.5	0.06	280.1-9	50	1459	
279.1	55	347		24A.306,300	74	885	0.16	280.1-9	70	1470	1.82
279.1	140	558.5	0.4	24A.306,300	77	789.5	−0.03	280.1-9	90	1617	0.14
279.1	230	1250	0.13	24D.105,365	85	1369.5		280.1-9	130	140	−0.03
282.1	10	396.5		24D.105,365	97.5	1279	−0.14	280.1-9	153	2202	0.01
282.1	90	1554	0.07	24D.105,365	103	1617	0.02	280.1-9	170	2126	−0.22
407.1	15	2322.5		24D.105,365	151.5	1412	−0.24	280.9-3	50	1285	
407.1	35	2225.5	−0.21	24D.105,365	176	1307.5	−0.23	280.9-3	130	1313	2.86
407.1	45	2368.5	0.07	24D.111,349	59	1663.5		280.9-3	165	1835	0.07
450.5	10	640		24D.111,349	67	1400	−0.03	280.9-3	170	1835	0
450.5	57.5	1433	0.06	24D.111,349	159	1946	0.17	280.EXU1	15	577.5	
450.5	80.5	1700	0.09	24D.123,347	56	796		280.EXU1	45.5	1012	0.07
450.7	15	526		24D.123,347	67	687.5	−0.1	280.EXU2	15	616.5	
450.7	45	330.5	−0.15	24D.123,347	92	1245	0.04	280.EXU2	55	974.5	0.11
450.7	75.5	1295	0.03	24D.130,352	39	1113.5		280.Ba.A	70	1461	
450.9	12.5	434.5		24D.130,352	78	1104.5	−4.33	280.Ba.A	110	1451	−4
450.9	32.5	427.5	−2.86	24D.130,352	92	1194.5	0.16	280.0-18	50	1483	
450.9	59	1150	0.04	24D.TAB	55	1407.5		280.0-18	70	1470	−1.6
451.2	10	243		24D.TAB	88	1351	−0.58	280.0-18	90	1532	0.32
451.2	30	422	0.11	24D.TAB	163	1519.5	0.45	280.0-18	110	1577	0.44
165.63.99	287	2687.5		24D.TAB	168	1398.5	−0.04				
165.63.99	434	1182.5	−0.1	24D.TAB	192	1700	0.08				

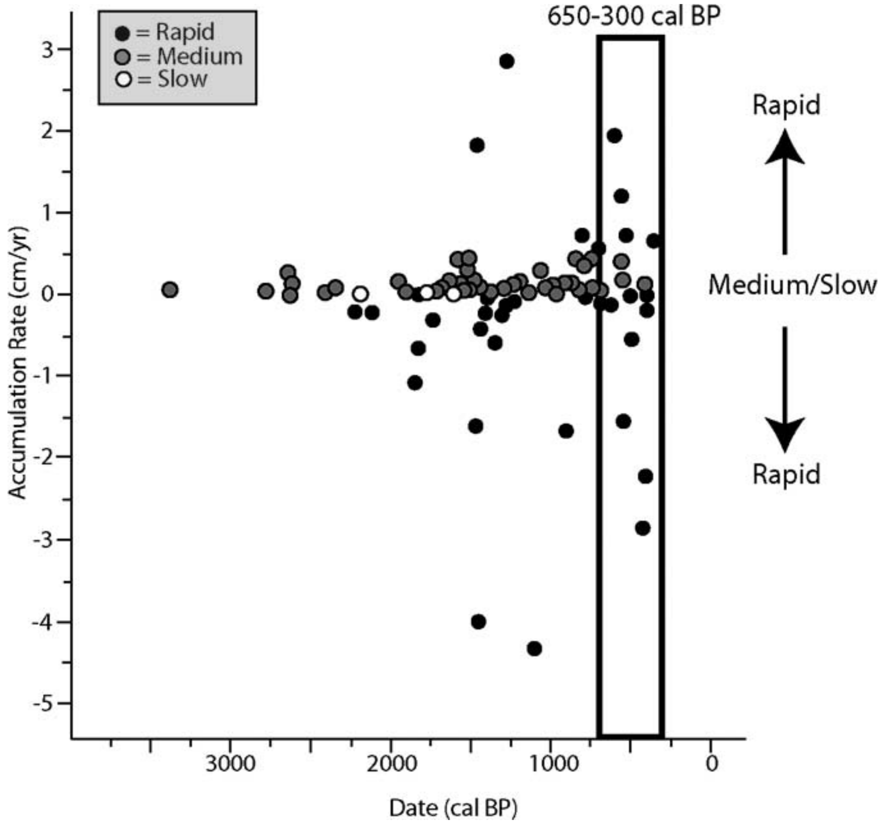

Figure 8. *Change over time in accumulation rates in the San Juan Islands.*

Table 4. **Results of chi-square tests determining whether pre- and post-650 cal BP sites differ significantly in accumulation rate for all sites, big sites only, and small sites only.**

