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Paleogeography of Human Settlement at Iqaluktuuq, Victoria Island, Nunavut

Julie M. Ross [1,*] and T. Max Friesen [2]

[1] Culture and Heritage, Department of Education Culture and Employment, Government of the Northwest Territories, Yellowknife, NT X1A 2L9, Canada
[2] Department of Anthropology, University of Toronto, 19 Ursula Franklin St., Toronto, ON M5R 2S2, Canada
* Correspondence: julesmross@yahoo.ca

Abstract: Change in sea levels, be they isostatic or eustatic, impact humans and the paleogeography they inhabit. In this paper we examine paleogeography at Iqaluktuuq, a section of the Ekalluk River, Victoria Island, Nunavut, between Tahiryuaq (Ferguson Lake) and Wellington Bay. The area's isostatic rebound impacted the Ekalluk River's development and the use of the area by two essential subsistence resources, Arctic char (*Salvelinus alpinus*) and caribou (*Rangifer tarandus*). This, in turn, impacted the choices of Pre-Dorset, Middle and Late Dorset, and Thule/Inuit people regarding site locations. A new relative sea-level curve developed using calibrated radiocarbon dates on marine shells and terrestrial material from archaeological sites is produced for Iqaluktuuq. Based on the data, large scale (1:50,000) paleogeography maps are presented for the period of human occupation of Iqaluktuuq, 3100 calibrated years Before Present (B.P. cal) to present, revealing how paleogeography impacts people's settlement choices.

Keywords: sea level; nunavut; archaeology; arctic; settlement patterns; Dorset; Thule; Inuit human-environment relationship; environmental archaeology

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1. Introduction

Changes in isostatic and eustatic sea level impact lands and waterways through time, with implications for migration, trade routes, resource availability, land availability, and more for people, past, present and future. The complexity and nature of interaction between people and fluctuating water levels are contingent on structural and quaternary geology, climate change, bathymetry, topography, and the longevity and location of human occupation of regions. Some of these intertwined histories are complicated by tectonic activity, regression, and transgressions caused by isostatic and eustatic changes. Examining the interwoven connections between humans and these fluctuations is always complex; however, the comparatively short human occupation of Inuit Nunangat (the Canadian Arctic) and the more straightforward Holocene portion of the Quaternary glacial history of the Central Arctic permit an investigation into how changes in paleogeography, resulting from fluctuating water levels, impacted human choices in the past.

Our research on southern Victoria Island (Kitlineq) differs from past Canadian Arctic sea level investigations (Figure 1). We use sea level curves, not to provide relative chronology or general comments about paleogeography, but rather to understand the details of changing landscapes to understand Paleo-Inuit and Inuit choices regarding settlement location.

An environmental archaeological case study was initiated within the framework of the Iqaluktuuq Project, a collaboration between the Pitquhirnikkut Ilihautiniq/Kitikmeot Heritage Society (PI/KHS) of Cambridge Bay, Nunavut, and the University of Toronto. Iqaluktuuq, meaning "place of many Arctic char", is the name of a 3 km stretch of the Ekalluk River that drains Tahiryuaq into Wellington Bay. Tahiryuaq, meaning the big lake, was formerly known as Ferguson Lake and is north of Cambridge Bay on Victoria Island, Nunavut (Figure 2).

Figure 1. Victoria Island (Kitlineq), Canada.

Among the goals of the Iqaluktuuq Project are the reconstruction of human settlement patterns from the area's earliest occupation to the recent Inuit period and how different groups incorporated the area into their annual cycles [1]. Knowing how, or if the environment changed, is the first step to determine if changes in the archaeological record are related, at least in part, to adjustments in the environment or other factors. Establishing the paleogeography of the area is one stage of evaluating whether environmental factors might have influenced the area's settlement; the second stage would be evaluating climate change.

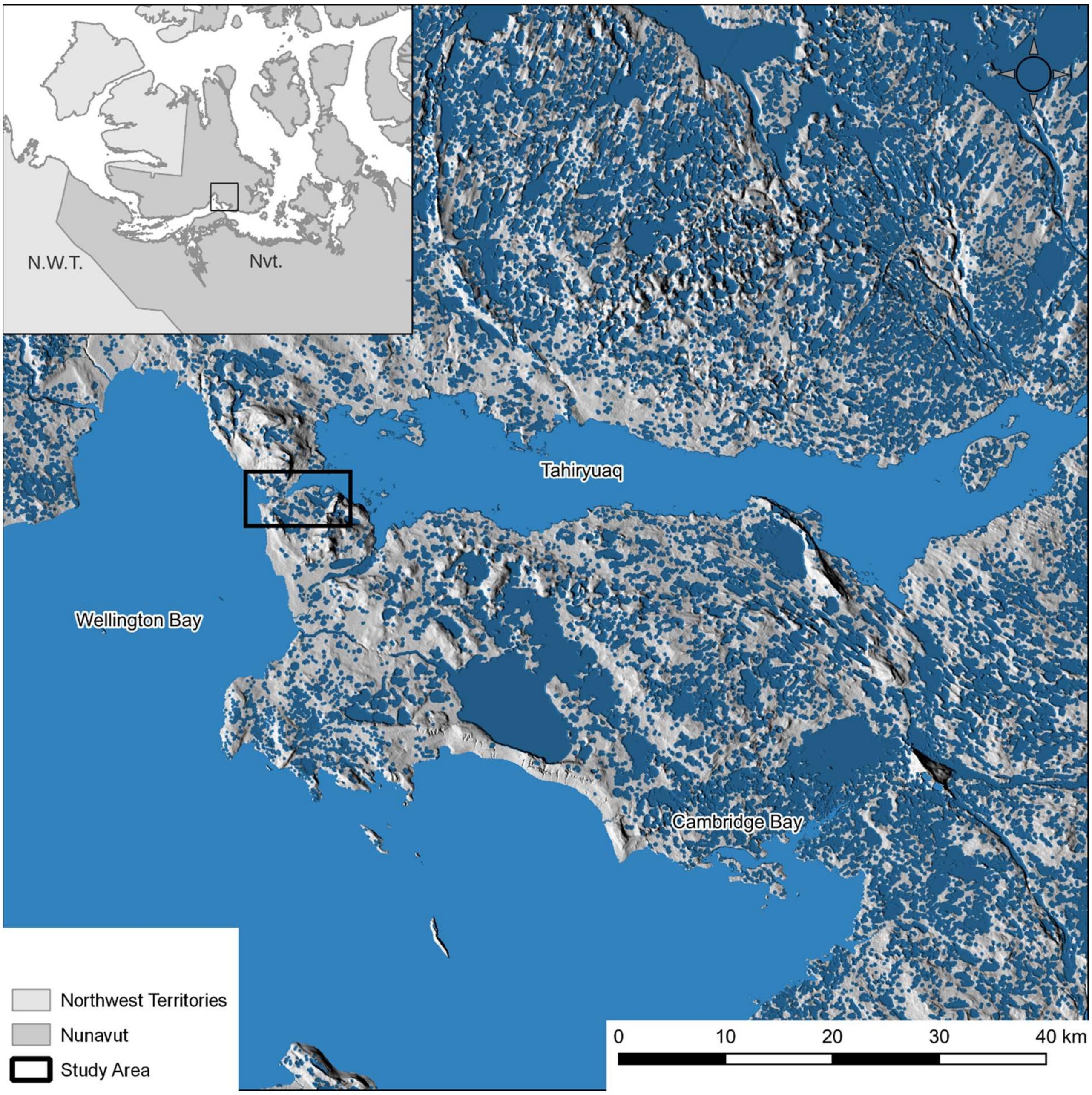

Figure 2. Iqaluktuuq Study Area.

