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Cathy Connor
University of Alaska Southeast, cathy.connor@uas.alaska.edu

Greg Streveler
Icy Strait Environmental Services

Austin Post
US Geological Survey

Daniel Monteith
University of Alaska Southeast

Wanye Howell
Glacier Bay National Park and Preserve

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Cathy Connor,[1]* Greg Streveler,[2] Austin Post,[3] Daniel Monteith[4] and Wayne Howell[5]

([1]Department of Natural Sciences, University of Alaska Southeast, Juneau, Alaska, USA; [2]Icy Strait Environmental Services, Gustavus, Alaska, USA; [3]US Geological Survey, Tacoma WA, USA; [4]Department of Social Sciences, University of Alaska Southeast, Juneau, Alaska, USA; Glacier Bay National Park and Preserve, Alaska, USA)

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Abstract: The Neoglacial landscape of the Huna Tlingit homeland in Glacier Bay is recreated through new interpretations of the lower Bay's fjordal geomorphology, late Quaternary geology and its ethnographic landscape. Geological interpretation is enhanced by 38 radiocarbon dates compiled from published and unpublished sources, as well as 15 newly dated samples. Neoglacial changes in ice positions, outwash and lake extents are reconstructed for *c*. 5500–200 cal. yr ago, and portrayed as a set of three landscapes at 1600–1000, 500–300 and 300–200 cal. yr ago. This history reveals episodic ice advance towards the Bay mouth, transforming it from a fjordal seascape into a terrestrial environment dominated by glacier outwash sediments and ice-marginal lake features. This extensive outwash plain was building in lower Glacier Bay by at least 1600 cal. yr ago, and had filled the lower bay by 500 cal. yr ago. The geologic landscape evokes the human-described landscape found in the ethnographic literature. Neoglacial climate and landscape dynamism created difficult but endurable environmental conditions for the Huna Tlingit people living there. Choosing to cope with environmental hardship was perhaps preferable to the more severely deteriorating conditions outside of the Bay as well as conflicts with competing groups. The central portion of the outwash plain persisted until it was overridden by ice moving into Icy Strait between AD 1724–1794. This final ice advance was very abrupt after a prolonged still-stand, evicting the Huna Tlingit from their Glacier Bay homeland.

Key words: Glacier Bay, southeastern Alaska, Neoglacial, 'Little Ice Age', outwash plain, ethnographic landscape, Tlingit history.

Introduction

Since the visits of George Vancouver in 1794 (Lamb, 1984), John Muir in 1879, 1893 and 1899, and G.K. Gilbert in 1899 (Burroughs and Muir, 1899); cartographers, scientists and the public alike have been fascinated with the ongoing disappearance of a once huge Glacier Bay Icefield. This icefield extended more than 6000 km^2 over the landscape and reached thicknesses of up to 1.5 km by AD 1750, the 'Little Ice Age' (LIA) maximum (Larsen *et al*., 2005). Dramatic deglaciation over the last 250 years has been documented by numerous workers including Reid (1896), Klotz (1899), Field (1947), Lawrence (1958) and Molnia (2006).

The archaeological record for Glacier Bay (the Bay) was extirpated by the last ice advance, so we must rely on ethnography to provide the entire cultural record of the pre-LIA human tenure in the Bay. The Huna Tlingit, indigenous people of northern Southeast Alaska, actively retain a living memory of this time before the last ice when Glacier Bay was the centre of their world. However, they describe a very different landscape to the deglaciated fjordscape of today. This paper will characterize these remembered ethnographic and geographic landscapes and link them through time with their points of geologic coincidence.

Although fragments of the rich oral human history and geologic record for this period have been published, no overview is available for the Neoglacial sequence of landscape evolution between 5500 and 200 years ago, when this formerly inhabited landscape was being created, occupied and destroyed. This work is the first serious attempt to integrate the geologic and ethnographic records. This dearth of information was recognized by the Glacier Bay National Park & Preserve staff in 2003 as an obstacle to full understanding of

*Author for correspondence (e-mail: cathy.connor@uas.alaska.edu)

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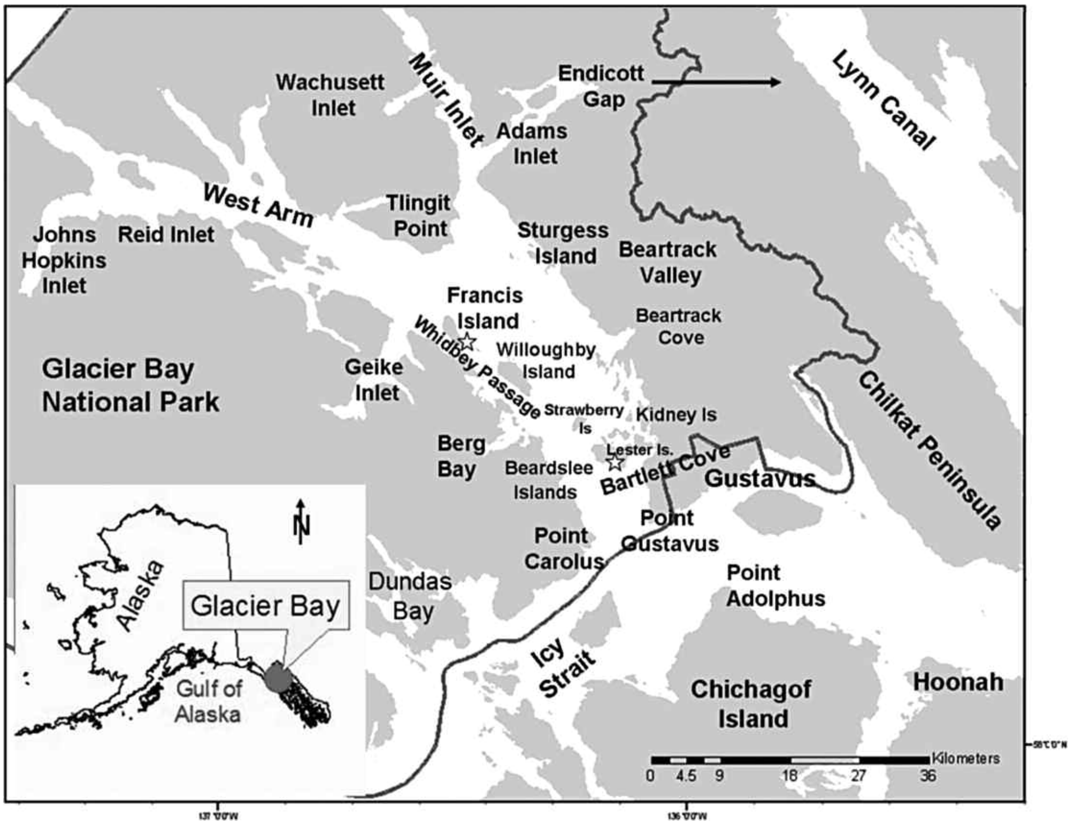

Figure 1 Modern place names and locations used in text: Adams Inlet, Bartlett Cove, Berg Bay, Dundas Bay, Endicott Gap, Francis Island, Geike Inlet, Gustavus, Hoonah, Icy Strait, Johns Hopkins Inlet, Kidney Island, Lester Island, Muir Inlet, Point Carolus, Point Gustavus, Reid Inlet, Sturgess Island, Tlingit Point, Wachusett Inlet, West Arm, Whidbey Passage, and Willoughby Island. Locations for the stratigraphic sections shown in Figure 3a and b are depicted as stars on southern Francis Island and southwestern Lester Island, respectively

the tenure by Huna Tlingits, and an impediment to formal nomination of portions of the Bay as a Traditional Cultural Property under National Register Criteria (Parker and King, 1990; Monteith, 2006), which require rational boundary and landscape descriptions. In 2004, Connor and Streveler, with Post's overview, summarized and supplemented available information on the Bay's Neoglacial landscape (Monteith *et al.*, 2007). We gave particular attention to the middle and lower Bay, where ethnographic information indicated concentration of former Tlingit use. As part of this effort, Howell and Monteith assembled the Bay's ethnographic record.

