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The environment of late Pleistocene - early Holocene Queen Charlotte Islands archipelago, Western Canada and implications for early peoples

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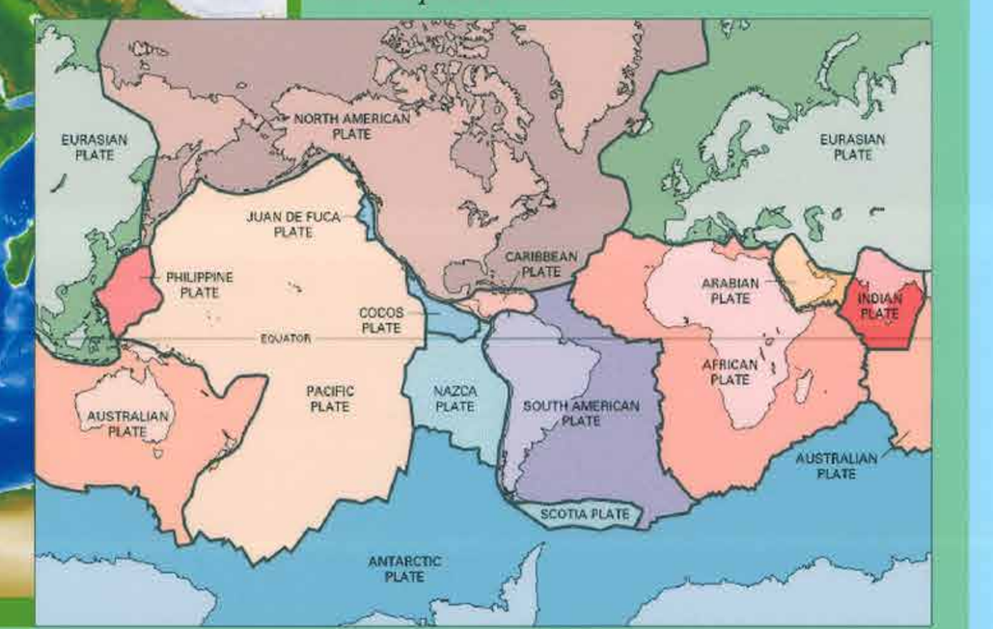
The Peopling of the Americas, the Coastal Migration Route, and Plate Boundaries

Figure 1a. Map of the Peopling of the Americas'

Map: Ed Wiebe and Renée Hetherington

Figure 1b. Major tectonic plates of the world

Map: USGS http://geology.er.usgs.gov/eastern/plates.html



Until recently, many researchers believed peopling of the Americas stretched back only ~11 200 radiocarbon years before present (^{14}C YBP) and that the first North Americans traveled from northeast Asia across the "Beringia land bridge", hunting large mammals with their biface *Clovis* stone tools, and colonizing the Americas via an "ice-free corridor" east of the Canadian Rocky Mountains. This has been contradicted by evidence in southern Chile dated to ~12 500 ^{14}C YBP, approximately 1300 years earlier than the *Clovis culture.* This dilemma has focused interest on an alternative - a coastal migration route, which follows a chain of glacial refugia along North America's west coast (Heusser 1960; Fladmark 1979). The problem with the coastal migration hypothesis is that no archaeological evidence dating earlier than ~10 300 ^{14}C YBP (Dixon 2001) has yet been found along the northwest coast of North America. WHY? The coastal migration route skirts the destructive plate boundaries where the Pacific and Nazca Plates abut the North and South American Plates (Fig. 1b). The continental shelf lithosphere adjacent to the plate boundaries is thin, flexible, and responds to changes in eustatic sea level, sedimentation, ice and water loading, and tectonic movement. This has resulted in the continental shelf being a region of continuous change and possessing a complex sea-level history. Understanding the complexities of this early environment and its geography thus becomes critical in our understanding of its influence on the Americas' first peoples, particularly if those people inhabited coastal zones.

The Last Glaciation along Canada's North Pacific Coast

Figure 2a. East Greenland coastal ice sheet

The coastlines along Canada's Pacific continental shelf were impacted by rapid changes in sea level and climate during the late Pleistocene - early Holocene (18 000 to 8 000 ^{14}C YBP), as continental and alpine glaciers advanced and retreated across the region. The weight of glaciers depressed the landscape with ice over 2 km thick and forced peripheral regions to lift up - similar to placing weight on a waterbed. Consequently, the position of coastlines changed, both substantially and swiftly; the degree and direction of those changes were dependent on where coastlines were situated relative to glacial ice.

Photo: James P.M. Syvitski

Figure 2b. Schematic representation of the QCI region showing an ice sheet over a relatively flexible lithosphere

Subsequent to ~13 500 ^{14}C YBP the weight of ice sheets depressed the British Columbia (BC) mainland, while adjacent areas in the Queen Charlotte Islands (QCI) archipelago were uplifted, forming a peripheral bulge. Eustatic and isostatic adjustments resulted in relative sea levels over 120 m higher than present along the BC mainland, and more than 150 m lower than present in the adjacent QCI archipelago, located only 150 km offshore. A few coastlines that were subsided during glaciation have been found above present sea-level along the fringe of the BC mainland and the QCI. The complexity of sea level change has made finding early (pre- 10 000 ^{14}C YBP) coastal archaeological sites difficult. In addition, we would expect the environment of the North American western margin to be significantly different than today. Interdisciplinary methods, including malacology and geology, were used to decipher this region's complex history.