1.1. Background

1.1.1. Archaeology

Iqaluktuuq contains evidence for settlement by peoples of most major traditions in Eastern Arctic culture history, including Pre-Dorset, Middle Dorset, Late Dorset, Thule, and recent Inuit. Iqaluktuuq was abandoned several times since its initial occupation around 3100 calibrated years Before Present (cal B.P.) (Table 1). Abandonment was likely caused by a combination of social and environmental factors, including fluctuation in critical subsistence resources including Arctic char (*Salvelinus alpinus*) and caribou (*Rangifer tarandus*), fluctuations in climate conditions, and changes to the local topography.

Table 1. Date ranges for the four major periods of occupation at Iqaluktuuq.

Tradition	Phase	Time Period
Inuit	Thule/Inuit	550 cal B.P [1]–present
Paleo-Inuit	Late Dorset	950–600 cal B.P.
	Middle Dorset	2000–1600 cal B.P.
	Pre-Dorset	3100–2900 cal B.P.

[1] year calibrated Before Present (cal B.P.).

William Taylor was the first archaeologist to record the sites at Iqaluktuuq. Research on the area continues, though it is important to note that Inuinnait (modern Inuit of the region, sometimes referred to as "Copper Inuit" in the scholarly literature) always knew Iqaluktuuq was culturally important [2,3]. Renewed fieldwork as part of the Iqaluktuuq Project occurred from 1999 to 2010 and included further survey and mapping as well as excavations at ten sites [4–15] (Figure 2). Primary attributes of each significant site are summarised in Table 2, though it must be noted that information on these sites is somewhat uneven; some have been excavated and published intensively, while others have only been observed during a rapid survey or are known only through Taylor's [16] field notes. Of note, on the north side of the river is an extensive caribou drive system probably used by all but perhaps the Pre-Dorset peoples who lived at Iqaluktuuq [7]. The area also contains large numbers of stone caches of varying ages (based on lichen cover), but which, for the most part, cannot be dated accurately. Further details about these sites are available in the publications cited above; major additional results regarding chronology, subsistence, and settlement are currently being prepared for a forthcoming monograph. The present paper is focused on the broadest patterns of human settlement concerning environmental change represented by topographic developments.

Table 2. Summary of Iqaluktuuq archaeological sites.

Site Name	Pre Dorset	Middle Dorset	Late Dorset	Thule/Inuit	m A.S.L [1]	Dominant Fauna
NiNg-1 Buchanan Area 1		A [2]				C
NiNg-1 Buchanan Area 2	A				22	C
NiNg-1 Buchanan Area 4	A	A				C
NiNg-1 Buchanan Area 2	A				22	C
NiNg-1 Buchanan Area 5	A				18–19	C
NiNg-1 Buchanan Area 6		AS				CF
NiNg-2 Bell		AW?	AW	AWS	16	CF
NiNg-3 Ballantine		AS			20	C
NiNg-4 Drive System		O?	O?	O		
NiNg-5 Ferguson Lake		AW		AO	13–17	CF
NiNg-7 Wellington Bay	A				30	CS
NiNg-8 Freezer			AS		4–9	FC
NiNg-10 Menez	A				28–30	C
NiNg-11				W?		
NiNg-12		AS				
NiNg-13 Hess				ASW		CF
NiNg-15 Peetuk		W?	AW		16	C

Table 2. *Cont.*

Site Name	Pre Dorset	Middle Dorset	Late Dorset	Thule/Inuit	m A.S.L [1]	Dominant Fauna
NiNg-16		A				
NiNg-17			AS		8–10	CFSB
NiNg-18		A	A	AS	13	
NiNg-24		AS				
NiNg-25		A				
NiNg-26		A		AS		
NiNg-29 Camp Site				ASW		

[1] metre above sea level (m a.s.l.). [2] Abbreviations: A = Diagnostic artifacts; W = winter dwelling; S = summer dwelling; O = other; ? = uncertainty in assessment. Dominant fauna: C = Caribou; S = Seal; F = Fish; B = Birds. This category does not include rare taxa.

Paleo-Inuit

Eastern Arctic prehistory is commonly divided into two major Traditions. The earliest is Paleo-Inuit (also known as Paleo-Eskimo). At Iqaluktuuq, there are three sequential phases in the Paleo-Inuit period: Pre-Dorset, Middle Dorset, and Late Dorset (Tuniit).

Pre Dorset

Pre-Dorset people arrived in the Nunavut region from Alaska around 5000 cal B.P., after which their populations fluctuated across time in the various regions of the Eastern Arctic. The Pre-Dorset occupation of Iqaluktuuq occurs at three sites and is restricted to a narrow span, from ca. 3100–2900 cal B.P. The Buchanan site, NiNg-1, is a large and complex site with several spatially separated Pre-Dorset components. At two sites, NiNg-1 and NiNg-10, faunal samples were dominated by caribou, while at site NiNg-7, caribou and seal are both relatively common. No Pre-Dorset site contained definite dwelling features, though excavators suspected the former presence of tent occupations at most or all of them.

Middle Dorset

There is an occupational hiatus of almost a millennium in the project area following Pre-Dorset, with the next major occupation being Middle Dorset. Migration likely came from the east. The primary Middle Dorset occupation at Iqaluktuuq lasted from ca. 2000–1600 cal B.P.; however, it must be noted that Middle Dorset groups continued to occupy adjacent regions until at least as late as 1300 cal B.P. based on radiocarbon dates at aggregation sites near Oxford Bay [17]. Thus, occasional visits to Iqaluktuuq likely continued from 1600–1300 cal B.P.

The 12 Middle Dorset sites indicate a relatively dense and variable occupation. Most of the Middle Dorset occupations listed in Table 2 consist of surface or buried components with diagnostic Middle Dorset artifacts (mainly harpoon heads) as well as faunal remains, but without clearly defined dwelling features. However, four sites (NiNg-1 Area 6, NiNg-3, NiNg-12 and NiNg-24) contain definite, or probable remains of summer tents. In addition, NiNg-5 is a cold season site with two Middle Dorset semi-subterranean structures. NiNg-2 and NiNg-15 may also contain similar cold season structures based on preliminary test excavation, however the evidence is inconclusive. While most Middle Dorset sites appear to have an economic focus on caribou, at least two, NiNg-1 Area 6 and NiNg-5, also contain significant quantities of fish bones. Fish bones are likely greatly under-represented at several other Middle Dorset sites due to taphonomic issues–most components are not deeply buried, and therefore fish bones are likely to have been destroyed in much higher frequencies than mammal bones.

Late Dorset

Following a second hiatus in the archaeological record at Iqaluktuuq, Late Dorset people arrived as a new migration from the east. The Late Dorset period is well represented at Iqaluktuuq, lasting in this region from ca. 950–600 cal B.P. [18]. Cold season occupations are evident at NiNg-2, which contains a minimum of 10 Dorset semi-subterranean houses, plus extensive middens dating primarily to the Late Dorset period. NiNg-15 also contains several Late Dorset semi-subterranean houses, though this site was not investigated closely. Warm season occupations are evident at NiNg-8, which contains the remains of a single tent structure and extensive middens. Most spectacularly, NiNg-17 is a very large Late Dorset aggregation site consisting of four boulder-outlined "longhouses" up to 38 m in length and an abundance of other features [1]. Subsistence at NiNg-2 and NiNg-17 show an emphasis on caribou and fish, with the former also having an abundance of Arctic fox. NiNg-17 has a more diverse economy, as evident from the presence of high frequencies of bird and seal bones in addition to caribou and fish. The diversity probably results from the season of occupation (summer) and location (outer coast), which did not support dense populations of a specific resource as did the river in the autumn.