Methods

Geology

Review of the published Neoglacial record for the Bay centred on extensive research carried out in the Muir Inlet area (Figure 1) by the Ohio State Institute of Polar Studies (Haselton, 1966; Goldthwait *et al.*, 1966; Mickelson, 1971; McKenzie and Goldthwait, 1971; Goldthwait, 1987; Goodwin, 1988). Of the numerous published radiocarbon dates for the Bay, we selected six for particular relevance here (Table 1).

The present study reports 32 previously unpublished dates (Table 1, Figure 2). Thirteen are from work by Post, Streveler and Mann since 1975. Seven samples (four unpublished ages and three undated wood samples with stratigraphic context) were generously contributed by Daniel Lawson and analysed for this study. We focused on information gaps through field studies in the lower and mid Bay during the summers of 2004 and 2005, resulting in 12 new dates. These 32 previously unreported ages and the six dates from previous studies provide the 38 radiocarbon ages used to anchor the geologic and overlapping human events in this study.

Samples collected by Connor, Streveler and Lawson were dated using standard and AMS methods by BETA Analytic. Radiocarbon ages from three marine shell samples were corrected for the marine carbon reservoir effect by subtracting 470 years (Kovanen and Easterbrook 2002; Mann and Streveler, 2008). Unpublished and older measured ^{14}C ages were calibrated using Calib 5.0.1 (Stuiver and Reimer, 1993). Radiocarbon ages are reported here as 2σ calibrated years before AD 1950 (cal. yr ago; Table 1, Van der Plicht and Hogg, 2006). Stratigraphic context (Figure 3a, b) provided information about palaeoenvironments enabling us to distinguish evidence for tree mortality caused by slowly encroaching, ice-distal, outwash sediments from tree deaths caused directly by ice contact. A description of lower Bay sediments, which we here name the Beardslee Formation, and our interpretations, is included in Appendix 1.

Data for the early Neoglacial, *c.* 5500–2000 yr ago were generally characterized in terms of glacier terminus, outwash and glacial lake positions, based principally on the existing literature. For the late Neoglacial, we selected three periods with the best landscape information and relevance to the history of human tenure in the Bay, as supported below, for detailed palaeoenvironmental reconstructions. This 'time slice' methodology allows the creation of landscapes in coherent detail, but de-emphasizes changes that may have occurred between the chosen periods.

Ethnography

The ethnographic literature provided references to landscape character during and prior to the final LIA advance (Scidmore, 1893; Swanton, 1909; Black, 1957; Hall, 1962; Olson, 1967; de Laguna, 1972; James, 1973; Dauenhauer and Dauenhauer, 1987; Emmons, 1991, no date; Hoonah Indian Association (HIA), 2006). Emphasis was placed on multiple tellings of two particularly

Table 1 Radiocarbon dates used in this study

Links to sample locations in Figure 2	Sample no.[a]	Location	Dated material	Measured ^{14}C age	$^{13}C/^{12}C$ ratio	Conventional ^{14}C age (yr BP AD 1950)	Average of calibrated 2 σ radiocarbon age cal.BP (yr before AD 1950) rounded to nearest 10[b]	Marine reservoir effect correction (–470 years)[c]	Sample source
1	UW 597	Mouth of Reid Inlet	reworked wood in till	4980 ± 90		5681 ± 90	5750		A. Post and G.P. Streveler (unpublished data, 1981)
2	UW 598	Near Topeka Glacier Johns Hopkins Inlet	reworked wood in till	4655 ± 75		5389 ± 75	5430		A. Post and G.P. Streveler (unpublished data, 1981)
3	UW 596	Whidbey Passage	*in situ* stump	4385 ± 60		4925 ± 60	5220		A. Post and G.P. Streveler (unpublished data, 1981)
4	B 207584	Francis Is, S	*in situ* peat	4090 ± 40	–27.0	4060 ± 40	4790		this study
5	UW 671	Sturgess Island	*in situ* stump	4165 ± 80		4689 ± 80	4690		A. Post and G.P. Streveler (unpublished data, 1981)
6	B 194096	Kidney Island	shells in marine silt	4310 ± 40	–4.0	4650 ± 40	5030	4560_{mr}	this study
7	B 194100	Head of Berg Bay	shells in marine silt	4380 ± 50	0.0	4790 ± 50	4760	4290_{mr}	this study
8	B 207583	Francis Is, S	*in situ* spruce root	3780 ± 80	–23.1	3810 ± 80	4190		this study
9	B 207586	Willoughby Is	*in situ* spruce root	3440 ± 60	–23.6	3420 ± 60	3710		this study
10	B 207585	Willoughby Is	*in situ* stump	3190 ± 70	–25.1	3180 ± 70	3420		this study
11	UW 595	Upper Muir	N side *in situ* stump	2635 ± 60		2758 ± 60	2790		A. Post and G.P. Streveler (unpublished data, 1981)
12	I 1305	Forest Creek	wood in lake silt	2620 ± 120		2771 ± 120	2660		Haselton (1966)
13	OWU 489	Central Wachusett	stump pushed by ice	2520 ± 87		2566 ± 87	2560		Mickleson (1971)
14	I 3398	Lower Muir	wood below clay	2390 ± 110		2439 ± 110	2520		McKenzie and Goldthwait (1971)
15	B 194103	Lars Island	reworked stick	2300 ± 40	–25.7	2290 ± 40	2520		this study
16	B 194102	Lars Island	reworked woody debris	2120 ± 40	–26.0	2100 ± 40	2270		this study
17	B 148007	Gustavus	shells in marine silt	2410 ± 40		2420 ± 40	2670	2200_{mr}	G.P. Streveler (unpublished data, 2000)
18	I 2687	SE Adams Inlet	stump under silt	1700 ± 100		1621 ± 100	1860		McKenzie (1970)
19	B 194104	N of Rush Pt.	reworked organics	1860 ± 40	–21.2	1920 ± 40	1800		this study
20	B 220875	Netland Island	*in situ* stump	1760 ± 40	–23.6	1780 ± 40	1780		D. Lawson (unpublished data, 2006) this study
21	B 194099	N. Fox Farm Is.	reworked stump	1630 ± 60	–23.7	1650 ± 60	1670		this study
22									
23	DIC 941	Gustavus	reworked wood	1530 ± 50		1388 ± 50	1430		R.P. Goldthwait and G.P. Streveler (unpublished data, 1975)
24	B 9529	W of Casement Gl	organics in silt	1150 ± 60		1009 ± 60	1220		Goodwin (1988)
25	UW 672	Kidney Island	*in situ* spruce stump	750 ± 65		705 ± 65	890		A. Post and G.P. Streveler (unpublished data, 1981)
26	Y-305	Hunter Cove	*in situ* wood	850 ± 50		743 ± 50	880		Goldthwait (1963)
27	DIC 939	Upper Beartrack	*in situ* stump	380 ± 40		466 ± 40	470		A. Post and G.P. Streveler (unpublished data, 1981)
28	B 194097	Kidney island	shrub rooted in peat	430 ± 60	–26.4	410 ± 60	420		this study

(Continued)

Table 1 *(Continued)*

Links to sample locations in Figure 2	Sample no.[a]	Location	Dated material	Measured ^{14}C age	$^{13}C/^{12}C$ ratio	Conventional ^{14}C age (yr BP AD 1950)	Average of calibrated 2 σ radiocarbon age cal.BP (yr before AD 1950) rounded to nearest 10[b]	Marine reservoir effect correction (–470 years)[c]	Sample source
29	B 194095	Lester Point	root near stump	370±50	–23.7	390±50	420		this study
30	B 220874	Lester Point	wood	370±40		370±40	410		D. Lawson (unpublished data, 2006)
31	B 86328	N of Pt Gustavus	*in situ* spruce stump	233±40		290±40	400		D. Mann and G.P. Streveler (unpublished data, 2000)
32	B220866	Pt Carolus	wood	280±40	–23.3	310±40	390		D. Lawson (unpublished data, 2006) this study
33	B86378	Halibut Cove	stump rooted intertidal	240±60			360		D. Mann and G.P. Streveller (unpublished data, 2000)
34	B 220872	South Halibut Cove north of Pt Gustavus East side	wood	190±40	–23.5	210±40	280		D. Lawson (unpublished data, 2006)
35	B 220873	South Halibut Cove north of Pt Gustavus East side	wood	180±40	–23.5	200±20	280		D. Lawson (unpublished data, 2006)
36	B 220871	Lester Point	wood	180±40	–25.0	180±40	280		D. Lawson (unpublished data, 2006) this study
37	B 86379	Lester Point	*in situ* devil's club root	150±60		198±60	170		D. Mann and G.P. Streveler (unpublished data, 2000)
38	B122187	Lester Point	stump	220±40		168±40	170		D. Lawson (unpublished data, 2006)

[a]Radiocarbon lab identification: B, Beta Analytic; DIC, Radioisotopes Laboratory, Dicar Corporation, Cleveland, Ohio; UW, Univeristy Washington; I, Isotopes – a Teledyne Company, Westwood, New Jersey; OWU, Ohio Wesleyan University Radiocarbon Lab; Y, Yale.
[b]Corrected radiocarbon age (CALIB 5.0.1), 2 σ calendric age BP (AD 1950), Stuiver and Reimer (1993).
[c]Correction for marine reservoir effect (–470 ^{14}C years after Kovanen and Easterbrook, 2002; and Mann and Streveler, 2008).