	Pre-650 cal P	Post-650 cal BP	Total	Adjusted residual	χ^2
All sites, slow	3	0	3	0.88	11.78
All sites, medium	45	4	49	**3.07**	
All sites, rapid	24	14	38	**−3.41**	***p* = .003**
All sites, total	72	18	90		
Big sites, slow	3	0	3	0.68	6.21
Big sites, medium	37	2	39	**2.17**	
Big sites, rapid	21	7	28	**−2.48**	***p* = .045**
Big sites, total	65	11	76		
Small sites, slow	0	0	0		5.05
Small sites, medium	8	2	10	**2.25**	
Small sites, rapid	3	7	10	**−2.25**	***p* = .025**

sites throughout the year. They visited small fishing and shellfishing sites and deposited shell at both big sites and small sites more constantly than they had before. We turn to paleoclimate data to explore explanations for this shift.

Paleoenvironmental Data

To assess whether a settlement shift after 650 cal BP is attributable to environmental change, we review Holocene climate change in the Gulf of Georgia and settlement locations relative to freshwater. At 2400–1200 cal BP, the Gulf of Georgia became drier due to fluctuations in solar activity (Koch et al. 2007). An increase in soil charcoal (Hallett 2001; Hallett et al. 2003) and breaks in glacial advances (Koch et al. 2007) establish this "Fraser Valley Fire Period" in southwestern British Columbia. Paleoecologists (Fujikawa 2002; Fujikawa et al. 2004; Sugimura et al. 2008) establish a similar dry period in the San Juan Islands based on an increase in charcoal and pine pollen in cores from Orcas Island. Evidence from paleoecological research in the Olympic Mountains (Gavin and Brubaker 1999) and southwestern British Columbia (Hallett et al. 2003) suggest that the islands may have become warmer and drier again at 1050–600 cal BP during the Medieval Warm Period. This climate fluctuation has not yet been established in the San Juan Islands, but shell isotope research by Daniels (2009) in the islands suggests that a period of warmer ocean water and correspondingly less productive marine environment coincides with both the Fraser Valley Fire Period and the Medieval Warm Period. The islands are also less ecologically diverse than the neighboring mainland, with only 2 of 13 Gulf of Georgia biogeoclimatic variants (Lepofsky et al. 2005), and are therefore more vulnerable to food shortages during times of drought. Lack of freshwater may also have been a limiting factor in establishing permanent settlements, and people would have relied on more difficult and costly ocean salmon fishing rather than stream fishing.

To evaluate our hypothesis that a full-scale settlement of the San Juan Islands did not begin until freshwater supply and associated resources were more reliable after 600 cal BP, we investigate spatial patterns in site location relative to sources of perennial freshwater. The islands are drier than the surrounding area due to the rain shadow effect. Warm moist air flowing off the Pacific Ocean loses moisture as it rises to the tops of the Olympic Mountains. Most streams in the San Juan Islands have no flow between June and November (Dietrich 1975:68). The higher elevation areas on eastern Orcas Island receive more rainfall than other areas with approximately 30–45 inches per year while southern San Juan Island and Lopez Island are drier, receiving 20–25 inches per year (Dietrich 1975:60). We predict that during the Fraser Valley Fire Period and Medieval Warm Period, sites should be located within easy access of the most reliable freshwater sources identified in Dietrich (1975) and Wixom and Snow (2004) (Table 5; Figure 9). After 600 cal BP when precipitation levels increased and freshwater became easier to find, sites should be more variable in their distribution across the landscape.