Illustration originally created by Richard Franklin
Adapted from: Hetherington et al. 2003

Queen Charlotte Islands region - Today

Figure 3: Queen Charlotte Island Region - Present Day with inset of North America showing "Traditional" human migration route (yellow) and "Coastal" migration route (red)

Map projection:
NAD83, Transverse Mercator, central meridian 130°W.

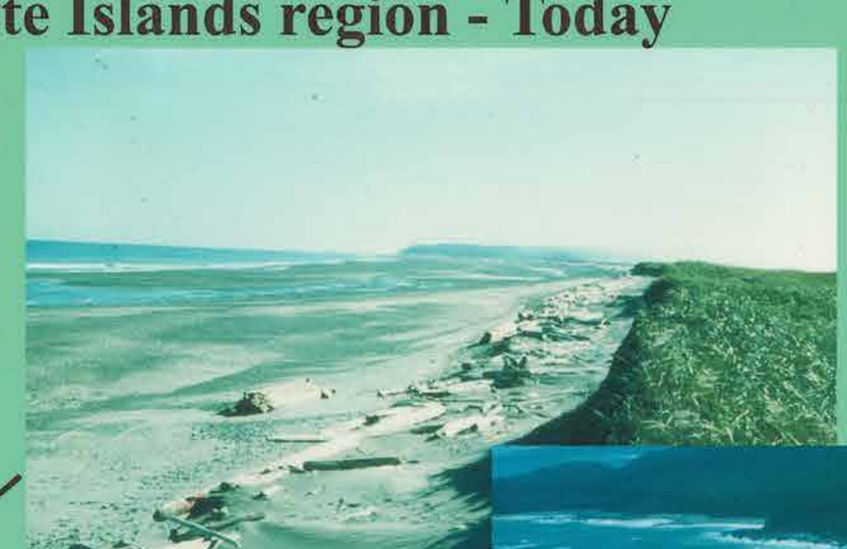


Photo: J. Vaughn Barrie

The present day Queen Charlotte Islands region is very different than it was during the late Pleistocene - early Holocene (~18 000 to 8 000 ^{14}C YBP).

? What was the environment of the northwest Pacific coast like when early peoples were to have traveled through the region?

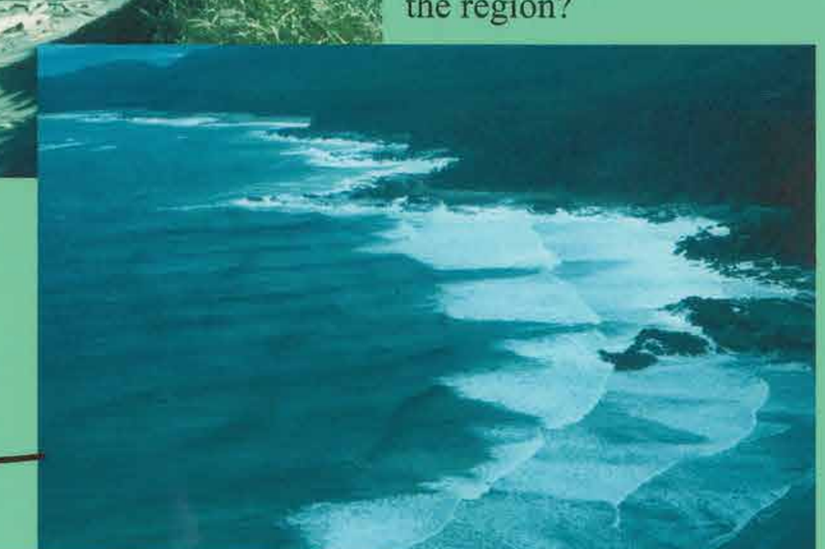


Photo: J. Vaughn Barrie

? Was there a viable coastal migration route that by-passed the uninhabitable continental and alpine glaciers?

? Did the region possess a suitable climate and sufficient natural resources to support an early migrating coastal people?