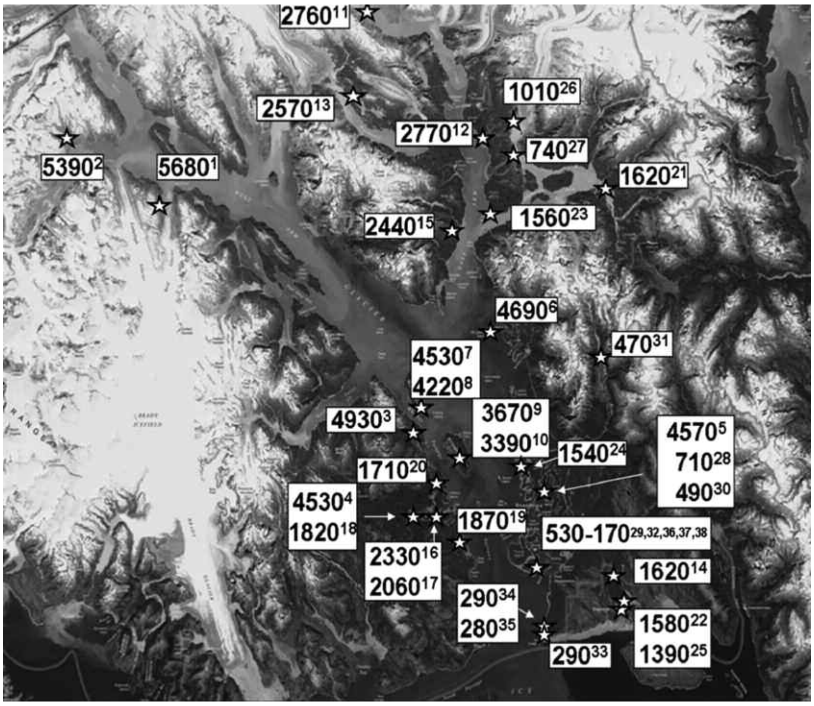

Figure 2 Radiocarbon sample site locations and ages cited in text are indicated by stars. Superscript numbers link these sites to more information in Table 1

relevant narratives – the *Glacier Bay Story* (Scidmore, 1893; Black, 1957; James, 1973; Dauenhauer and Dauenhauer, 1987; Emmons, no date) and *The Story of Kakequte* (the modern orthography is Kaakeix'wtí, used hereafter) (Swanton, 1909; Olson, 1967; James, 1973; Dauenhauer and Dauenhauer, 1987). We supplemented the written accounts with contemporary ethnographic interviews and consultation with elders from the community of Hoonah, for whom the old stories and landscapes remain very much alive (Thornton, 1995; James, 1996; Johnson, 1996; Hanlon, 2000; White, 2003).

Of integral importance was a place-name map for the Huna Tlingit homeland (HIA, 2006). This map captures over 250 Tlingit toponyms that include historic period names but also extends into a remembered pre-LIA past. These names are tied to locales with linguistic modifiers that when 'unpacked' offer nuanced details of geology, geography, landscape change, mythology, history and more (Thornton, 1995, 2008). These map names occur in various forms in all of the pertinent oral narratives recorded over the past 125 years, and corroborate the relative durability of oral history and its utility for anchoring the stories in space. The Tlingit language used in this work, unless otherwise quoted from older texts, is the modern Tlingit orthography (Story and Naish 1973, 1976; Dauenhauer and Dauenhauer, 1987, 1991; Thornton, 1995; HIA, 2006).

Results

The following sequence of Neoglacial events portrays a Glacier Bay episodically transformed from a glaciomarine system into a terrestrial environment dominated by an immense icefield with associated lake and terminus outwash features. We begin with a

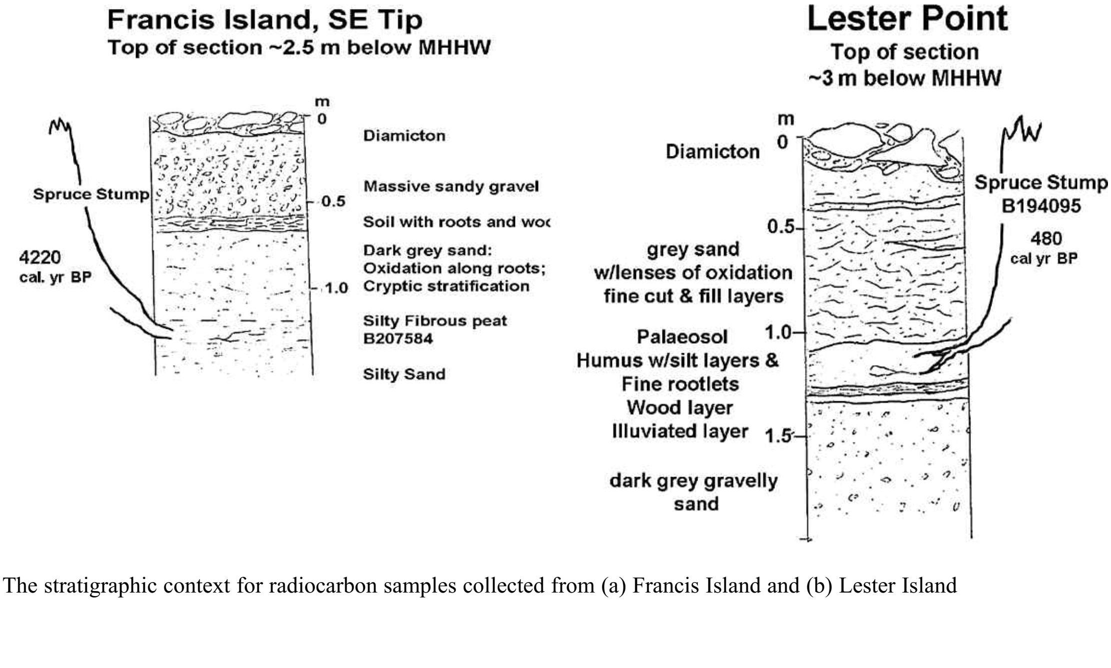

Figure 3 The stratigraphic context for radiocarbon samples collected from (a) Francis Island and (b) Lester Island