Thule/Inuit

At the end of the Late Dorset period, Paleo-Inuit were replaced by Inuit, who arrived from Alaska in a series of migrations beginning in the 13th century A.D. The earliest Inuit are known as Thule; later Inuit of this region, including modern residents, are known as Inuinnait.

Thule

The earliest known Thule Inuit sites in the southeastern Victoria Island region date to ca. 550 cal B.P. [8]. At Iqaluktuuq, site NiNg-2 has a particularly dense and varied Thule occupation. It contains six large stone-built semi-subterranean houses, tent rings, and dense middens which in some places grade into the underlying Dorset middens at the same site. Other Thule sites include NiNg-13 with tent rings, midden, and one possible semi-subterranean house; NiNg-29 with a single winter house; and NiNg-11 which contains three semi-subterranean houses assumed to be Thule in age, an identification which cannot be confirmed due to a lack of diagnostic artifacts.

Inuinnait

The Inuit occupation of Iqaluktuuq appears to have been continuous from the earliest Thule settlement of the Bell site to the present. Several sites are clearly recent, based on the presence of Eurocanadian trade goods and a lack of lichen cover on stone structures such as tent rings or caches. However, it has proven extremely difficult to isolate sites across the full temporal range between early Thule and very recent; thus, we consider Thule and Inuinnait as a single continuous period in Tables 1 and 2. During the more recent Inuinnait period, NiNg-2 continued to be occupied, as did NiNg-13 and NiNg-29. Tent rings relating to Inuinnait settlement are relatively common; however, faunal samples are not, though it is clear from the region's oral histories that fish and caribou were significant resources.

1.1.2. Sea Level Background

Interdisciplinary archaeological and geological studies have been used to understand the complexity of sea level changes across the globe [19,20]. Technological advances in the past twenty years, including the development of Geographic Information Systems (GIS) models of paleoshorelines, predictive models for submerged landscapes, and Virtual Reality, allow a vivid presentation of past landscapes [21–23]. These interdisciplinary studies address fundamental questions for understanding the human past such as nature of human migration [24]; explaining apparent regional hiatuses [25]; establishing relative dates of sites [26,27], shifts in demographics [28], and changes in subsistence resources [29,30].

The connection between archaeological sites and sea level development was proposed during some of the earliest Arctic archaeological investigations. Mason [31] provides a concise history of beach ridge studies tracings its origins to Darwinism. Many of the synthesized observations are still relevant today. Mathiassen [32] (p. 544) likely made the first Canadian Arctic connection between beach ridge sequences and ages of archaeological sites, Collins [33] (p. 256) used beach ridges to infer the age of archaeological sites on St. Lawrence Island in Alaska, and Meldgaard developed a prehistoric sequence in the Eastern Arctic using beach ridge chronology to date sites and harpoon styles. In the 1970s, researchers started questioning the direct relationship between beach ridge sequences and the ages of archaeological sites. Based on multidisciplinary research, it was established that beach ridges could be used locally to establish possible relative ages and to establish a minimum elevation at which archaeological sites within a defined region and from a specific cultural tradition might be located, but not for larger, pan Arctic use [34]. The practice of using raised beaches as a relative dating method continues [35,36]. However, assuming a correlation between relative sea level and the age of an archaeological site can be misleading [37,38]. Sea level changes are credited with variations in resource availability [39–41] (McGhee p. 91, Schledermann p. 12) and polynya development [42]. Arthur Dyke, a quaternary geologist and James Savelle, an archaeologist, have used their combined disciplines to address a diversity of environmental and archaeological issues using beach ridges and relative sea level changes, including proposed fluctuation in human populations [43–47].

The geological understanding of the beach ridge formation process has become more nuanced since its first application to the Arctic archaeological record. As knowledge increased, it became apparent that the glacial load of an area will impact the resulting relative sea level (r.s.l.) curve in complex ways, leading to significant interregional variability [48–53]. Quinlan and Beaumont [54] suggest that sea level curves that reflect local changes caused by subsiding or uplifting of the earth's surface vary significantly over distances of 500 km, owing to specific glacial histories. The smaller the area sampled to establish a curve, the more accurate the results. Beach ridges associated with the earliest Paleo-Inuit occupations less than 30 km apart can differ a metre in elevation [55,56]. Dyke and Peltier [49] explored the variability of North America's relative sea level based on 51 curves. After eliminating outliers, they based their analysis on curves with between five and 31 dates; the average number of dates is 13. Establishment of marine limits, being the greatest height quaternary marine features are recorded on land, decline in elevation from east to west. Conversely, rate of isostatic rebound rises west to east [57,58]. The literature deals less with north to south variability; however, more southern locations would generally have lower marine limits and less isostatic rebound.

Victoria Island presents a complicated glacial landscape which indicates changes in the direction of ice flow and speed during deglaciation [59]. A simplified glacial history contextualizes this work. During the Last Glacial Maximum (21,400 cal. B.P.), Victoria Island was ice covered [48,50,52]. By 10,000 cal B.P., deglaciation of southern Victoria Island began; after which, large portions were inundated with seawater [49,60]. The elevation of past marine limits for Victoria Island ranges from 0 to approximately 225 m [61]. Evidence of the inundation, such as shingly to sandy marine beaches and marine shells found inland, varies across the region [61]. The highest point in the Wellington Bay area where the case study is situated is approximately 158 m above sea level (a.s.l.). However, Sharpe's [62] highest dated shell sample from the region is from an elevation of 130 m a.s.l. (GSC-4234, 9140 $\pm$ 100).

2. Materials and Methods

Field methods used followed those of Arthur Dyke [63]. Aerial photographs were used to identify raised beaches within a reasonable distance of the base camps, accessible by all-terrain vehicles (ATVs). These beaches were surveyed for dateable material, and if located, it was collected. Sample locations were recorded using a Garmin handheld geographic positioning system (GPS). Altimeter readings were recorded at the sampling site and archaeological sites. Throughout the day, readings were recorded at reference locations and sea level, allowing accurate calculations of sample elevations.

Accuracy of the altimeter readings, confidence in samples' association with past marine levels, and knowledge of mollusc species' habitats [64] guided the assessment of sample submission choices. Species identifications relied on published comparative material [65–67].

Sample preparation for dating included removing lichen or redeposited calcareous material from the shells using a dremel tool, after which pressurized air removed dust adhering to the sample. Isotrace provided Accelerator Mass Spectrometry (AMS) dates on selected samples; the Geological Survey of Canada (GSC) provided conventional radiocarbon dates from two sampling locations for redundancy.

Friesen's research program has resulted in extensive dating of the archaeological sequence at Iqaluktuuq [18]. While the archaeological sequence has a riverine focus, the land at the time of human occupation would be above the corresponding marine limit and the sites discussed are within a short distance from the coast of Wellington Bay. Curve development utilized the oldest accepted date from each archaeological context associated with an accurate altimeter reading. Archaeological dates were processed at the W. M. Keck Carbon Cycle AMS facility at the University of California, Irvine, which uses a well-described and refined pre-treatment method, particularly for bone. This method involves cleaning, decalcification, gelatinization, and ultrafiltration (for further details, see dos Santos Neves [68]).

Sea level curves were produced using calibrated radiocarbon dates. All dates were calibrated in Oxcal 4.4 [69], using the IntCal20 calibration curve [70]. Radiocarbon dates on marine shells were calibrated using a ΔR 190 $\pm$ 96, which is an average of seven corrections, all from the Coronation Gulf area [71,72].

In cases where calibrated dates yielded multiple intercepts due to fluctuations in the calibration curve, dates from the range with the highest probability were used to construct the Iqaluktuuq curve. It is not uncommon for archaeological sites to cover areas spread across elevations. In cases where an archaeological site is associated with a range in elevation, the lowest elevation was used as a data point to develop a relative sea level curve. Curve construction was interpolated to ensure the majority of the calibration range associated with either terrestrial or marine material remained above or below the curve, respectively. However, even when using point data such as a radiocarbon date, data points may fall above or below the interpolated curve [43] (p. 375).

