SHIFTING SITES AND SHIFTING SANDS: A RECORD OF PREHISTORIC HUMAN/LANDSCAPE INTERACTIONS FROM PORCUPINE STRAND, LABRADOR

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Shifting sites and shifting sands:
A record of prehistoric human/landscape interactions from Porcupine Strand, Labrador

by

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ABSTRACT

Porcupine Strand, on the central coast of Labrador, has experienced dramatic landscape changes since deglaciation: sea level has fallen over 110 m; the former nearshore seabed now lies exposed, forming the coastal lowlands; powerful glacier-fed braided rivers flowed across the northern lowlands, carrying sand and gravel to the sea; with sea-level change, the coastline configuration has evolved from a large indented embayment to a relatively straight shoreline. Although most of this landscape change occurred quite rapidly during the two or three millennia following deglaciation, considerable change must have been witnessed by humans since they first occupied the Strand over 7200 ^{14}C BP. Perhaps the most notable of these were changes in sea level and related coastline displacement, climate variability and its impact on landscape processes (e.g., coastal erosion, sand dune activity), and vegetation change. Because prehistoric cultures relied heavily on marine resources and located their habitation sites close to the active shoreline, the position of ancient shorelines is critical in planning archaeological surveys and interpreting site function in the context of local environment and landscape.

The primary objectives of this research are: (1) to refine postglacial relative sea-level history using new radiocarbon-dated geological and archaeological samples; (2) to reconstruct palaeoshoreline elevation and configuration for selected time slices using relative sea-level records, topography and mapped raised marine features; and (3) to interpret the local landscape context of archaeological sites preserved in sand dunes and on raised beaches.

Two 1:50,000 scale surficial geology maps (13H/14 E and W and 13I/3 W) were prepared from aerial photograph interpretation and limited field mapping as baseline data for the study. Glaciofluvial sand and gravel, deposited in front of the retreating Laurentide Ice Sheet, constitute a large proportion of the surficial sediment in the map area. Coastal exposures, extending tens of kilometres along the Strand, reveal thick deposits of glaciomarine mud and sand overlying rare occurrences of till and bedrock. Glaciomarine sediments were deposited by glacier-fed meltwater streams onto the glacioisostatically depressed coastal lowlands, forming Hjulström type deltas. Raised shorelines were identified up to 116 m above present sea level. Fossiliferous mud and sand underlie much of the coastal lowlands, and in places is obscured by bog. Organic samples (4 shell, 2 driftwood) from raised marine sediments were collected for radiocarbon dating. They range in age from 30 to 8820 ^{14}C BP. Aeolian deflation of emerged glaciomarine sand has resulted in the development of dune systems discontinuously along the entire Strand. Radiocarbon dates on buried soils (n=10) and peaty horizons (n=2) in the dunes range between 40 and 3000 ^{14}C BP and indicate periodic cycles of stabilization and reactivation. Coastal hills and upland surfaces consist mostly of exposed or concealed bedrock having only minor till cover.

Holocene marine limit elevation declines from 116 m in the south to 98 m above sea level (asl) in the north. The establishment of marine limit is estimated to be between 9000 and 8000 ^{14}C BP based on a marine shell date in the south and a previously published age on

the isolation of a freshwater basin to the north, respectively. Initial emergence was rapid in the south at 6.4 m/century until 7000 ^{14}C BP, when relative sea level dropped below the modern shoreline. No data are available to reconstruct the submerged interval of sea-level history. Farther north, initial emergence was slightly slower at 4.6 m/century until 6000-7000 ^{14}C BP. After this time the relative sea-level record is poorly constrained and may represent either continued slow emergence to present or emergence followed by submergence. This latter scenario is supported by the apparent absence of raised marine deposits in the age range 30 to 6750 ^{14}C BP and evidence for recent coastal submergence (e.g. coastal cliff recession).

Many archaeological sites are located on raised beaches. All prehistoric groups are represented by sites within 15 m of sea level. No obvious pattern is identified between site age and elevation; however this may be explained by the small change in the relative sea level position over the last 6000 to 7000 ^{14}C BP. If sites older than 7000 ^{14}C BP are present, they should occur on shorelines higher than 15 m asl. The position and configuration of these shorelines are reconstructed using the refined sea-level history and available topographic data for the Strand. These shorelines tend to be highly embayed in contrast to the relatively straight shorelines of the last 7000 ^{14}C BP or so. These reconstructed coastal landscapes should help refine search strategies for older archaeological site on the Strand.

The oldest radiocarbon-dated soil suggests that sand dune development has primarily occurred over the last 3000 ^{14}C BP. Buried soils and peat horizons overlie strongly indurated marine and glaciomarine sediments. These sediments are the likely source of the aeolian sand. Twelve radiocarbon-dated buried soils and peat indicate eight periods of dune re-vegetation and stabilization in the last 500 ^{14}C BP, which were likely due to changing local conditions (e.g., aridity, forest fires, and human activity).

Over half of the archaeological sites recorded on the Strand are exposed in sand dunes through deflation. As a result, much of the artifact evidence and related cultural features (e.g., fire hearths) are reworked onto the bottoms of blowouts and have lost their stratigraphic context. Archaeological sites were located in four blowouts which also contain dated soil horizons. Generally, there is weak correspondence between the interpreted age of the cultural material and the radiocarbon-dated soil horizons exposed in blowout walls. This is thought to reflect the locally variable and complex dune stratigraphy. Caution is therefore advised in using dated soil horizons in sand dunes to define cultural history of local archaeological sites along the Strand.

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CHAPTER 1 – INTRODUCTION AND RESEARCH QUESTIONS

1.1 Introduction

This thesis examines the last 10,000 years of landscape evolution along Porcupine Strand, Labrador (Fig. 1-1). In particular, it documents sea-level changes and aeolian activity, and relates these changes to prehistoric settlement patterns. Porcupine Strand was occupied by four prehistoric cultures over the last 7200 years. Characteristic artifacts found on raised beaches and in sand dunes on the Strand identify these people, in chronological order, as the Labrador Archaic Indian (LAI), Intermediate Indian, Groswater Palaeoeskimo and Dorset Palaeoeskimo.

Porcupine Strand is situated between Sandwich and Groswater Bays (Fig. 1-1), and consists of 40 km of sandy beaches backed by eroding coastal cliffs. These cliffs are located at 10 m above sea level (m asl), and represent the eastern margin of a low coastal plain. The plain rises inland to form the coastal uplands (Fig. 1-1). Numerous raised beaches and sand dunes are located on the coastal plain. The dune sand is derived from wind-blown beach material, the removal of which forms large depressions called blowouts. The bottoms of these blowouts are littered with a lag of discoid-shaped clasts and abundant prehistoric artifacts and lithic debitage. The Porcupine Strand is an important area to study, as detailed studies regarding landscape change and archaeology have not been conducted in this area. In addition, the landscape is quite dissimilar to the bedrock-dominated coastline so common elsewhere in Labrador.

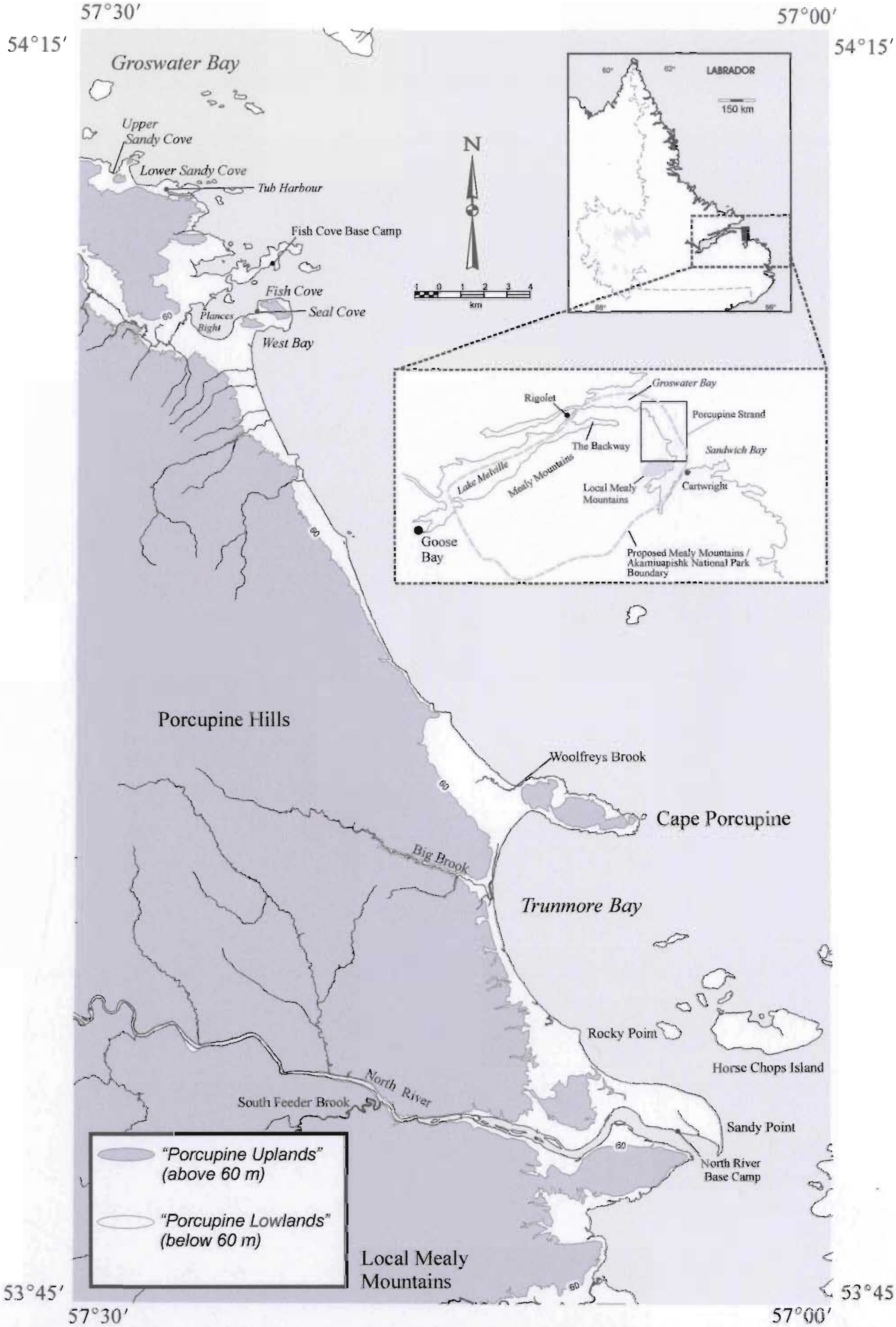

Fig. 1-1: Map of Porcupine Strand within the proposed Mealy Mountain/ Akamiuapishk National Park study area. The 60 m contour roughly separates the Porcupine Uplands from the Porcupine Lowlands. The Local Mealy Mountains is an unofficial name (Rogerson 1977) and is different from the Mealy Mountains farther inland.

Prehistoric peoples would have seen and experienced a much different landscape than that observed today. Over the last 10,000 years, sea level fell over 100 m, and coastal lowlands formed from the emerging seabed and became vegetated. Shifting coastal sand underwent alternating phases of erosion and re-vegetation, forming buried soils (palaeosols). The study of changing landscapes, primarily sea-level change and aeolian history, presents an opportunity to integrate palaeogeography and archaeology for various periods of prehistoric occupation. This allows temporal and spatial changes to be identified in cultural settlement patterns.

The integration of sea-level studies and archaeology has been successful at sites along the coasts of Canada, for example along the Gulf of Alaska (Crowell and Mann 1996), and the Queen Charlotte Islands (Fedje and Christensen 1999). The knowledge of sea-level change is used to locate archaeological sites, as well as to provide explanations for the presence or absence of sites in the archaeological record. It is important to consider the prehistoric groups involved, their connection to the sea and the location of their sites in relation to sea-level change. For example, most of the maritime-based prehistoric groups in Labrador often relied heavily on marine resources and as a result lived close to the sea. Clark and Fitzhugh (1992) suggested that archaeological sites in Labrador generally are located approximately 1 to 3 m above the corresponding high tide line for each period of cultural occupation. Therefore, by identifying palaeoshorelines, probable areas of archaeological sites also are located. Sea-level history was used in the following examples to explain both the presence and absence of sites in the archaeological record.

In Katmai National Park and Reserve, along the Gulf of Alaska, preservation of sites younger than 7000 Cal BP[1] corresponded to a fall in sea level during this time (Crowell and Mann 1996). A more complex sea-level history in the Queen Charlotte Islands region of Canada's northwest coast reveals a subaerial prehistoric record that extends to 9500 ^{14}C BP (Fedje and Christensen 1999). However, the earlier part of the record, 13,000 to 10,500 ^{14}C BP, is submerged as a result of sea level being 140 m below present at that time (Fedje and Christensen 1999). Other studies within this area identified similar results (Josenhans *et al.* 1997; Hetherington *et al.* 2004). In Port au Choix, Renouf and Bell (2000) used sea level as a tool, along with ideal site location preferences, to identify areas with the highest potential for Maritime Archaic Indian settlement (Bell and Renouf 2003; Renouf and Bell in press). Their model for site detection was successful in locating the Gould Site in Port au Choix, Newfoundland (Renouf and Bell 2000). These studies demonstrate the usefulness and practical application that a detailed knowledge of sea-level history can have for archaeology.

Prehistoric artifacts were identified within sand dune systems in both coastal and interior areas of North America. Archaeology and sand dune systems were studied in areas including: San Miguel Island, California (Rick 2002); Peace River Valley, B.C. (Valentine *et al.* 1980) and the Nenana Valley, Alaska (Powers and Hoffecker 1989). Artifacts appear at the surface of dunes and blowouts as the result of wind erosion. The result can be an accumulation of material from different time periods (Rick 2002).

[1] Dates within the text are presented as calibrated radiocarbon years or radiocarbon years before present. These are denoted as Cal BP, and ^{14}C BP respectively.

However, the study of these aeolian systems is a useful tool for archaeology because a chronology can be reconstructed using buried soils or palaeosols (Valentine *et al.* 1980). This chronology can then be compared to, and correlated with, the archaeological record. In some cases, artifacts can be traced back to buried soils within the aeolian sequence providing a reconstructed stratigraphy. Buried soils also provide clues to local palaeoclimatic conditions. Thus, both studies of sea-level change and aeolian history are useful tools in determining and reconstructing the palaeoenvironment of prehistoric peoples.

The study of landscape change along Porcupine Strand is part of the Porcupine Strand Archaeological Project (PSAP), initiated in 2002 and is ongoing. Only the southern tip of the Strand had undergone archaeological investigation prior to this project (Stopp 1997). During the PSAP 2002 survey, archaeological sites were identified on raised beaches and blowout floors, so it was necessary to understand the history of these landforms and to determine how the changing environment influenced the pattern of settlement along the Strand. The area is considered to have been a prehistoric travel route, so research in this area not only promises to fill a gap in the distribution of prehistoric cultures, but also presents an opportunity to study the cultures that preferentially lived along a sandy portion of Labrador's coastline (Rankin 2002). It is possible to reconstruct the Holocene history of landscape change by documenting how shorelines and coastal dune systems have changed over time and thereby gaining a better understanding of the settlement patterns of the Strand's prehistoric inhabitants.

1.2 Landscape Change

Landscape change has been ongoing along Porcupine Strand since the last glaciation, however the most notable changes have taken place during the retreat of the Laurentide Ice Sheet about 14,000 ^{14}C BP. While substantial changes occurred since deglaciation the most important period for studying landscape change (from the point of view of this study) is the last 7500 ^{14}C BP, because it coincides with the first recoded human occupation of the landscape. This literature review provides a synopsis of the research that documented the evolution of Porcupine Strand during the Holocene, starting with glacial extent and deglaciation, and then focusing on sea-level changes and sand dune history. The literature review will highlight data gaps and conflicting hypotheses regarding landscape change that will form the underlying themes of the research questions which are included at the end of each subsection.

1.2.1 *Review of Ice Extent and Deglaciation*

During the Late Wisconsinan glaciation, ice forming the Labrador sector of the Laurentide ice sheet advanced from interior Labrador/Quebec eastward and southeastward, toward the coast of central and southern Labrador (Vincent 1989). Ice flow diverged around local topographic highs, such as the Mealy Mountains (Gray 1969), and ice flow was influenced near the coast by marine troughs, e.g. Sandwich and Groswater Bays (Rogerson 1977). Many workers, including Flint (1957), Prest (1969), Fillon (1975, 1976), Josenhans *et al.* (1986), and Vincent (1989), proposed that the eastern margin of the Laurentide Ice Sheet extended across the Labrador coast onto the continental shelf during the Late Wisconsinan. Others proposed that coastal portions of

Labrador remained ice-free (Ives 1978; Hughes et al. 1981; Rogerson 1977, 1981; Prest 1984). On the basis of differential weathering and ice-marginal moraines, Rogerson (1977) argued that the summit of the *Local Mealy Mountains*[2] remained ice-free and consequently, ice may have extended only a few kilometres offshore along Porcupine Strand (Rogerson 1977). Josenhans *et al.* (1986) and Hall *et al.* (1999) suggest glacial ice was present on the continental shelf during the last glacial maximum. However, it still remains difficult to construct the exact position of the Last Glacial Maximum ice margin on the continental shelf (Dyke *et al.* 2002).

The timing of deglaciation along the Labrador coast is also subject to debate. Vilks and Mudie (1978), Josenhans (1983) and Josenhans *et al.* (1986) proposed that deglaciation of the shelf begun by 20,000 ^{14}C BP, yet Fillon and Harnes (1982) suggest it did not start until 9000 – 10,000 ^{14}C BP. Rogerson (1977) reported that ice had retreated along Porcupine Strand as early as 12,000 ^{14}C BP, while ice remained in the adjacent Sandwich and Groswater bays as late as 8000 and 7000 ^{14}C BP respectively. Farther inland to the southwest, a regionally extensive glacial still-stand was suggested by the prominent Paradise Moraine (Fulton and Hodgson 1979). Although the composition and genesis of the moraine is poorly understood, with elements described as hummocky till (Fulton and Hodgson 1979) and glaciofluvial outwash (McCuaig 2002a), it is thought to extend as far northeast as Sandwich Bay. Initially, the moraine was interpreted to represent the terminal position of the Laurentide Ice sheet, based on a bulk sediment radiocarbon date

[2] Local Mealy Mountains is an informal name used by Rogerson. All names which do not appear on the 1:50 000 scale map sheets are considered informal names and are italicized in the text.

of 21,000 ^{14}C BP from a nearby lake basin (Vilks and Mudie 1978); however, subsequent resampling and dating by King (1985) provided a radiocarbon age of 10,000 ^{14}C BP, suggesting that the earlier sample was contaminated by older carbon (King 1985). The revised age of the moraine suggested that the associated Laurentide ice margin may have extended to the Labrador coast in the Sandwich Bay area and may correlate with proposed deglacial ice margins mapped by Rogerson (1977) across Porcupine Strand.

Objectives Related to Deglaciation of Porcupine Strand

The timing of deglaciation of Porcupine Strand and the adjacent troughs is critical in determining the earliest time the area would have been available for prehistoric occupation. Thus the main objectives relating to deglaciation are presented as two questions: How is deglaciation recorded on the landscape? Can the timing of deglaciation for Porcupine Strand be refined? These questions may be answered by using aerial photograph interpretation to identify the relationships between glacial, outwash, and marine derived sediment. Features such as marine deltas and outwash plains can be investigated in the field to determine if they contain shells, whalebone, or driftwood for radiocarbon dating. Dates from these units would provide minimum estimates of deglaciation for the area. Dates from organic material from tills overlying marine sediment would provide maximum age estimates for deglaciation. Additional questions arise when the archaeology of the area is considered: How does the timing of deglaciation within the Porcupine Strand area affect the migration of Labrador's prehistoric groups to this area? What might the landscape look like to the first occupants? Where are the earliest sites located in relation to the ice margin? These questions may also be answered through the integration of archaeological information about prehistoric cultures and geological data on the timing of deglaciation.

1.2.2 *Review of Sea-Level Studies*

During glacial retreat, the sea inundated the glacioisostatically depressed coast. Since deglaciation, the varying temporal and spatial changes of relative sea level along the Labrador coast is the result of complex interactions between ice thickness, ice extent and a thin rigid lithosphere (Clark and Fitzhugh 1992). Differential loading of the crust and asynchronous ice retreat is responsible for the spatial variation in marine limit elevations identified throughout Labrador (Quinlan and Beaumont 1981). These changes in sea level resulted in the preservation of raised marine features such as raised beaches, terraces and sea stacks along different palaeoshoreline configurations over time. Identification of these shorelines is useful in determining the sea-level history, and in locating the times of prehistoric inhabitants who occupied these ancient shorelines over the last 7500 ^{14}C BP.

Rogerson (1977) conducted detailed field-based sea-level investigations along Porcupine Strand. The highest marine limit mapped was at *South Feeder Brook* delta, at 113 m asl. Marine limit was spatially variable throughout the Strand, especially south of Cape Porcupine, where it was mapped as low as 20 m asl (Fig. 1-2; Rogerson 1977). The marine limit, north of Cape Porcupine ranged between 80 and 92 m asl, was based on raised beaches and is less variable in comparison to the North River area (Rogerson 1977). Rogerson (1977) suggested that the variations in marine limit were explained by

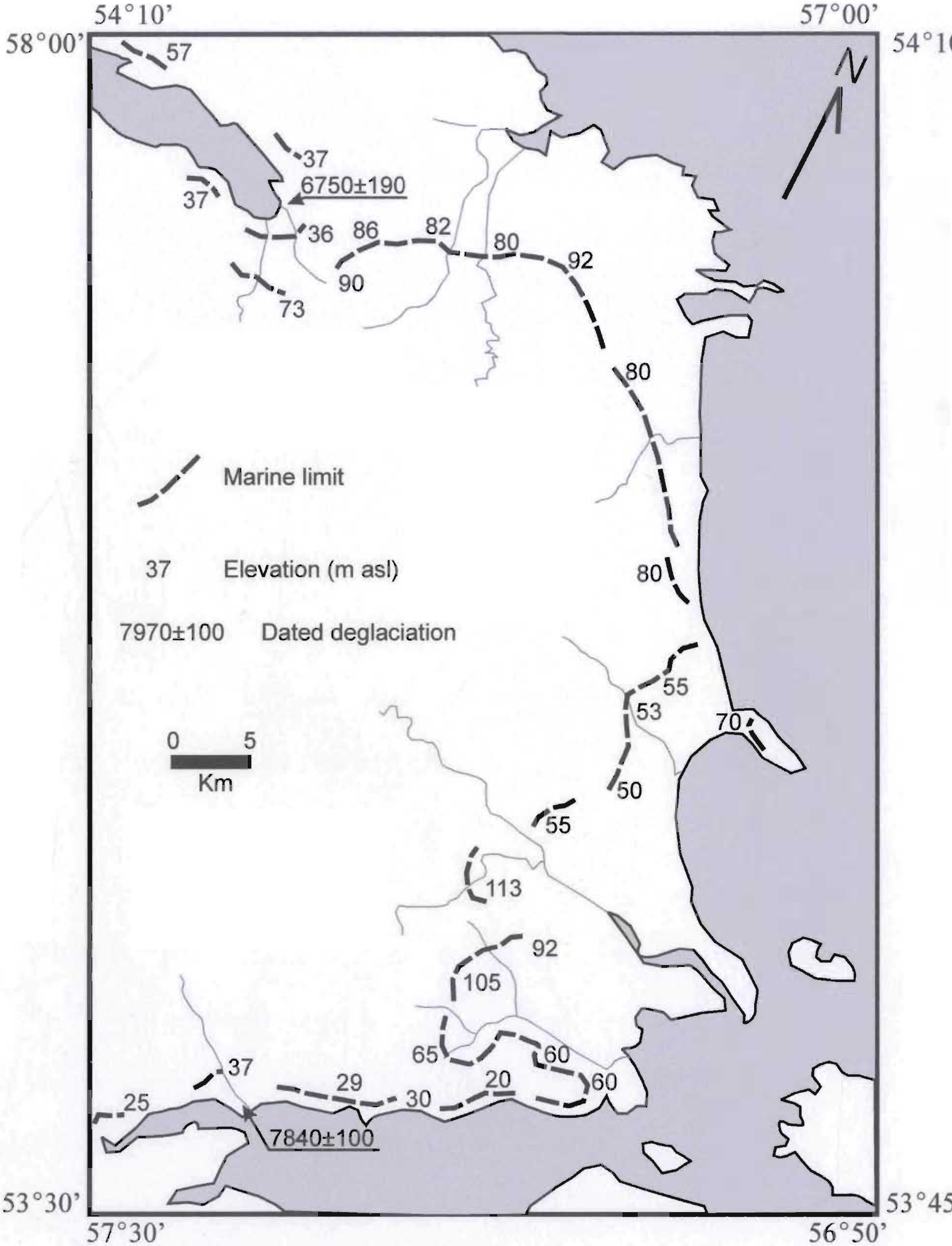

Fig. 1-2: The variation in marine limit elevation across Porcupine Strand (modified from Rogerson, 1977).

varying ice thickness causing differential rebound and as a result Rogerson (1977) used a median value of 57 m to construct a sea-level history for Porcupine Strand (Fig. 1-3).