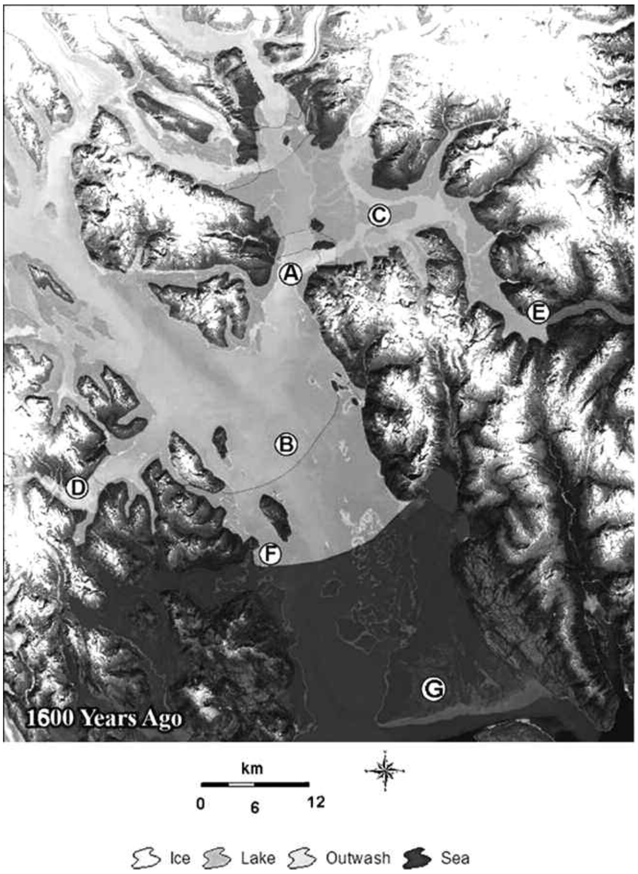

Figure 4 Glacier Bay 1600 years ago. A, the West Arm ice terminus advanced across Muir Inlet; B, the West Arm Ice terminus advanced across lower Glacier Bay; C, extent of Glacial Lake Adams in the present Muir Inlet; D, the location of the Geike Inlet ice terminus; E, the Endicott Gap lake overflow outlet to Lynn Canal; F, the extent of the forefield (outwash plain); and G, the extent of marine conditions in lower Glacier Bay that filled the fjord prior to the deposition of the central Beardslee Islands and Gustavus outwash plain

general sketch of Neoglacial events. Goldthwait *et al*. (1966) attempted a general depiction of ice positions at four points in time, based on considerably less information than is now available. Ice positions presented in this paper are broadly compatible with Goldthwait's work. Our focus is on the latter portion of this period when ethnographic information directly applies.

The early Neoglacial, 5500–2000 years ago

Initial evidence for Neoglacial ice advance in the Bay comes from the mouths of Reid Inlet, 5750 cal. yr ago, and Johns Hopkins Inlet, 5430 cal. yr ago (Figure 2; Table 1, UW597, UW598) where wood-bearing tills were being deposited. Between 5220 and 4790 cal. yr ago, outwash gravels were burying the bases of trees near sea level along Whidbey Passage, Francis Island and Sturgess Islands, respectively (Figures 2, 3a; Table 1, UW596, UW671, B207583-4) indicating that the terminal position of West Arm ice remained somewhere up-Bay from these localities. Marine silts deposited at Kidney Island 4560 cal. yr ago and Berg Bay 4290 cal. yr ago (Figure 2; Table 1, B194096, B194100) record shallow water marine conditions in portions of the lower Bay. The lack of iceberg-deposited dropstones in these silts further suggest that an outwash plain spanned the West Arm in front of the glacier by that time. *In-situ* stumps (3710 and 3420 cal. yr ago) buried in outwash at Willoughby Island, several miles to the north of Berg Bay (Figure 2; Table 1, B207586-5) support this assumption. Dates from 2520 and 2270 cal. yr ago on unrooted wood from non-local outwash sediments near Berg Bay (Figure 2; Table 1, B194103-2) suggest strongly that the forefield extended well south of the West Arm ice front by 1000 years later.

By about 2660 cal. yr ago, glacial lake silts laid down in numerous portions of the East Arm of Glacier Bay (Figure 2; Table 1, I 1305) indicate that West Arm ice had extended sufficiently far south to impound 'Glacial Lake Muir' in a still largely ice-free Muir Inlet area (Mickelson, 1971; Goodwin, 1988). At this time McBride Glacier in upper Muir Inlet was inferred to be near the mouth of its inlet and calving into lake water (Goodwin, 1988). Carroll Glacier had advanced over trees at mid-Wachusett Inlet by 2560 years ago (OWU 489), while Muir Glacier was somewhere above the midpoint of its upper fjord, based on 2790 year old vegetated outwash at that position (UW 595, Figure 1). Muir Lake persisted until sometime after 2520 cal. yr ago (Figure 2, Table 1, I 3398), after which retreat of West Arm ice collapsed the ice dam, draining Muir Lake.

The late Neoglacial readvance, 1600–1000 years ago

The minimum terminus position (Figure 4, points A, B) for West Arm ice by 1860 cal. yr ago (Figure 2, Table 1, I 2687) is indicated by the onset of 'Glacial Lake Adams' in Muir Inlet (Figure 4, point C). Lake Adams persisted until at least 1220 cal. yr ago (Table 1; B9529). To establish the dam necessary to impound this lake, Goodwin (1988) portrayed the West Arm ice front entering Muir Inlet as far as the mouth of Adams Inlet. Given that position, we extrapolate the main ice terminus in the central Bay southward to the location depicted in Figure 4, where it would have advanced into Geikie Inlet (point D). Small lakes would have been trapped along the east margin of the main Bay where the ice margin blocked the mouths of tributary valleys.

It is at this time that we get this first possible link with the ethnographic record. The name La.aayí Tukhyee (*Area Below 'Building the Lake*) appears on the Tlingit place-name map in the general area below Muir Inlet (HIA, 2006). There are no lakes in the vicinity today, and the active verb tense of this name implies that an observer may have been on hand to witness the process of a lake being built at some time in the past. There is also mention in the historical record of Huna Tlingits recounting an ice-damming event that impacted a salmon run (Scidmore, 1893), and one likely possibility is the impoundment of Lake Adams (or Lake Muir a millennium earlier).

Muir Inlet ice termini for this scenario are positioned in accordance with Goodwin (1988). Some of them are in contact with Lake Adams, based on the presence of dropstones in lake sediments at that time (McKenzie and Goldthwait, 1971). Lake Adams filled much of the lower Muir and the Adams basins, and likely overflowed by way of an outlet through Endicott gap, draining to the east into Lynn Canal (Figure 4, point E) during lake stages higher than 220 m (Goodwin, 1988). The lake may have also drained southward during its formative and waning stages, perhaps catastrophically.

Four radiocarbon dates (1800, 1610, 1670 and 1430 cal. yr ago) on non-rooted materials embedded in outwash sediments from widespread localities in the lower Bay suggest the existence of an extensive outwash plain extending southward from the ice during this period, but they do not define its distal edge (Figure 2; Table 1, B194104, DIC 943, B194099, DIC 941). A stump rooted in outwash at the mouth of Berg Bay dating from 1780 cal. yr ago (Figure 4, point F; Table 1, B220875) places this forefield edge at least as far advanced as that locality. A date on *Macoma* sp. shells from Gustavus at 2200 cal. yr ago (Figure 4, point G; Table 1, B148007) demonstrates the persistence of marine conditions there.

We locate the ice terminus near the southern margin of the bathymetric deeps northwest of the Beardslee Islands (Figure 5),

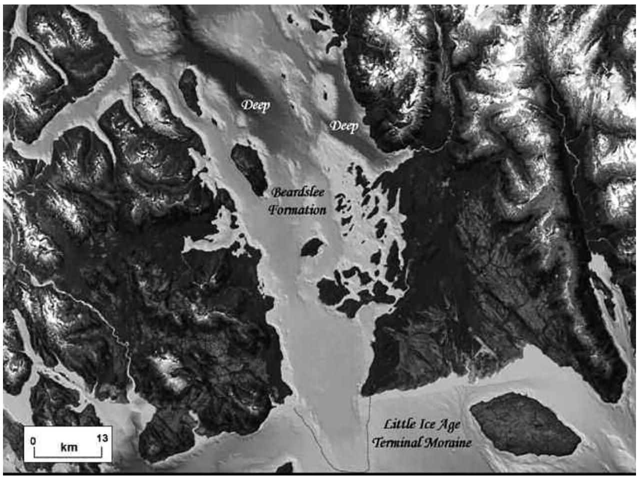

Figure 5 A bathymetric map showing the 'deeps' north of the Beardslee Islands and the presently submerged 'Little Ice Age' terminal moraine just south of and outside the bay entrance. This is a MODIS Image 2004 provided by Bill Eichenlaub of Glacier Bay National Park

and posit that the ice remained in that position for over a millennium prior to the LIA maximum. There is no indication of bedrock control in the Beardslee Islands and ice loading and crustal subsidence throughout the Neoglacial would have deepened lower Bay depositional environments (Larsen *et al*., 2005). We believe the Beardslee Islands consist of an accumulation of sediments with a maximum thickness equal to the bathymetric deeps just to the north (*c*. −250 m) plus the elevation of the highest northern Beardslee island (*c*. 30 m) for a total of *c*. 280 m. The inception of Lake Adams *c*. 1800 years ago sets an upper temporal limit for ice advance to a position at the southern extent of the deeps. A maximum period of *c*. 1550 (1800–250) years is thus indicated, from lake formation to the final LIA advance, during which time sediments accumulated at an average rate of *c*. 18 m/century. This estimate is similar to the rates of *c*. 19 m/century calculated for the Berg Formation in Adams Inlet (McKenzie and Goldthwait, 1971) and *c*. 14 m/century for the Van Horn Formation in Wachusett Inlet (Goldthwait, 1963).