3. Results

When dating palaeoshorelines, errors can be introduced due to the source material dated, the relative stratigraphy of all the dates, and technical caveats associated with all radiocarbon dates [61,64,73–80]. Twenty-five field localities were sampled, representing a range in elevation from 4 to 130 m a.s.l. Of these, thirteen shell samples from 11 locations were submitted for radiocarbon dating. Construction of the curve used these dates and twelve dates from archaeological sites associated with altimeter readings (Table 3).

Table 3. Radiocarbon dates used for construction of the sea level curve at Iqaluktuuq and Kent Peninsula.

Lab Number	14C Age BP	2-Sigma Calibration (%)	Highest Elevation	Lowest Elevation	Material Dated	Site, Provenience
Iqaluktuuq						
GSC-6618	4950 $\pm$ 80	5214–4471 (95.4)	10	10	*Hiatella arctica*	
GSC-6620	6430 $\pm$ 70	6780–6199 (95.4)	36	33	*Hiatella arctica*	
TO-10001	4750 $\pm$ 80	4904–4200 (95.4)	16	16	*Hiatella arctica*	
TO-10002	5010 $\pm$ 100	5287–4522 (95.4)	23	21	*Hiatella arctica*	
TO-10003	5690 $\pm$ 70	5985–5397 (95.4)	36	33	*Mytilus edulis*	
TO-10004	6030 $\pm$ 80	6344–5736 (95.4)	37	35	*Mytilus edulis*	

Table 3. *Cont.*

Lab Number	14C Age BP	2-Sigma Calibration (%)	Highest Elevation	Lowest Elevation	Material Dated	Site, Provenience
TO-10006[1]	4220 ± 70	4227–3527 (95.4)	22	22	*Hiatella arctica*	
TO-10007	8250 ± 60	8642–8047 (95.4)	50	50	*Hiatella arctica*	
TO-10008	8580 ± 70	9094–8419 (95.4)	48	48	*Hiatella arctica*	
TO-10009	7710 ± 60	8053–7542 (95.4)	65	62	*Hiatella arctica*	
TO-10010	5800 ± 70	6117–5518 (95.4)	29	29	*Hiatella arctica*	
TO-10011	4280 ± 50	4282–3626 (95.4)	16	16	*Hiatella arctica*	
TO-10012	4804 ± 50	4942–4319 (95.4)	7	4	*Mya edulis*	
TO-10013	4720 ± 60	4841–4199 (95.4)	10	8	*Hiatella arctica*	
UCIAMS-106719	1930 ± 20	1925–1782 (91.9)	16	16	*Rangifer tarandus*	NiNg-2 Bell
UCIAMS-106726	2935 ± 20	3166–3002(95.4)	30	30	*Rangifer tarandus*	NiNg-7 Wellington Bay
UCIAMS-112637	775 ± 15	723–672 (95.4)	13	13	*Rangifer tarandus*	NiNg-18
UCIAMS-112640	1950 ± 15	1925–1828(95.4)	15	15	*Rangifer tarandus*	NiNg-1 Buchanan A6
UCIAMS-112649	955 ± 15	875–792 (77.3)	9	4	*Rangifer tarandus*	NiNg-8 Freezer
UCIAMS-75297	2075 ± 15	2106–1991(93.4)	16	16	*Rangifer tarandus*	NiNg-15 Peetuk
UCIAMS-75306	990 ± 15	931–901(61.7)	10	8	*Rangifer tarandus*	NiNg-17 Cadfael
UCIAMS-76621	2935 ± 20	3166–3002 (95.4)	22.5	22	*Rangifer tarandus*	NiNg-1 Buchanan A2
UCIAMS-76624	2880 ± 15	3071–2955 (95.4)	19	18	*Rangifer tarandus*	NiNg-1 Buchanan A5
UCIAMS-76627	2955 ± 15	3178–3062 (94.1)	30	28	*Rangifer tarandus*	NiNg-10 Menez
UCIAMS-76641	2000 ± 20	1996–1877(95.4)	20	20	*Rangifer tarandus*	NiNg-3 Ballantine
UCIAMS-76642	2025 ± 15	2001–1924(94.6)	17	13	*Rangifer tarandus*	NiNg-5 Ferguson
Kent Peninsula [2]						
UCIAMS-30328	1750 ± 15	1709–1612 (1)	45.5	45.5	Salix charcoal	NfNg-27-F2
UCIAMS-30360	1745 ± 15	1709–1607 (1)	45.5	45.5	Salix charcoal	NfNg-27-F1
UCIAMS-29241	3680 ± 20	4086–3967 (0.954)	43	43	Caribou or muskox bone	NfNh-10-F1
UCIAMS-30359	4070 ± 15	4583–4517 (0.814)	40.5	40.5	Salix charcoal	NfNg-17
UCIAMS-30358	4415 ± 20	5047–4950 (0.762)	37.5	37.5	Salix charcoal	NfNg-9-F4
UCIAMS-30363	3925 ± 15	4422–4347 (0.696)	33	33	Salix charcoal	NfNf-10-F1
UCIAMS-30433	3405 ± 15	3696–3613 (0.987)	32.5	32.5	Picea charcoal	NeNi-4
UCIAMS-30366	3695 ± 15	4086–3982 (1)	31.5	31.5	Salix charcoal	NfNh-4
UCIAMS-30365	3910 ± 15	4418–4293 (1)	31	31	Salix charcoal	NfNh-3-F2
UCIAMS-30356	3960 ± 15	4444–4409 (0.77)	30.5	30.5	Salix charcoal	NfNg-6-F1
UCIAMS-30357	3775 ± 15	4161–4089 (0.753)	29.5	29.5	Salix charcoal	NfNg-7-F4
UCIAMS-30381	3955 ± 15	4445–4404 (0.827)	29	29	Picea charcoal	NfNh-6-F25
UCIAMS-30361	3025 ± 20	3274–3201 (0.633)	24	24	Salix charcoal	NfNf-7
UCIAMS-30364	2465 ± 20	2618–2449 (0.582)	22	22	Salix charcoal	NfNh-2-F1
UCIAMS-30362	2690 ± 15	2799–2756 (0.797)	18.5	18.5	Salix charcoal	NfNf-8-F1
UCIAMS-30380	2025 ± 15	2003–1927 (0.987)	15	15	Picea wood	NfNf-12-F1
UCIAMS-29157	1460 ± 15	1379–1309 (1)	8	8	Burnt moss Dicranum sp.	NfNg-30
UCIAMS-29156	1480 ± 15	1400–1327 (1)	8	8	Burnt moss *Dicranum* sp.	NfNg-15-F1
UCIAMS-29155	1465 ± 15	1383–1311 (1)	7	7	Burnt moss *Dicranum* sp.	NfNg-14-F5
UCIAMS-29158	1430 ± 20	1356–1296 (1)	6.5	6.5	Burnt moss *Dicranum* sp.	NeNi-5
UCIAMS-30332	8345 ± 20	8740–8419 (1)	77	77	*Mya truncata*	
UCIAMS-29149	7310 ± 15	7651–7452 (1)	48	58.5	*Mytilus edulis*	
AECV-948C1	8200 ± 150	8890–8095 (1)	58	58	*Mya truncata*, *Mya arenaria*	
UCIAMS-30331	7025 ± 20	7417–7203 (1)	47	54	*Hiatella arctica*	
UCIAMS-29148	5760 ± 20	6046–5741 (1)	35	42	*Mytilus edulis*	