The sea-level history, as suggested by the sea-level curve in Figure 1-3, indicated that the Strand experienced emergence until 5640±100 ^{14}C BP (GSC-2480), followed by a marine transgression. Submergence continued until 5000 ^{14}C BP and was followed by emergence until present. Rogerson (1977) indicated the mechanism responsible for the marine transgression was variations in eustatic sea level caused by changing ice volumes. He further speculated that this 5600 ^{14}C BP transgression was responsible for the formation of the coastal cliffs along the Strand.

Clark and Fitzhugh (1992) constructed three sea-level histories for southern Labrador that show spatial variation in marine limit elevation (Fig. 1-4). Sea level fell from elevations of 152 m asl in southern Labrador, 75 m asl in outer Groswater Bay and 135 m asl in inner Lake Melville (Clark and Fitzhugh 1992). Sea-level histories constructed by Clark and Fitzhugh (1992) were constrained using ages derived from radiocarbon dated shells and the presence of archaeological sites. Clark and Fitzhugh (1992) incorporated five data points from Rogersons' (1977) sea-level curve, into the sea-level history for Groswater Bay (Fig. 1-3). An archaeological site located at 8 m asl on Clark and Fitzhugh's (1992) curve appears to negate Rogerson's (1977) marine transgression that occurs until 5000 ^{14}C BP. The use of marine shell and archaeological data was only able to constrain the younger parts of the curve. In order to constrain the location of sea level

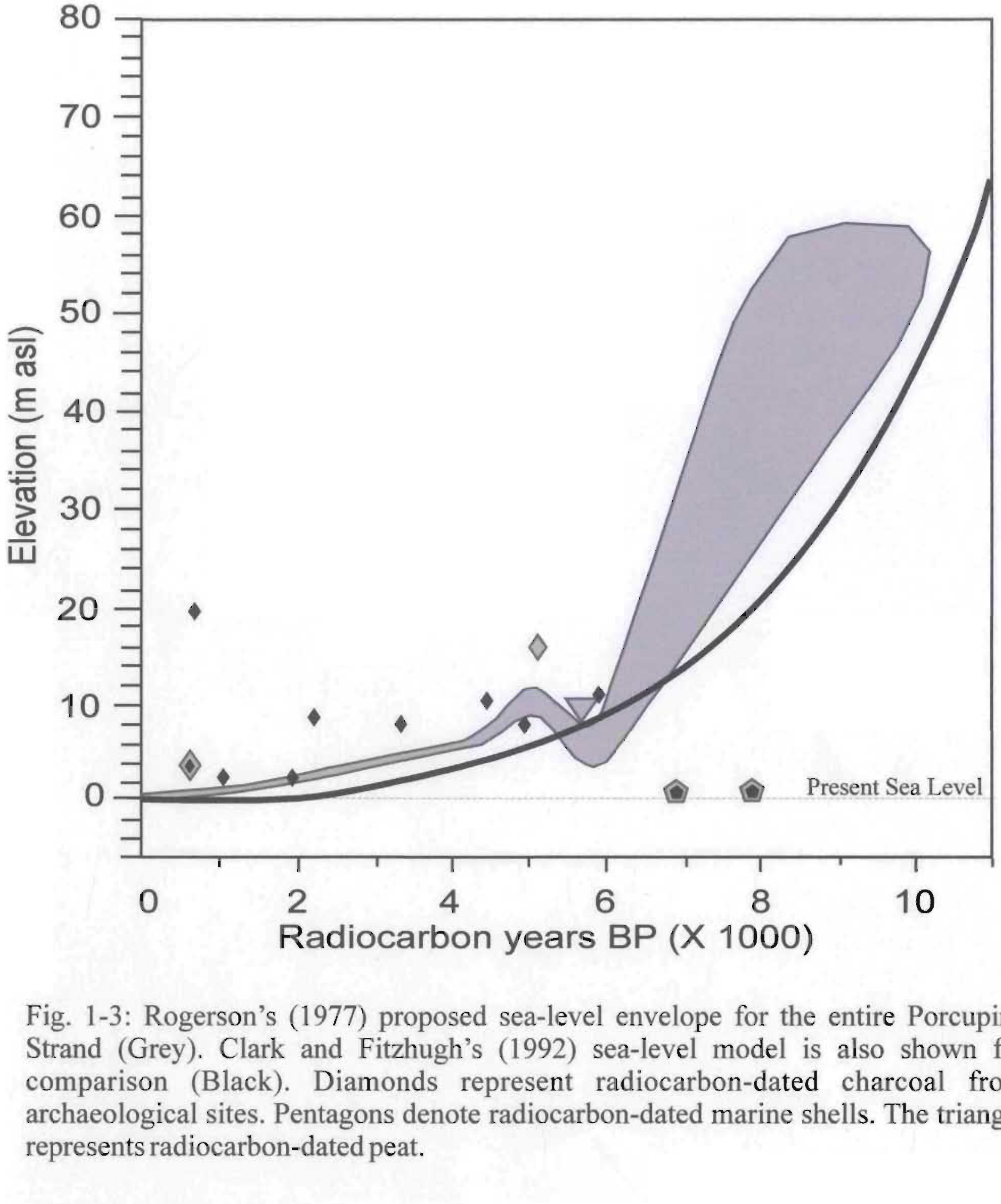

Fig. 1-3: Rogerson's (1977) proposed sea-level envelope for the entire Porcupine Strand (Grey). Clark and Fitzhugh's (1992) sea-level model is also shown for comparison (Black). Diamonds represent radiocarbon-dated charcoal from archaeological sites. Pentagons denote radiocarbon-dated marine shells. The triangle represents radiocarbon-dated peat.

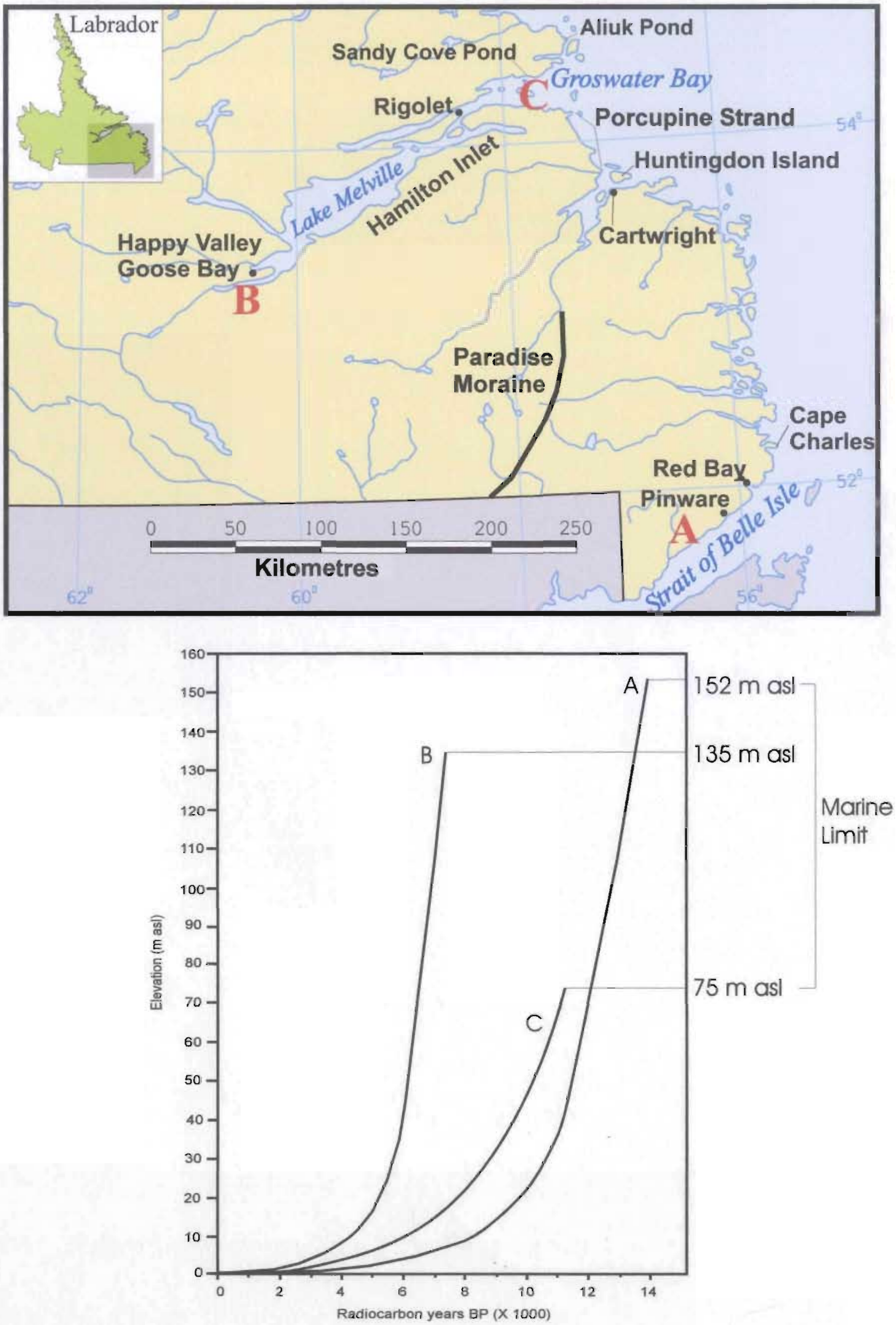

Fig. 1-4: Map showing the location of the sea level history curves for Pinware (A), Goose Bay (B), and Groswater Bay (C), produced by Clark and Fitzhugh (1992). Place names from the region that are used in the text are also shown.

from the last data point to deglaciation, a geophysical model was used. This model extrapolated the age of marine limit using the height of marine limit and a decay constant and inputting the information into an equation for exponential decay.

The resulting sea-level histories for Pinware, Goose Bay and Groswater Bay represent a Type-A sea-level history, (as defined by Quinlan and Beaumont 1981) characterized by a continuous exponential decline in the rate of sea-level fall from the establishment of marine limit to present (Quinlan and Beaumont 1981; Fig. 1-3). The Strait of Belle Isle experienced the greatest amount of emergence due to early deglaciation at 14,000 ^{14}C BP (Clark and Fitzhugh 1992). Inner Lake Melville experienced a faster rate of emergence since deglaciation (~7550 ^{14}C BP). This amount of emergence during this short amount of time is likely due to the rapid retreat of ice within Inner Lake Melville (Clark and Fitzhugh 1992). The sea-level history for Groswater Bay is intermediate between the other two curves with sea level falling 75 m over the last 11,000 ^{14}C BP (Fig. 1-3 and Fig. 1-4).

Rogerson's (1977) and Clark and Fitzhugh's (1992) sea-level histories are similar in that they represent a Type-A sea-level history, however they are based on limited geological data from Porcupine Strand (Fig. 1-4). As well, both sea-level histories have differing implications for the preservation of the archaeological record along the Strand. Rogerson's (1977) curve indicates that archaeological sites between 6000 and 5000 ^{14}C BP underwent submergence followed emergence and as a result these sites may be eroded and disturbed. This is in contrast to Clark and Fitzhugh's (1992) model that suggests there should be a continuous record of archaeological sites located above sea level, with the oldest sites identified at higher elevations and younger sites being found at lower elevations.

Objectives Related to Sea-Level Change

As a result of differences between Rogerson's (1977) and Clark and Fitzhugh's (1992) sea-level histories, and new archaeological data from Porcupine Strand, further investigation of sea level within this area needs to be conducted in order to answer the following questions, that form some of the thesis objectives: What is the pattern of sea-level change and how has it been recorded on the landscape along Porcupine Strand? Sea-level change can be studied by using air photo interpretation to identify the presence of raised marine features, and the pattern they form on the landscape. The timing of sea-level change may be determined by conducting fieldwork to examine these features for datable organics. Using the results from fieldwork and radiocarbon analysis, a refined sea-level history curve for the Strand may be produced. The integration of the refined sea-level curve with archaeological data may provide answers to these questions: How has the palaeogeography of Porcupine Strand changed since deglaciation? How do the changing palaeoshorelines correspond to the distribution patterns of archaeological sites? What are the implications of changing sea level on the preservation of archaeological sites? How can sea-level history be implemented as a tool in identifying new archaeological sites?

1.2.3 *Review of Aeolian Studies*

Sand dune systems are often associated with major outwash plains throughout Labrador, particularly along the coast. These aeolian systems have been identified on the south coast between Blanc-Sablon and Pinware (Tuck and McGhee 1975; McCuaig 2002a), Porcupine Strand (Rogerson 1977), around Nain (Gilbert *et al.* 1984) and along the upper terraces of the Churchill River (Liverman 1997). However, most of these have not been described in detail. Many of these sand dunes are relicts of a past environment that had different moisture and climate regimes. These sand deposits may help document landscape change, and also may preserve a rich prehistoric occupation record.

Many archaeological sites have been found in sand dunes along the southeastern and central coast of Labrador, but these dune fields have not been studied in any detail. Rogerson (1977) documented relict sand dunes along Porcupine Strand, most located on the coastal lowlands (Fig. 1-5), while smaller occurrences of sand dunes were located at *Woolfreys Brook*, The Backway and southwest of *Plances Bight*. Many of the dunes were classified as parabolic and longitudinal and are located on the widest portion of the coastal lowlands. Rogerson (1977) proposed that the formation of these dunes predates the formation of the coastal cliffs because the dunes extend to the edge of the cliffs. The orientation of these vegetated dunes suggests a palaeowind direction from the west and west-northwest and they therefore did not form as a result of inland migration of beach sediments (Rogerson 1977). In areas where dunes were reactivated due to wind erosion and fire, sections through the aeolian sediment revealed buried soils that indicated stable

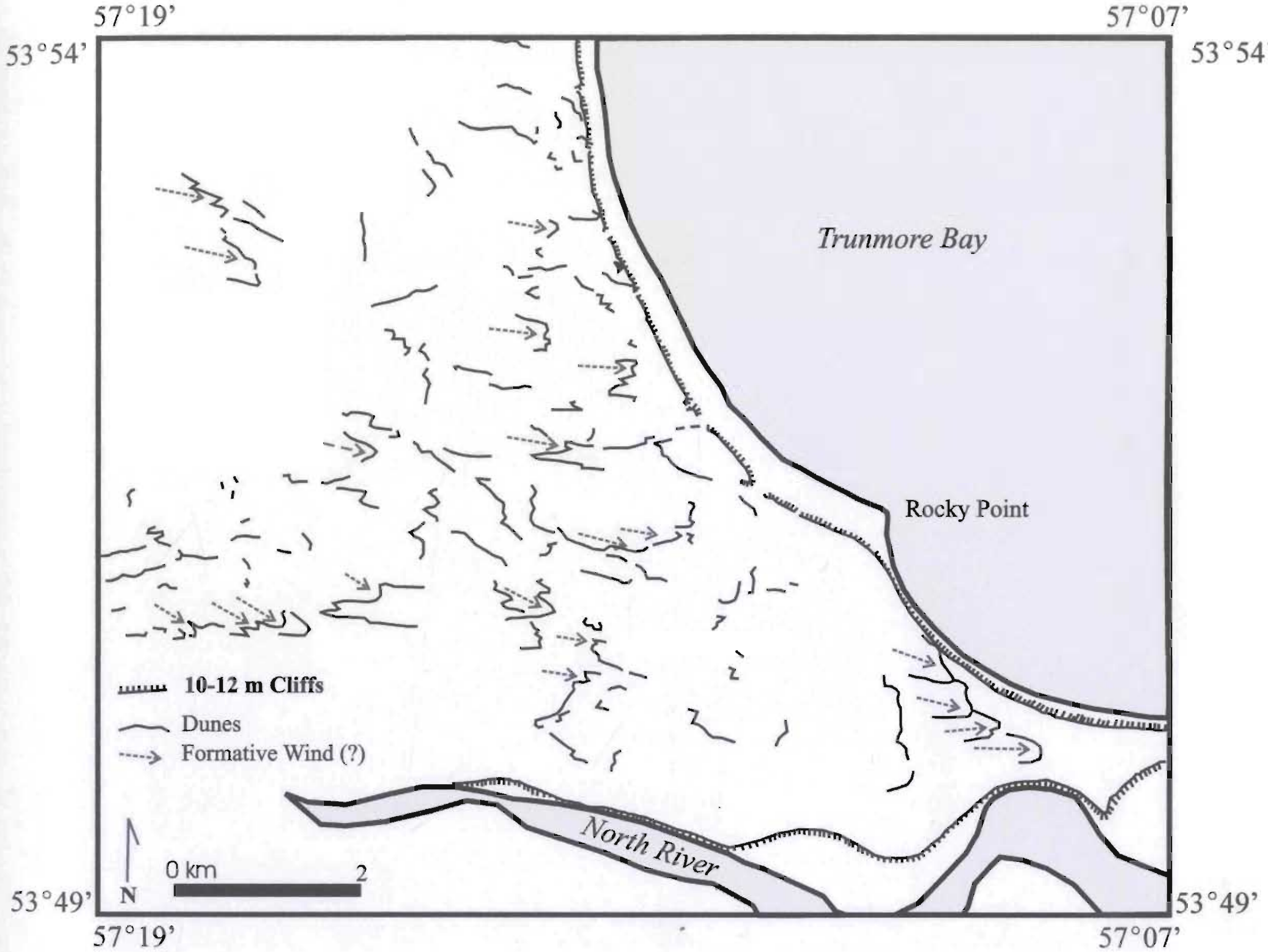

Fig. 1-5: Map of sand dunes on the coastal lowlands (modified from Rogerson 1977).

periods during the formation of dunes. While the scope of Rogersons' (1977) research did not include radiocarbon dating of these horizons, he suggested they formed in the mid Holocene when sea level had fallen below 10 m asl.

Objectives Related to Aeolian Sand and Palaeosols

The following is a list of questions that form the objectives related to aeolian sand and palaeosols. What is the distribution of aeolian sands and buried soils along the Strand? What is the source of aeolian sands? At what time were aeolian deposits covered with vegetation? Answers to these questions may be determined by using aerial photographic interpretation to map the distribution of aeolian sediments. Collection and examination of buried soil samples will identify the relationship between buried soils and aeolian sand. Dating of these soils will provide their age prior to burial by aeolian sediments. This data can be used in conjunction with the archaeology of the area to answer further questions: What is the relationship between the timing of buried soil horizons and prehistoric occupation? Were prehistoric peoples simply living on raised beaches that became buried by aeolian sand or were they living in this area during periods of vegetation growth and when aeolian deposition was minimal or non-existent?

CHAPTER 2 – BACKGROUND AND METHODS

2.1 Introduction

This chapter is divided into two parts: the first part provides an introduction to Porcupine Strand through a brief examination of geographic setting, physiography, bedrock geology, climate soils, prehistoric occupation and a review of pollen diagrams from outer Groswater Bay; the second part describes the methods used to collect and analyze data for this project.

2.2 Background

2.2.1 *Location*

Porcupine Strand is situated between Groswater Bay and Sandwich Bay, on the central coast of Labrador. The Strand is the eastern boundary of the proposed Mealy Mountain/ Akamiuapishk National Park study area (Fig. 1-1). No year-round settlements are located along the 40 km-long Porcupine Strand; the nearest communities are Rigolet and Cartwright. Rigolet, located to the northwest, is about 50 km inland along the northern shore of Groswater Bay. Cartwright lies 13 km to the southeast on the southern shore of Sandwich Bay. The residents of Cartwright and Rigolet use Porcupine Strand as a recreational area for salmon fishing, berry picking and cottages. Access to Porcupine Strand is only by boat or snowmobile when the season permits.

2.2.2 *Bedrock Geology*

Porcupine Strand lies within the Grenville Province, the youngest and most southerly of the five structural geological provinces of Labrador (Fig. 2-1; Wardle *et al.* 1997a). The Grenville records a long history of mountain building, igneous magmatism and deformation (Gower 1996; Davidson 1998). Porcupine Strand is located within the Groswater Bay terrane, and the bedrock consists of grandioritic gneiss, granite, quartz monozonite, granodiorite, quartz diorite and intrusions of gabbronorite and anorthosite (Fig 2-1; Gower 1996). These rocks were strongly deformed during the late Mesoproterozoic Grenville Orogeny (1.3 to 1.0 Ga)[3] (Gower 1996). The older grandioritic gneiss (~1.6 Ga) is also highly deformed and underlies most of the coastal lowlands and forms prominent headlands along the Strand (e.g., Cape Porcupine). The *Porcupine Uplands*, including the *Porcupine Hills* and the *Local Mealy Mountains*, are consists of gabbronorite and anorthosite that protrude through the thick overlying Quaternary sediment (Rogerson 1977; Gower 1996). Diorite and quartz diorite make up the eastern edge of the *Local Mealy Mountains*, whereas granitic rocks outcrop north of *Fish Cove* on the southern shore of Groswater Bay (Gower 1996).