The youngest date for rooted wood in Muir Inlet is from 880 cal. yr ago (Figure 2; Table 1, Y-305), which suggests, first, that West Arm ice had retreated sufficiently to release Glacial Lake Adams and allow tree growth (Goodwin, 1988; Mann and Streveler, 2008), and second, shortly thereafter Muir region glaciers had coalesced to fill the Muir basin with ice.

Before the 'Little Ice Age' maximum, 500–300 years ago

The main ice front (Figure 6, point B) lay north of the central Beardslee Islands by 420 cal. yr ago, based on wood rooted in peat atop outwash at Kidney Island (Figures 1, 2 and 6, point B; Table 1, B194097). A minor advance sufficient to trap a lake in Beartrack Valley at 470 cal. yr ago (Figure 6, point D; Table 1, DIC 939) occurred during this period.

In the centuries before the LIA maximum, the outwash plain built southward from the stationary ice front to the Bay mouth (Figure 6, points C, E and F; Table 1, B194095, B220874, B86328, B220873), and probably into the Berg-Dundas Basin (Figure 6, points G, H). The lack of constraining bedrock features within the Bay margins and the existence of vegetation rooted in outwash midway between these margins suggest that this forefield stretched laterally from the eastern to western shorelines of the present Bay and across the Gustavus lowlands. Patches of young forest (Table 1, UW 672), thicket and fen (Table 1, B194097) were scattered across a generally barren outwash on a surface

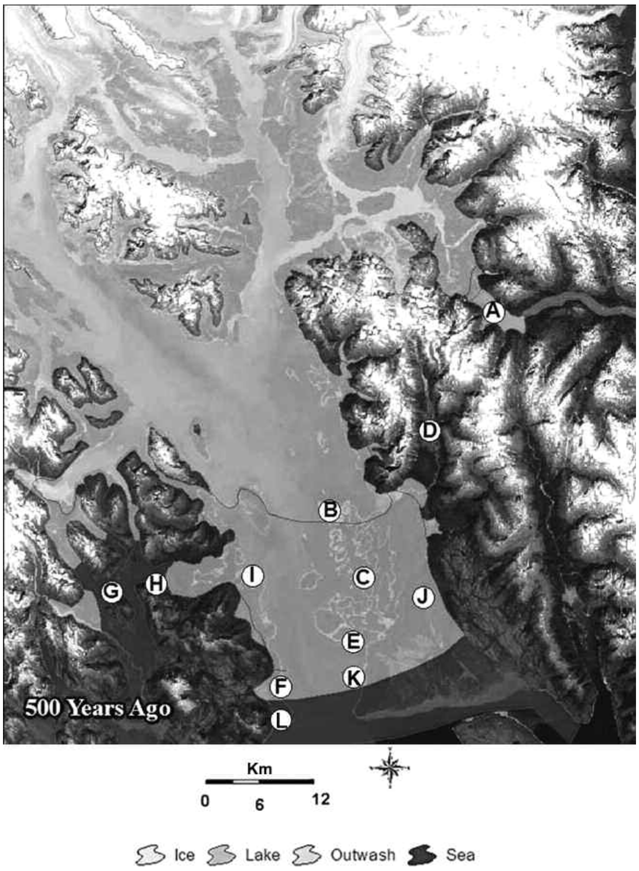

Figure 6 Glacier Bay 500 years ago. A, the relict Lake Adams; B, the extended West and Muir Arm Ice terminus; C, the central Beardslee Outwash Fan complex; D, Beartrack Valley; E, Lester Island in Bartlett Cove; F, Rush Point; G, Dundas Bay; H, Geike Inlet overwash; I, Lars Island; J, Bartlett River; K, Point Gustavus; and L, Point Carolus

chronically disturbed by aggrading streams. In contrast, the Lester Island-Bartlett Cove vicinity (Figure 6, point E) supported large trees and podzolic soils, with a range of dates spanning several centuries, indicating a forest of considerable antiquity (Table 1, B122187, B194095, B86379, Figure 3b, Appendix 1).

Two observations regarding the LIA terminal moraine configuration (Figures 7 and 8) suggest that this forest was associated with a pre-existing topographic feature in the Bartlett Cove vicinity. First, the lateral moraine aligns diagonally into the centre of the Glacier Bay trench instead of following the eastern bedrock margin, as does the western lateral moraine. Second, a pronounced inflection in the eastern moraine (Figure 8, point A) occurs at Bartlett Cove. As there are no indications of bedrock in the area, we suggest the existence of some pre-existing geomorphic feature such as a moraine or an area of aeolian dunes. The authors opt for the sand hill interpretation as we did not find evidence of elevated ice-contact deposits other than low-lying ground moraine capping the Beardslee Formation stratigraphy of the Bartlett Cove area.

The Tlingit homeland

The linkage between geological evidence and Tlingit toponyms is clearer for this period 500 to 300 years ago. Huna Tlingit memory corroborates and further focuses the geological reconstruction of the glacial landscape during the centuries prior to the catastrophe of the LIA final ice advance upon the Tlingit homeland (Figure 7).

The interpretation of the Tlingit homeland hinges on 11 Tlingit toponyms that anchor two enduring oral narratives. The *Glacier Bay Story* is a sacred story owned by the Chookaneidi Clan that recounts a human settlement located on a salmon stream in the Bay that was

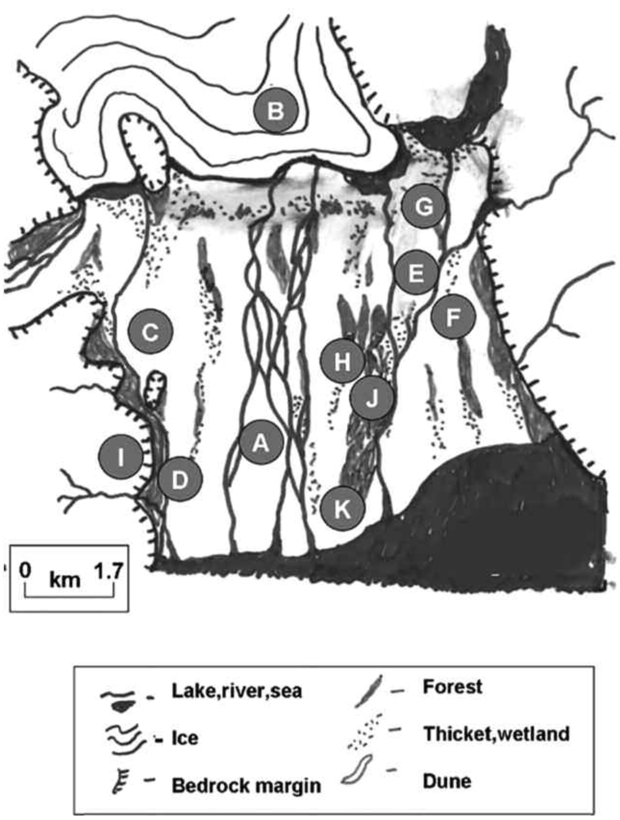

Figure 7 Conjectured Huna Tlingit Homeland of 300 years ago. Tlinglit place names from ethnohistoric accounts are A, S'é Shuyee (*Area at the End of the Glacial Silt*); B, Sít'k'i T'ooch' (*Little Black Glacier*); C, Chookanhéeni (*Grassy River*); D, Chookanhéeni Yadi (*Child of Chookanhéeni,* tributary stream); E, Ghathéeni (*Sockeye Salmon River*); F, Ghathéeni Tlein (*Big Sockeye Salmon River*); G, Aax'w X̲oo (*Among the Little Lakes*); H, L'eiwshaayí (*Sand Mountain*); I, T'ooch' Ghí'l'i (*Black Cliff*); J, L'eiwshaa Shakee Aan (*Town on Top of the Glacial Sand Dunes*); and K, Tleiw Shayee (*Clay Point*)