Table 3. *Cont.*

Lab Number	14C Age BP	2-Sigma Calibration (%)	Highest Elevation	Lowest Elevation	Material Dated	Site, Provenience
UCIAMS-29150	4680 ± 15	4791–4468 (0.991)	24	29	*Mytilus edulis*	
AECV-947C1 [1]	5170 ± 100	5542–4941 (1)	27.4	27.4	*Mya truncata,*	
UCIAMS-29147	4050 ± 20	3906–3606 (1)	13	19	*Mytilus edulis*	
UCIAMS-29146	2845 ± 15	2421–2131 (1)	9	14	*Mytilus edulis*	
UCIAMS-29152	2995 ± 15	2661–2336 (1)	5	11	*Serripes groenlandicus*	
UCIAMS-29151	2355 ± 15	1829–1551 (1)	8.5	8.5	*Mytilus edulis*	
UCIAMS-29586 [1]	1130 ± 20	790–590 (0.983)	5.5	5.5	*Balaena mysticetus*	
UCIAMS-29233 [1]	1000 ± 15	658–506 (1)	3	3	*Balaena mysticetus*	

[1] Indicates a potentially anomalous date. [2] Kent Peninsula dates from Paleoeskimo Demography and Sea-Level History, Kent Peninsula and King William Island, Central Northwest Passage, Arctic Canada [44].

The curve for this area is typical of many other relative sea level curves for the Canadian Arctic (Figure 3). The curve indicates an initial rapid rebound which slows after between 6000 and 5000 cal B.P. [34,49,81–83]. The nearest established curve at Kent Peninsula is the most similar [44]. This reinforces confidence in the accuracy of the Iqaluktuuq curve. The main difference is the Iqaluktuuq curve is slightly steeper in order to account for more of the calibrated date range of TO-10006.

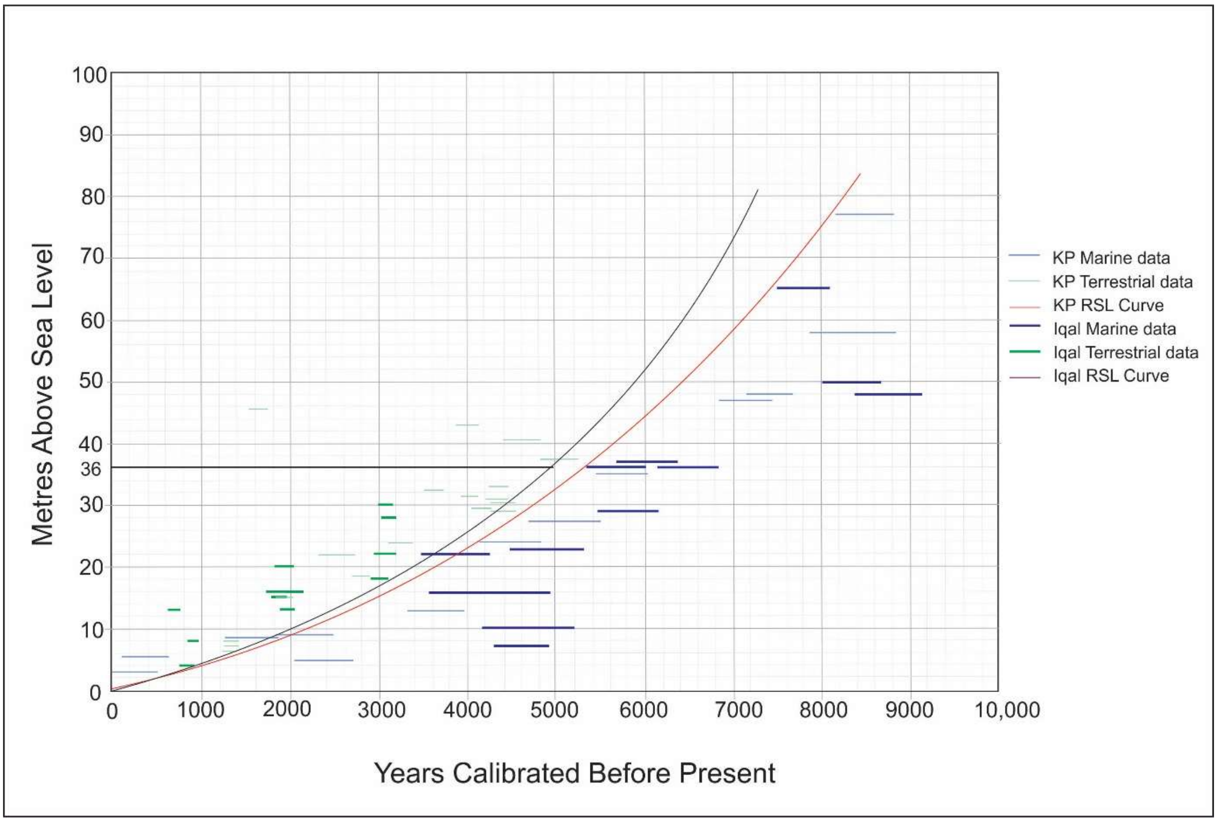

Figure 3. Relative sea-level curves for Kent Peninsula (KP) and Iqaluktuuq (Iqal). Barring elevation or age anomalies, dates on marine materials (blue bar) should fall on or below the relative sea-level curve and dates on archaeological materials (green bar) should fall on or above the curve.

4. Discussion

The Relative Sea Level curve allows for the development of paleotopographies for Iqaluktuuq prior to and during the Paleo-Inuit and Inuit occupations. The placement of each archaeological site on the developing topography can only be approximated due to the errors inherent in radiocarbon dates and the sea level curve. Even with inherent uncertainty, this reconstruction can yield important insights into the developing settlement patterns in the area.

4.1. Pre-Dorset

Based on current data, when Pre-Dorset people arrived in the Canadian Arctic around 5000 cal B.P., lands at and above 36 m above current sea level in the Iqaluktuuq region would have been available for use (Figure 4). At this time, the paleogeography would have consisted of smaller and more widely spaced islands than those currently in the study area. However, unlike some other areas in the region, Iqaluktuuq did not have an early Pre-Dorset occupation [44,56]; A plausible cause for the lack of early Pre-Dorset sites is the significantly different shorelines owing to higher sea levels before 3100 cal B.P.

Figure 4. Paleogeography at approximately 5000 cal. B.P.

When Pre-Dorset people first arrived at Iqaluktuuq around 3100 cal B.P., lands slightly below the modern 20 m contour would have been at sea level. The Ekalluk River connecting what is now Wellington Bay and Tahiryuaq would have been an ocean channel ranging from 0.5–1.5 km wide (Figure 5). The channel would have served as a natural caribou crossing, especially in the fall during migration. The Pre-Dorset sites are situated on the southwest side of a narrow saltwater channel, placing them along the edge of a wider Wellington Bay. Preference for site placement on the south side of a likely caribou crossing is common throughout most of the occupation history of the area. A likely reason is that fall hunting of caribou was most efficient if it occurred as caribou swam across the water, or shortly after they emerged on the south shore. The placement of sites on the north side might have alarmed caribou, making their progress less predictable. Since ringed seals are ubiquitous across the Arctic and evident in the faunal remains at NiNg-7, it is assumed they would have been available to hunt when ice conditions permitted. Arctic char could be expected to feed near shore during open water, and were therefore potentially available; however, they would have been difficult to acquire in significant numbers since the river did not yet exist [84].