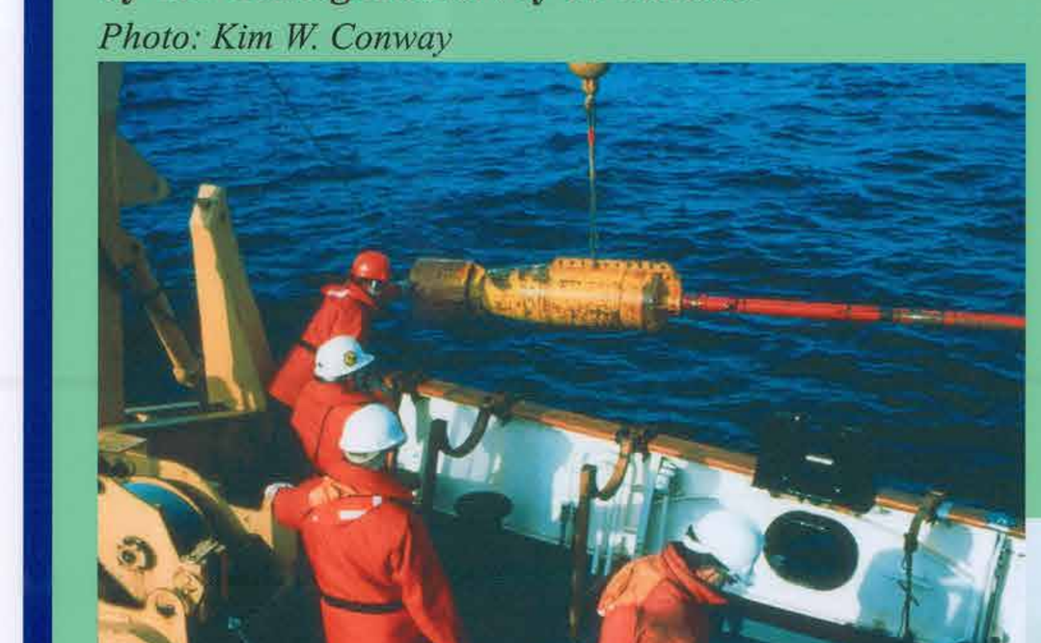
? Have archaeologists been looking in the right places for early archaeological sites?

Photo: Robert I. Thompson

Searching for paleoshorelines

Figure 4a: Submarine sediment coring by the Geological Survey of Canada

Photo: Kim W. Conway



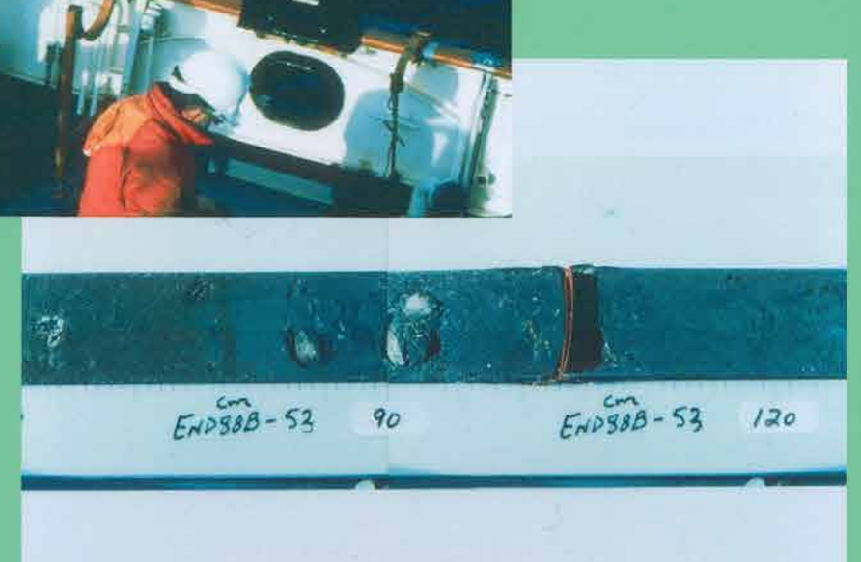


Figure 4b: Submarine sediment core E88B53 taken in Queen Charlotte Sound with intertidal beach deposits