destroyed by the advancing glacier which came down as a result of human agency, in this case a broken taboo (Scidmore, 1893; Black, 1957; Hall, 1962; James, 1973; Dauenhauer and Dauenhauer, 1987; Cruikshank, 2005; Emmons, no date). The second narrative is the pre-LIA story of K̲aakeix wtí (Swanton, 1909; Olson, 1967; de Laguna, 1972; James, 1973; Dauenhauer and Dauenhauer, 1987; Thornton, 2008). This relates the adventures of a wandering man whose entire village in nearby Dundas Bay (Figure 1), had died from a mysterious avian-borne epidemic. He migrated north to the Alsek River (and perhaps Copper River) and married into an Athabaskan tribe from the interior. Wanting to re-establish contact with his own people he organized a trading party and traversed the valleys and glaciers to a place called Chookanhéeni, likely entering from the Alsek River valley over the Alsek-Grand Pacific Glacier systems to the northwest.

As the oldest name, S'é Shuyee (*Area at the end of the Glacial Silt*) (HIA, 2006; Figure 7, point A) indicates, the Huna Tlingit clearly recognized that their ancestral homeland was a terrestrial environment and glacio-fluvial in character, even to the point of distinguishing grain size. The land is aptly described as the distal end of the glacier system indicating that the people preferred living farthest from the direct effects of that hostile environment, and closest to, or with reasonable access to, tidewater. The glacier is consistently described as being distant. 'The only glacier was way up on Mt. Fairweather' (Black, 1957). Susie James's narrative provides us poetic detail: 'It was said you could clearly see up the bay. Through the mountains there you could see the glacier waaaaaay up the bay; it was only a tiny piece. It was hanging there up the bay. It couldn't be seen much from the river; it could only be seen from way out' (Dauenhauer and Dauenhauer, 1987). Distance and appearance are also implied in the name – Sít'k'i T'ooch' (*Little Black Glacier*) (Dauenhauer and Dauenhauer, 1987; HIA, 2006; Figure 7, point B) suggesting it was well back from the settlements (little) and in a state of quiescence (dark and rock-strewn). Yet it must have been sufficiently close that residents of the village could see trading parties crossing it while coming from the interior (north) as related in the account of K̲aakeix wtí: 'The Athapascans on their way down used to be seen when still far back from the coast' (Swanton, 1909). The geologic model (Figure 5) posits such a glacier, though markedly closer than 'way up on Mt. Fairweather'.

Determining the number and placement of rivers is somewhat challenging. The setting of the Glacier Bay Story is often framed in a broad valley with a single river running through it as indicated by NPS historian George Hall (1962): 'People say that Glacier Bay was a great valley with a single river running through it'. Annie Houston, in an account recorded in the 1950s, also suggests a single river scenario: 'In the beginning Glacier Bay was like a river, not a bay' (Black, 1957) and, 'Along the river was where the village was. Now the river is the bay' (Black, 1957). But in her narrative she links this single river to the western margin of the fjord: 'Willoughby and the other islands were in the middle of the big river, on sand bars' (Black, 1957), but goes on to link it also with Ghathéeni on the far eastern side of the fjord: 'I figure villages were not on Willoughby Island but up and down the river, on Bartlett river, or at least on the right side of Glacier Bay goin' in [sic]' (Black, 1957). Given the physiography of the Glacier Bay fjord – about 15 km wide at the north end of our study area, opening to about 20 km on the southern end, a single river channel sweeping from west to east across an unstable and aggrading outwash plain is improbable.

In fact, the ethnographic accounts do name two distinct rivers, Ghathéeni (*Sockeye Salmon River*) and Chookanhéeni (*Grassy River*) (Swanton, 1909; Black, 1957; Olsen, 1967; Dauenhauer and Dauenhauer, 1987; HIA, 2006; Emmons, no date). Four modern rivers have become namesakes of these ancient rivers for the Huna Tlingit – Chookanhéeni and Chookanhéeni Yadi (Figure 7, points C, D) are a modern stream that flows into the southwestern margin of the fjord, while Ghathéeni and Ghathéeni Tlein (*Big Sockeye Salmon River*) (Figure 7, points E, F) is associated with the modern Bartlett River and Beartrack River (HIA, 2006). Names and stories related to these rivers imply that they were also productive salmon streams ancestrally, which further suggests that they were fed by clearwater tributaries entering the main valley from bedrock-constrained lateral valleys. Sockeye salmon prefer to rear in clearwater lakes. In one narrative, lakes are also associated with a place called Aax'w X̲oo (*Among the Little Lakes*) (Figure 7, point G), a place described as somewhere up near the glacier when viewed from the Ghathéeni village (Dauenhauer and Dauenhauer, 1987; HIA, 2006). Plausible locations for lakes are morainal impoundments formed when West Arm ice pressed against the either fjord wall; geologic evidence documents glacial damming in the Beartrack Valley about 470 cal. yr ago (Table 1, DIC 939). This kind of a lake system would have linked to the nearest river system (*Ghathéeni*) through outlet channels, providing spawning habitat for sockeye salmon.

The possibility of a third, mid-valley river system is based on two lines of reasoning. Going back to Anne Houston's account, Willoughby Island, which she relates as being an island in a river emanating from the glacier, is clearly not associated with either the Chookanhéeni or Ghathéeni drainages, which would have been fed by side-valley tributaries. Given what we know of modern glacial valleys, these drainage patterns can consist of migrating channels

Figure 8 The fully extended Glacier Bay ice terminus position ~250 years ago during the 'Little Ice Age' maximum. A, deflection of the LIA ice terminus; B, location of Endicott Gap and lake overflow outlet to Lynn Canal; C, various ice-marginal lakes; D, the Gustavus outwash fan complex; E, the outwash filled Dundas Basin; and F, maximum 'Little Ice Age' ice extent, into Icy Strait

on an aggrading plain or proglacial lakes with outlet rivers if the glacier has receded sufficiently to allow their formation.

A second line of reasoning for this 'third' river comes from the stories of Kaakeix wtí's travels. Having approached his homeland from the northwest, he led an Athabaskan trading party to their first meeting with his kinsmen at the place called Chookanhéeni. But upon arrival and greeting he was abruptly turned away. This is not surprising, as he must have been presumed long dead, and his kinsmen invoked shamanistic powers in dismissing him: So Kaakeix wtí responded to his travel companions, 'they are sending us away from here … At once the Athapascans put their packs over their shoulders … They went directly to the place whither they had been sent ['below', and to 'the other side'], and, crossing a glacier, came to Sand-hill-town.' (in the Bartlett Cove vicinity, Swanton, 1909). Given that the direct distance between the location of Chookanhéeni (along the lower Bay's western margin) and modern Bartlett Cove, is only a few straight-line kilometres away, it seems odd that Kaakeix'wtí's party would backtrack up-valley to take a glacier crossing. There must have been a serious impediment to travel in the path of the direct route, such as a glacial outwash river. Our interpretations of the geological situation supports this 'three river' scenario. An unnamed and inhospitable river covered the central part of the outwash plain, and two named rivers flowed into the plain from the east and west originating from clear-water sources, that would have been constrained along the valley margins by the aggrading plain. These named rivers would have supported salmon populations and provided a means of livelihood for human habitation.

Tlingit place-names and ethnography identify a topographic eminence on the valley floor called L'eiwshaayí (*Sand Mountain (Dune) Country*) (Figure 7, point H), described as extending from the current Point Gustavus to the base of the Beartrack Mountains. As previously argued, L'eiwshaayí could have been a region of aeolian dune features or a pre-existing glacial moraine.