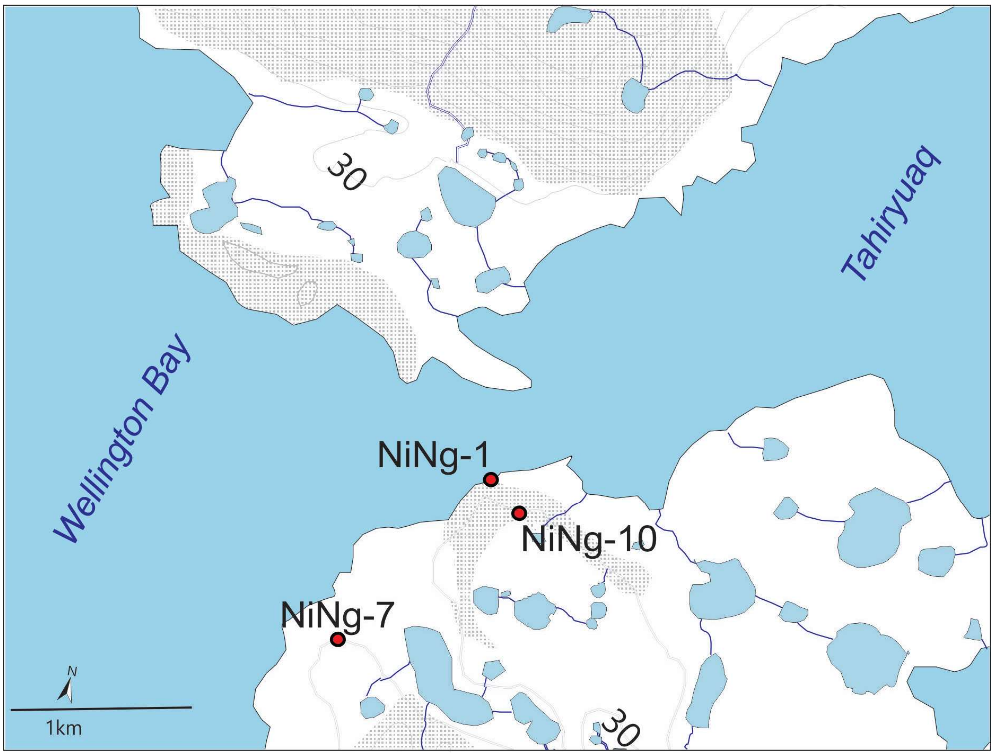

Figure 5. Pre-Dorset (3100–2900 cal B.P) site location situated on proposed paleogeography at approximately 3400 cal B.P. Marine limit would have been at the modern 20 m contour.

Of the three main Pre-Dorset sites at Iqaluktuuq, two, NiNg-1 and NiNg-10 are similar to one another and will be described first. NiNg-10 is a small, dense occupation on the south bank of the narrows. When first occupied, it would have been approximately 10 m above contemporary sea level and located approximately 200 m from the water. NiNg-10′s immediate location is characterized by a relatively flat expanse directly behind an ice-pushed cobble and gravel ridge. This location may have been chosen both as a stable place to pitch a skin tent and, perhaps, because the ridge partially obscured it from caribou crossing the narrows.

NiNg-1 is a more complex site with both Pre-Dorset and Middle Dorset components. The Pre-Dorset components consist of several flat areas at different elevations on a north-facing hill spur on the narrows' south side. Each consists of a relatively dense scatter of stone tools, debitage, and animal bones. Each flat area was likely an independent, sequentially occupied camp, as opposed to simultaneously occupied camps–this inference is suggested by the slight spread in dates. The lower areas, 4 and 5, are approximately 18 m a.s.l., and would have been approximately 1 m above contemporary sea levels. Area 2, on the other hand, is 22 m a.s.l., and would have been ca. 5 m a.s.l. when first occupied. The earliest radiocarbon date associated with Area 2 (3166–3002 cal BP, UCIAMS -76621) is slightly older than that associated with Area 5 (3071–2955 cal BP, UCIAMS-76624). While the two date ranges overlap, a tentative correlation between older dates and higher elevations associated with each component is possible. If the rebound rate was between 0.6 and 1 cm a year, two meters of land might have been uplifted from the water while NiNg-1 was occupied.

The third Pre-Dorset site, NiNg-7, provides a distinct contrast to the other two. It is located to the west on the outer coast and consists of a broad area covered with stone tools and debitage of variable concentrations. At least two stone hearths (fireplaces) were recorded, with others likely buried. NiNg-7 is the only Pre-Dorset site with significant numbers of seal remains, though caribou remains are also common. During use, NiNg-7 was approximately 13 m above the water. Although this seems like a significant height above the water; the site would have been less than 250 metres from the shore across a gentle slope. The greater elevation may have been chosen to allow monitoring of a larger area of land for caribou, and sea ice for seals.

This reconstruction of paleoshorelines provides new insights into the reason for Pre-Dorset site locations. NiNg-1 and NiNg-10 are both directly adjacent to the narrowest point in the narrows, directly to its south. In fact, on the north side a small peninsula extends southeast from the north shore, providing a likely access point for swimming caribou. The emphasis on caribou hunting is seen in the bone assemblages dominated by caribou bone. NiNg-7, on the other hand, is located to the southwest and while it would have allowed some monitoring of the crossing and access to caribou, its location on the outer coast was clearly based on different decision-making. The faunal sample, containing significant amounts of seal in addition to caribou, appears to confirm this. Though it is difficult to be certain about seasonality of occupation, NiNg-7 may have been occupied in spring, when basking seals were present and relatively easy to hunt.

4.2. Dorset

It is proposed that the formation of the western portion of the Ekalluk River began at about 2800 cal. B.P. or when waters were at 15 m a.s.l. (Table 4; Figure 6). The big lake, Tahiryuaq, is currently situated between 9 and 11 m a.s.l., which means separation of the lake from the river started before the lake reached current water levels. The most clearly defined and highest riverbank occurs at 15 m a.s.l. on the south side of the river. Further supporting river development at this time, there are no topographic features at this elevation or below along the river course associated with marine or lake facies such as raised beaches. The raised beaches, which occur at a 10 m elevation, are north and south of the river's mouth and would have resulted from marine action along Wellington Bay. Based on the air photographs, the early stages of the river's development might have meandered across the landscape on the north side while being held to a more set course by the steeper riverbank on the south side. Supporting the suggestion of a meandering river is evidence on the north side, where there is a dense layer of shells at approximately 10 m a.s.l., dating between 5214 and 4471 cal. B.P. (GSC-6618). The date of these shells is older than anticipated for their elevation. During downcutting and subsequent erosion, the river likely exposed these older marine deposits. There is a chance that a meandering river could have erased evidence of additional human occupation.

Table 4. Proposed dates that respective contour lines m a.s.l. emerged from marine waters based on Iqaluktuuq Relative Sea Level.

m a.s.l [1]	Approximate Emergence Date cal B.P.
5	1200
10	2050
15	2800
20	3400
30	4450
40	5200
50	5950

[1] m above sea level (m a.s.l.); calibrated before Present (cal B.P.).