To test this prediction, we calculated distance along shore from site to nearest stream and second nearest stream for the 50 dated sites in San Juan County. A T-test indicates no significant difference in mean distance to the nearest streams for sites inhabited prior to and after 650 cal BP ($F = .128$; $p = .345$). Mean distance to the nearest stream is only slightly greater during the later period at 12.82 km compared to 10.69 km during the earlier period. If distances to the nearest and second nearest streams are combined, mean sum distances are slightly greater after 650 cal BP at 32.82 km compared to 27.67 km before 650 km, but this difference is not statistically significant ($F = .851$; $p = .167$). The geographical distribution of shell middens does not appear to be correlated to proximity to stream access.

As noted by many archaeologists who study the relationship between climate and culture (e.g., Lepofsky et al. 2005:268), a temporal correlation between environmental change and shifts in settlement is easier to establish than a causal relationship between the two. Results on distances between sites and perennial streams do not strongly

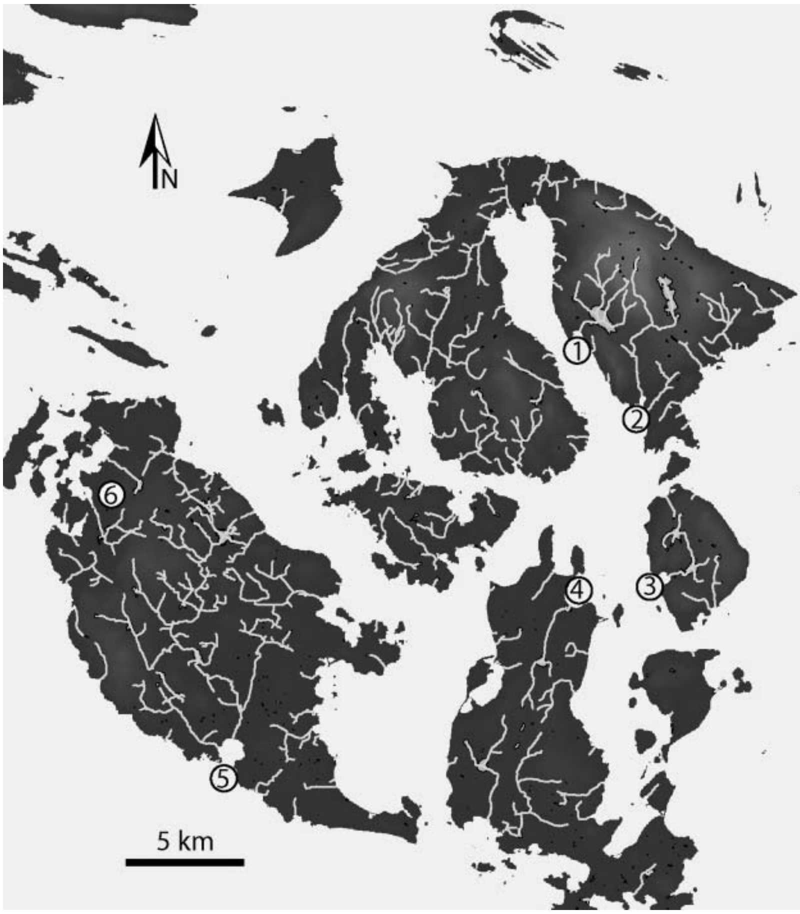

Figure 9. *Primary year-round freshwater sources on the San Juan Islands (Dietrich 1975; Wixom and Snow 2004). Numbers in the figure refer to Table 3. Streams were mapped using data from the USGS National Hydrology Dataset (http://nhd.usgs.gov/).*

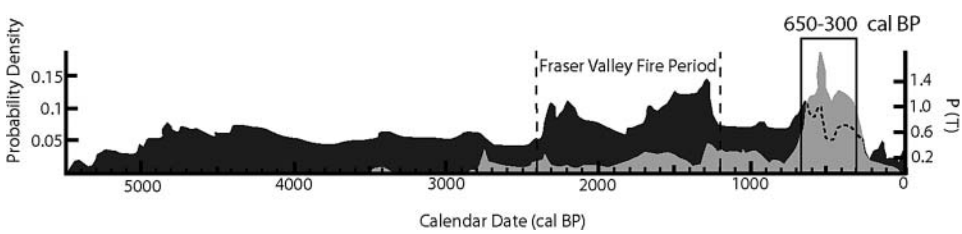

Figure 10. *A comparison of summed probability plots of calibrated radiocarbon dates from the San Juan Islands (Figure 6) with those from the Canadian Gulf of Georgia presented by Lepofsky et al. (2005). The left y-axis corresponds to the SJIAP dates and the right y-axis corresponds to Lepofsky et al.'s dates.*