There is some discrepancy in ethnography as to the desirability of this valley for habitation. One Gustavus homesteader was told by his native acquaintances that the old Tlingit settlements were in an area with 'scarcely no brush or timber' (Parker, 1940). Yet modern Tlingits perceive Se' Shuyee, as having been an ideal place to live, even a 'Tlingit Garden of Eden' (Johnson, 1996). Oral history clearly identifies two inhabited areas. One was along the meadow-lined Chookanhéeni, with family groups living in houses scattered along the river, recognized in relation to each other as upstream-downstream (Dauhenhauer and Dauenhauer, 1987). Placing Chookanhéeni on the west margin of the Bay between modern namesake rivers at Berg Bay and Rush Point on the western shore of Glacier Bay (Figure 1) is supported by oral history. An informant in the 1930s located Chookanheeni near the western mouth of Glacier Bay (Olson, 1967). It is also remembered that a prominent cliff stood near one Chookaneidi village, at a place called T'ooch' Ghí'l'i (*Black Cliff*) (Figure 7, point I) (White, 2003). One rock type stands out, a black siliceous shale (Rossman, 1963) that occurs in prominent outcrops on the southern shore of Berg Bay and at a prominent cliff at Rush Point on the western shore of Glacier Bay not far south from Berg Bay (Figure 1). The cliff at Rush Point is quite prominent and south-facing, and would have provided shelter from the cold winds blowing off the glacier. Interestingly, the stream that flows into the modern Bay just north of Rush Point is called Chookanhéeni Yádi (*Child of Chookanhéeni*) (HIA, 2006), a name that implies a secondary rank, such as a tributary to a larger stream.

The other, more prominent habitation mentioned in the narratives is L'eiwshaa Shakee Aan (*Town on Top of the Sand Mountain (Dune)*) (Figure 7, point J), which was said to be a major village situated on a large dune within L'eiwshaayí. From the earliest recorded accounts, this village has been identified as being in the Bartlett Cove vicinity. For example: 'Long, long ago, the glacier advanced and swept away Klemshawshiki, the city on the sand at the base of the mountains, where the Beardslee Islands now rise' (Scidmore, 1893). Legends of the Wooshkeetaan Clan anchor to named places extending from Point Gustavus (Figure 1), Tleiw Shayee (*Clay Point*) (Figure 7, point K), through Bartlett Cove and to the Beartrack Mountains, with the Bartlett Cove area considered the specific location of the ancestral village (Hanlon, 2000; HIA, 2006; Thornton, 2008). Though now located along the eastern margin of the lower Bay, the Bartlett Cove area would have been terrestrial during the LIA and well out onto the plain (Figure 6).

How was life at L'eiwshaa Shakee Aan more tolerable than conditions we have described for the rest of the outwash plain? For one thing, tall sand dunes (or moraines) could have provided sheltered breaks from winds blowing off the glacier, particularly if their relief was sufficient as the name translation 'mountain' implies according to several Huna Tlingit elders (James, 1996; Hanlon, 2000). The story of Kaakeix wtí also offers some insights regarding the local environmental conditions. Following his arrival at L'eiwshaa Shakee Aan the narrative relates: 'the people were going to build a feast house out of the wealth the Athapascans had brought them. Every morning before they had eaten anything they went after large trees for house timbers' (Swanton, 1909). Thus, timber would have been close by the village. Evidence for a mature ancient forest is precisely in the Bartlett Cove vicinity, with the rooted stumps of large trees relatively common in the intertidal zone along the northern and southern shorelines.

These human occupation sites could have also provided defensive attributes. Archaeological evidence from throughout the Pacific Northwest indicates the region was a socially hostile environment during much of the LIA, as demonstrated by the number of forts and defensive sites (Moss and Erlandson, 1992). Several lines of evidence suggest this situation was prevalent in the S'é Shuyee region. Willie Marks, in relating his version of the Kaakeix'wtí story, recounts that '… Ghathéeni was the kind of a place ancient people lived in. They used to live there away from war parties; they lived in a safe place. A difficult place; this was how people lived' (Dauenhauer and Dauenhauer, 1987). There are also a number of stories recorded in Swanton (1909) that pertain to war events, including one specific to the Hoonah area that recounts a Haida war party from the south on a slave raid (Swanton, 1909). Also, a number of fort sites and refuge rocks have been documented throughout the region (de Laguna, 1960; Ackerman, 1968; Crowell, 1995). Defensive sites were built on elevated landforms that offered views of surrounding terrain, preferably long open vistas with difficult or restricted water access. T'ooch' Ghí'l'i, the cliff at Rush Point, and L'eiwshaa Shakee Aan, the high dune, would have afforded this advantage. George Emmons in the 1880s clarified the relationship of the two habitation areas: 'Klem sha shakian (Town on sand under high mountain) was the most populous and important older village hereabouts. All of the families are mentioned as living here … Tchuconheenie was contemporaneous with Klenshawshikeean' (Emmons, no date). Chookanhéeni village may have actually been several summer camps where families went to harvest fish, returning to the winter village of L'eiwshaa Shakee Aan, the common pattern in the Tlingit seasonal subsistence activities. Alternatively, it may have been left unoccupied before the advance of the glacier, if, for example, the river had moved away from the village, making canoe travel difficult. All of the oral histories focus on the glacier destroying Leiwshaa Shakee Aan, but none describe it overrunning Chookanheeni.

The 'Little Ice Age' maximum, 250 years ago, and the exodus

Evidence for the extent of LIA maximum is etched clearly on the modern landscape (Larsen *et al.*, 2005; Figure 8). The Adams basin was filled with ice and outwash, switching drainage to the east through the Endicott Gap into Lynn Canal (Figure 8, point B). The trace of the ice margin infers that lakes were trapped along the glacier flanks, the largest of which flooded most of Beartrack Valley (Figure 8, point C). Outwash issued from large rivers to create the Gustavus area fan complex (Figure 8, point D) and filled the former Dundas basin (Figure 8, point E). The glacier's terminus is marked by prominent moraines. It projected well into Icy Strait, leaving a now submarine, terminal moraine (Figure 5, Figure 8, point F). Ice loading from the glacier resulted in marine transgression in Icy Strait that reached 3–5.7 m (most likely *c.* 4 m) above present sea level (Larsen *et al.*, 2005; Mann and Streveler, 2008).

The five youngest radiocarbon dates at or below the latitude of Bartlett Cove, range from 280 to 170 cal. yr ago (Figure 2; Table 1, B20871-3; B86379, B122187) and record an average time of 275 years relative to AD 2000. This provides a minimum estimate of AD 1725 for the Tlingit-evicting LIA ice advance. In 1794 Lt. Whidbey of the Vancouver expedition mapped the Glacier Bay icefield terminus when it had already begun its retreat back from its terminal moraine (Lamb, 1984) allowing a 70 year window during which time the glacier must have advanced from Bartlett Cove into Icy Strait and then begun its retreat. The median date of this window – AD 1759 – aligns with a published estimate of AD 1770 based on dendrochronolgy data (Larsen *et al*., 2005).

Once ice had extended into Icy Strait, the now-tidewater terminus began to destabilize. In the tidewater glacier cycle (Post and Motyka, 1995) such destabilization is generally followed by extensive calving retreat such as occurred after the Bering Glacier surge of 1993–1994 into Vitus lake (Molnia and Post, 1995) and the LeConte Glacier calving retreat of 1996–2000 in LeConte Bay near Petersburg, Alaska (Motyka *et al.*, 2003).

Exodus ethnohistory

The accounts of eviction handed down through generations of Tlingit elders describe this final stage of the LIA advance as a catastrophic event that over-ran the village, barely giving the people time to escape. The Glacier Bay Story is an example: 'What's wrong with the glacier? It's growing so much. They used to see it wa-a-a-a-a-y up the bay. But now it was near, getting closer, … It was now growing fa-a-a-a-a-st. They said the way it was moving. The way it was growing, was faster than a running dog' (Dauenhauer and Dauenhauer, 1987). Annie Houston provides this view of the next stages: '… The glacier came and pushed all the sand away. The glacier came almost to Pt. Adolphus on Chichagof Island' (Figure 1, Black, 1957). The people were so concerned that the glacier would advance across Icy Strait, cutting their world in half, that they 'threw a slave into a crevasse and so propitiated the Ice Spirit, and the glacier retreated' (Emmons, 1991). Point Adolphus bears that woman's name – Sdakweixh Lutú (*Sdakweixh's Point*) (HIA, 2006).