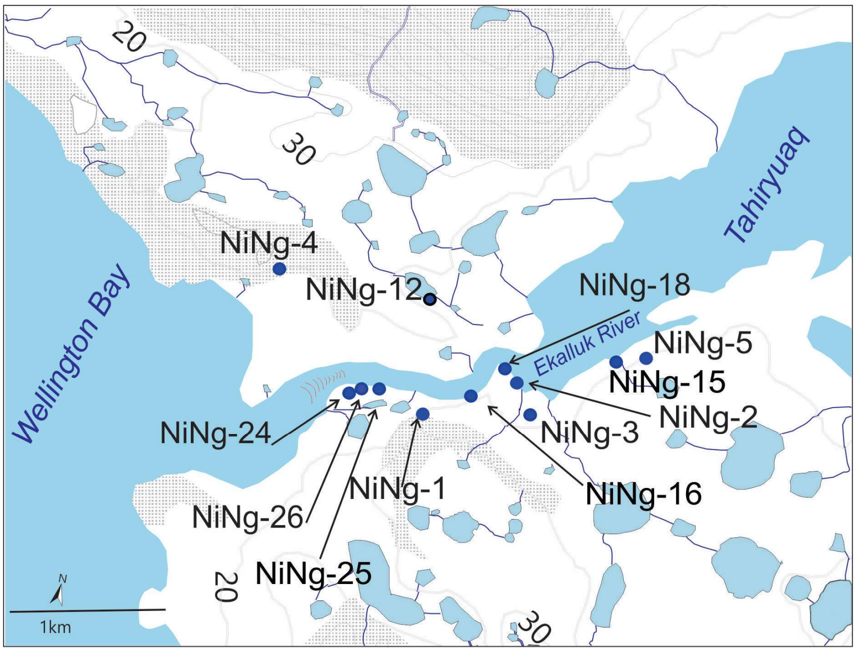

Figure 6. Middle Dorset (2000–1600 cal B.P) site location situated on proposed paleogeography at approximately 2050 cal. B.P. Marine limit would have been at the modern 10 m contour.

The river's absence and transitional state may have contributed to the absence of Early Dorset. The formation of Tahiryuaq and Ekalluk River were critical for the successful and dense human occupation of the region by Dorset and Inuit. Without the development of the lake and river, the acquisition of Arctic char would not have been practical when only an ocean inlet existed. Arctic char require freshwater to spawn and overwinter in; even their young fry have microhabitat river preferences [75,85], and therefore the formation of Tahiryuaq would have provided additional habitat and likely increased the char population. On the other hand, caribou were probably much less impacted by the changes in sea level since they can easily swim across rivers or short stretches of open water [85,86]. While the Iqaluktuuq curve only offers an approximate date for this separation, additional studies might allow a more precise picture of river development [86,87].

Approximately 800 years before the initial arrival of Middle Dorset people at Iqaluktuuq (2000 cal. B.P.) parts of the river would have formed. It is likely that the primary historically known resources, caribou and Arctic char, would have been established around this time in something close to their current distributions [17,88]. There are 11 sites with a Middle Dorset component (Figure 6). A twelfth site, NiNg-4, the Drive System, cannot be assigned a definite affiliation but was likely initially constructed in Middle Dorset times [3]. Besides the Drive (NiNg-4) and NiNg-12, a poorly understood surface site, the Middle Dorset occupations are situated on the south side of the river.

The five oldest Middle Dorset sites are associated with dates ranging between 2100 and 1780 cal B.P. On the modern landscape, these sites vary from 13 to 20 m a.s.l.; they would have ranged from 3 to 10 m a.s.l. when occupied. There is no clear correlation during the Middle Dorset between water level and site age; for example, NiNg-15 is associated with the oldest date range and is situated at 16 m a.s.l. This lack of correlation may reflect the more riverine focus of the Middle Dorset occupants and more varied micro-topography due to river development.

Rapids should be a tenable morphologically resistant feature of a river [89] and could potentially have been a river feature at this time. The Middle Dorset sites are situated at these rapids or upriver, a distribution which likely relates to an emphasis on fishing at many of these sites. Fish fauna are evident at three (NiNg-1 Area 6, NiNg-2, and NiNg-5) of the five sites for which faunal analysis has been conducted, and all sites are associated with caribou remains. In addition, all Middle Dorset sites are associated with large numbers of small, self-bladed harpoon heads, which local Elders interpret as having been used for fishing. A cold season structure at NiNg-5 was excavated by its builders into a slope, and microtopography likely influenced site location in this case.

For the Middle Dorset period, perhaps the most significant result of this paleogeographic reconstruction is understanding the overall distribution of occupations. As can be seen in Figure 6, they are concentrated in the eastern half of Iqaluktuuq. The reason for this is almost certainly related to the rate at which the different parts of the river formed. The eastern half had likely formed by 2800 cal BP, with Arctic char present and available in significant numbers from the beginning of the Middle Dorset occupation of the region. However, for the western, downstream half, the river channel remained relatively wide and deep and was probably less conducive to fishing than it was in more recent times. In the more recent Late Dorset and Thule/Inuit periods, the eastern half was still more densely settled than the western half–but not to the extreme extent that is seen in Middle Dorset.

The Late Dorset occupation of Iqaluktuuq is relatively well-dated [18]. The landscape at the time of occupation (ca. 950 to 600 cal B.P.) would have been very close to its current form. Over the past thousand years, the rebound rate has been estimated at 4 mm a year. Five sites are affiliated with Late Dorset, one of which is the caribou Drive System (NiNg-4) (Figure 7). Two sites, NiNg-2 and NiNg-15 were occupied during the cold season based on the presence of well-preserved semi-subterranean dwellings. At the time of occupation, these sites were roughly 6 m a.s.l. and a few metres above Tahiryuaq and the river but were situated beside small streams. Their locations likely result partly from appropriate microtopography for constructing semi-subterranean dwellings. For example, NiNg-2, the largest, has a southeast facing slope, which may have been favored to capture sunlight. However, the site's location must also relate to its proximity to a caribou crossing at the outlet of Tahiryuaq. Caribou bones dominate the NiNg-2 faunal assemblage [88], likely indicating occupation of the site during the fall hunt and consumption of stored caribou meat during the winter.

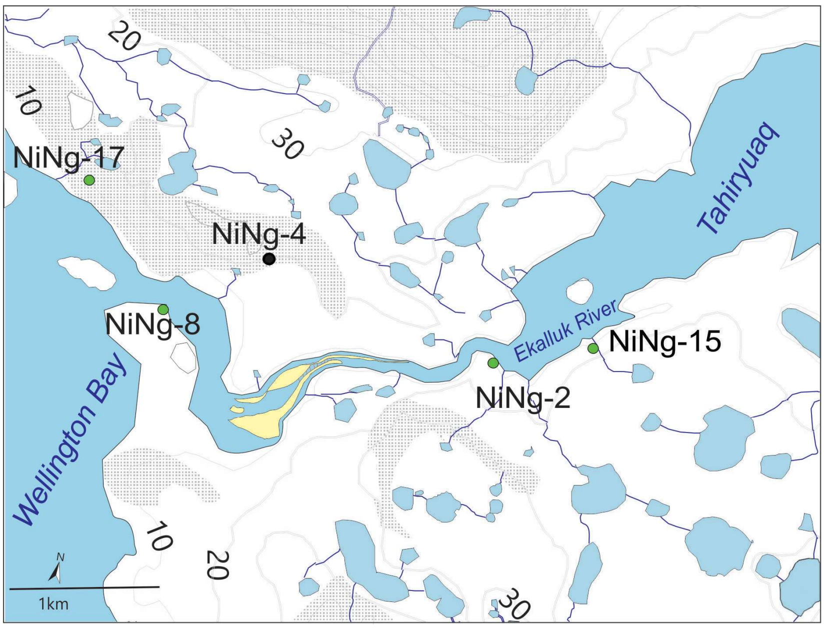

Figure 7. Late Dorset (950–660 cal B.P) site location situated on proposed paleogeography at approximately 1400 cal B.P. Marine limit would have been at the modern 5 m contour. Yellow indicates possible sand bars.

NiNg-17 is a remarkable Late Dorset site north of Iqaluktuuq on the outer coast. This aggregation site includes four boulder-outlined "longhouses" up to 38 m in length, and many other features, approximately 300 m from the shore of Wellington Bay. The longhouses, which likely contained skin tents, as well as the many features associated with them, range from 4 to 6 m a.s.l when occupied. The structures are on well-drained gravel beaches, which may have been associated with early snowmelt allowing site use relatively early in spring. This attribute, and access to appropriate boulders for construction, likely influenced the immediate site choice. As is true of most other longhouse sites [90,91], the NiNg-17 faunal assemblage includes seals, birds, caribou, and fish, indicating a late spring or summer occupation [88,92]. It is not clear whether proximity to particular resources played a major role in site placement; however, on a more general level, proximity to caribou hunting and Arctic char fishing must have been the primary reason for locating NiNg-17 in the Iqaluktuuq region.