Table 5. **Descriptions of primary freshwater sources in the San Juan Islands (Dietrich 1975; Wixom and Snow 2004).**

Map #	Freshwater source area	Description
1	Cascade Bay, Orcas Island	Cascade Bay provides access to an unnamed creek 400 m SW of Cascade Lake (volume 4,600 acre-ft.). This is a high precipitation area surrounding Mt. Constitution with a large spring that feeds Cold Creek, a high-flow perennial stream that runs into Cascade Lake.
2	Buck Bay, Orcas Island	Buck Bay provides access to the mouth of Cascade Creek, a high discharge stream fed by Mountain Lake (volume 8,800 acre-ft.) located in the high precipitation area surrounding Mt. Constitution.
3	Unnamed Bay, Blakely Island	The large bay on western Blakely Island provides access to an unnamed creek and is 200 m from Spencer Lake (volume 5,400 acre-ft.).
4	Swifts Bay, Lopez Island	The Swifts Bay watershed is fed by Hummel Lake (volume 272 acre-ft.). An unnamed stream runs from the lake to the bay.
5	False Bay, San Juan Island	The False Bay watershed is fed by streams running from Trout Lake (volume 1,400 acre-ft.) on Mt. Dallas and Zylstra Lake (volume 350 acre-ft.). San Juan Valley Creek begins at Trout Lake and runs year round.
6	Garrison Bay, San Juan Island	The source of freshwater to Garrison Bay is a year-round creek with its head on the north side of Mt. Cady, a high precipitation area on northern San Juan Island.

support the hypothesis that an increase in permanent settlement on the San Juan Islands after 650 cal BP was directly related to a shift towards a wetter climate. One possible problem with the calculation is that shortest distance over water from site to stream access point does not adequately reflect the water routes that people would have chosen based on tides and currents. Future work on changes in location, abundance, and diversity of floral and faunal resources during warmer and drier periods will also provide further insights on human response to climate shifts.

DISCUSSION AND CONCLUSIONS

The discovery of a peak in radiocarbon date frequency at 650–300 cal BP in the San Juan Islands led us to investigate settlement patterns shifts and human response to climate change in the southern Gulf of Georgia. We also considered why our results differed from recent dating work in the Gulf Islands and Fraser Valley (Lepofsky et al. 2005). Lepofsky and her colleagues report a peak in radiocarbon dates at 2400–1200 cal BP, a time period that corresponds to the Fraser Valley Fire Period and the Marpole phase. Although there is a slight increase in sites in the San Juan Islands at this time, the peak after 650 cal BP is more pronounced. Lepofsky et al.'s (2005) figure shows a secondary peak at this time. A reasonable explanation for the higher frequency of dates for the Canadian Gulf of Georgia than the San Juan Islands during the Fraser Valley Fire Period is that the biogeoclimatic diversity and extreme productivity of the Fraser as a salmon river allowed people of the lower Fraser River to prosper during the dry period (Lepofsky et al. 2005). Population growth in this region during the Fraser Valley Fire Period, the Medieval Warm Period, and afterwards may have led to an influx of people to the more marginal surrounding regions. A wetter climate in the islands could support larger and potentially more permanent communities. If the Gulf Islands dates were considered separately from the lower Fraser dates, the Gulf Islands summed probability plot might reflect the San Juan Islands temporal patterns.

In part due to the emphasis in central Northwest Coast archaeology on the development of sociopolitical institutions during the Marpole phase, there has been minimal attention to cultural developments after 1200 cal BP. In the San Juan Islands, this period is known as the San Juan phase (Carlson 1960). Researchers note a decrease in chipped stone, an increase in bone and antler artifacts, the reappearance of the toggling harpoon, and other slight technological shifts (Carlson 1960), but the San Juan phase is not considered to be fundamentally different from the Marpole phase. Carlson (1960) and Mitchell (1971) do not note significant settlement shifts during late prehistory, and recent work by Lepofsky et al. (2005) does not address a secondary peak in frequency of radiocarbon dates at approximately 700–600 cal BP (Figure 10). Thompson (1978), however, records an increase in small "limited activity" sites in the Gulf of Georgia and Puget Sound region to the south and Moss and Erlandson (1992:85) discuss Grant Keddie's evidence for trench embankment features near Victoria, BC that date within the last 1500 years. Evidence for settlement pattern shifts after 1500 BP in the San Juan Islands presented in this work encourages a closer look for associated shifts in territoriality, technology, and subsistence strategies.