Photo: Richard Franklin

Figure 4c: Haines Creek, western Graham Island, intertidal marine deposits

Photo: Renée Hetherington

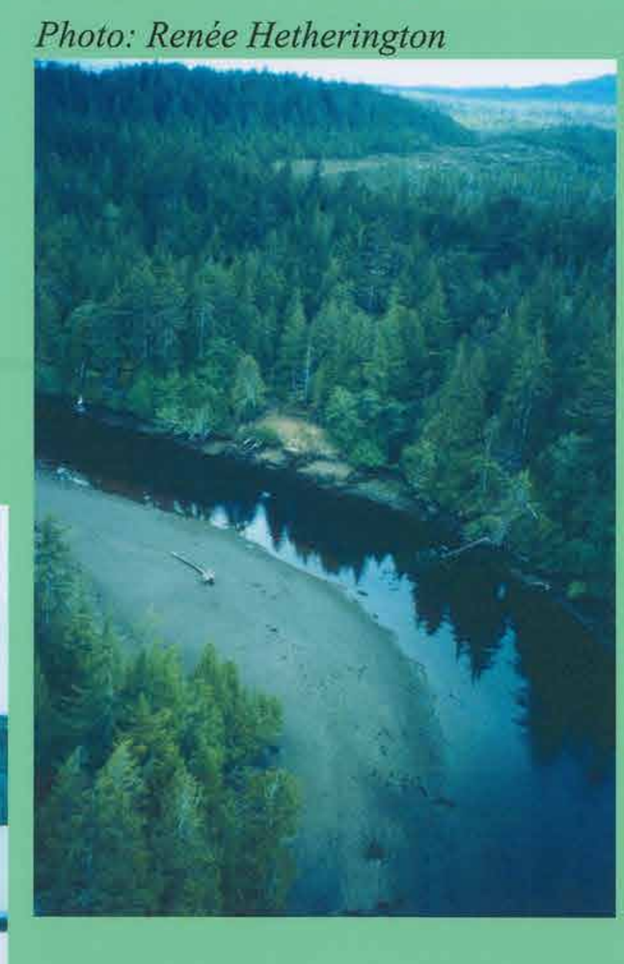


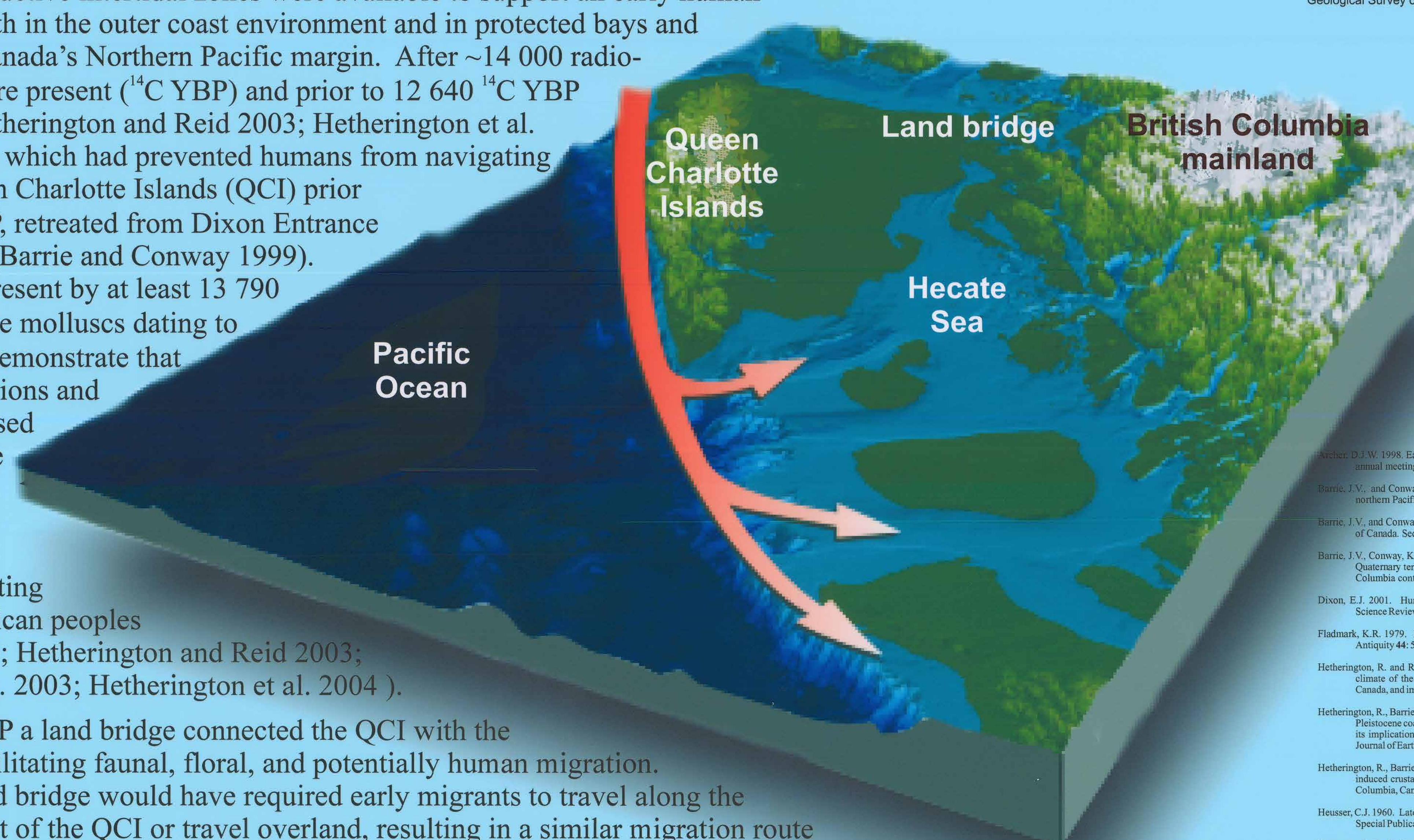
Figure 4d: Haines Creek, western Graham Island, intertidal marine deposits

Photo: Renée Hetherington

The history of sea-level change, including both eustatic and isostatic change, is recorded in raised (Fig. 4c and 4d) and submerged beaches (see sediment core of submerged beach Fig. 4b). Submarine sediment cores and raised beach deposits were sampled for molluscs and other macrofauna. The varied sea-level histories of the region were reconstructed from radiocarbon dated intertidal marine shells found in the beach deposits.

Canada

Despite rapid and sudden changes in sea level during the late Pleistocene and early Holocene, highly productive intertidal zones were available to support an early human coastal culture both in the outer coast environment and in protected bays and estuaries along Canada's Northern Pacific margin. After ~14 000 radiocarbon years before present (^{14}C YBP) and prior to 12 640 ^{14}C YBP (Archer 1998; Hetherington and Reid 2003; Hetherington et al. 2003), glacial ice, which had prevented humans from navigating north of the Queen Charlotte Islands (QCI) prior to 14 000 ^{14}C YBP, retreated from Dixon Entrance north of the QCI (Barrie and Conway 1999). Ice-free terrain, present by at least 13 790 ^{14}C YBP and edible molluscs dating to 13 200 ^{14}C YBP, demonstrate that open-water conditions and Sub-aerially exposed land was available to provide habitat for plants, animals, and also to coastally migrating early North American peoples (Barrie et al. 1993; Hetherington and Reid 2003; Hetherington et al. 2003; Hetherington et al. 2004).