2.2.3 *Physiography and Surficial Geology*

Porcupine Strand is divided into two main physiographic units: the *Porcupine Lowlands* and the *Porcupine Uplands* (Fig. 1-1; Rogerson, 1977). The *Porcupine Lowlands* form a

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[3] Ga refers to billions of years

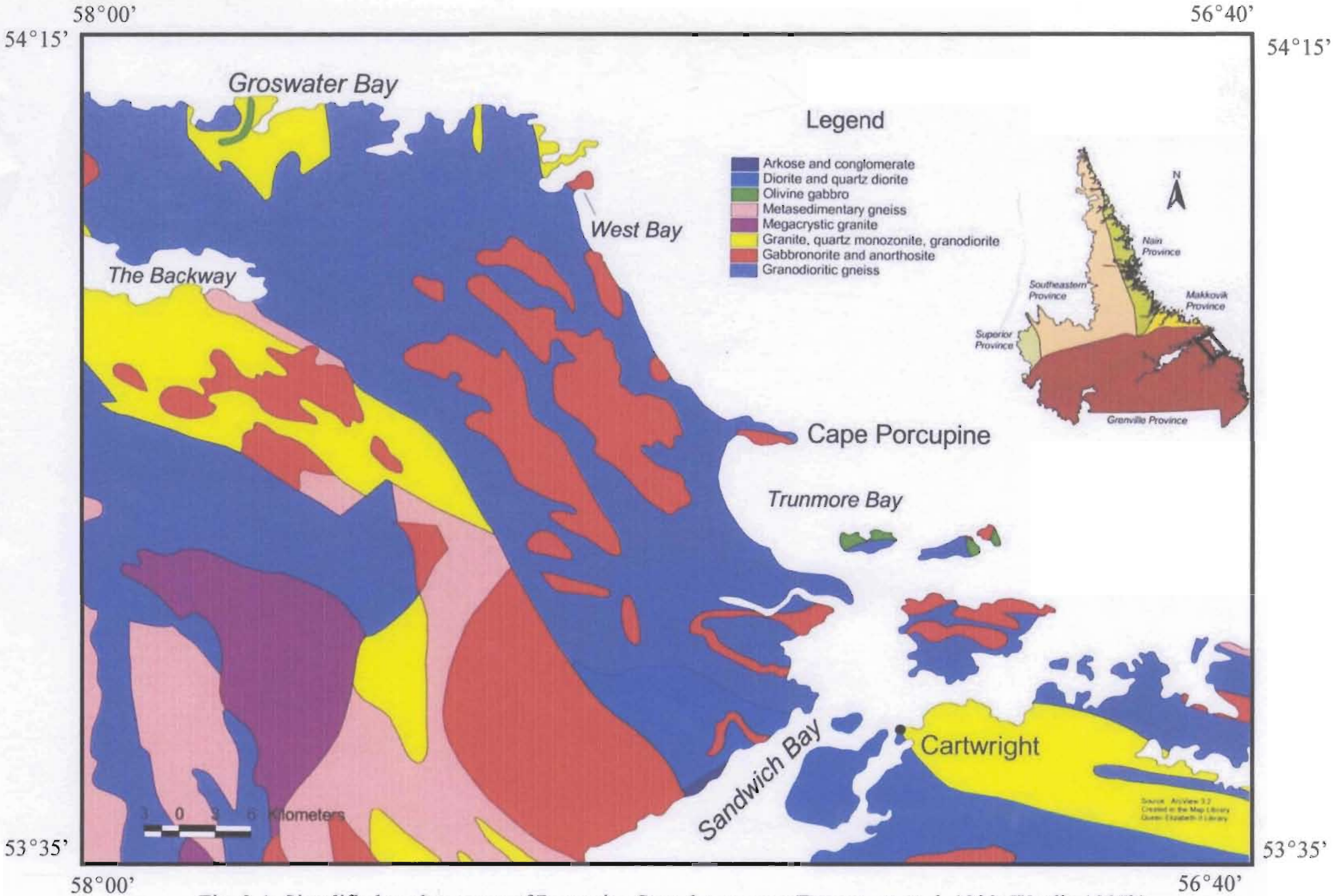

Fig. 2-1: Simplified geology map of Porcupine Strand map area (Davenport et al. 1999; Wardle 1997b).

broad plain that stretches 40 km from Sandy Point to west of *Plances Bight*. The lowlands are found up to 60 m asl and extend 5-10 km inland from the modern coastline. The coastal plain consists of glacial outwash (primarily sand and gravel) that is underlain by marine mud (Rogerson 1977). The rocky headland, Cape Porcupine, divides Porcupine Strand into two parts: the South Strand (Trunmore Bay) and the North Strand. The area north of *West Bay* is dominated by bedrock, overlain by deposits of marine sand/gravel and aeolian sand (Fulton 1986). The coastal lowlands give way to the *Porcupine Uplands*, that rise to 350 m asl in the *Porcupine Hills* and to 650 m asl in the uplands along the north shore of Sandwich Bay.

North River, the largest river in the study area, drains an area of approximately 2234 km^2, running across the coastal plain and emptying into Sandwich Bay at Sandy Point (Keith 2001). Many of the streams and small rivers, including *Big Brook* and *Woolfreys Brook*, become shore parallel as longshore drift has deflected the outlets of these streams to the south (Batterson and Liverman 1995). Numerous ponds are associated with the extensive bog deposits on the coastal lowlands. The most of the bogs and ponds are found on the South Strand south of *Big Brook*, while some also occur northwest of *Plances Bight* along the North Strand.

Fulton (1986) mapped the surficial geology of the Cartwright region at a scale of 1:500,000. The Porcupine Strand was characterized by four main surficial units: marine littoral, marine sub-littoral, glaciofluvial and till. The coastal lowlands consist of marine littoral (gravel, sand and boulders) and sub littoral (silt and clay) deposits overlain by peat deposits, while the uplands have glaciofluvial material (sand and gravel) in valley bottoms and till on hill slopes. Exposures of bedrock are confined to coastal areas north of *West Bay*, offshore islands, and uplands.

2.2.4 *Climate*

The climate of Porcupine Strand is classified as subarctic with cool summers and cold winters. This climate is primarily influenced by seasonal atmospheric circulation patterns and the proximity of the Labrador Sea (Banfield 1993).

The presence of a major low-pressure system off southern Greenland during the winter results in prevailing northwest winds over Labrador (Banfield 1993). Strong winter cyclones track to the southeast of Porcupine Strand, most commonly through the Strait of Belle Isle region, and are often rejuvenated by renewed moisture and energy received from moving offshore (Banfield 1993). The presence of anticyclones along coastal Labrador during the winter is normally brief and is associated with cold clear weather. Summer circulation patterns are characterized by westerly airflow in Labrador as a result of low-pressure systems in Ungava Bay (Banfield 1993). Cyclones are generally smaller and weaker during the summer and track through the Strait of Belle Isle or central Labrador.

Cartwright has an annual mean daily temperature of –0.3°C, based on climate normals calculated for 1961-1990 (Environment Canada 1993). Daily mean temperatures between

November and April remain below 0°C. The lowest daily mean temperature occurs in the month of January (–13.8°C), while the highest occurs in July (12.3°C). Annual precipitation exceeds 950 mm, of which 475 cm falls as snow. The wettest period is between mid-November and March, while May and June are the driest months. Freeze-up of coastal waters occurs between mid-November and early December, and ice remains until at least early March or as late as early May.

2.2.5 *Soils*

Within the field area there are three classes of modern soils defined by the Soil Landscapes of Canada Working Group (SLCWG 2001). Mesisols are located along the lowlands between North River and Cape Porcupine. These soils consist of organic material that is at an intermediate stage of decomposition. Mesisols are formed on fine-grained marine sediments that impede soil drainage and as a result are poorly to very poorly drained (Soil Classification Working Group 1998). The remaining two classes are subgroups of the Podzol class; these are generally iron rich soils that are characteristic of cool to very cold humid climates. They are strongly acidic soils that are associated with boreal forest and heath environments (Soil Classification Working Group 1998). Ferro-Humic Podzols are located north of Cape Porcupine. These soils are typical of more humid areas within the region of Podzolic soils and occur under moss-rich forest or heath environments (Soil Classification Working Group 1998). Ferro-Humic Podzols are recognized by their dark-coloured podzol B horizon that is characterized by high organic content and considerable amount of extractable iron and aluminum content (Soil Classification Working Group 1998). These are associated with cemented B horizons that may exceed 40 cm. Humo-Ferric podzols are associated with the *Porcupine Uplands*. They often have less organic matter than the Ferro-Humic Podzol and form in forest to shrub vegetation (Soil Classification Working Group 1998). The B horizon shows reddish hues that fade with depth. It is not uncommon for the B horizon to be cemented by iron oxides.

2.2.6 *Prehistoric Occupations - Labrador*

Labrador has a rich record of prehistoric occupation that spans almost 9000 ^{14}C BP. Eight prehistoric cultures have at various times existed in Labrador. This section reviews the temporal and spatial settlement patterns of these groups, along with a review of both previous and current work completed along Porcupine Strand.

Differences in temporal and spatial settlement patterns are in part linked to where cultural groups originated (Fig. 2-2). The first Amerindian group to inhabit southern Labrador, the Palaeo-Indians, moved along the Quebec Lower North Shore into the Strait of Belle Isle (Tuck 1976, n.d.). The Palaeo-Indians may be ancestral to the Labrador Archaic Indians (LAI) who, by 7500 ^{14}C BP, had become fully maritime-adapted (Tuck n.d.). The

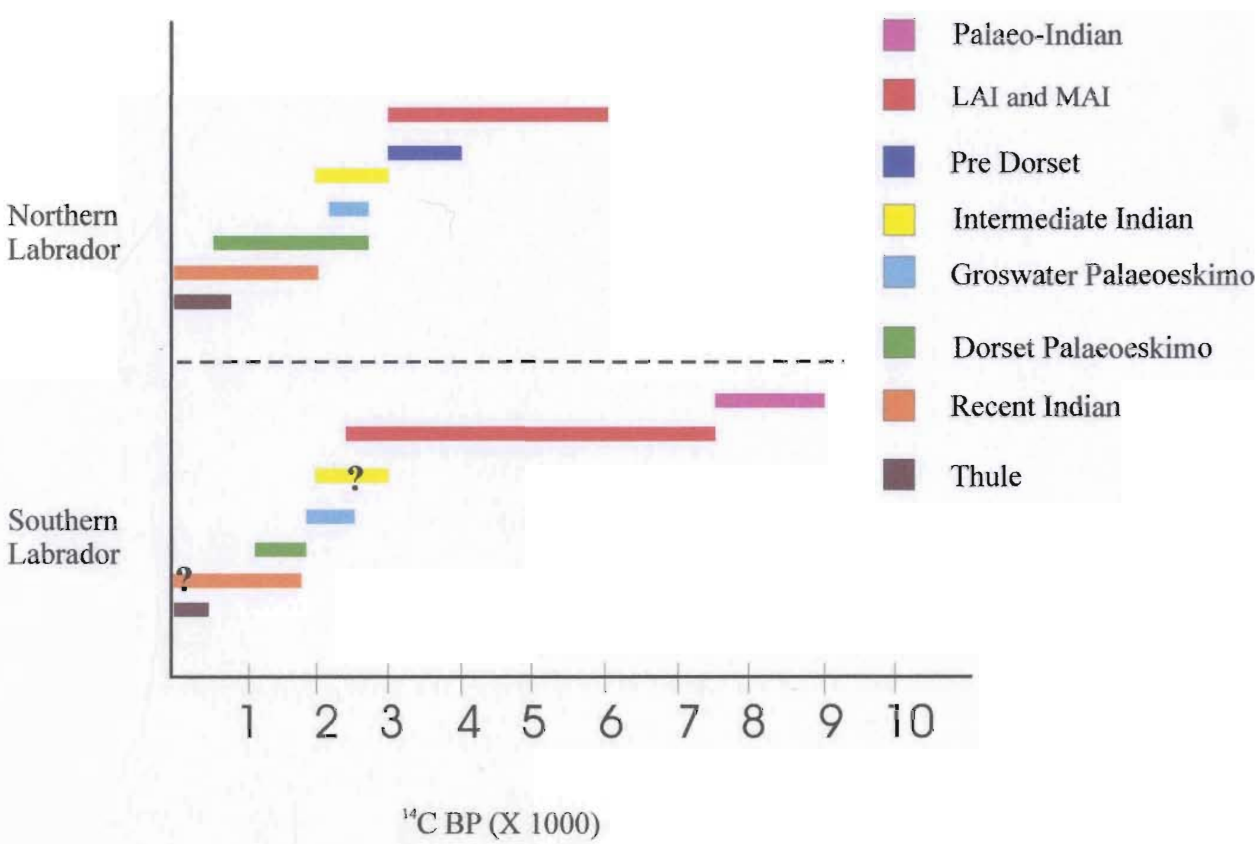

Fig. 2-2: Spatial and temporal patterns of 9000 ^{14}C BP of prehistoric cultural occupation of Labrador (Tuck 1976; Tuck n.d; Cox 1978; Auger and Stopp 1986; Penney 1986; Fitzhugh 1982, 1989; Loring 1992). Prehistoric groups in legend are listed from oldest to youngest based on their appearance on the Labrador coast.

Labrador Archaic Indian culture spread from the south into northern Labrador. A second Amerindian group known as the Maritime Archaic Indians (MAI) established themselves in southern Labrador by as early as 6000 ^{14}C BP. They used a chipped stone technology of notched bifaces that were noticeably different than those of the LAI (Tuck n.d.). Their sites are found as far north as Groswater Bay (Tuck n.d.).

Little is known about the Intermediate Indian period in Labrador (Stopp 1997; Tuck n.d). Their arrival on the Labrador coast appears to coincide with the disappearance of the Maritime Archaic Indian. This has led to two conflicting viewpoints on the origins of the Intermediate Indian: 1) the Intermediate Indian are descendants of the southern branch of the Maritime Archaic Indians 2) at around the same time the Maritime Archaic Indians disappeared, the Intermediate Indians moved from interior Labrador and Quebec to Hamilton Inlet and coastal Labrador (Tuck n.d). A slow transformation took place approximately 2000 ^{14}C BP when the Intermediate Indians were replaced by Recent Indians, who occupied the Labrador coast until only a couple of hundred years ago (Tuck n.d).

Unlike the Amerindians, the Palaeoeskimo groups represent separate waves of migration from the eastern high Arctic into northern Labrador. The first group was the Pre Dorset who arrived around 4000 ^{14}C BP. Their sites are confined to northern Labrador (Tuck 1976). Groswater Palaeoeskimo, Dorset Palaeoeskimo and Thule cultures spread from northern Labrador into southern Labrador, occupying the entire Labrador coast (Cox 1978; Auger and Stopp 1986; Tuck 1976; Tuck n.d).

Many of the tool assemblages from the different cultures throughout Labrador appear to convey some type of maritime subsistence. Although little is known about the earliest settlers, the Palaeo-Indians, Tuck (n.d) suggests that it would be unlikely for these people to have settled so close to the sea unless they were familiar with exploiting marine resources. The Labrador and Maritime Archaic Indians had tools suggestive of a sophisticated technology for hunting sea mammals, such as toggling harpoons (Tuck n.d). This provides an explanation for site locations on raised beaches as well as those identified close to the coast. These people relied on the sea for much of their food, so the majority of their dwelling sites were located as close to the sea as possible. Groswater and Dorset Palaeoeskimo groups also tended to live along the coast, as suggested by tool assemblages and marine fauna. For example, harpoons and winter ice hunting technology were used to hunt marine mammals.

2.2.7 *Prehistoric Occupations – Porcupine Strand*

Archaeological investigations of Porcupine Strand, adjacent offshore islands and the Cartwright area are limited to five surveys conducted by Fitzhugh (1982; 1989), Penney (1986), Stopp (1997), and Rankin (2002).

Fitzhugh's (1982, 1989) work was confined to the east side of Huntingdon Island, southeast of Porcupine Strand, where he identified a number of early Palaeoeskimo, LAI, Groswater and Dorset Palaeoeskimo sites. The Cartwright area and nearby Cartwright Island were surveyed by Penney (1986), who identified LAI, Archaic Indian (Maritime Archaic Indian?), early Palaeoeskimo (Groswater), Dorset, Point Revenge Indian (Recent Indian) and Thule sites. The most comprehensive survey of southern Labrador was conducted by Stopp (1997) between Cape Charles and Trunmore Bay (Fig.1-4). She identified 135 new sites of which 93 were prehistoric. It was the first survey to recognize that prehistoric people had lived on Porcupine Strand. Four prehistoric Indian sites - one LAI, two Intermediate Indian and one late Prehistoric Indian - were identified on Sandy Point, while three late Palaeoeskimo sites were located on nearby islands.

The Porcupine Strand Archaeological Project (PSAP) is a multi-year archeological survey of Porcupine Strand and the adjacent islands that began in the summer of 2002. The goals are: 1) to determine if Porcupine Strand, including the south shore of Groswater Bay, was occupied by resident or seasonal populations, and to reconstruct the sequence of cultural occupation; 2) to establish through time any economic adaptations of such populations, 3) to determine the relationship that different populations may have had with each other while occupying the region simultaneously, and 4) to provide a palaeoenvironmental context for the occupational sequence (Rankin 2002).

Surveys of sites have been generally limited to 1 km inland of the present coastline. Extensive site surveys of the southern half of Porcupine Strand and the south shore of Groswater Bay identified over 100 new sites (Rankin 2002). These sites have been found primarily on Sandy Point (19), offshore islands (23) and isolated bays between *West Bay* and *Upper Sandy Cove*[4] (63). Using culturally diagnostic tools and raw materials, 21 sites were found to have a prehistoric cultural affiliation (LAI – 10, Groswater Palaeoeskimo – 1, Dorset Palaeoeskimo – 8, and Intermediate Indian – 2, Table 2-1; Fig. 2-3), while the remaining sites were designated as unknown prehistoric, unknown or historical sites. All four cultural groups were identified within a relatively small area on Sandy Point, whereas, in the northern portion of the field area only Dorset Palaeoeskimo and LAI sites were identified. All of these sites including unknown prehistoric sites are located close to the present shoreline.

Time of occupation for many of these prehistoric groups could not be refined beyond their known occupation range for southern Labrador. However, three LAI sites contained enough diagnostic tools to be associated within a number of different LAI complexes. LAI site FkBg-13 (archaeology Borden Number), believed to be the oldest prehistoric site along Porcupine Strand, was identified in the bottom of a large blowout on Sandy Point. The relative age was based on the lack of Ramah chert tools and the presence of sandstone projectile points similar to LAI artifacts found at the Arrowhead Mine Site

[4] The *Sandy Cove* refers to a small peninsula north of *West Bay*. The eastern side of the peninsula is referred to by PSAP as *Lower Sandy Cove*, while the west side is referred to as *Upper Sandy Cove*. Unless specified in the text, *Sandy Cove* is used to refer to this area.

Table 2-1: Tables showing the name, location, elevation, and environment of archaeological sites with known cultural affiliation on Porcupine Strand. Elevations associated with archaeological sites in blowouts are given as minimum estimates as erosion has changed the original elevation. In some cases a range of elevations may be associated with a site.

Labrador Archaic			
Site Name	**Location**	**Elevation (m asl)**	**Environment**
Lower Sandy Cove 3	Lower Sandy Cove	14	blowout
Lower Sandy Cove 4	Lower Sandy Cove	14	blowout
Upper Sandy Cove 3	Upper Sandy Cove	13	blowout
Tub Harbour 3	Tub Harbour	10	blowout
Tub Harbour 4	Tub Harbour	19	blowout
New Harbour 8	New Harbour	12	blowout
New Harbour 9	New Harbour	6	blowout
Plances Bight 4	Plances Bight	15	blowout
Porcupine Strand 6	Porcupine Strand	10	blowout
Cartwright Island 2	Cartwright Island 2	5-15	raised beach

Intermediate Indian			
Site Name	**Location**	**Elevation (m asl)**	**Environment**
Porcupine Strand 4	Porcupine Strand	5-6	blowout
Porcupine Strand 5	Porcupine Strand	10	blowout

Groswater Palaeoeskimo			
Site Name	**Location**	**Elevation (m asl)**	**Environment**
Porcupine Strand 8	Porcupine Strand	10	blowout

Dorset Palaeoeskimo			
Site Name	**Location**	**Elevation (m asl)**	**Environment**
Seal Cove 6	Seal Cove	12	blowout
Seal Cove 3	Seal Cove	14	blowout
Plance's Bight 3	Plances Bight	8	blowout small
Upper Sandy Cove 11	Upper Sandy Cove	13	blowout small
Horse Chops Island 3	Horse Chops Islands	5	raised beach
Snack Cove 2	Snack Cove	5	raised beach
Porcupine Strand 7	Porcupine Strand	10	blowout
Porcupine Strand 23	Strand	5	blowout small

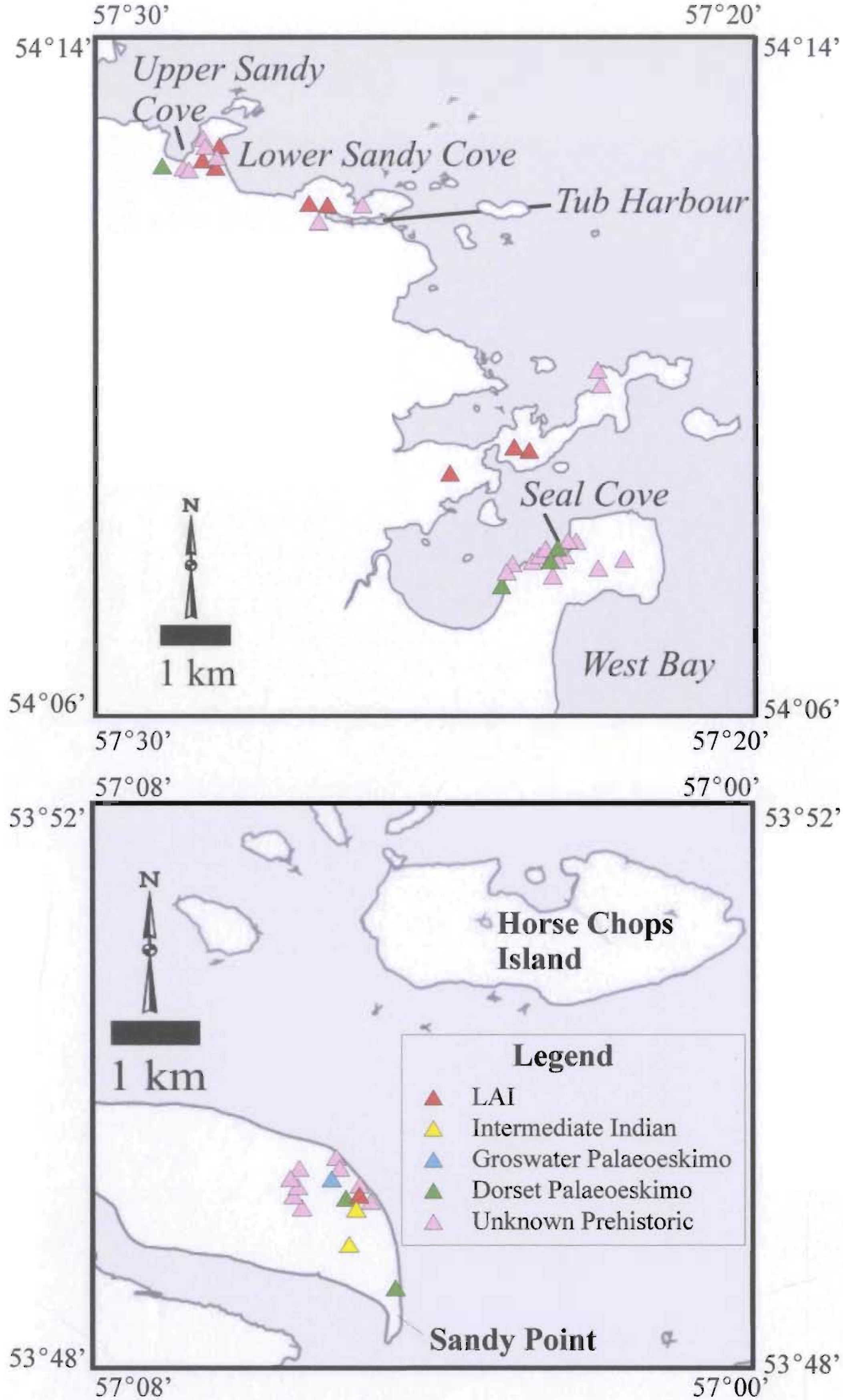

Fig. 2-3: Distribution of prehistoric sites on Sandy Point and north of *West Bay*.