The NiNg-8 site is located on a knoll near the river mouth and is currently between 4 and 9 m a.s.l.; when initially occupied, it would have less than 1 m a.s.l. and closer to the river. The knoll emerged from the marine waters between 1700 and 1000 cal B.P. Currently, this portion of the river is deeper and lacks sand bars, so it is unclear how the river's micro-topography, such as depth and sand bar deposition, might have impacted fishing strategies during the Late Dorset occupation. The fishing subsistence strategies of Late Dorset differ from modern analogs and tactics used by Thule in the region [12,93]. While fish, caribou, and seal bones are all relatively common at the site, preliminary analysis [93] indicates that fish were a critical resource. Topographic attributes might explain why fishing strategies at NiNg-8 are distinctive or perhaps could be used to suggest multiple seasons of occupation. NiNg-8 is close to the estuary between the ocean and river; during the open water season, Arctic char frequent estuaries [84], and thus this location might point toward use during the summer. Alternatively, it could be that the river depth and the possibility that spring and autumn ice formation would result in ice jams upstream led to this being a favored fishing location [94,95]. On the other hand, specific river attributes may not have impacted site preference. Given that NiNg-8 has more seal fauna than NiNg-2 but less than NiNg-17, its location might relate to proximity to diverse resources and not a topographic attribute.

Late Dorset faunal assemblages from the region, particularly at NiNg-17, contain several bird species [11,93]. Numerous migratory bird species, particularly ducks and geese, are currently available on Victoria Island; the number of species has remained essentially unchanged over the past 30 years [96]. Many of these species occupy wetlands. With rebound rates slowing over the past 1000 years, it is possible that wetlands became increasingly available as habitats during the Late Dorset period.

The paleotopographic reconstruction indicates that with the onset of the Late Dorset period, shorelines were approaching their modern positions, and several changes are seen in how people made decisions about site locations. In particular, we see the first occupations near the mouth of the river on Wellington Bay. This is probably related to acquisition of fish as well as the emergence of well-drained land for spring and summer settlement. Winter settlement continues to be concentrated at the east end of the river, as it had been during Middle Dorset–perhaps due to proximity to the most important caribou crossing. NiNg-17, the longhouse aggregation site, stands out as an anomaly; its position north of the river relates at least partly to the presence of well-drained beach ridges, but its specific location is away from major resource concentrations hinting at social or ritual reasons for its positioning.

4.3. Thule/Inuit

Upon the arrival of Thule/Inuit around 550 cal B.P., the shoreline was very close to its current location. Including NiNg-4, the drive system, there are eight Thule/Inuit sites, many of which are multi-component sites (Table 2, Figure 8). With one exception, all sites are situated on or near the modern riverbank; one site is so close it is eroding downslope to the river. Only NiNg-5 is not associated with the modern riverbank; this site contains burials, and therefore its site placement is influenced by other cultural factors. Most dwelling sites are on the south shore; however, NiNg-13 and NiNg-29 are on the north shore; besides location, they contain dwellings and middens similar to those at other Thule sites. By far, the largest and most complex Thule site at Iqaluktuuq is NiNg-2, which contains six substantial semi-subterranean cold-season dwellings, tent rings and extensive midden deposits. NiNg-2 fauna is dominated by caribou and fish, likely obtained in summer and fall and stored for winter consumption. Since NiNg-2 is also the largest cold-season site occupied by Late Dorset, both Thule and Late Dorset probably relied on similar topographic features in making site location decisions. In particular, the houses are built into a southeast-facing slope, which would be well-situated to receive sunlight in the winter; and the site is located at what may be the most important point for caribou crossing the river during the fall migration. Three other sites, NiNg-11, 13, and 29, also have semi-subterranean houses that were likely built by Thule; however, none of these has been studied enough to allow substantive conclusions regarding reasons for their locations.

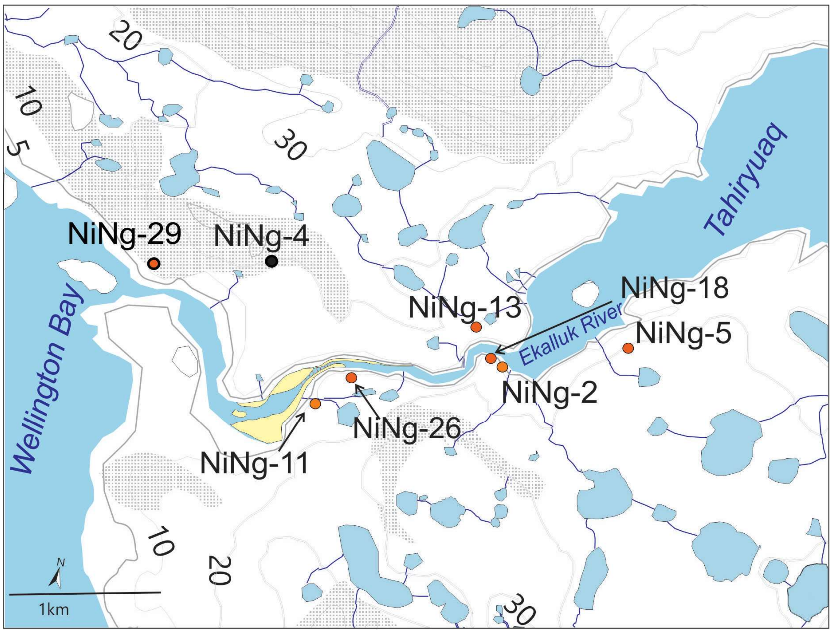

Figure 8. Thule/Inuit (550 cal B.P to present) site location situated on modern landscape. Yellow indicates possible sand bars.

There is no apparent clustering of winter or summer site locations, and caribou dominate all sites' faunal assemblages, followed by fish. Thus, subsistence activities do not indicate seasonal location preferences. Other than NiNg-2, resource preferences cannot be attributed based on the available topographic, archaeological or zooarchaeological evidence. It could be that the diverse fishing strategies available to Thule [11,96] resulted in less restriction for optimal site placement.

5. Conclusions

Changes in sea level, whether caused by isostatic rebound or eustatic changes, have impacted coastal peoples around the globe. Isostatic rebound changed the paleotopographies of Iqaluktuuq from the first occupation by Pre-Dorset people (3100 cal B.P.) to Thule and recent Inuinnait occupations. Paleotopographies may have been a factor in the absence of sites associated with the earliest date ranges associated with Pre-Dorset and Dorset peoples. The narrow ocean channel, which would eventually become the Ekalluk River, was likely a preferred fall caribou crossing which resulted in more sites situated on the southern riverbank. The narrows likely influenced the choice of Pre-Dorset people regarding site location of NiNg-1 and NiNg-10. The Arctic char run likely developed at approximately 2800 cal B.P. soon after the Ekalluk River formed. The char run and the caribou crossing allowed for a denser Middle Dorset occupation of the area. Middle Dorset sites are less dispersed than Late Dorset or Thule sites and are located east of river rapids which likely related to river development. Late Dorset and Thule sites are more dispersed along the river, and both intensely utilized the same site, NiNg-2, suggesting similar subsistence strategies and choices regarding site placement. Ultimately, our analyses strongly support the interpretation that past choices regarding site placement at Iqaluktuuq were significantly impacted by paleotopographies.

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