By 11 250 ^{14}C YBP a land bridge connected the QCI with the BC mainland, facilitating faunal, floral, and potentially human migration. The emergent land bridge would have required early migrants to travel along the uplifted west coast of the QCI or travel overland, resulting in a similar migration route to that when ice filled Dixon Entrance. The development of subaerially exposed coastal plains and an intermittent land bridge may explain the survival, and have facilitated the migration of, a large number of QCI endemic and widely disjunct species found on Brooks Peninsula, Vancouver Island. Reduced coastal zone productivity and the presence of a land bridge likely altered migration and habitat conditions (Hetherington and Reid 2003; Hetherington et al. 2004) forcing people to migrate greater distances to collect coastal resources and/or to expand their reliance on land-based resources. Numerous resource-rich coastal zones in Hecate Strait and QC Sound have been cored and dated, and although these would make excellent potential habitation sites for early peoples, many are now drowned and difficult to access. Paleocoastline reconstructions (Fig. 10) estimate the location of potential and accessible early (pre 10 000 ^{14}C YBP) coastlines where people may have lived, and which are currently located above water .

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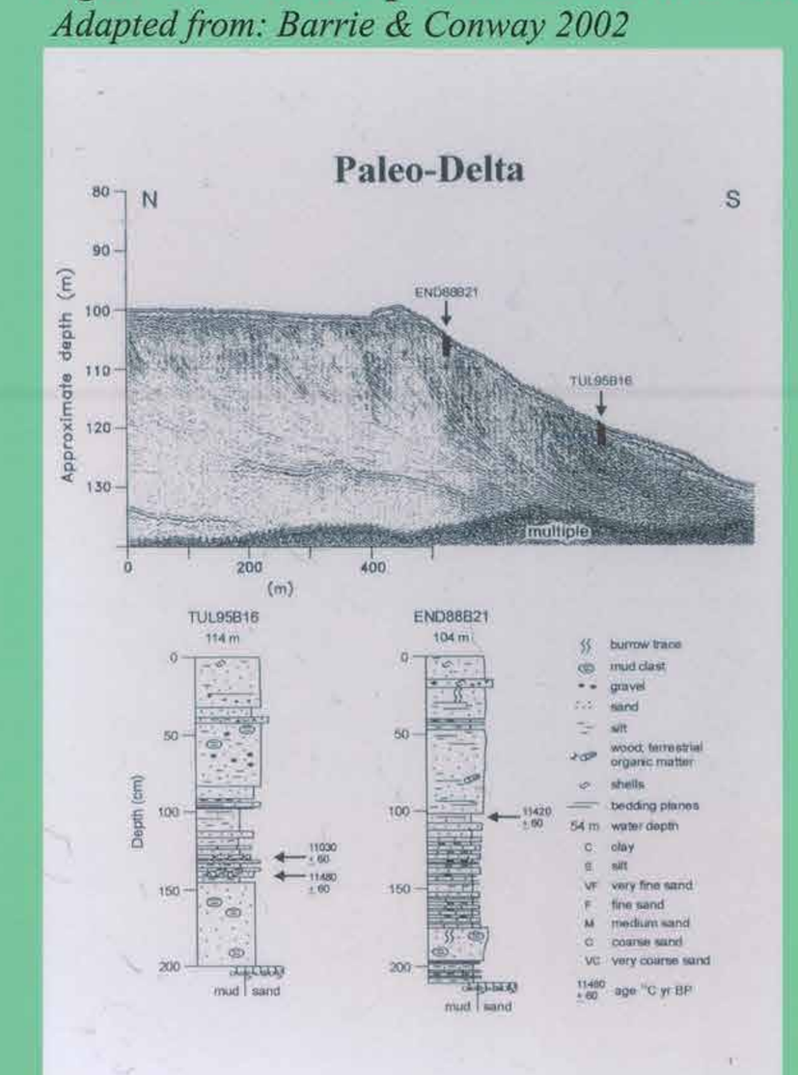
Fossil evidence

Figure 5a: Seismic profile submarine sediment core T95B16 taken in Hecate Strait intersecting a delta foreslope
Adapted from: Barrie & Conway 2002