(EjBe-16; 7255 and 6770 ^{14}C BP ; SI-1799 and SI-1800B); Tuck and McGhee 1975) in the Strait of Belle Isle (Rankin personal communication 2004). Upper Sandy Cove 3 (GbBi-07) site contains the remains of three LAI longhouses that were identified on the blowout floor, eroding from the blowout wall as well in an adjacent blowout. Artifacts associated with these longhouses are diagnostic of the Sandy Cove Complex of the LAI that dates between 6000 and 4700 ^{14}C BP. Recent radiocarbon dating of charcoal from a hearth associated with one of the longhouses, indicates this site was occupied at 5150±40 ^{14}C BP (Beta-198381). Artifacts associated with the Lower Sandy Cove 3 (GbBi-16) site are comparable to the Rattler's Bight Complex that dates between 4000 and 3800 ^{14}C BP.

Over 60% of the archaeological sites were located in sand dune blowouts, 15% were found on raised beaches (including small blowouts), 6% were associated with bedrock believed to have been quarry locations, and 17% were not classified. Of the sites associated with sand dune blowouts only 11 exposed buried soils were identified along the blowout wall.

2.2.8 *Review of Pollen Diagrams From Outer Groswater Bay*

Jordan (1975) studied fossil pollen from five lake sediment cores in Hamilton Inlet. This was done in order to determine the environmental conditions and implications for the Labrador Archaic Indian. The five lakes were sampled on a transect from the wooded interior (west of Goose Bay) to the coastal tundra along Hamilton Inlet. Sandy Cove Pond and Aliuk Pond (unofficial names) lie on the north shore of outer Groswater Bay and these were the two most easterly lakes studied by Jordan (1975; Fig. 1-4). Sediment cores from these two lakes not only provide evidence of what the vegetation consisted of but also geological evidence regarding sea-level history. Jordan's (1975) generalized dates from these two lake sediment cores are briefly described in the context of how they relate to sea-level history for outer Groswater Bay including the northern part of the Strand.

Sandy Cove Pond is a large basin (1800 m long by 1100 m wide) located at 100 m asl. Located above the limit of continuous forest, this area is dominated by sedge-shrub or lichen-heath tundra (Jordan 1975). Two hundred and sixty centimeters of sediment were recovered from Sandy Cove Pond. The bottom few centimeters of the core were comprised of inorganic clay that were overlain by 15 cm of transitional gyttja/clay. The upper 238 cm of the core was composed of a dark brown gyttja. The clay contained two diatom species that ranged from brackish water to freshwater environments along with a large range of freshwater diatom species. This was interoperated by Jordan (1975) as a marine brackish to freshwater transition in which sedimentation began during a time when the basin was at or slightly above marine limit and was isolated from marine inundation due to glacioisostatic rebound. A bulk sample, of 25 linear centimetres, of the gyttja/clay transition was radiocarbon dated but reduced organic amounts yielded an unsatisfactory date of 4555±145 ^{14}C BP (SI-1333; Jordan 1975). Resampling and further radiocarbon dating of the transition in slightly deeper water resulted in what Jordan (1975) indicated as a more satisfactory date of 8155±405 ^{14}C BP (SI-1739).

Aliuk Pond is a small basin (450 m long by 350 m wide) located at 25 m asl. The pond is situated by sedge-shrub or lichen-heath tundra with small isolated clumps of dwarfed spruce trees present. The core retrieved from this pond was only 90 cm in length. The lowermost part of the core (15 cm) consisted of grey clay that was overlain by 25 cm of greenish-brown clay/gyttja transition. Thirty centimetres overlying the transition were not recovered as a result of being water laden. The uppermost 50 cm were composed of an organic rich dark brown gyttja. The clay contained diatoms characteristic of a shallow marine environment, while the overlying clay/gyttja transition contained species indicative of shallow circumneutral freshwater with only freshwater diatom species found within the top of the core. Jordan (1975) interpreted this as deposition in a shallow marine environment in which sea level was at least 25 m lower than present. As glacioisostatic rebound took place the basin was isolated from the sea and became a freshwater pond forming a good clay/gyttja transition (Jordan 1975). This transition was bulk radiocarbon dated at 7170±180 ^{14}C BP (SI-1531A).

2.3 Methods

2.3.1 *Aerial Photograph Interpretations*

Prior to fieldwork, preliminary interpretation of the surficial geology of Porcupine Strand (NTS map sheets 13H/14 and 13I/3) was completed using 1:50,000-scale aerial photographs taken in 1968 and 1970 by the Government of Newfoundland and Labrador. Two surficial geology maps were produced for the Geological Survey of Newfoundland and Labrador (GSNL). These are included in a folder at the end of this thesis (Figures 2-4 and 2-5). Mapping was done in order to document evidence of landscape change, and to suggest areas where landforms and sediments could be further studied in the field.

The classification of surficial materials follows the protocol used by the GSNL (e.g. McCuaig 2002b). This method classifies deposit types by using up to three genetic categories and modifiers that are listed by assigning representative letter symbols in the order of dominance. Table 2-2 outlines the landform classification system, with the nine genetic categories and 15 landform morphologies that may be used in the classification scheme. In addition, the classification of surficial materials used by GSNL has been modified in this study to reflect the diversity of marine sediments along Porcupine Strand. In this modified version, areas of marine sand and clay are distinguished from one another where possible, and are identified with subscripts 's' or 'c'.

Surficial units on aerial photographs were differentiated based on their reflective characteristics, textural properties and surface patterns (Avery and Berlin 1992). For example, areas with dense vegetated cover (trees) had dark reflective properties and smooth textures. These areas were often characterized by till. Areas with low vegetation cover commonly had light tones and rough textures, typical of glaciofluvial sand and gravel.

Table 2-2 (a): Description of the landform classification system (top) adopted by the GSNL. Landform types are described by genetic categories and 15 landform morphologies (bottom). Coloured boxes represent deposit types found on the accompanying surficial maps. Descriptions of each of the genetic and landform categories are found in Table 2-2 (b) and Table 2-2 (c) (modified after McCuaig 2002b).

LANDFORM CLASSIFICATION

Each outlined area is assigned a classification consisting of up to three genetic categories and modifiers that designate the types of deposits within each area. Each category, within a classification, is listed in order of dominance and is separated from the other categories by a slash (e.g., Tv/R). Generally, the areas are divided so that three landforms or deposit types are identified within a given area. The classification system is also used to denote the approximate percentage of landforms occurring within an outlined area, but those which comprise less than 5 percent of the area are not included in the classification. Four variations of the landform system are as follows:

1. Where three different landforms are included in a single map unit they are each separated by a single slash (/) and their relative percentages are (60 - 85), (15 - 35), and (5 - 15).

2. Where two landforms are included in a single map unit, a double slash (//) or single slash (/) is used to separate them, and their relative percentages are (85 - 95) and (5 - 15) for double slash, or (60 - 85) and (15 - 40) for a single slash.

3. A hyphen between two landform types indicates that they are approximately equal in area. For example, Tv-Rc indicates that till veneer and rock concealed by vegetation or a thin regolith are equal in area.

4. A composite symbol is used to show combinations of the above cases. For example, $\frac{F/G}{T}$ indicates that about 60 -85 percent of the area is covered by fluvial sediment, 15 - 40 percent by glaciofluvial sediments, and is all underlain by till.

LANDFORM CLASSIFICATION

	GENETIC								
MORPHOLOGY	Fluvial (F)	Colluvial (C)	Aeolian (E)	Glaciofluvial (G)	Lacustrine (L)	Marine (M)	Glacial (T)	Organic (O)	Rock (R)
apron (a)		Ca							
blanket (b)	Fb	Cb		Gb	Lb	Mb	Tb	Ob	
concealed by vegetation (c)		Cc							Rc
drumlinoid (d)							Td		Rd
eroded and dissected (e)	Fe	Ce	Ee	Ge	Le	Me	Te		Re
fan (f)	Ff	Cf		Gf					
hummock (h)			Eh	Gh			Th		
kettle (k)				Gk			Tk		
lineated (l)			El				Tl	Ol	
plain (p)	Fp			Gp	Lp	Mp	Tp	Op	
ridge (r)	Fr		Er	Gr	Lr	Mr	Tr	Or	Rr
terrace (t)	Ft			Gt	Lt	Mt	Tt		Rt
veneer (v)	Fv	Cv	Ev	Gv	Lv	Mv	Tv	Ov	
weathered (w)									Rw
complex (x)				Gx	Lx	Mx	Tx		
undivided	F	C	E	G	L	M	T	O	R
sand (s)						M_s			
clay (c)						M_c			

Table 2-2 (b): Table showing descriptions of the nine genetic categories used in the GSNL landform classification (modified after McCuaig 2002b).

LANDFORM CLASSIFICATION: GENETIC

Symbol	Depositional Environment	Origin and Characteristics of Materials
F	Fluvial	Alluvium consisting of silt and clay to bouldery gravel, forms terraces and plains associated with modern stream channels, their floodplains and deltas; usually less than 1 m thick; deposited by fluvial action at or below maximum flood levels
C	Colluvial	Colluvium; consists of coarse-grained bedrock derived materials, but may include sand, silt or clay, accumulates on the lower parts, or at the base of steep rock faces; transported by gravity
E	Aeolian	Medium to fine grained sand and silt, well sorted, poorly compacted; commonly occurs as dunes up to 10 m high; transported and deposited by wind
G	Glaciofluvial	Fine grained sand to coarse grained cobbly gravel; occurs as plains, ridges (eskers), hummocks, terraces and deltas; generally greater than 1 m thick; deposited as outwash in an ice-contact position or proglacially
L	Lacustrine	Silt, clay, gravel and sand; occurs as plains and blankets; silt and clay deposited in freshwater lakes from suspension, sand and silt by lake-floor currents, gravel and sand by shoreline wave action
M	Marine	Clay, silt, gravel and diamicton; sand is present in some places, generally moderately to well sorted and commonly stratified, but may be massive; occurs as beach ridges, deltas, terraces and bars deposited in a marine environment; gravel and sand by shoreline wave action; may include shells, clay and silt deposited from suspension and turbidity currents; gravel is generally a wave washed lag. M_s (sand) or M_c (clay) indicate areas where the grain size is known
T	Glacial	Includes all types of till; composed of diamicton; transported and subsequently deposited by/or from glacier ice with no significant sorting by water
O	Bog	Poorly drained accumulations of peat, peat moss and other organic matter; developed in areas of poor drainage
R	Rock	Bedrock

Table 2-2 (c): Table showing the descriptions of the 14 morphologies used in the GSNL landform classification (modified after McCuaig 2002b).

LANDFORM CLASSIFICATION: MORPHOLOGY

Symbol	Morphology	Description
a	apron	A relatively gentle slope at the foot of a steeper slope, commonly used to describe colluvium at the base of a rock escarpment; consists of materials derived from the usually steeper upper slope
b	blanket	Any deposit greater than 1.5 m thick; minor irregularities of the underlying unit are masked but the major topographic form is still evident
c	concealed by vegetation	Vegetation mat developed on either colluvium surfaces or a thin layer of angular frost-shattered and frost-heaved rock fragments overlying bedrock; includes areas of shallow (less than 1 m), discontinuous overburden
d	drumlinoid	Elongate ridge(s) between 1.5 and 20 m high, 20 and 300 m wide, and 200 to 5000 m long; ridges have a rounded end pointing in the up-ice direction and gently curving sides that taper in the down-ice direction; exhibit a convex longitudinal profile, commonly with a steeper slope in the up-ice direction; consist of subglacially formed deposits shaped in a streamlined form parallel to the direction of glacial flow; commonly consist of till, although some may contain stratified drift; may have a rock core
e	eroded and dissected	Series of closely spaced gullies or deeply incised channels; can have a dendritic pattern or may be a single straight or arcuate channel; gullies and channels may contain underfit streams
f	fan	A gently sloping accumulation of debris deposited by a stream issuing from a valley onto a lowland; has its apex at the mouth of the valley from which the stream issues; the fan shape results from the deposition of material as the stream swings back and forth across the lowland; fluvial fans are usually derived from eroded glacial and glaciofluvial deposits; glaciofluvial fans (deltas) are deposited in standing water rather than a terrestrial environment; colluvial fans are derived from bedrock and are usually steeper (i.e., Cone shaped)
h	hummock	An apparently random assemblage of knobs, mounds, ridges and depressions without any pronounced parallelism, significant form or orientation; formed by glacial melting during ice stagnation and disintegration. Includes subglacial, englacial, supraglacial and stratified materials
k	kettle	A basin or bowl-shaped closed depression or hollow in glacial drift; results from the melting of a buried or partly buried detached block or lens of glacier ice; commonly occurs in association with hummocks
l	lineated	Elongate spindle-shaped ridge(s) between 6 and 60 m high, 75 and 300 m wide and up to 4000 m long; ridges are commonly straight sided, taper at one or both ends, and have a flat longitudinal profile; consist of subglacially formed deposits shaped in a streamlined form parallel to the direction of glacial flow; commonly consist of till, although some may contain stratified drift; may have a rock core. Includes slope lineated bogs (Ol)
p	plain	A comparatively flat, level, or slightly undulating tract of land; materials are either till, glaciofluvial, alluvial, marine, lacustrine or organic sediments; bedrock features are commonly masked by the overlying sediments
r	ridge	Narrow, elongated and commonly steep-sided feature that rises above the surrounding terrain; materials are either rock, till, glaciofluvial, fluvial, marine, lacustrine, aeolian, or organic sediments. Includes string bogs (Or)
t	terrace	Long, narrow, level or gently inclined step-like surface, bounded along one edge by a steeper descending slope or scarp and along the other by a steeper ascending slope or scarp; materials are either till, glaciofluvial, fluvial or lacustrine sediments; generally formed by fluvial and glaciofluvial erosion and marine wave action
v	veneer	Any deposit less than 1.5 m thick; morphology of the underlying unit is evident
w	weathered	A thin layer, generally less than 1 m thick, of frost-heaved and frost-shattered bedrock fragments

Preliminary interpretation of surficial geology was supplemented by ground-checking and adjusted on field maps to reflect ground observations. Due to limited access, only about 10% of the field map area was ground-checked and therefore the surficial geology map relies heavily on aerial photographic interpretation. Porcupine Strand is divided into two areas, the map area and the field area (Fig. 2-6). The map area is where the surficial geology was mapped using aerial photographs alone, while the field area refers to the area in which ground observations were made. Surficial geology maps were produced and released as Open File Map 2003-26 (13H/14; Fig. 2-4) and Map 2003-25 (13I/3; Fig. 2-5).

2.3.2 *Fieldwork*

Fieldwork was conducted over 56 working days in July and August 2001. During this time, a total of 158 sites were visited in the field area (Fig. 2-6). Sites were limited to 1 km inland of the coast south of Cape Porcupine and selected coves north of *West Bay*. Most of the coast between Cape Porcupine and *West Bay* and south of Sandy Point was unsuitable for safe boat landing and was therefore not ground-checked. Each field site was located with a handheld GPS. Site elevations were recorded using a digital Sokkia altimeter (Model AIR-HB-IL), which has a resolution of 0.1 m. Each elevation measurement was corrected for temperature and barometric changes in pressure.

Preliminary surficial geology maps were checked through observation of sediments exposed on the surface and in sections or test pits (Appendix 1). The distribution of raised

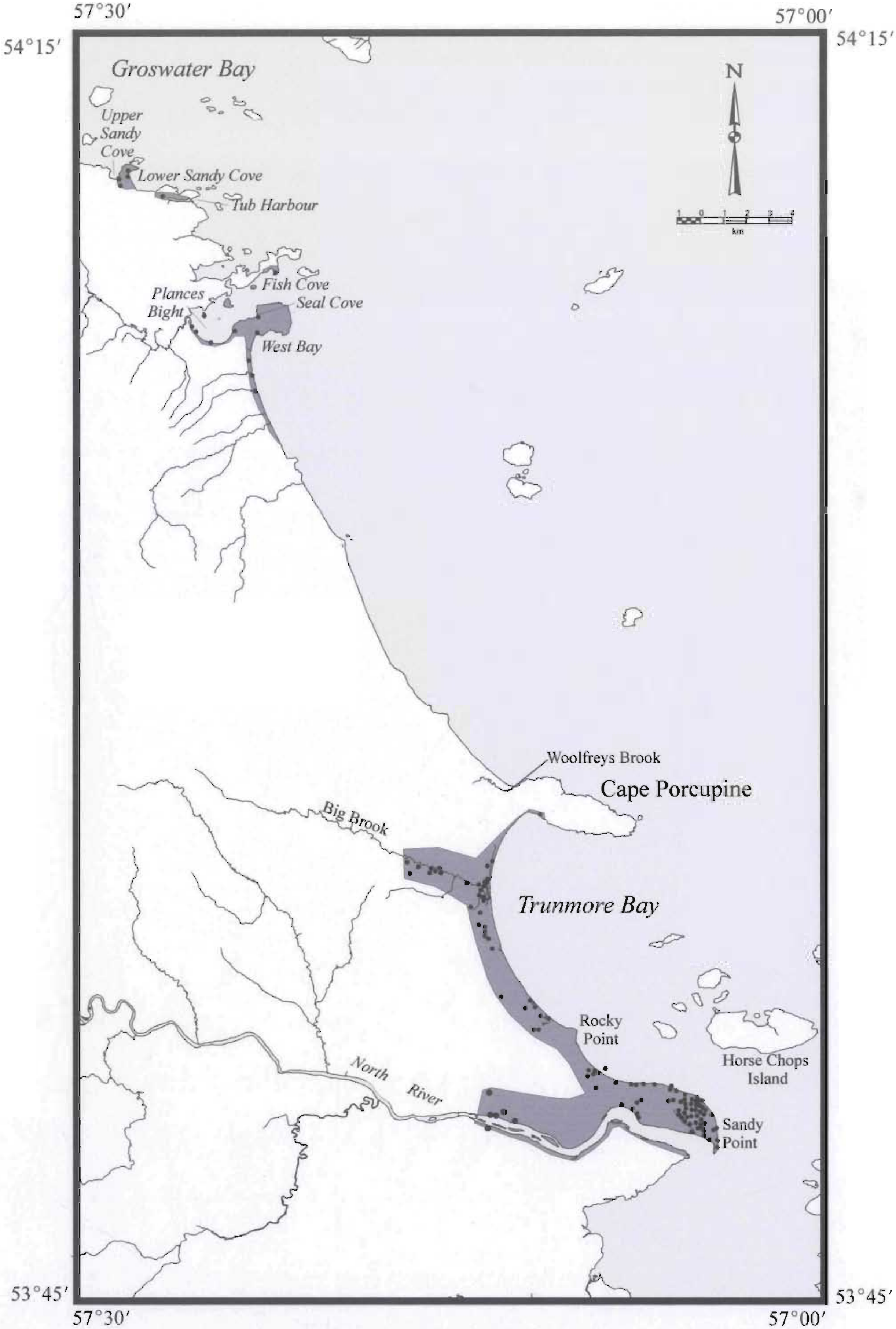

Fig. 2-6: Location of field sites (dots) along Porcupine Strand. Shaded area shows the extent of ground mapping (field area), whereas the entire area was mapped from aerial photographs (map area).

shorelines and sand dunes were mapped in detail and dateable material was recovered where present. Seven types of material were collected for laboratory analysis: wood, freshwater peat, palaeosols, marine shells, whalebone, driftwood and sediment.

Detailed mapping of aeolian systems was conducted at Sandy Point, *Seal Cove*, and *Sandy Cove*. At these locations, in addition to identification and sampling of palaeosols, the presence of blowouts and archaeological sites were also noted. Palaeosol and peat identification followed that of Catt (1990). The following blowout characteristics are identified in Appendix 2: shape, size, elevation, direction of sediment transport and presence of archaeological sites. Samples of aeolian sand and underlying sediment were collected for grain size analysis.

2.3.3 *Laboratory Analysis*

Grain Size Analysis

Sixty sediment samples from different surficial units were analyzed for grain size distribution to characterize their textural differences (Appendix 3). These data allow comparisons to be made between the surficial units and will aid in determining source areas for the aeolian deposits. General procedures followed those of the GSNL, outlined by Ricketts (1987). The sieves selected for analysis included: -2ϕ, -1.5ϕ, -0.5 ϕ, 1.0 ϕ, 1.5 ϕ, 2.32 ϕ, 3.64 ϕ, and 4.5ϕ.

Radiocarbon Analysis

Radiocarbon analysis was used to determine the age of selected samples. A total of 21 samples of various types, including freshwater peat, wood, shells, and driftwood, were submitted for analysis (Table 2-3). Four different laboratories were used: Beta Analytic Inc., Brock University Radiocarbon Dating Laboratory, Geological Survey of Canada Radiocarbon Laboratory and IsoTrace Laboratory, University of Toronto. The first three labs conducted conventional radiocarbon dating on 19 samples. IsoTrace performed AMS (atomic mass spectrometry) dating on two very small amounts of shell and wood.

Prior to laboratory submission, samples were cleaned of modern roots and sand, dried, weighed and packaged in aluminum foil and plastic bags. Sample sizes were selected based on recommendations by Beta Analytic Inc. for conventional radiocarbon analysis, that suggested sample weights of 15-100 g for wood, 10-30 g for peat, and 20-100 g for shells.

Samples analyzed at Beta Analytic Inc., Brock University and Isotrace were normalized to $\delta^{13}C$ of –25‰. For some terrestrial samples the $\delta^{13}C$ value was estimated based on values typical of the material type. The marine shell date from IsoTrace was normalized to a base of $\delta^{13}C$ –25‰, however, this age needed to have the 540 year Northwest Atlantic marine reservoir correction applied. Terrestrial GSC dates are normalized to a base of $\delta^{13}C$ –25‰, while marine samples have been normalized to a base $\delta^{13}C$= 0‰. Normalizing GSC dates to a base of zero incorporates a marine reservoir correction of

Table 2-3: Sample locations and details of organic samples submitted for radiocarbon dating from the Strand.

Sample No.[a]	Radiocarbon date (years ^{14}C BP)[b]	Laboratory No.[c]	Analytical technique[d]	Calibrated age (cal years BP)[e]	Sample elevation	Material dated[f]	Enclosing sediment	Location	Easting	Northing
1	8820±70	TO-10947	AMS	9568 (9910) 10170	0.5	Shell (*M.c.*)	Mud	*Big Brook*	485119	5974053
2	7430±100	GSC-6677	R	8041 (8277) 8481	1.8	Shell (*H.a*)	Sand	South of Rocky Point	489949	5965647
3	5580±80	GSC-6675	R	6265 (6369) 6549	7.4	Freshwater Peat	Peat	South of Rocky Point	491598	5965100
4	2910±45	BGS-2455	R	2923 (3048) 3168	11.8	Organic Material	Sand	*Little Sahara*	487130	5967444
5	2590±60[#]	Beta-175379	R	2467 (2675) 2763	6.4	Organic Material	Sand	Sandy Point	493850	5963679
6	2465±40	BGS-2456	R	2426 (2546) 2621	12.37	Organic Material	Sand	*Little Sahara*	487130	5967444
7	2040±40[#]	Beta-191933	AMS	1946 (1994) 2043	5.5	Wood (*P.*)	Peat	South of Rocky Point	489593	5965989
8	1660±50	GSC-6714	R	1418 (1564) 1632	8.35	Freshwater Peat	Peat	South of Rocky Point	491598	5965100
9	1568±40	BGS-2454	R	1367 (1460) 1534	5.7	Freshwater Peat	Peat	Sandy Point	495124	5963097
10	1430±50	GSC-6723	R	1263 (1460) 1534	1.3	Wood (*A.*)	Sand and cobbles	North side of Sandy Point	492438	5965111
11	400±70[#]	Beta-175380	R	309 (438) 533	10	Organic Material	Sand	*Sandy Cove*	469276	6005094
12	390±60[#]	Beta-175377	R	312 (434) 518	4.9	Organic Material	Sand	Sandy Point	494625	5963934
13	308±40	BGS-2453	R	295 (386) 467	5.9	Freshwater Peat	Sand	Sandy Point	495124	5963097
14	290±50	GSC-6750	R	278 (375) 480	5.5	Wood (*P.*)	Sand	*Sandy Cove*	469413	6005046
15	160±70[#]	Beta-175378	R	-2 (162)300	6.9	Organic Material	Sand	Sandy Point	493850	5963679
16	133±40	BGS-2457	R	171 (135) 279	12.7	Organic Material	Sand	*Little Sahara*	487130	5967444
17	130±80	GSC-6758	R	-4 (146) 292	8.25	Wood	Sand	*Seal Cove*	474969	5998739
18	80±70	GSC-6683	R	0 (112) 245	1.3	Shell (*M.sp., M.e.*)	Sand and cobbles	North side of Sandy Point	492438	5965111
19	40±80	GSC-6716	R	9 (115) 150	8.5	Organic Material	Peat and sand	South of Rocky Point	491598	5965100
20	40±60	GSC-6766	R	13 (104)147	Intertidal zone	Wood (*P.*)	Sand	North of Big Brook	485401	5974843
21	30±60	GSC-6685	R	N/A	0.5	Shell (*V.m.,M.e.,M.*)	Sand and gravel	*Seal Cove*	474700	5998750

[a] Sample No. is the number used to refer to sample on all figures, and is consistant throughout the text.