The contribution of the SJIAP (2005–2009) to San Juan Islands and Gulf of Georgia prehistory includes a more comprehensive set of dates for shell middens in this region, accumulation rates, an erosion study, and suggested explanations for the meaning of temporal patterns in site distribution. A peak in frequency of radiocarbon dates at 650–300 cal BP suggests that prehistoric San Juan Islanders may have experienced phenomena typically associated with the earlier Marpole phase—more sites, larger sites, and large multi-family houses—in a different way, or perhaps at a different time, than their neighbors in the lower Fraser Valley. If differences in climate were the main factor differentiating the San Juan Islands record from the Canadian Gulf of Georgia, our preliminary analysis of distance from site to freshwater source did not detect it. A more thorough analysis of subsistence resources affected by drier and wetter climate regimes has potential to provide more information on the role of climate in settlement pattern change, and perhaps suggest new hypotheses for temporal and spatial patterns. We are also in the process of investigating and dating non-shell midden archaeological sites both inland and on the coast. This work on settlement patterns in the San Juan Islands provides essential background information for asking and addressing new questions about the nature of sedentism and the development of social complexity on the central Northwest Coast.

ACKNOWLEDGEMENTS

We thank the Raven Foundation, the Quaternary Research Center, and the Institute for Ethnic Studies in the United States for their generous support for this work. We also thank many members of the San Juan Islands community for their support and hospitality: Tom Alberg and Judi Beck, the Anderson family, Susan Baker, Wade Ballinger, Lynn Barych, Christopher and Cynthia Bayley, Tyler and Julie Beach, John Bogert, Skip Bold and Fiona Stewart, Mike and Lee Brown, Don Bucknell, Stephanie Buffum-Field, David and Gina Burger, Scott Burns, Christa Campbell, Elizabeth Chadwick, Frances Chevalier, Jon and Joan Christoffersen, Beverly Confranseco, Elaine and Bill Cook, Lola Deane, Peter Dederich and Martha Ibister, Kathleen Dickinson, Richard and Lauren Donner, Dean Dougherty, Ruthie Dougherty, Jen Edinton, Frank and Barbara Fagan, Bob *and Winnie Gamble, Bruce Garman, William and Mimi Gates, Joe and Oakley Goodner, Doc Griffin, Eliza Habeggar, Bob and Lynn Hall, Will Hamilton, Paul Henriksen, John Howell and Claire Powers, Shaun Hubbard, Peggy and George Hunt, Keith and Sue Jefferts, Robert Johnson, Harold Kawaguchi, George and Nancy Kenagy, Dell and Laurie Laursen, Ronald Mayo, Alex and Willie Macleod, Kurt and Eleanor McMillen, Doug and Thelma McTavish, Bob and Jerry McTavish, Charles and Eleanor Nolan, Mike and Dawn Parnell, Dorothy Powell, Pam Powers, Boyd and Lovel Pratt, Pat Pugsley, Brooks and Susie Ragen, Steve and Adrienne Remmer, Ira Rubinstein, Scott Schwinge, Friday Harbor Labs, Greg and Karen Scott, Eliot and Grant Scull, Mary Schoen, Paul Skinner, Kip Smith, Barbara Stenson Spaeth, Jim Syck, Craig Tall, Joanne Terry and Tom Metke, Camille and Jim Uhlir, Chris Weaver, Dennis Willows and Susan Mahoney, and Ron and Carolyn Woodard.*

Sarah Campbell, Lena Tso, and the Lummi Nation Cultural Resources Department provided valuable insights during the planning stage of the project. We thank Stephenie Kramer at the Department of Archaeology and Historic Preservation, Dona Wuthnow at San Juan County Parks, Kris Allen at Washington State Parks, and Alison Hitchcock at Washington State Department of Natural Resources for their help with permitting; Laura Phillips and Kelly Meyers for their curation expertise; Diana Barg at the Samish Indian Nation Cultural Resources Department, Catherine Foster West, Erik Gjesfjeld, Becky Kessler, Emily Peterson, Colby Phillips, and Alecia Spooner for their assistance in the field; Dana Lepofsky and Christopher Ramsey for their assistance with creating summed probability plots; Jay Flaming for his GIS work; and Shelby Anderson and three anonymous reviewers for commenting on a previous draft of this article.

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