The people, now known as the Xunaa Kawoo (*Lee of the North Wind people*) for the place they migrated to after their exodus, returned to their Glacier Bay homeland and applied many names of the remembered landscape – such as Chookaheeni or Gathéeni They also applied new names to the transformed landscape – first Xáatl Tú (*Among the Icebergs*), and eventually Sít' Eeti Gheeyí (*The Bay in Place of the Glacier*). The stories of their time in S'é Shuyee are still very much alive for the Huna Tlingit, and their relationship with this ancestral place defines who they are as a people.

Discussion

Human occupation throughout the 5000 year Neoglacial history in Glacier Bay has been tempered by several environmental factors. Glaciers were more extensive than today and directly excluded human habitation in large parts of the Bay. The large, glacially generated, aggrading outwash features would have created exposed, unstable human habitation sites. Proxy temperature records indicate that cooling mean summer temperatures (12.25°C) relative to the Holocene Warm period (15.8°C during Hypsithermal high, 8000–6000 years ago) would have begun to challenge human occupants beginning about 5000 years ago (Mann *et al*., 1998). Cooling would have climaxed during the late stages of the LIA, when even in mid summer '… the surrounding ice duffused a chill we could scarcely endure' (Menzies, 1991). For parts of the mid Neoglacial, large ice-dammed lakes in Muir Inlet may have created glacial lake outburst flood hazards for outwash plain occupants. Earthquakes and tsunamis generated along the Fairweather fault system in the eastern Gulf of Alaska (Mazzotti and Hyndman, 2002) would have created episodic hazards, especially along oversteepened fjord walls (Wieczorek *et al*., 2007).

Before the final LIA advance, climate, topography and resource availability made S'é Shuyee 'a difficult place' for human occupants (Dauenhauer and Dauenhauer, 1987). Despite these conditions, Tlingit oral history makes it clear that people did maintain important villages there. Convergent evidence from geology and ethnography suggests that habitation sites were available where landforms such as bedrock points, moraines or stabilized dunes constrained rivers, provided shelter and permitted forests to develop. River estuaries would have provided access to the sea as well as proximity to overland trade routes such as those available to the ancient and modern villagers of Klukwan along the Chilkat River north of the Glacier Bay near Haines, Alaska.

Deteriorating conditions in Icy Strait makes human residence within the Bay much more explicable. Sea level rose to about 4 m higher than present as advancing ice loaded the underlying crust (Larsen *et al*., 2005; Mann and Streveler, 2008). This destabilized and eroded the forest margins making them wind-prone and without meadowy upper beaches. At Point Adolphus 'Mussels and clams used to wash way up in the woods' (Annie Houston in Black, 1957). unstable storm beaches formed along shorelines and were covered with silt from glacial river discharge. Deep snows impacted lowland and subapline habitats and many streams were invaded by glacial meltwater and a transgressing sea. Conditions for key food resources such as mountain goat, deer, shellfish and salmon would have been greatly compromised. Tlingit eviction narratives say nothing of joining extant villages or encountering other occupants as they fled across Icy Strait. Deteriorating LIA conditions are correlated throughout northern Southeast Alaska with increased settlement of defensive sites during the last millennium (Moss and Erlandson, 1992).

Conclusions

Data sources from different disciplines enable us to portray landscape conditions during periods of advancing glacial ice from the upper west side of Glacier Bay to the Bay mouth between 5000 and 250 yr ago, with at least one ice reversal. Stratigraphy and geochronologic evidence from the Beardslee Formation indicates the existence of a large outwash plain, very likely for the millennium prior to the LIA maximum, and certainly for the centuries just before that 'final' ice advance. Human living conditions on this plain were difficult because of deteriorating climate and landscape dynamism, including probable jokulhlaups when glacial lakes Muir and Adams may have drained catastrophically across it. However, Tlingit oral history makes it clear that people lived there in significant numbers just prior to the LIA maximum, perhaps in response to even more severely deteriorating conditions elsewhere or conflicts with competing groups. The final ice advance to the Bay mouth about 250 yr ago was very abrupt after a prolonged still-stand, and evicted the Tlingit from their ancestral heartland.

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Appendix 1: the Beardslee Formation

The extensive suite of late-Holocene unconsolidated sediments occupying central and lower Glacier Bay is here termed the 'Beardslee Formation'. These deposits form the Beardslee Islands, the perimeter of Beartrack Cove, the Gustavus forelands, Lars and Netland Islands on the Bay's western shore near Berg Bay, and occur as discontinuous pockets along island and mainland shores in the mid Bay (Figure 1). The Beardslee Formation is comprised of eroded fluvial, lacustrine and marine sediments, in some localities sparsely overlain by aeolian sands and silts or erratics and till, sometimes deformed. Waterlain deposits rarely consist of particle sizes larger than fine gravel except in the formation's northern extent, atop Strawberry Island, and along the shore of Beartrack Cove. Silt and sand crop out along many shores. Such deposits on Kidney Island and upper Berg Bay contain the marine bivalve *Macoma* sp. Other occurrences such as the Strawberry Island bluffs contain varved sediments of possible lacustrine origin, but their biotic sterility has left this interpretation uncertain. The LIA lateral moraine cuts NE–SW across the Beardslee Formation. Outside the moraine, the Gustavus forelands are unmodified by ice, and reflect the formation's overall topography prior to the final LIA advance.

Soil, peat and rooted woody plants are generally scarce. Localities with such remains include Kidney Island, Berg Bay, Rush Point, Francis Island, Willoughby Island, Lester Point, Bartlett Cove and Point Gustavus (Figure 1). *In situ* organics at these sites are immediately overlain by generally fine-grained fluvial sediments, possibly accumulated in areas of local subsidence related to ice loading upvalley. The Sitka Spruce tree stumps we observed rooted on Francis, Willoughby and various Beardslee Islands, Bear Track Valley and the Gustavus area were in growth position and showed no signs of lateral offset from their roots, tension fractures, curved trunks, ice abrasion, or other uprooting (Figure 3a). Fleisher *et al*. (2006) observed buried forests (Spruce, cottonwood and alder) that had been previously killed by outwash in the forefield stratigraphy of the Bering Glacier which were subsequently sheared and deformed during the 1993–1995 surge. We did not see such deformation in Glacier Bay tree stumps. At Kidney Island we collected a shrub rooted in peat that had been uplifted and rotated sideways as a block, presenting itself in cross-sectional view on the beach, suggestive of ice deformation 400 yr ago. Wiles *et al*. (1999) attributed the general demise of spruce forests in the Bering Glacier foreland during the fifth and sixth centuries AD to foreland aggradation indicative of glacial advance up valley and not direct ice contact. In Glacier Bay our observations indicate burial of terrestrial forested surfaces by aggrading outwash rather than direct shearing of forests by over-riding glacial ice. We interpret a prevalent surficial diamicton in the Beardslee Formation to be till associated with the LIA ice advance and retreat, and not the direct cause of tree mortality.

Nearly all *in situ* organics (Figure 3a, b) are comprised of thin soil, peat, shrubs or youthful spruce trees exposed by wave action in a rapidly uplifting (38–32 mm/yr; Larsen *et al*., 2005) upper intertidal zone. The prevalence of fine-grained, well-sorted, laminar and cut-and-fill deposits are interpreted to have been laid down in a low-energy fluvial environment. Locally subsiding areas related to ice loading probably created depositional lows in which these sediments accumulated. The general scarcity of *in situ* organic materials is an indication of an outwash surface generally barren of vegetation.

Contrasting with the general characteristics of the Beardslee Formation palaeoenvironment described above is a zone of abundant *in situ* forest remains extending from near Point Gustavus northward through the Bartlett Cove vicinity and discontinuously to Beartrack Cove (Figure 1). These include numerous tree stumps > 0.5 m in diameter. In one site on Lester Point, at least one 0.8m diameter spruce is present, as were forest floor palaeosols with devil's club (*Echinopanax horridum*), which today seldom occurs in forests less than a century old. Persistence of forest at this location is indicated by dated stumps ranging in age from the LIA maximum to over 500 years ago (Table 1) and buried soil exhibiting a podzolic e-horizon (Figure 3b).

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