[b] All dates, except those on marine shell samples with GSC laboratory designations or marked with a # symbol, have been normalized to a base of $d^{13}C$ = –25‰, and where applicable have been adjusted for a marine reservoir effect of 540 years. GSC shell dates have ben normalized to a base of $d^{13}C$=0‰, which is roughly the same as a correction to a base of $d^{13}C$ = –25‰ and a marine reservoir correction of 400 years. An additional 140-year correction has been applied to htese dates to make them equivalent to other dates on marine shells. Dates with a # symbol have estimated $d^{13}C$ values, based on values typical of the material type.

[c] Beta - Beta Analytic Inc., BGS -Brock University, Radiocarbon Dating Laboratory, GSC - Geological Survey of Canada Radiocarbon Laboratory and TO - IsoTrace Laboratory, University of Toronto

[d] AMS - Atomic mass spectrometry, R - Conventional radiocarbon

[e] 2 sigma (95%) calibrated age range (minimum and maximum) with median probability given in brackets

[f] *A. Abies, H.a. Hiatella arctica, M.c. Macoma Calcarea, M. Mya* sp., *M.e Mytilus edulis, P. Picea, V.m. Volsella Modidus*

400 years. An addition of a marine reservoir correction of 140 years has been applied to GSC dates to make them equivalent to new reservoir correction age of 540 years for the Northwest Atlantic proposed by Dyke *et al.* (2003). Making this correction to GSC dates makes them comparable to non-GSC marine dates that have been normalized to $\delta^{13}C$ – 25‰ and have had marine reservoir correction applied.

Generally all samples have been left uncalibrated so that they can be compared to the age of archaeological sites that are given only in radiocarbon years. However, in order for the ages of peat and palaeosol to be comparable to calibrated climate data in Chapter 4, these ages were calibrated. Calibration was completed using Calib HTML version 4.4 (Stuiver and Reimer 1993). Inputs to the program included normalized non-marine and marine radiocarbon ages with a 1-sigma standard deviation. Terrestrial samples were calibrated using the decadal atmospheric calibration set, INTCAL 98 (Stuiver *et al.* 1998a). Marine organisms were subjected to different levels of ^{14}C than terrestrial samples and as a result the MARINR98 calibration data set was used (Stuiver *et al.* 1998b). The global ocean reservoir correction in Calib is 400 years and must be adjusted to accommodate local effects (ΔR). The correction for the Northwest North Atlantic is 540 years (Dyke *et al.* 2003) so a Δ R value of +140 was used in calibrating marine dates. The full 2 sigma calibrated age range (95%) for each sample is given in Table 2-3, while the median probability calibrated age (in brackets in Table 2-3) is used in figures in Chapter 4.

CHAPTER 3 - RESULTS

3.1 Surficial Geology

Introduction

Preliminary aerial photographic interpretation combined with 40 km of foot traverses and detailed sedimentological observation of 33 sections and 46 test pits resulted in the identification of eight surficial units in the study area. The surficial geology of Porcupine Strand is compiled on two 1: 50,000 scale maps, which appear in the pocket at the back of this thesis (Fig. 2-4 and Fig. 2-5). A simplified version is reproduced in Figure 3-1. General observations reveal that glaciofluvial and marine units dominate the study area. Marine, aeolian, organic and fluvial deposits occur on the *Porcupine Lowlands*, whereas glaciofluvial and bedrock units, along with minor occurrences of till and colluvium, are found in the *Porcupine Uplands* (Fig. 3-1).

The following section describes the distribution and characteristics of surficial units in the map area. Particular attention is paid to surficial units that occupy the coastal lowlands where most archaeological sites are located. Complete sedimentary and morphological characteristics of units and subunits are presented in Appendix 4.

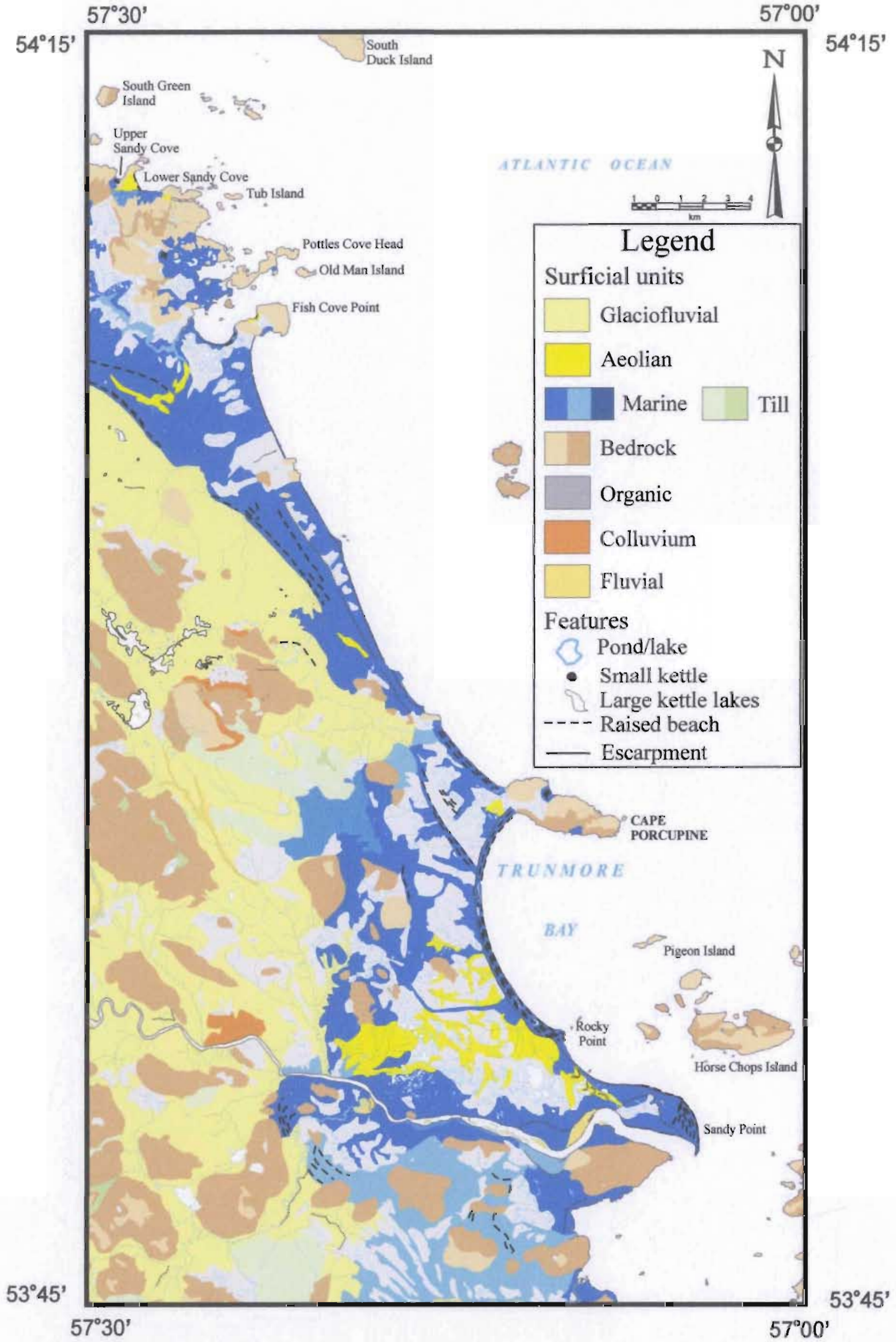

Fig. 3-1: Surficial geology of the Porcupine Strand. For further details see Table 2-2 or Fig. 2-4 and Fig. 2-5.

Surficial Geology of Porcupine Lowlands

The coastal lowlands are dominated by marine sediments, overlain in most areas by either large bogs or wind-blown sand. Marine sediments are mapped up to 116 m asl (local marine limit) and 17 km inland in the southern portion of the study area. Farther north along Porcupine Strand, marine sediments are confined to within 2-6 km of the modern shoreline. Organic deposits occur throughout the study area, but are most extensive between Cape Porcupine and Sandy Point. Over 90% of aeolian deposits are found on the coastal lowland just north of North River.

3.1.1 *Marine Deposits*

Marine deposits cover 25% of the study area, occurring as plains (Mp), blankets (Mb), eroded areas (Me), veneer (Mv), terraces (Mt) and ridges (Mr; Fig. 3-2). They consist of well-sorted sediment and are commonly stratified. Where deposited under the influence of glacial meltwater are called glaciomarine[5] (the majority of these deposits). In section, the majority of marine deposits are composed of fine to very fine sand with beds of medium to coarse-grained sand. Grain size analyses of 16 samples taken from marine deposits indicate that 56% of the samples are composed of fine sand, 38% is made up of medium sand and 1% composed of very fine sand (Appendix 3). These sediments were deposited in shallow to deep-water environments of the sublittoral zone when sea level was higher than present. Marine sediments deposited in the littoral zone as beaches are often

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[5] Marine deposits as classified by the GSNL include both marine and glaciomarine sediments, and as a result, they are not differentiated as such on the surficial maps. However, clay deposits (glaciomarine) are separated from marine and glaciomarine sand deposits.

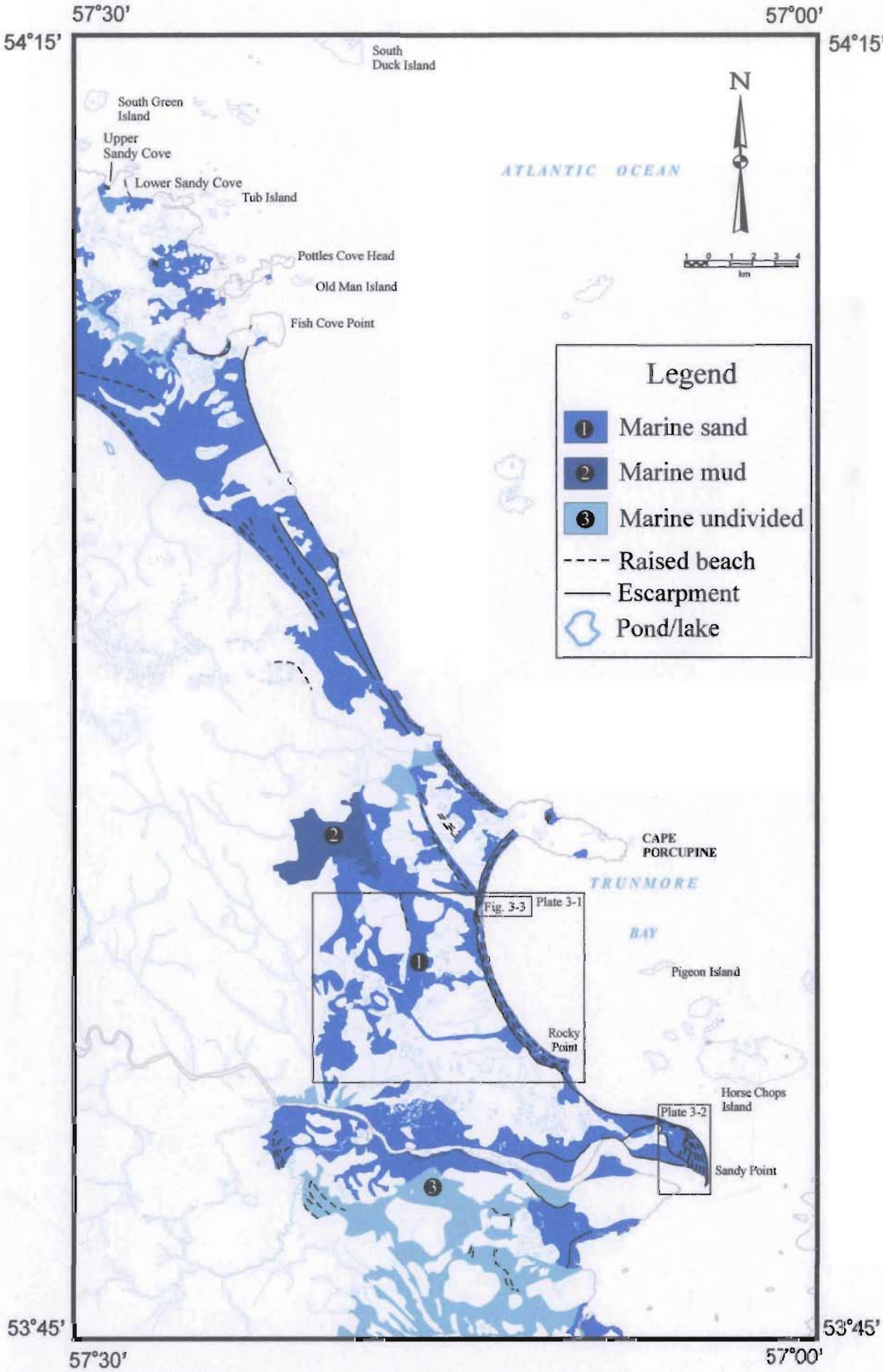


Fig. 3-2: Distribution of marine sediments in the study area. For further details see Table 2-2 or Figures 2-4 and 2-5.

composed of reworked glaciomarine material. The following is a brief description of marine units focusing on the composition of marine plains and beaches.

Marine plains and blankets are generally made up of glaciomarine sediments although they are not distinguished as such in the surficial geology legend (Table 2-2). Marine plains are relatively flat or slightly undulating areas of land in which the thickness of the deposit masks underlying bedrock (McCuaig 2002b). The thickness of marine blankets are often greater than 1.5 m, and may mask minor irregularities of the underlying unit, however, major topographic features are still evident (McCuaig 2002b). Numerous coastal sections reveal that the lowlands are composed of 2 to 19 m thick glaciomarine deposits of fine to medium sand underlain by mud. This surficial unit is mostly flat and is classified as marine plain (Mp; Plate 3-1). It is generally found below 90 m asl and is overlain by peat bogs. Marine blankets (Mb) are found south of North River between elevations of 12 and 116 m asl.

Thinner deposits of marine veneer (Mv) and varying thicknesses of eroded marine (Me) deposits refer to either glaciomarine or marine sediments. Eroded marine deposits are easily identified on aerial photographs (Plate 3-1). Areas such as *Big Brook* exhibit closely spaced, steep 'v' shaped gullying characteristic of eroded marine sediment (Me; Plate 3-1). Steep slopes are maintained due to the competency of the mud-dominated sediments.

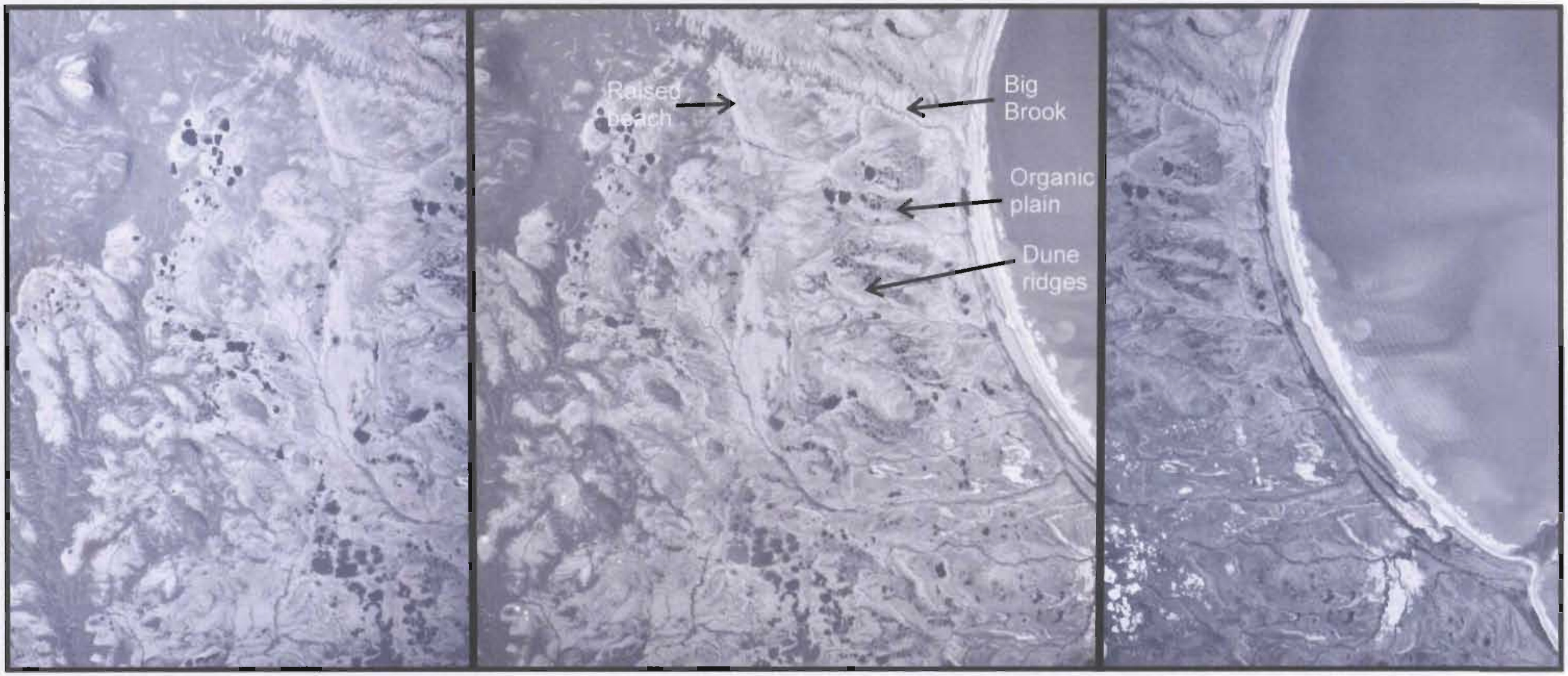


Plate 3-1: Glaciomarine plain located south of Cape Porcupine at approximately 24 m asl. It is overlain in places by peat bog and sand dunes. Where the plain is eroded, steeply incised gullies are formed in the fine grained sediment (see for example Big Brook). Raised beaches are visible on top of the glaciomarine plain (Aerial photographs obtained from the Department of Environment and Conservation, Flight line 20575, frames 46, 47, and 48).

Marine terraces (Mt) are located along the edges of coastal plains where wave action reworked glaciomarine sediments during sea level fall. They are interpreted to represent former sea level stands at elevations between 6 and 92 m asl. Marine terraces are found north of Cape Porcupine, and on the south side of *Plances Bight* and along North River.

Marine ridges (Mr) are beaches that record the postglacial emergence of Porcupine Strand. These beach berms are largely composed of reworked sublittoral sediment deposited in the littoral zone. They are recognized on aerial photographs as linear to curvilinear features, with a pale reflective tone, and are outlined by subtle changes in drainage and low shrub vegetation (Plate 3-2).

Raised beaches are found backing the modern coastline, at elevations as low as 0.5 m above modern high tide, and up to 19 km inland, where they reach elevations of 92 m asl. Raised marine ridges often occur in a series, (e.g. Sandy Point, Plate 3-2). A number of elevations were measured from unaltered beach ridges on the south side of Sandy Point. This shows that beach ridges gradually decrease from 10 to 5.6 m asl from west to east and each successive beach shoreward is located at a successively lower elevation. Beach ridges are on average 5 m wide and between 50 and 5500 m long (e.g. North Strand; Table 3-1).

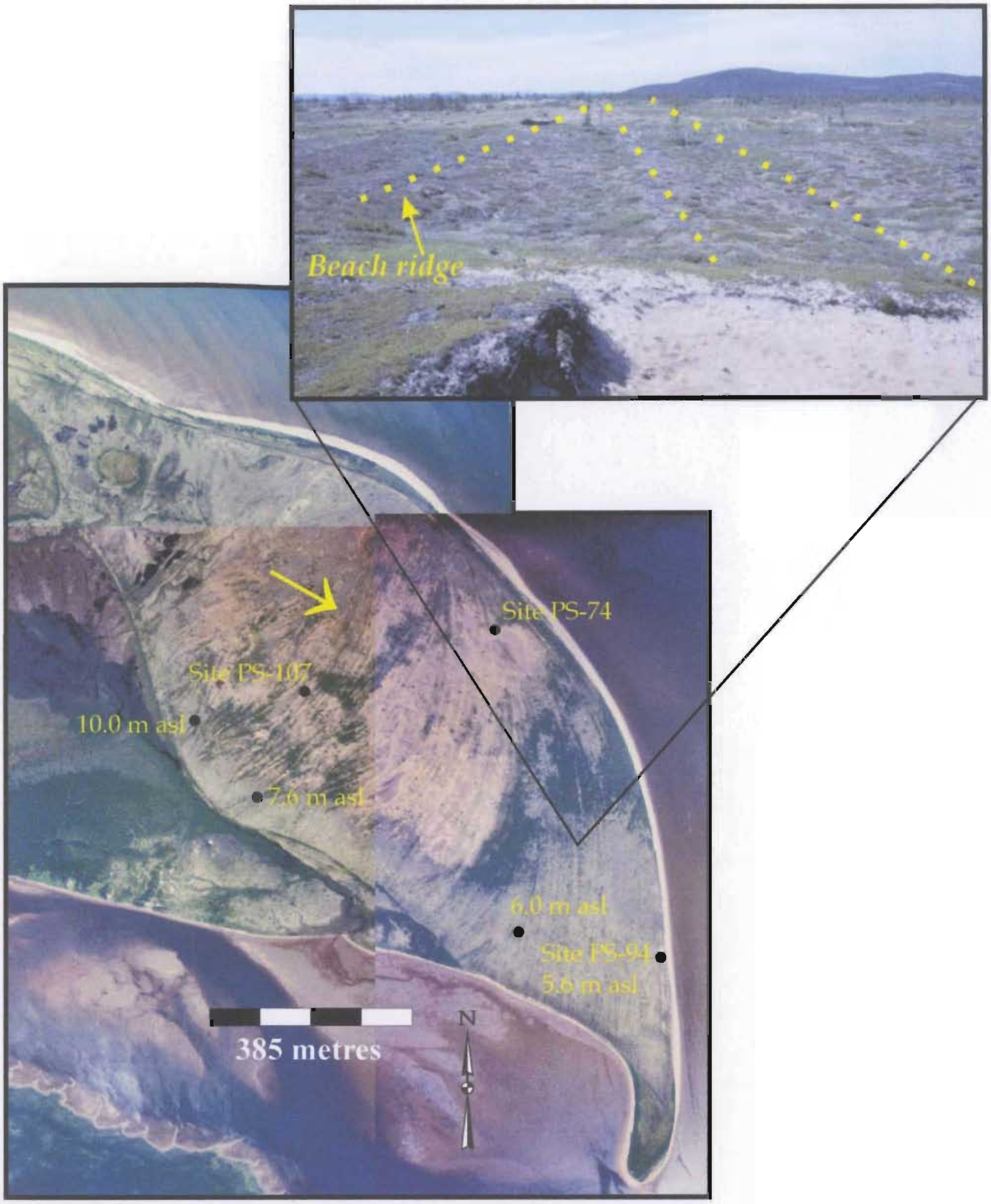


Plate 3-2: Composite of three 1:12 500-scale air photographs that show a series of emerged beach berms. The arrow indicates the direction in which successive beach berms were built as sea level fell (note decrease in elevation). Sites refer to locations where buried organic horizons were radiocarbon dated. The inset shows an oblique photograph looking southwest across the berms. Note the aeolian deflation and blowout of the beach sand in the foreground (Aerial photographs obtained from the Department of Environment and Conservation, Flight line 92005, frames 190 and 192; Flight line 92006, frame 3).