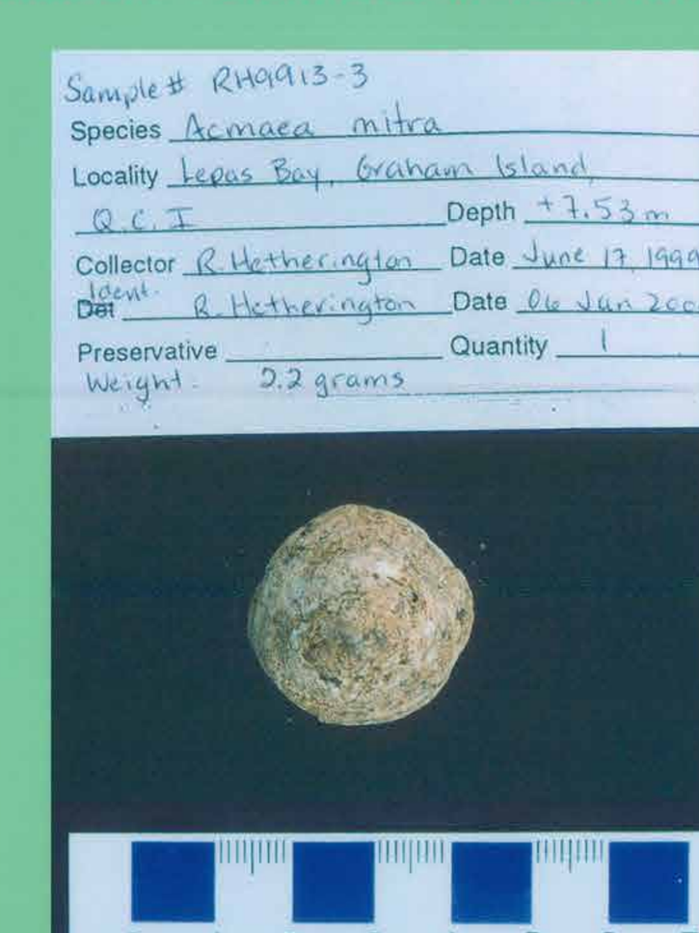


Figure 5b: Intertidal marine shell
Acmaea mitra
Photo: Richard Franklin

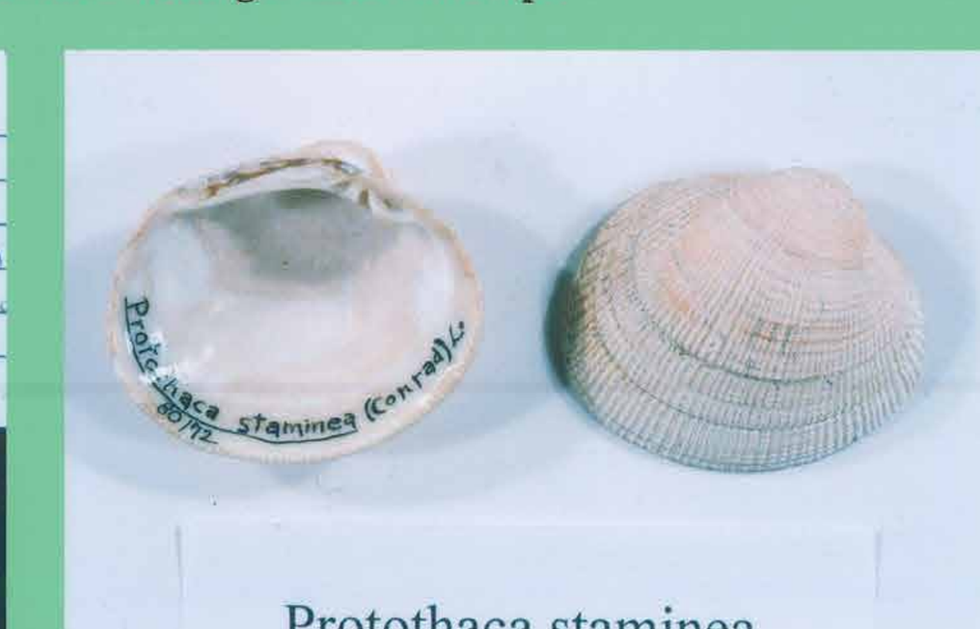


Figure 5c: Edible Intertidal marine shell
Protothaca staminea
Photo: Richard Franklin

Geologic evidence such as this T95B16 seismic profile (Fig. 5a) were interpreted in combination with sampled sea level indicative molluscs such as these *Acmaea mitra* (Fig. 5b) and *Protothaca staminea* (Fig. 5c). Molluscs were collected from raised beaches, submarine sediment cores, and underwater grab samples. They were radiocarbon dated to ascertain when sea level was at the sampled elevation. Based on the characteristics of sampled fossil molluscs, and on our understanding of the physiology and environmental preferences of present-day mollusc species, paleohabitat characteristics including sediment type, wave and storm action, exposure, sea-surface temperature, and vertical distribution were inferred for the sampled and dated horizon. For example, *Acmaea mitra* survives along a narrow range of the beach, between 0 and -1 m. The edible butter clam *Protothaca staminea* lives in the mid-intertidal zone (0 to -10 m) in sea-surface temperatures between +2 to +27 degrees C. The presence of intertidal molluscs elucidates not only the ancient environment, but also that grounded glacial ice was gone and that an accessible food source for early people was present.

Paleogeography 13 250 to 12 750 ^{14}C YBP

Figure 6a: Paleogeographic reconstruction

Adapted from: Hetherington et al. 2004

Photo: Rolf W. Mathewes

Figure 6b: North Dempster Highway in Yukon and N.W.T. Outwash Channel tundra, analogue for emerging coastal plains

Waning ice sheets in Dixon Entrance resulted in migration of the forebulge northward into Hecate Strait. Lowered eustatic sea-level, combined with uplift in Hecate Strait, resulted in eastward expansion of the northern coastal plain almost to the BC mainland (Fig. 6a and 6b). The coastline near Dogfish Bank probably extended more north-eastward than shown; subsequent erosion has likely consumed a coastal plain that extended north to Rose Spit on northeast Graham Island. The edible bivalve *Macoma nasuta,* colonized central Hecate Strait as melting ice sheets deposited large quantities of sediment onto an outwash plain. Note: Orange dots indicate sample locations.