Table 3-1: General characteristics of raised beaches along Porcupine Strand. The orientation of beaches on the western part of Sandy Point is northeast-southwest, whereas beaches to the east have a more north-south orientation. Raised beaches located between *Big Brook* and *Woolfreys Brook* are located in front of the coastal cliff have elevations less than 10 m (denoted with *), whereas the remaining beaches are located above the coastal cliff. Where the width of individual beaches is not known, width of the group was measured and denoted (gr). Fs – fine sand; Ms - medium sand; Pb – pebble; Cb – cobble; Bo- boulder; HML – heavy mineral lamination;. SA – sub-angular; SR – sub-rounded; R – rounded; WR – well rounded.

Location	**Number of raised beaches**	**Width (m)**	**Length (m)**	**Elevation (m asl)**	**Orientation**	**Grain size**	**Exposure type**	**Exposure height/ depth (m)**	**Structures**	**Radiocarbon sample**
Sandy Point	>65	1-3	260-3750	6-10	Varied, see Plate 3-2	Fs	Test pit Blowout Exposures	2-3	Discoid clasts HML, parallel laminations, low dips	
Seaward of coastal cliff	>20	500 (gr)		1- 3.8	Mimic modern shoreline	Fs and Cb gravel	Test pit	1.5	HML, parallel laminations, ripples	GSC – 6683 GSC – 6723
South of *Big Brook*	2	100	2000	43	North-south	Fs-Ms 20% clasts	Test pit	0.3	Clasts: 0.5-6 cm SA-SR	
*Big Brook - Woolfreys Brook**	>9*	300 (gr)	2500*	<10*	Northeast-southwest (same for both)					
	8	150-800 (gr)	4500	24						
North Strand	5	<50	5500	36.5-91	Parallels modern coastline in south, curves NW-SE northward					
Fish Cove	1	10 -15	100	12	Northwest-southeast	Pb-Cb gravel	Test pit	0.5	Angular clasts massive	
Seal Cove	East 4	?	200	1.6-6	Northeast-southwest	Gravelly sand	Test pit	0.75	WR clasts Pb-Cb massive	
	West 1	<5		0.5	Northeast-southwest	Pb-Cb gravel	Test pit	0.5	Angular clasts massive	GSC – 6685
Plances Bight	3	<5	100	8.1-11.4	Northeast-southwest	Fs-Ms	Test pit	0.4	Rounded clasts massive	
Sandy Cove	6	5-10	20-100	3.4-6.8	Northeast-southwest	Fs-Ms and Cb gravel	Test pit	1.5	Granules pebbles R-SA Cb and Bo	
South of North River	7	50-100	500-2000	73-91	Northwest-southeast					

Raised beaches identified at lower elevations (less than 10 m asl) generally mimic the modern coastline, whereas those at higher elevations have orientations that range between oblique and perpendicular to the modern day coastline.

The majority of raised beaches within Trunmore Bay are composed of matrix supported, fine to very fine well-sorted sand that contains occasional discoid shaped cobbles. The exceptions are two clast supported raised beaches identified in Trunmore Bay. These are composed of discoid to well rounded pebbles and cobbles. North of *West Bay*, where bedrock is more common, raised beaches are composed of angular to sub-angular pebbles and cobbles.

Sedimentary Characteristics of Marine and Glaciomarine Sediments

The sedimentary description of marine littoral deposits and sub-littoral deposits is derived largely from 46 test pits and 33 logged sections (Appendix 1). The marine/coastal plain is composed of three units (1) glaciomarine mud that is overlain by a (2) shallowing upward sequence that consists of fine to medium moderately well-sorted sand with heavy mineral laminations and shell lags that is overlain by (3) moderately well-sorted fine- to medium sand with high concentrations of heavy minerals and occasional discoid clasts. Thick organic deposits composed of wood and leaf litter overlie these glaciomarine sediments.

Glaciomarine mud is composed of massive, well-sorted, silt and clay, with rare cobble dropstones and shells (Fig. 3-3). The contact between mud and overlying sand deposits is sharp and erosional as shown by the presence of mud rip-up clasts in the overlying sand.

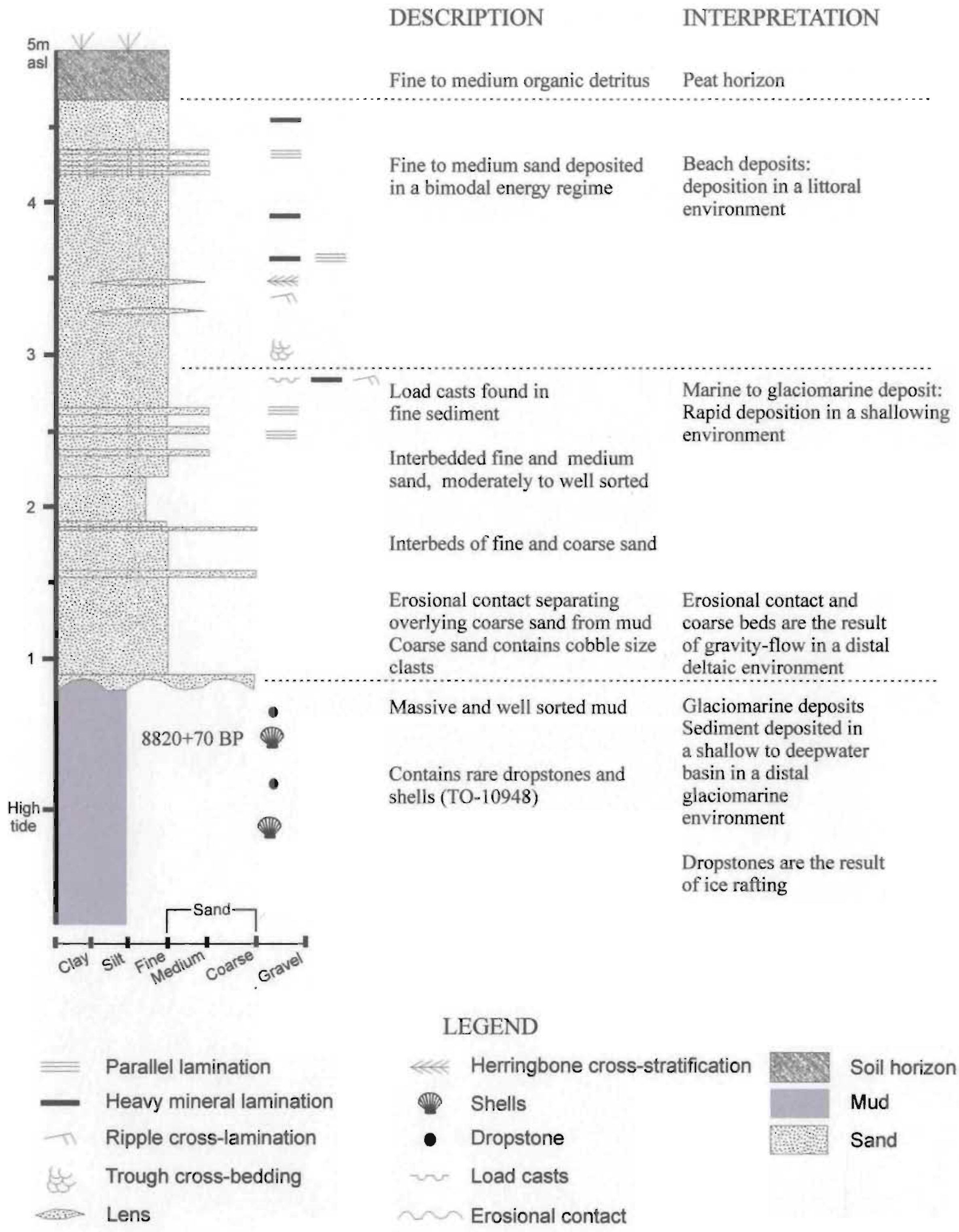
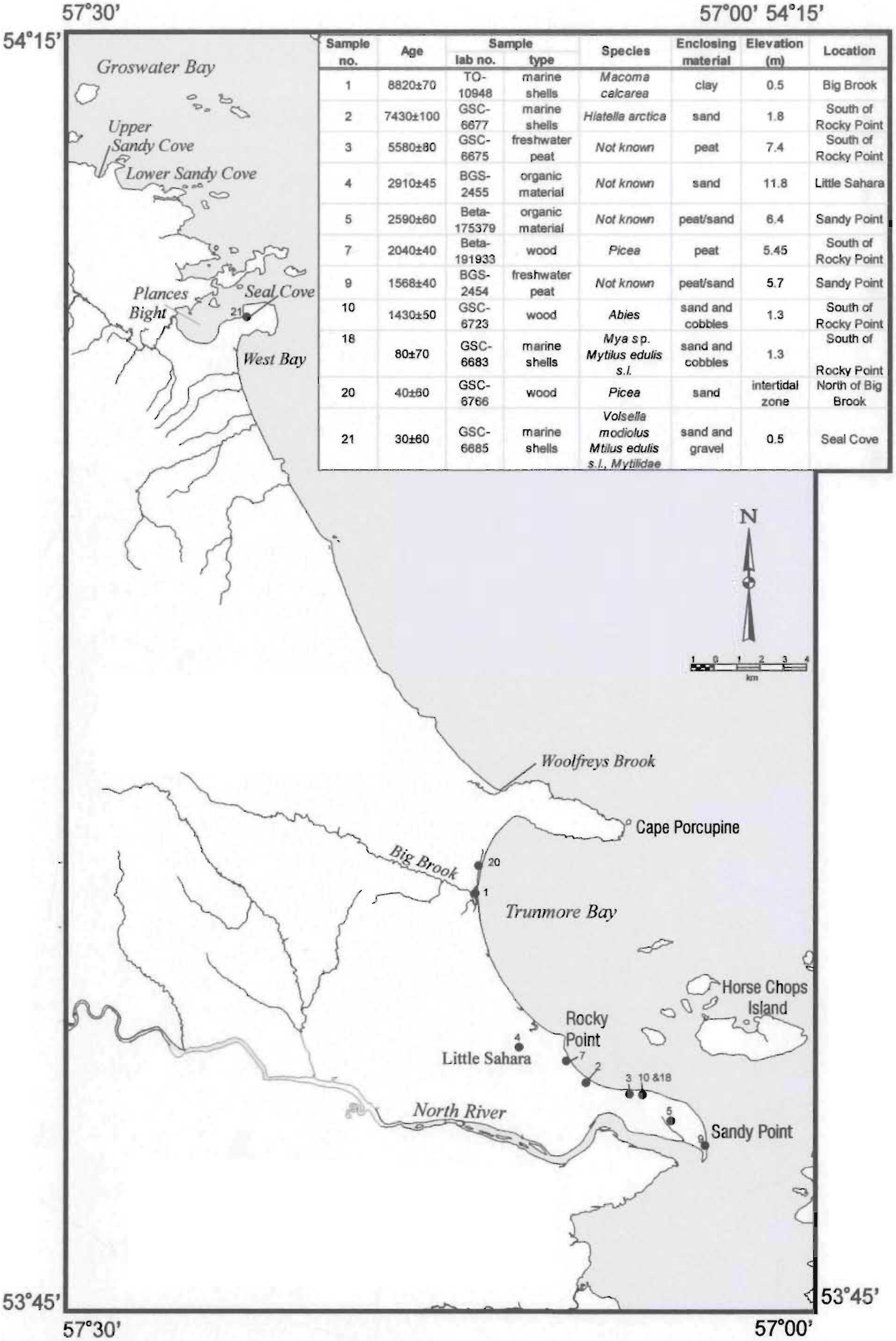


Fig. 3-3: An example of a sedimentary log through glaciomarine sediments found at the mouth of Big Brook.

Mud is often identified in the intertidal zone. When seen in section it underlies glaciomarine sand and as a result is presumed to underlie much of the coastal lowlands. At the coast, near the mouth of *Big Brook*, this mud/glaciomarine sand contact is identified at 0.5 m asl; however, farther inland along *Big Brook* and North River, the contact rises to approximately 10 m asl. *Macoma Calcarea* shells collected from the mud were dated at 8820±70 ^{14}C BP (TO-10948; Fig. 3-4). At *Big Brook*, the overlying sediment is coarse sand containing some rounded pebbles forming a lag. Above the mud/sand contact, silty to fine sand commonly exhibits characteristic dewatering structures, such as convolute bedding and load casts. *Hiatella arctica* shells collected from silty fine sand were dated at 7430±100 ^{14}C BP (GSC-6677; Fig. 3-4).

Ripple cross lamination is identified throughout the sand unit, but in a number of sections is more common in the lower sand unit. Horizontal beds and planar crossbeds occur throughout the entire sandy part of the glaciomarine unit. Sedimentary structures such as trough crossbeds are generally observed within the upper three metres of the sand unit. Easterly dipping parallel beds are generally identified in the middle to upper part of the sections. These beds exhibited angles that range from 5° to 18°. Lenses and thin beds of coarse sand and granule gravel, along with a few dispersed discoid clasts, are often found within the upper 3-5 m of the coastal sections. The upper 3 m of the coastal sections, the sand unit contained parallel laminations, cross laminations and herringbone crossbeds are highlighted by their heavy mineral content.



Sample no.	Age	Sample lab no.	Sample type	Species	Enclosing material	Elevation (m)	Location
1	8820±70	TO-10948	marine shells	*Macoma calcarea*	clay	0.5	Big Brook
2	7430±100	GSC-6677	marine shells	*Hiatella arctica*	sand	1.8	South of Rocky Point
3	5580±80	GSC-6675	freshwater peat	*Not known*	peat	7.4	South of Rocky Point
4	2910±45	BGS-2455	organic material	*Not known*	sand	11.8	Little Sahara
5	2590±60	Beta-175379	organic material	*Not known*	peat/sand	6.4	Sandy Point
7	2040±40	Beta-191933	wood	*Picea*	peat	5.45	South of Rocky Point
9	1568±40	BGS-2454	freshwater peat	*Not known*	peat/sand	5.7	Sandy Point
10	1430±50	GSC-6723	wood	*Abies*	sand and cobbles	1.3	South of Rocky Point
18	80±70	GSC-6683	marine shells	*Mya sp. Mytilus edulis s.l.*	sand and cobbles	1.3	South of Rocky Point
20	40±60	GSC-6766	wood	*Picea*	sand	intertidal zone	North of Big Brook
21	30±60	GSC-6685	marine shells	*Volsella modiolus Mtilus edulis s.l., Mytilidae*	sand and gravel	0.5	Seal Cove

Fig. 3-4: The spatial distribution of radiocarbon dated organic samples from raised marine sediments. Additional sample information can be found on Table 2-3.

In a number of locations along the coast, a 4 to 6 m terrace fronts the larger 10 to 24 m coastal cliff. This terrace differs slightly from the coastal cliff in that it is largely composed of fine- to medium-grained sand with heavy mineral laminations that emphasize a change from horizontal to slightly dipping beds. At one locality, 85 cm of cobble gravel is overlain by 65 cm of horizontally bedded fine-grained sand, highlighted by heavy mineral laminations. The gravel unit occurs at 4.8 m asl.

Exposures in beach ridges are generally limited to areas of aeolian deflation and test pits. Most beach ridges are composed of parallel laminated, rarely rippled, fine- to medium-grained sand with occasional discoid-shaped clasts (Fig. 3-3). Laminations are commonly highlighted by concentrations of heavy minerals. There are a few gravel-dominated beaches along the Strand; however, the majority are found north of *West Bay*. Gravel beaches in this area are located adjacent to exposed bedrock outcrops that were eroded and reworked by wave action. They consist of moderately well sorted, clast-supported pebbles and cobbles. Clast shape varies from discoid to spherical, while the degree of clast roundness ranges from sub-angular or angular to sub-rounded and well-rounded in individual beaches. No structures were evident in these gravel beaches. Two beaches were found containing datable shells. Located only 20 m landward of the present shoreline, raised gravel beaches identified on the east side of Sandy Point and in *Seal Cove* record young ages of 80±70 ^{14}C BP (GSC-6683) and 30±60 ^{14}C BP (GSC-6685), respectively (Fig. 3-4).

The upper 1.5 m of almost all sections and test pits containing glaciomarine/marine sediment is commonly indurated and stained very dark brown (Munsell colour 7.5 YR 2.5/2) to dark reddish brown (5 YR 2.5/2).

Interpretation

The Porcupine Strand as seen today was formed during deglaciation as the finer fraction of glacial outwash was deposited in a marine setting at the distal end of sandar plains. As described previously, sediments comprising the Strand are divided into three units: glaciomarine mud, glaciomarine sand and modern marine beach sands. These units are used to interpret the formation of the Strand.

The glaciomarine mud (lowermost unit) was likely deposited during the early stages of deglaciation. As ice retreated the glacioisostatically depressed land was induated by the sea up to 116 m. At a tidewater margin, sediment-laden meltwater carried the fine-grained fraction away from the margin and deposited the silt clay fraction through suspension settling (Benn and Evans 1998). A massive clay unit was formed with no visible structure other than occasional pebble-cobble sized clasts. These lonestones are likely ice-rafted dropstones due to the remote location from glacial output. Radiocarbon dated shells were collected from the clay in two locations, *Big Brook* and The Backway. The oldest shells collected from the upper part of the clay unit at *Big Brook* indicates that this unit began forming sometime before 8820±70 ^{14}C BP (TO-10947). The shells dated at The Backway record a later timing for the deposition of the mud at 6750±190 ^{14}C BP

(GSC-2465). Ecological preferences of shell species collected from the mud indicate that water depths were on the order of 10's of meters (Table 3-2; Abbott 1968; Peacock 1993). Aitken and Bell (1998) described marine clays from the high Arctic that were formed in both a shallow ice-proximal environment and a deep prodeltaic environment.

As deglaciation continued the ice margin moved onto land forming an outwash plain that prograded into the sea. Coarser material was deposited on the sandur plain, while the finer fraction was carried by meltwater streams to the distal edge of the sandur and deposited through suspension settling and gravity flows in a deltaic environment. The fine-grained sand was deposited over the clay as the sandur prograded. Dewatering structures such as convolute bedding and load casts in the lower part of the sand unit indicate that initial deposition of the sediment was rapid. Marine shells (*Mya arenaria*) collected from this lower unit suggests that deposition of sand had started by 7590±160 ^{14}C BP (GSC-1284; Lowden and Blake 1973; Fulton 1986). Radiocarbon dated *Hiatella arctica* shells collected from the lower sand unit also recorded a similar age 7430±100 ^{14}C BP (GSC-6677). Shell species identified within this sand unit were generally confined to the lower part. Many of these species are indicative of water depths that range from 5 to 50 m (Table 3-2; Abbott 1968; Peacock 1993). This area of sedimentation would likely be located on the distal delta front. Dipping beds in the middle of the sand unit ranged from 5° to 18°. Rogerson (1977) identified these beds as delta foresets typical of a Gilbert style delta. However, during the present study these were not consistently identified in the measured sections. The average angle of dip for

Table 3-2: Faunal identification of shell samples collected from fossiliferous sediments in the study area (Includes those collected by Rogerson (1977)). Identification by J. Maunder, Newfoundland Museum. Shallow water species denoted by * commonly occur in water depths less than 10 m, whereas other species denoted by ** commonly occur between 5-50 m this water depth (Abbot 1968; Peacock 1993).

Glaciomarine sand (n=5)	Glaciomarine mud (n=2)	Gravel Beach (n=2)
Astare sp.	*Balanus* sp.*	*Mya* sp.
Astarte borealis ? *	*Clinocardium ciliatum* **	*Mya arenaria***
Astarte elliptica	*Hiatella arctica* **	*Mytilidae*
*Astarte undata**	*Nucula tenuis***	*Mytilus edulis s.l.* *
Balanus sp.*	*Macoma balthica* **	*Volsella modidus***
Balanus crenatus	*Macoma calcarea***	
*Clinocardium ciliatum***	*Yoldia hyperborea*	
Cockle?		
Hiatella arctica **		
Macoma balthica **		
*Macoma calcarea***		
Mya sp.		
*Mya arenaria***		
*Mya truncata***		
Mytilidae		
Mytilus edulis s.l. *		
Serripes groenlandicus		
Trichotropis borealis ?		
Turridae		

these beds was 12°, much too low for Gilbert style foreset beds. Nemec (1990) indicates that foreset beds are generally more than 20° and in sandy deposits often range between 24° and 27°. The upper 3 to 4 m of the coastal sections, particularly north of Cape Porcupine, consisted of beds of coarser material, particularly pebble lags and trough cross bedding. This deposit was interpreted as outwash extending further seaward as sea level fell. In some places these sediments were overlain by beach material that consisted of fine to medium sand that was planar-bedded with high concentrations of heavy minerals. This beach material resulted from reworking of outwash and glaciomarine sand as sea level fell. Sorting of heavy minerals was the result of swash and backwash wave action.

Overall, the system represents the distal part of Hjulström type delta that is comprised of relatively well-sorted sand that is gently sloping. Shallow marine fauna present within the sand suggest that the deposition occurred in a shallow marine environment, likely less than 50 m. Coarser material (gravelly to bouldery sand) is not generally associated with the marine part of Hjulström type deltas because the coarser sediment is carried as bedload that is deposited close to the glacial margin and generally does not reach the marine environment (Hjulström 1952). Coarser gravelly sand is associated with the sandur deposits in the *Porcupine Uplands* (Rogerson 1977; Fulton 1986). Bell *et al.* (2003) described a similar Hjulström type delta in St. George's Bay, Newfoundland. In this location the delta was comprised of inverse grading of mud to planar-bedded sand and gravelly sand (Bell *et al.* 2001, 2003). The planar-bedded sand was deposited at the distal end of a gently sloping sandur plain and the overlying gravelly sand was attributed to glacial outwash that was deposited as sea level fell. These types of deltas have been documented in Alaska, where the retreat of glaciers on land has resulted in glaciofluvial transport of material to a marine environment where well-sorted deposits are formed from suspension settling (Molnia 1983).

The indurated appearance of sediments both within the littoral and upper sublittoral zones likely is the result of post-depositional pedogenesis and chemical reactions between heavy minerals and humic acids during soil and peat development (Soil Classification Working Group 1998). These horizons are commonly associated with the development of Podzolic soils (Soil Classification Working Group 1998).

3.1.2 *Aeolian Deposits*

Aeolian sediments are present in only 4% of the map area, however, they have particular significance for archaeology. Over 90% of these deposits are confined to the coastal lowlands, particularly south of Cape Porcupine; the remaining 10% occur in bayhead localities farther north (Fig. 3-5). Aeolian sediments are most commonly found between 2 and 30 m asl, but do occur up to 67 m asl southwest of *West Bay*. All the aeolian deposits observed in this study overlie fine-grained sand that comprises glaciomarine or marine sediments.

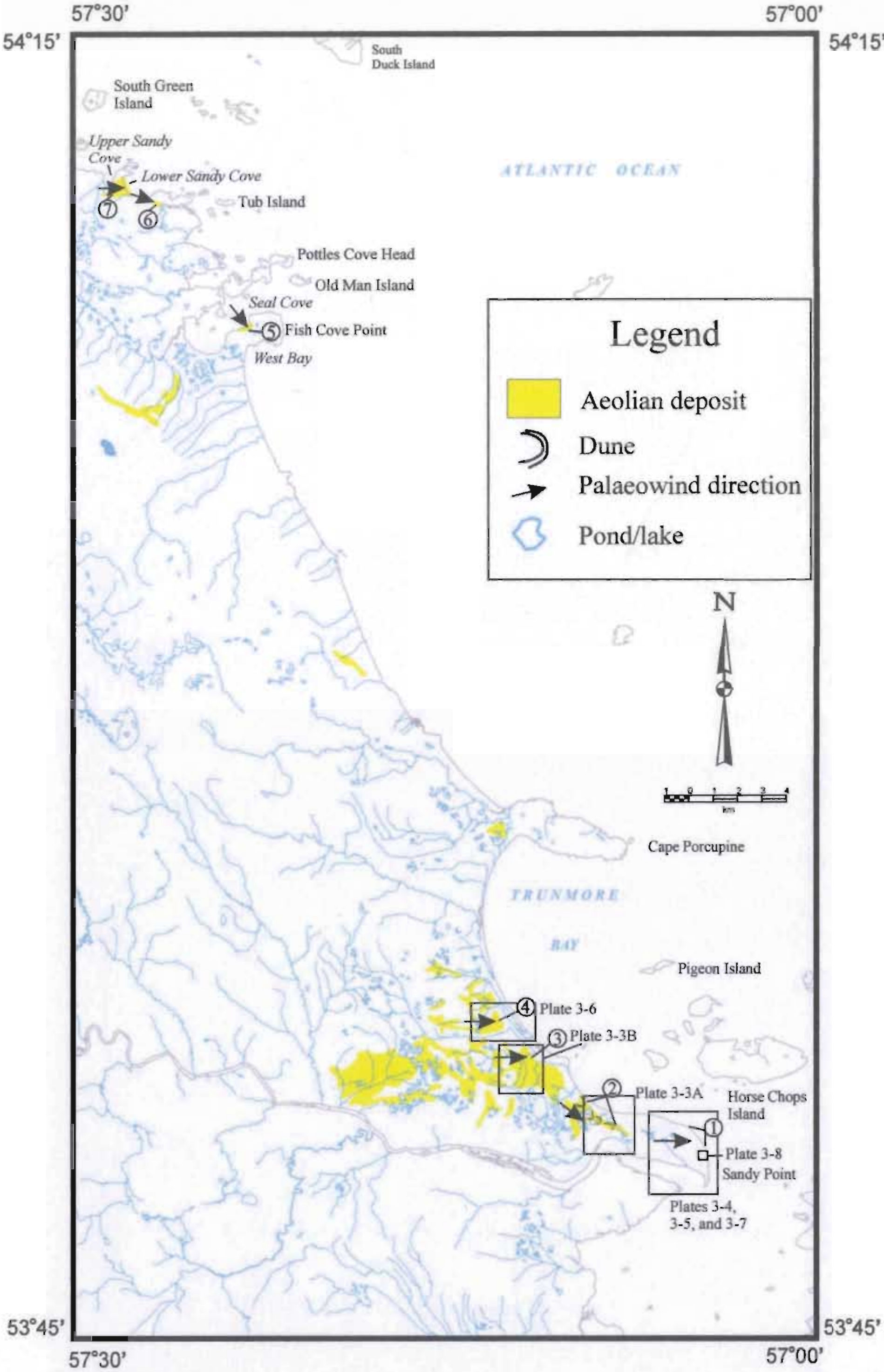


Fig. 3-5: Distribution of aeolian deposits in the study area. Seven areas characterized by aeolian material described in the text include: (1) Sandy Point, (2) *Parabolics*, (3) *Little Sahara*, (4) *Black Bear Blowout*, (5) *Seal Cove*, (6) *Tub Harbour*, and (7) *Sandy Cove*.

On the surficial geology map, aeolian sediments are classified as either forming a veneer (Ev), (less than 1.5 m thick), or as ridges (Er) forming dunes. On aerial photographs aeolian deposits have a range of reflective characteristics that depend on the amount of vegetation cover. Areas of active aeolian deposition have the highest reflective properties, ranging from light grey to white, whereas stable and vegetated aeolian sediments appear slightly darker, but generally lighter than surrounding surficial units (Plate 3-3).

Areas of aeolian veneer are associated with underlying marine/glaciomarine sands and commonly contain deflation hollows. These are saucer-shaped depressions or blowouts that result when vegetation cover is disrupted (drought, fire, grazing) and strong winds are able to remove damaged vegetation and erode the underlying sediment moving individual grains by saltation (Seppälä 2004). A number of conditions are needed other than strong winds to form blowouts; these include: (1) material with a suitable grain size to be transported by the wind, (2) well-sorted material, (3) non-vegetated soil surfaces, or surfaces with scattered or patchy vegetation, and (4) low-lying ground water table (Seppälä 2004). The number, size and orientation of blowouts varies by site location (Plate 3-4; Appendix 2). The largest area of aeolian deflation (0.39 km^2) was identified at *Little Sahara* (Fig. 3-5; Plate 3-3). In contrast, blowouts at Sandy Point, *Tub Harbour* and *Sandy Cove* are numerous but generally small and discontinuous (Plates 3-4, 3-5).

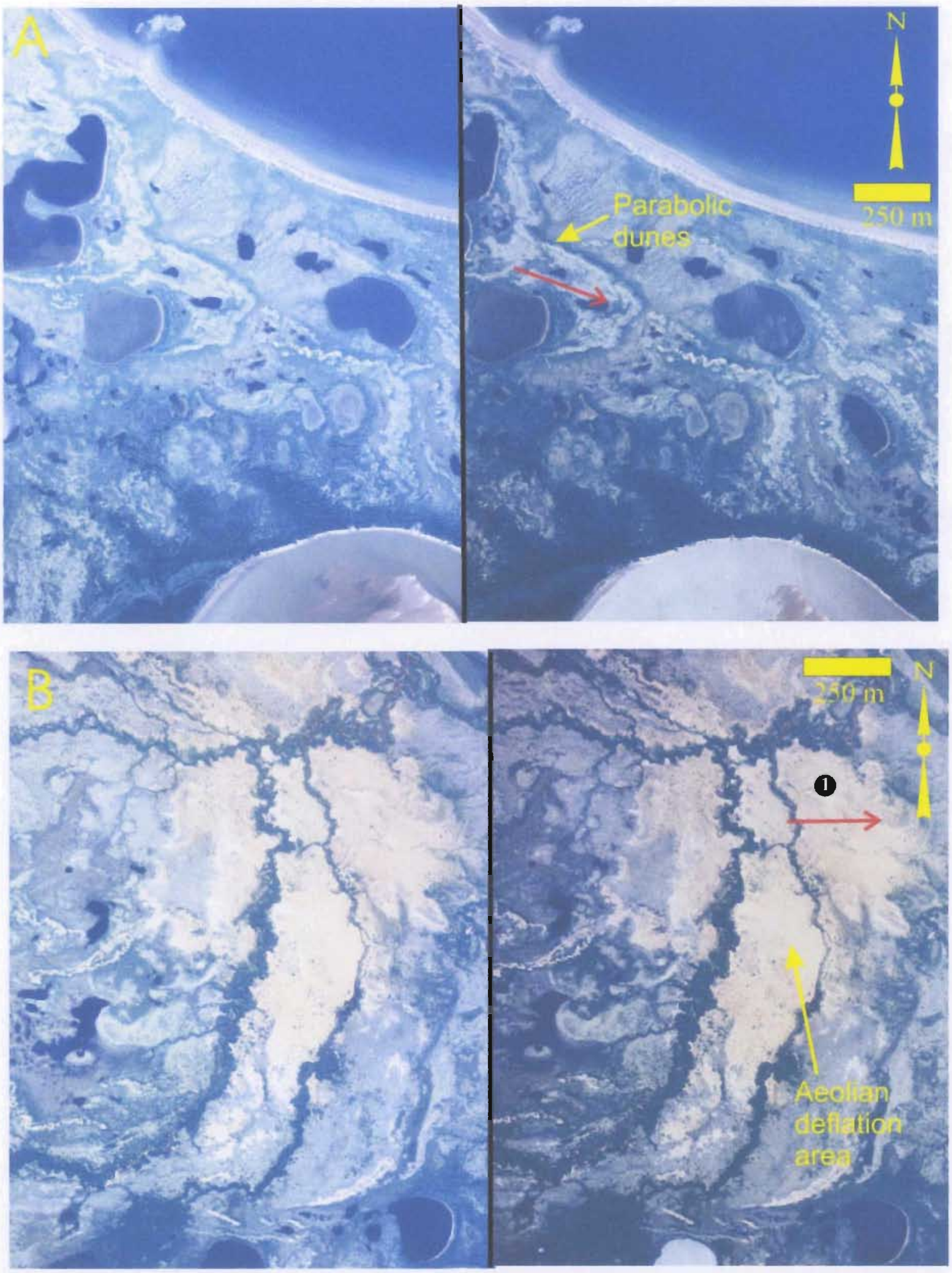


Plate 3-3: Stereo pairs showing the reflective properties of aeolian material (Scale 1: 12,500). Vegetated dunes generally are located on top of the coastal plain. These areas have darker reflective properties (parabolic dunes, A; Flight line 92006, frames 5 and 6). The parabolic dunes formed from a northwest palaeowind (red arrow). Areas of deflation have light reflective tones as seen in the Little Sahara (B; Flight line 92006, frames 64 and 65). In this location, small blowout dunes covered with dune grass are currently building eastward. Green dots within the deflation zone are trees and small areas of vegetation. (1) refers to site PS-147b that is the location of radiocarbon samples BGS-2455, BGS-2456 and BGS-2457. Palaeowind directions are shown by red arrows. (Aerial photographs obtained from the Department of Environment and Conservation).

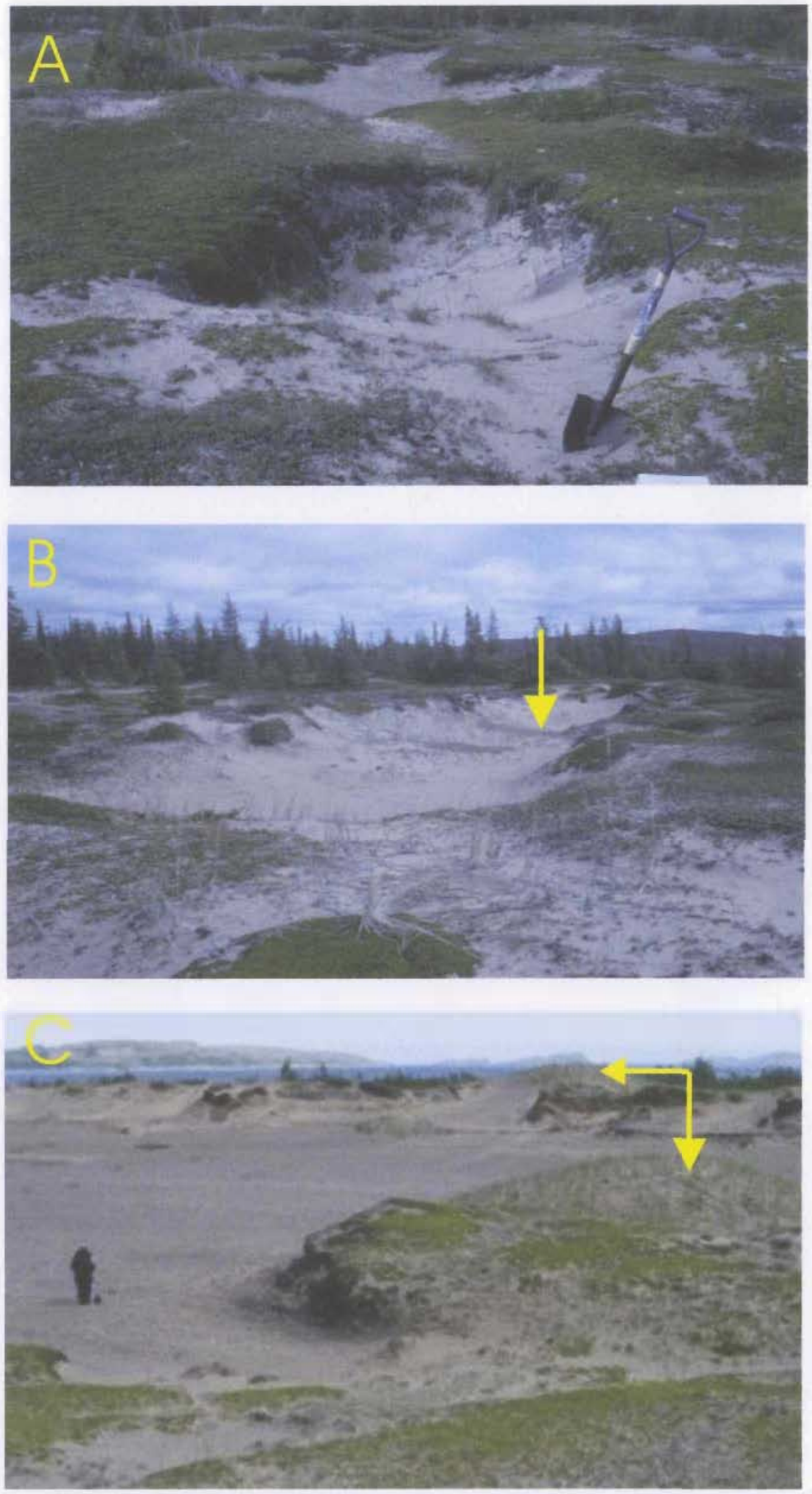


Plate 3-4: Photos showing the various sizes and shapes of blowouts at Sandy Point. (A) Shallow saucer-like blowout approximately 2 x 4 m. (B) Linear blowout, 5 x 15 m. The bottom of the blowout contains marram grass (*Ammophila arenaria*, arrowed). (C) One of the largest blowouts on Sandy Point (0.01 km^2). Dunes (arrowed) are sparsely covered with marram grass and are found on the eastern edges of the blowout.

Plate 3-5: Composite of three 1:12,500-scale aerial photographs. It shows the main area of aeolian deflation (outlined in yellow) on Sandy Point. Blowouts are generally elongate northeast/ southwest and appear to mimic the orientation of the raised beaches. The largest blowouts are denoted by an asterisk and are 0.01 and 0.02 km^2. Diamond (Site 71) marks location of buried soil shown in Fig. 3-8 (Aerial photographs obtained from the Department of Environment and Conservation, flight line 92005, frames 190 and 192; flight line 92006, frame 3).

The sediment removed from blowouts by wind action generally accumulates downwind forming dune ridges (Er). These ridges have various sizes and orientations throughout the map area.

The most prominent dunes identified in the map area rise 20 m above the coastal lowlands between Sandy Point and *Rocky Point*. The dunes in this location generally are composed of two steep-sided ridges that coalesce producing a 'v'-or 'hairpin'-like shape (Plate 3.3A). The ridges or arms making up the dune range in length from 50 to 500 m whereas the distance between the arms ranges between 250 and 400 m. The orientation of the 'v' shape is such that the 'v' opens to the west-northwest and parallels the edge of the coastal cliff (a result of the prevailing palaeowind direction). The outside slopes of the ridges are generally steeper than those of the inner slopes. All the dunes that have this configuration and orientation are covered in low shrub vegetation.

Straight, sharp-crested ridges are also identified on top of the coastal lowlands, between Sandy Point and *Big Brook*. These dunes often span one kilometre in length and may have widths of 50 m. The heights of these features rarely exceed 6 m. These ridges are identified among extensive organic deposits and were formerly sparsely covered by trees as shown by standing dead wood from a forest fire. According to cabin owners on Sandy Point an extensive forest fire some 30 years ago (Davis, Lewis and Doris personal communication 2002) destroyed much of the forest and vegetation cover, which has since been replaced by shrub vegetation. In some areas (*Black Bear Blowout and Dune*, north of the *Little Sahara*) there is no vegetation and dunes are active (Plate 3-6).

Not all aeolian ridges are sharp crested. In areas like Sandy Point and *Seal Cove*, sand accumulation appears to be at the downwind end of the blowout, forming small, rounded, hill-like mounds. The size and height of these features are generally comparable to the amount of material removed from the blowout. The height usually ranges from between 0.5 and 5 m, however, some may be as high as 10 m. These dunes are typically covered in marram grass (*Ammophila arenaria*; Plate 3-7).

Sedimentary Characteristics

Characteristics of aeolian sediments are best studied along the sidewalls of blowouts and test pits. The morphology and sedimentary characteristics of the blowouts and dunes varied from site to site. A 'typical log' identifying what aeolian material along the Strand consists of and the sedimentary structures that are present is shown on Figure 3-6.

A number of characteristics distinguish aeolian sediments from glaciomarine or marine sediments. Aeolian sediments are composed of very well-sorted, fine to very fine sand (Appendix 3). While the underlying marine and glaciomarine sand is composed of similar material, it contains beds of coarser material (coarse sand and granule gravel) along with occasional clasts that are not found in aeolian sediment. Heavy mineral content within aeolian sediments ranges from very thin wispy discontinuous laminations to continuous

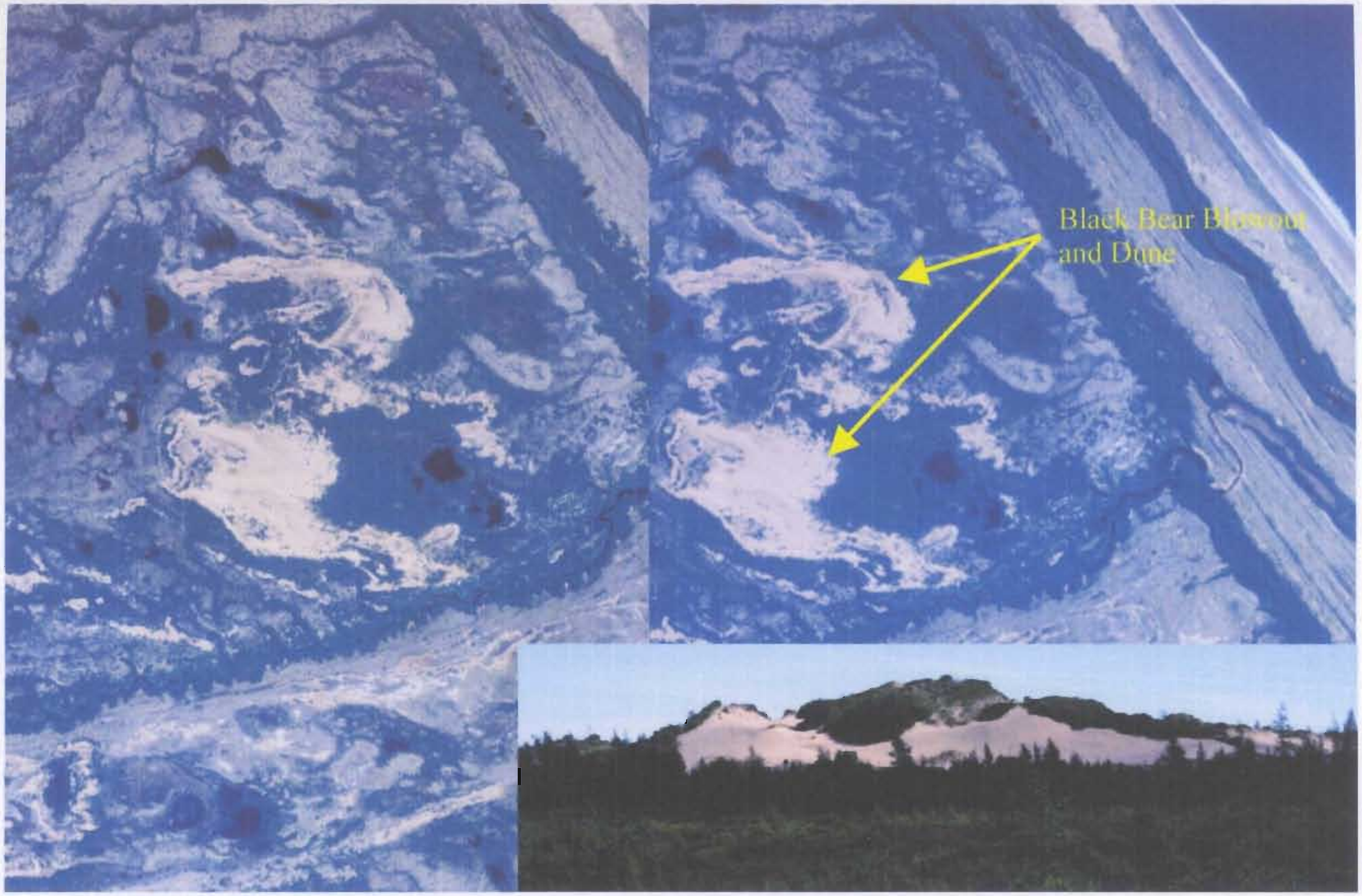


Plate 3-6: Stereo pair of Black Bear Blowout and Dune on the coastal lowlands. This is the largest active dune identified along Porcupine Strand. The eastward movement of sand is burying the modern forest. Inset shows the eastern margin of the dune which is currently active. Aerial photographs obtained from the Department of Environment and Conservation, flight line 92006, frames 56 and 57, scale 1:12,500.

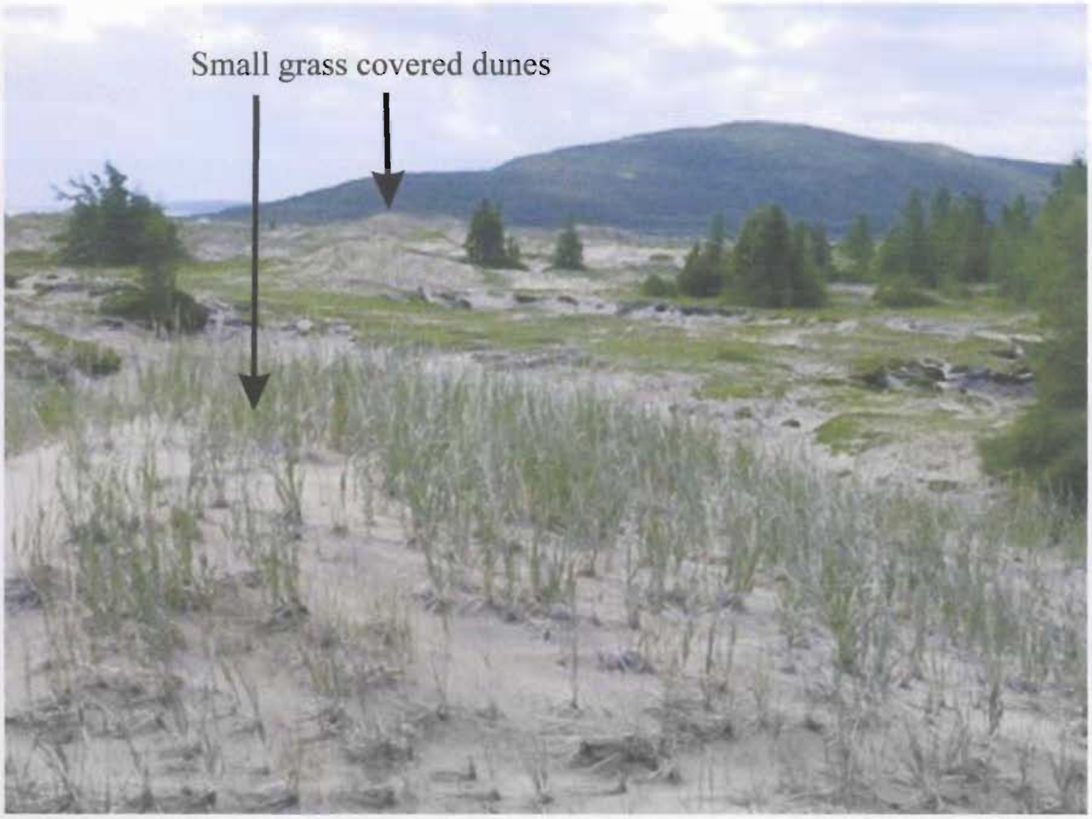


Plate 3-7: Small blowout dunes, in the foreground and background (arrowed), covered in marram grass (*Ammophila arenaria*). The area between dunes is sparsely vegetated with partridgeberries (*Vaccinium vitis-idaea* L.), while the west (left) side of the photo supports spruce trees (*Picea* sp.).