Paleogeography 11 750 to 11 250 ^{14}C YBP

Figure 7a: Paleographic Reconstruction

Adapted from: Hetherington et al. 2004

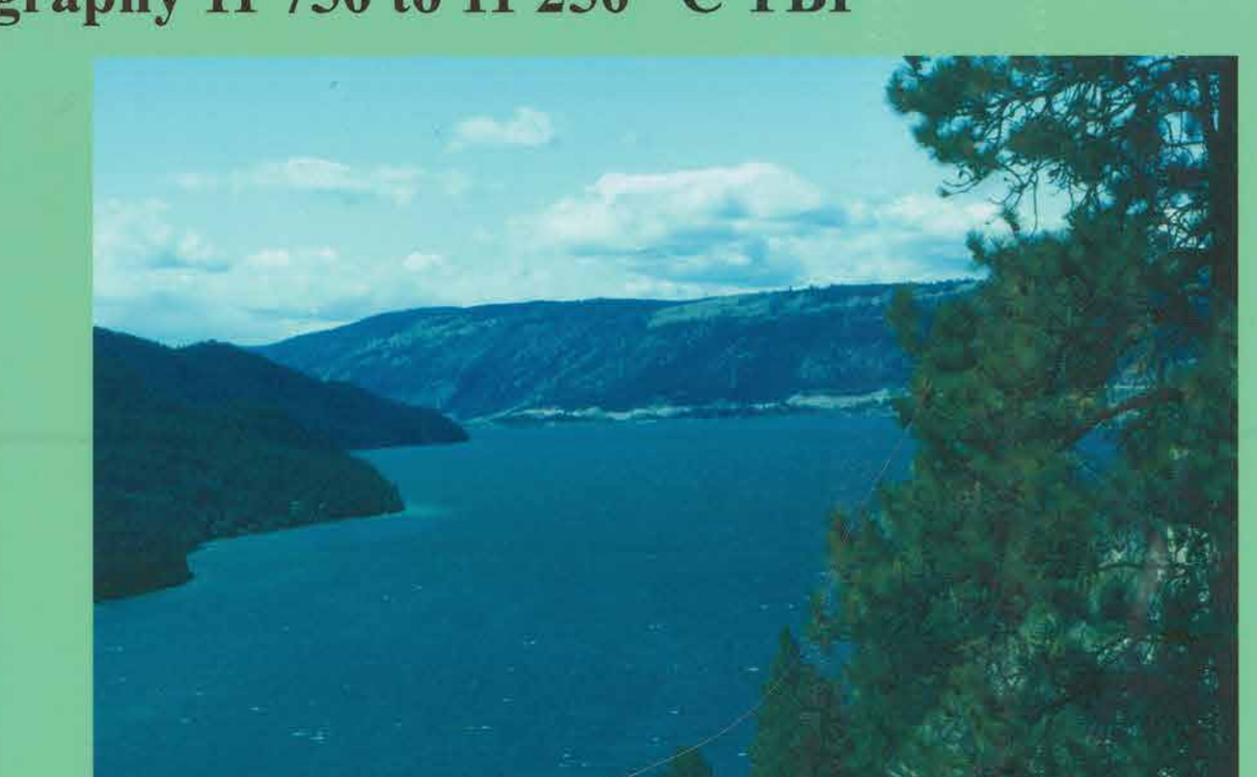


Photo: Robert I. Thompson

Figure 7b: Kalamalka Lake Park, BC, analogue for QCI pine forests and lakes during climate warming

A warming climate supported pine forests; lakes were numerous (Fig. 7b). Despite rising eustatic sea levels, continued uplift in QCI, Hecate Strait, and QC Sound combined to permit the persistance of the two coastal plains (Fig. 7a). Hecate Strait closed, creating a land bridge between the QCI and the BC mainland, facilitating faunal, floral, and potentially human migration. Hecate Strait became "Hecate Sea" (Patterson *et al.*, 1995), a narrow, elongate, shallow water embayment that opened southward into QC Sound. Wood and organic matter were deposited in a post-glacial meltwater delta, which was constructed during sea level low-stand and early transgression at the head of Hecate Sea

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Paleogeography 10 750 to 10 250 ^{14}C YBP

Figure 8a: Paleographic Reconstruction

Adapted from: Hetherington et al. 2004

Photo: J. Vaughn Barrie

Figure 8b: Iceberg, Labrador shelf, Canada

Climate warming was followed by a brief, cold interval consistent in timing with the Younger Dryas cooling event. The appearance of cold-water molluscs (*Serripes groenlandicus* and *Clinocardium ciliatum*) signify the onset of a short interval of much cooler (< 9 °C) sea-surface temperatures. Figure 8a illustrates continued presence of the forebulge in central Hecate Strait and QC Sound, and although the land bridge no longer remains, the two coastal plains persist.

Paleogeography 10 250 to 9750 ^{14}C YBP

Figure 9a: Paleographic Reconstruction

Adapted from: Hetherington et al. 2004

Photo: Robert I. Thompson

Figure 9b: Southern Graham Island, QCI looking southwest

Temperate sea-surface conditions reappeared in southern Moresby Island region by 10 180 ^{14}C YBP and in Cook Bank by 9940 ^{14}C YBP. Fossil shellfish species collected throughout the region, suggest marine habitats very similar to those of today (Fig. 9b). Paleogeographic reconstruction shows persistence of the northern and southern coastal plain (Fig. 9a). Significant crustal depression occurred on the BC mainland at Hirsch Creek (447a), where seas 120 m higher than today deposited a foreset-bedded gravel unit that underlies a marine delta dating to 9700 ^{14}C YBP. Relative sea-level observations at Cape Ball (116f), Moresby Island, Hecate Strait, Queen Charlotte Sound, and Cook Bank, indicate puzzling subsidence in the north and west, despite no evidence of ice, and emergence in the south.

Palaeoshorelines and habitation sites

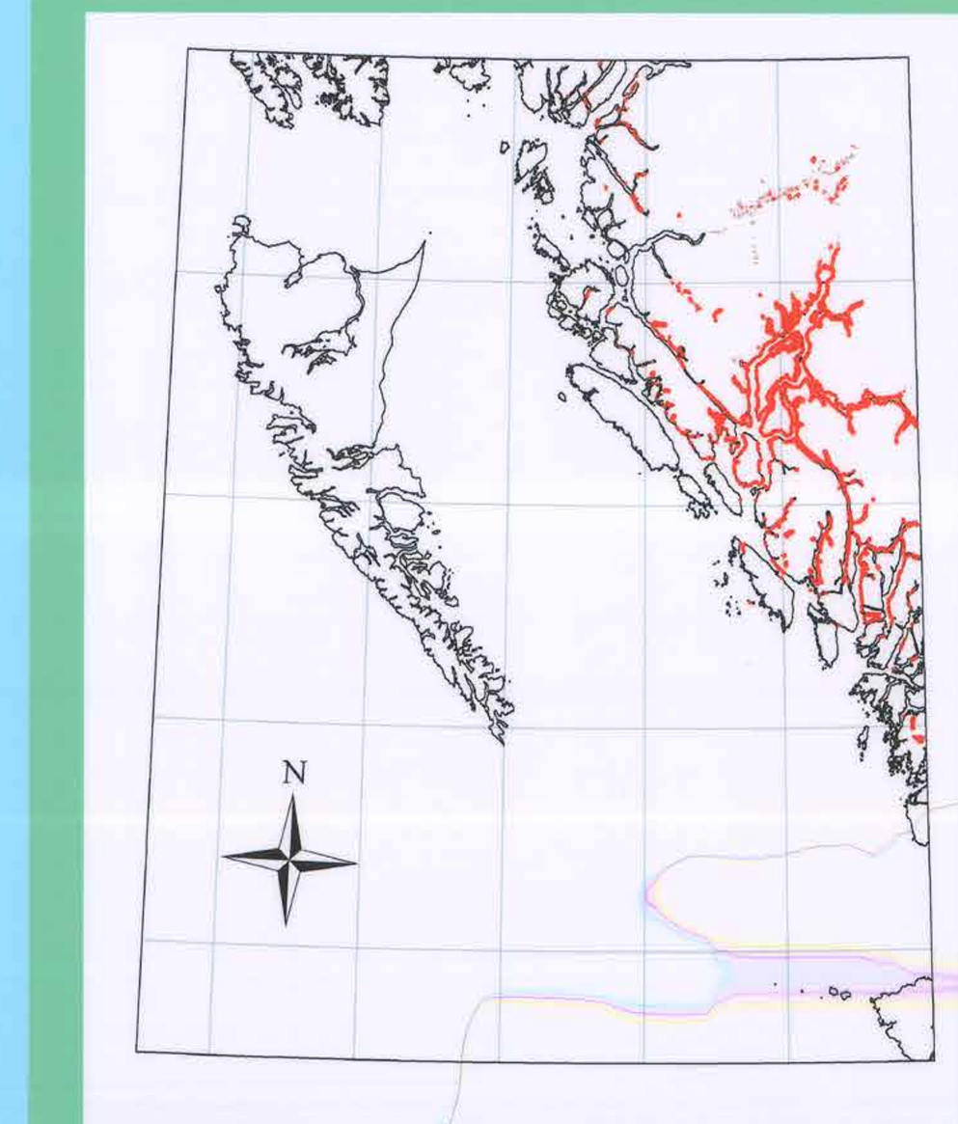

Figure 10a: Paleocoastlines persisting from 12 750 to 10 250 ^{14}C YBP that intersect present topography shown in red

Adapted from: Hetherington et al. 2003

Figure 10b: Paleocoastlines persisting from ~14 250 to 12 750 ^{14}C YBP that intersect present topography shown in red

Adapted from: Hetherington et al. 2003

Paleocoastlines overlaid on present-day topography illustrate the location of accessible potential early habitable landscapes that are presently above sea level. Such habitable landscapes may contain early archaeological sites. Paleocoastlines of particular interest lie along the west coast of the QCI and the westernmost sites along the BC mainland, where the effects of glaciation from the last ice age are reduced. Paleocoastlines appearing on both Figs. 10a and 10b offer the greatest potential for long-term colonization and archaeological site visibility.