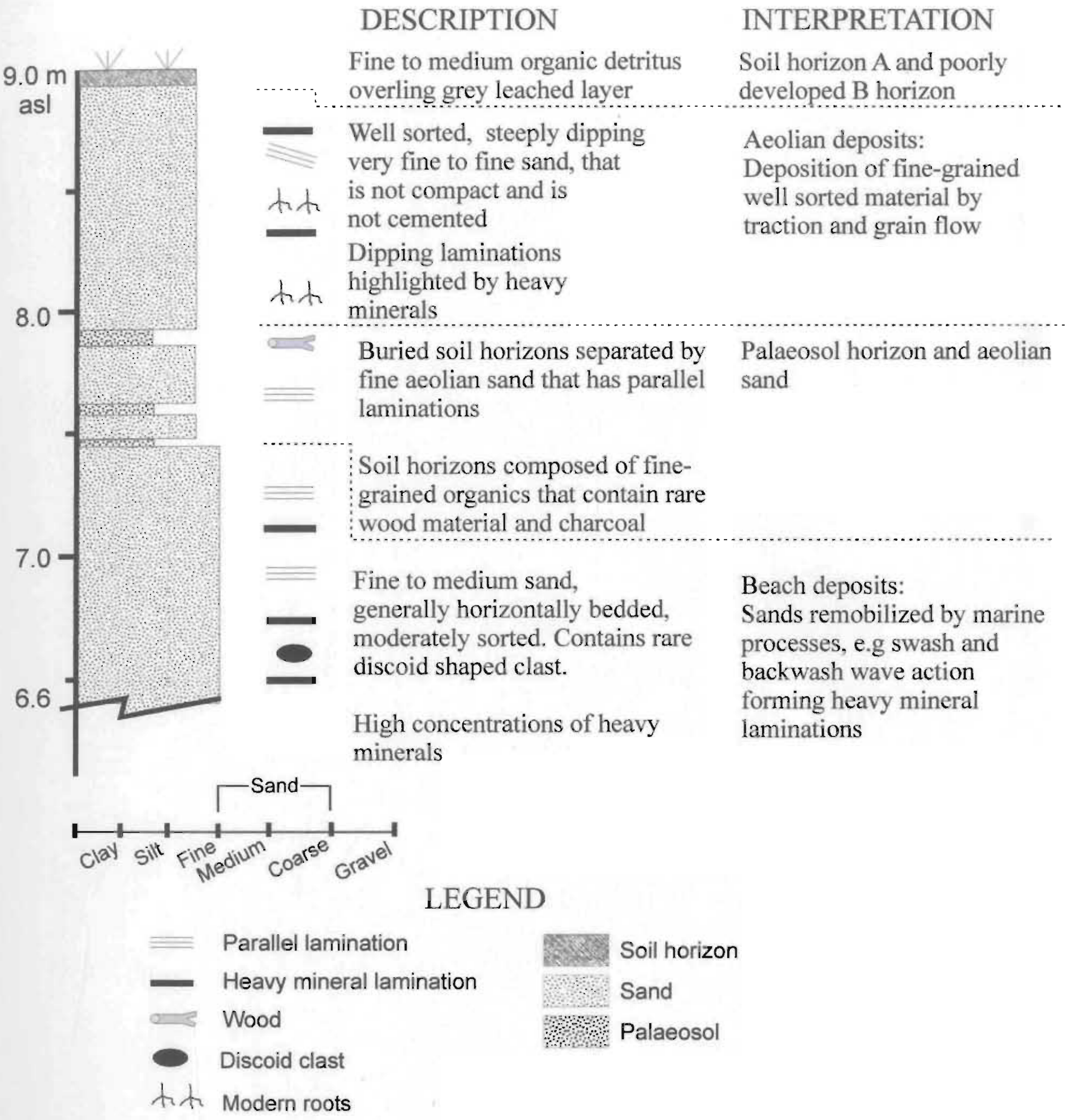


Fig. 3-6: Composite section log of marine and aeolian sediments.

laminations that highlight the plane of deposition. This is in contrast to the continuous thick concentrations of heavy minerals identified in marine sediments. Thickness of aeolian sediments ranges from 2 to 800 cm, however, the average thickness is only 100 cm, whereas marine/glaciomarine deposits are generally much thicker. Aeolian sediments often contain palaeosols or buried peats, identifying periods of past soil development or accumulation of organic material (Plate 3-8). None of these buried soils are found within marine or glaciomarine sediments. Instead soils and peats are found separating marine sediments from aeolian sediments. Over 75 palaeosols and peat horizons were identified and sampled in association with aeolian sediments.

Sedimentary structures within aeolian sediments were often difficult to identify as a result of modern root development. The most common structures were parallel laminations that exhibited moderate to high angle dips ranging from 10° to 26°. These dips represent slipfaces that were formed by sand migrating up the gentle windward side and saltate over the brink line and are deposited on the leeward side by grainfall (Lancaster 1995). In some cases avalanching of sand by grainfall occurs forming grainflow cross-strata that contain angles beyond the angle of repose for dry sand (28-34°; Lancaster 1995). These dipping laminations are highlighted by the presence of heavy minerals. The internal structure of sand dunes (steeply dipping beds) and dune morphology can be used to determine the palaeowind direction (Seppälä 2004). Small pieces of flaked rock and cultural debris were identified both within certain aeolian sections as well as on some of the blowout floors.

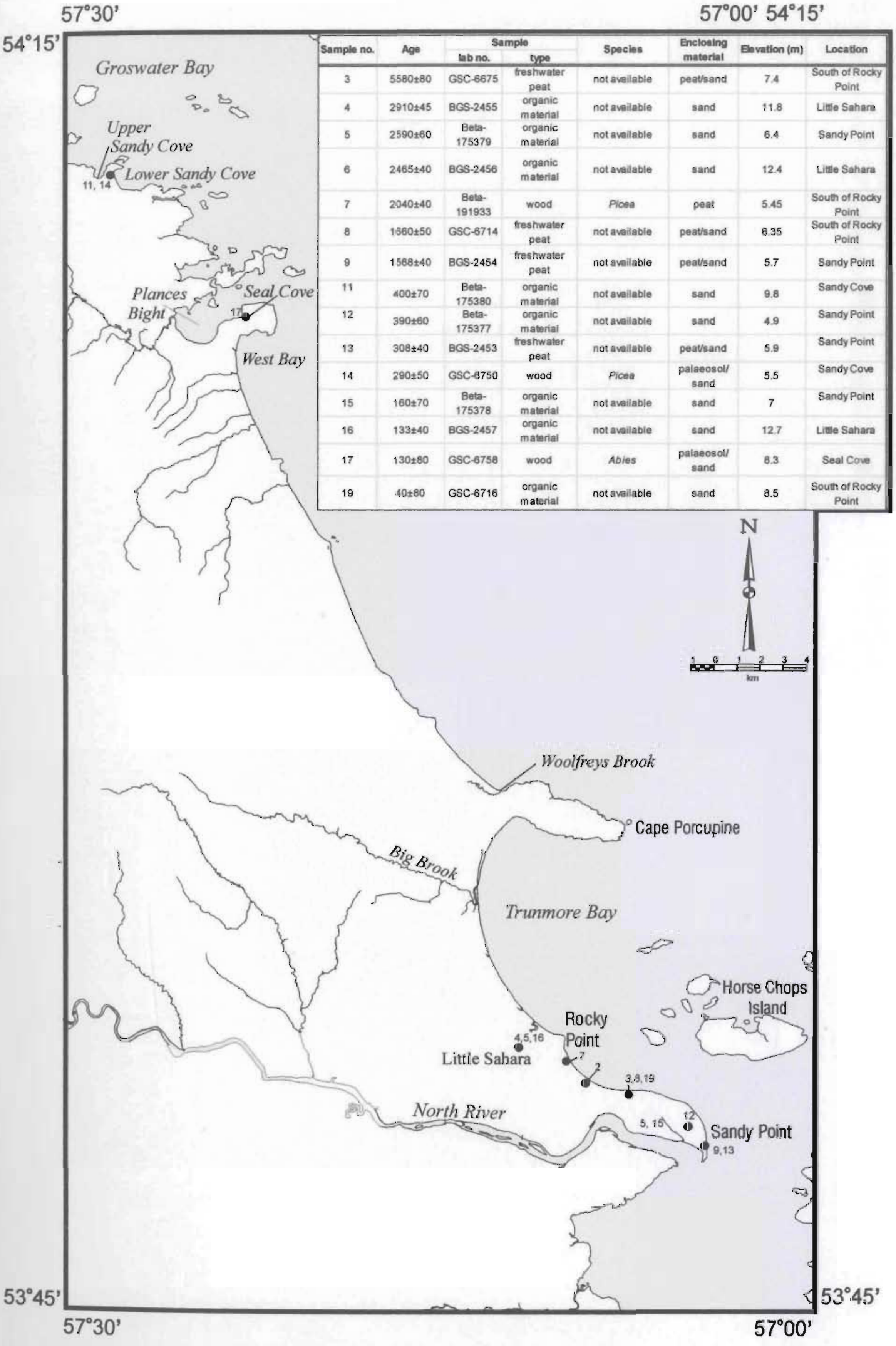
Plate 3-8: Section through raised beach deposit and overlying aeolian sand exposed in the side of a large blowout on Sandy Point (Site 71, Fig. 3-5, Plate 3-5). The contact (arrowed) is marked by an undated organic layer which represents the former vegetated beach surface. The section is capped by modern dune sand eroded from the bottom and sides of the blowout.

Palaeosols and buried peat samples yielded fewer artifacts than aeolian sediments. Charcoal was identified in 75% of the sampled buried peats and soils (Appendix 5). O horizons from eight palaeosols and four peat samples were selected for radiocarbon analysis. In addition, pieces of wood collected from two O horizons and one peat deposit also were dated. (Fig. 3-7). Of the organic samples radiocarbon dated only five were associated with aeolian deposits from on top of the coastal cliff, the remaining samples were taken from Sandy Point, *Seal Cove* and *Sandy Cove*.

Interpretation

The dune morphology and sedimentary characteristics of aeolian sediments described in the previous section allows for dune types and palaeowind direction to be determined. This can also be useful in explaining how these features formed. Generally dunes identified along the Strand can be divided into those large scale vegetated dunes that occur on top of the coastal plain (between 10 m and 24 m), and those small active dunes that occur on Sandy Point, *Seal Cove* and *Sandy Cove*.

The large scale 'v' shaped dunes on the coastal plain have the characteristic shape of parabolic dunes that form from a unidirectional wind regime (Lancaster 1995). The wind direction is given by the orientation of the nose of the v shape. On the coastal lowlands the v opens to the west northwest indicating the predominant wind direction which transported sediment down the arms of the dune (Pye and Tsoar 1990). While these dunes



Sample no.	Age	Sample		Species	Enclosing material	Elevation (m)	Location
		lab no.	type				
3	5580±80	GSC-6675	freshwater peat	not available	peat/sand	7.4	South of Rocky Point
4	2910±45	BGS-2455	organic material	not available	sand	11.8	Little Sahara
5	2590±60	Beta-175379	organic material	not available	sand	6.4	Sandy Point
6	2465±40	BGS-2456	organic material	not available	sand	12.4	Little Sahara
7	2040±40	Beta-191933	wood	*Picea*	peat	5.45	South of Rocky Point
8	1660±50	GSC-6714	freshwater peat	not available	peat/sand	8.35	South of Rocky Point
9	1568±40	BGS-2454	freshwater peat	not available	peat/sand	5.7	Sandy Point
11	400±70	Beta-175380	organic material	not available	sand	9.8	Sandy Cove
12	390±60	Beta-175377	organic material	not available	sand	4.9	Sandy Point
13	308±40	BGS-2453	freshwater peat	not available	peat/sand	5.9	Sandy Point
14	290±50	GSC-6750	wood	*Picea*	palaeosol/ sand	5.5	Sandy Cove
15	160±70	Beta-175378	organic material	not available	sand	7	Sandy Point
16	133±40	BGS-2457	organic material	not available	sand	12.7	Little Sahara
17	130±80	GSC-6758	wood	*Abies*	palaeosol/ sand	8.3	Seal Cove
19	40±80	GSC-6716	organic material	not available	sand	8.5	South of Rocky Point

Fig. 3-7: The spatial distribution of radiocarbon dated organic samples from palaeosols and buried peat horizons associated with aeolian systems. Additional sample information can be found on Table 2-3.

need a large sediment supply and strong winds, they also need vegetation to anchor the arms of the dune. If the nose of the dune becomes too narrow or it migrates on to a non-sandy substrate, the crest of the nose can become lowered allowing the wind to break through, essentially disconnecting the two arms. This is one theory of how straight crested or linear dunes formed (Verstappen 1970; Wasson *et al.* 1983). These dunes are also aligned parallel to the dominant wind direction (Pye and Tsoar 1990). Linear dunes identified on the lowlands have similar orientations to the parabolic dunes and may be separated arms of parabolic dunes. Formation of these large scale dunes would have had to taken place some time after emergence when sediment was susceptible to wind erosion and when there was at least sparse vegetation to anchor the arms of parabolic dunes. This would have likely taken place prior to the formation of peat deposits and standing water that currently occupy the coastal lowlands. The earliest date for the initiation of peat on the coastal plain is 5580±80 ^{14}C BP (GSC-6675). However, the oldest dates of aeolian activity on the coastal plain (not related to the parabolic dunes) suggests that aeolian material was not deposited until 2910±45 ^{14}C BP (BGS-2455). Since this time at least two other periods of aeolian activity have taken place on the coastal lowlands at 2465±40 ^{14}C BP (BGS-2456), and 133±40 ^{14}C BP (BGS-2457) as suggested by dated palaeosols.

The small aeolian dunes found on Sandy Point and in isolated bays north of *West Bay* are identified overlying raised beach sediments. Buried soils separate marine and aeolian sediments. Indicating that first these raised beaches formed and were vegetated prior to aeolian activity. In these areas aeolian development had no direct relationship to the timing of sea level fall. Instead aeolian activity occurred due to localized destabilization of vegetation on the raised beaches. Destabilization of vegetation could occur as the result of increased aridity, decreased precipitation, natural hazards (i.e. mass expansion of insects, forest fires), animal grazing, frost heaving, or human activity (Seppälä 2004). Once vegetation was destroyed, the underlying sand was eroded by the wind and transported and deposited in a down-wind direction. Wind direction of small dunes associated with blowouts was determined by the location of the sediment relative to the deflation area. In addition, the internal structure of the dune will show grainflow sedimentation (Seppälä 2004). Restabilization of the aeolian sediment occurs when vegetation growth is favoured, the source is limited, or the deflation area is eroded to the top of the water table (Seppälä 2004). These processes can be cyclic creating multiple periods of aeolian activity separated by buried soils. Aeolian activity has interrupted vegetation growth at the following times as indicated by dated palaeosols, 2590±60 ^{14}C BP (Beta-175379), 400±70 ^{14}C BP (Beta-175380), 390±60 ^{14}C BP (Beta-175377), 290±50 ^{14}C BP (GSC-6750), 130±80 ^{14}C BP (GSC-6758) and 40±80 ^{14}C BP (GSC-6716).

3.1.3 *Organic Deposits*

Organic deposits have a number of surface expressions that include plains (Op), blankets (Ob), lineated areas (Ol), ridges (Or) and undivided areas (O). They range in elevation from 6 to 335 m asl, and are associated with all major surficial units. Organic plains and ridges are the most common morphology identified within both the map and field area

(Fig. 3-8; Plate 3-1). Organic plains are flat-surfaced, thick, peat bogs generally associated with the flat, low-lying areas of the coastal lowlands. Organic ridge deposits are often referred to as string bogs and consist of ridges of organic material that rise above the surrounding area. On the coastal lowlands these ridges are often associated with bodies of standing water. Lineated organic deposits (Ol) are confined to the area southeast of the *South Feeder Brook* (85 to 30 m asl). These features form elongate deposits (2.5 to 5 km long) oriented northwest – southeast and are separated by brooks and rivers draining the *Local Mealy Mountains*. Between North River and Cape Porcupine, Op and Or deposits extend up to 70 m asl, whereas in the northern part of the map area they are most extensive between sea level and 30 m asl. These deposits generally overlie fine-grained, poorly drained, glaciomarine sediments and are more than 1 m thick in coastal sections. Peat deposits consist of organic detritus, including leaf and needle litter, and fallen trees. In addition to modern peat deposits at the surface, coastal sections also contain buried peat. These accumulations separate glaciomarine/marine sand and aeolian sand and range in thickness from 20 to 100 cm. Similar to modern deposits, buried peat deposits are generally fine to medium grained, although some coarse peat with preserved woody fragments was observed. Thick sections of buried peat were discontinuous along observed coastal sections. A few buried peat horizons have also been identified in test pits.

Interpretation

Organic deposits accumulate as a result of poor drainage. On the coastal lowlands, poor drainage is influenced by the fine-grained nature of marine sand and underlying clays.

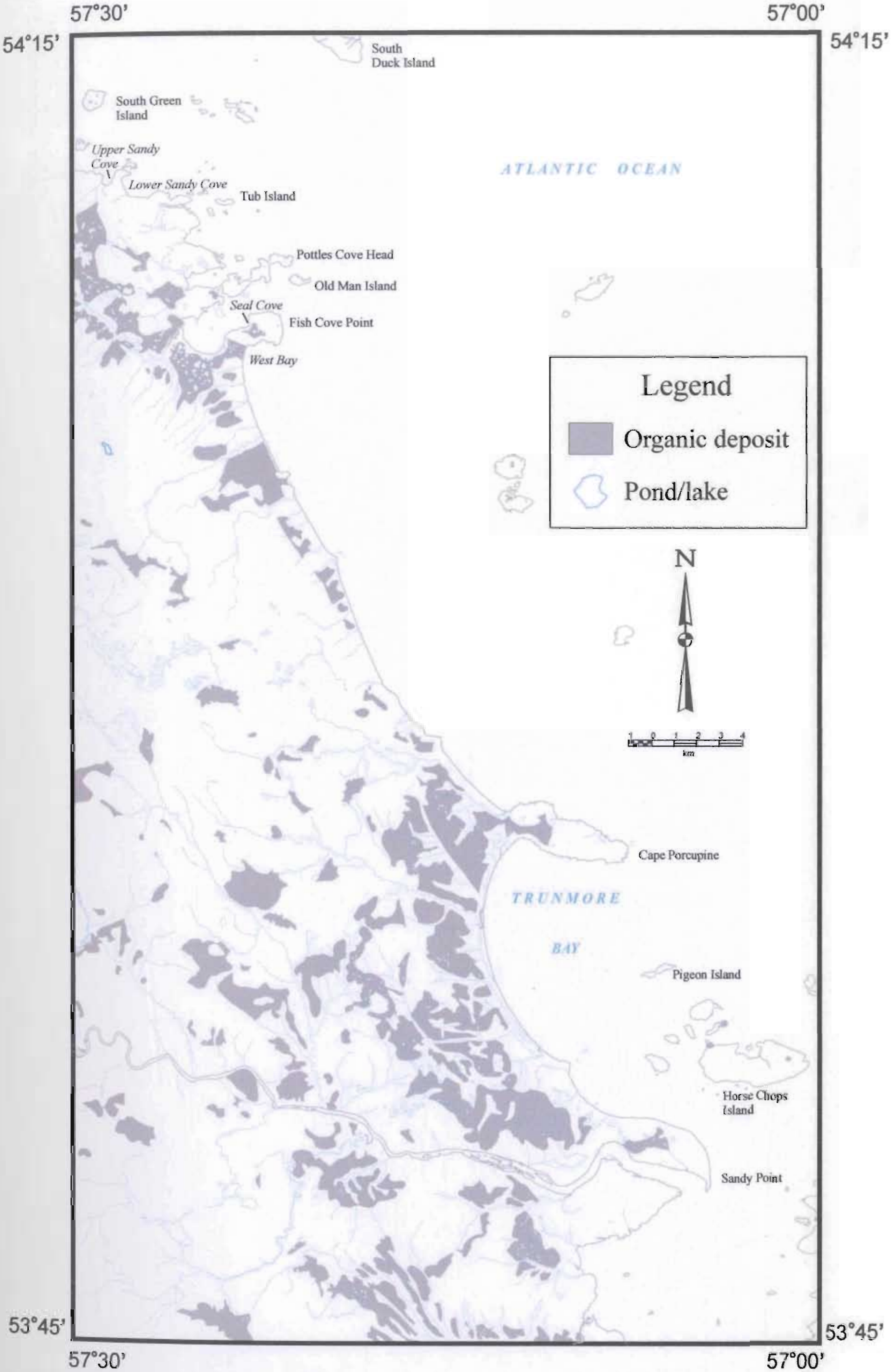


Fig. 3-8: Distribution of organic deposits within the study area. Grey polygons represent areas in which more than 60% of the surficial unit is characterized by organic material.

Both coastal erosion and climate can also contribute to the water logged areas in which organic deposits can accumulate. Valentine *et al.* (1987) suggested that accumulation of organics did not occur for several thousand years after the Late Wisconsinan deglaciation. The reasons for the delay are not well understood. Valentine *et al.* (1987) proposed that the warm dry conditions associated with the Hypsithermal could have delayed accumulation until it became cooler or that the delay was the result of the slow migration of wetland peat species. In southeastern Labrador, Enstrom and Hansen (1985) suggest that paludification began approximately 6500 ^{14}C BP. Along the Porcupine Strand the earliest date for the onset of peat development was 5580±80 ^{14}C BP (GSC-6675) that continued until 1660±50 ^{14}C BP (GSC-6715). Three remaining samples were collected from two other sites. Wood was sampled from the base of a peat section situated on the coastal cliff was dated at 2040±40 ^{14}C BP (Beta-191933). The remaining two samples were taken from the base and top of a peat exposure in a blowout. Radiocarbon dating revealed age of 1568±40 ^{14}C BP (BGS-2454) and 308± 40 ^{14}C BP (BGS-2453; Fig.3-7) respectfully. Along the Strand the accumulation of peat has been interrupted or stopped in places where coastal erosion has drained the deposit or where they have been buried by aeolian sand.

3.1.4 *Fluvial Deposits*

Fluvial deposits compose less than 1% of the field area (Fig. 3-9). While fluvial sediments are associated with all rivers, only the larger brooks and rivers such as

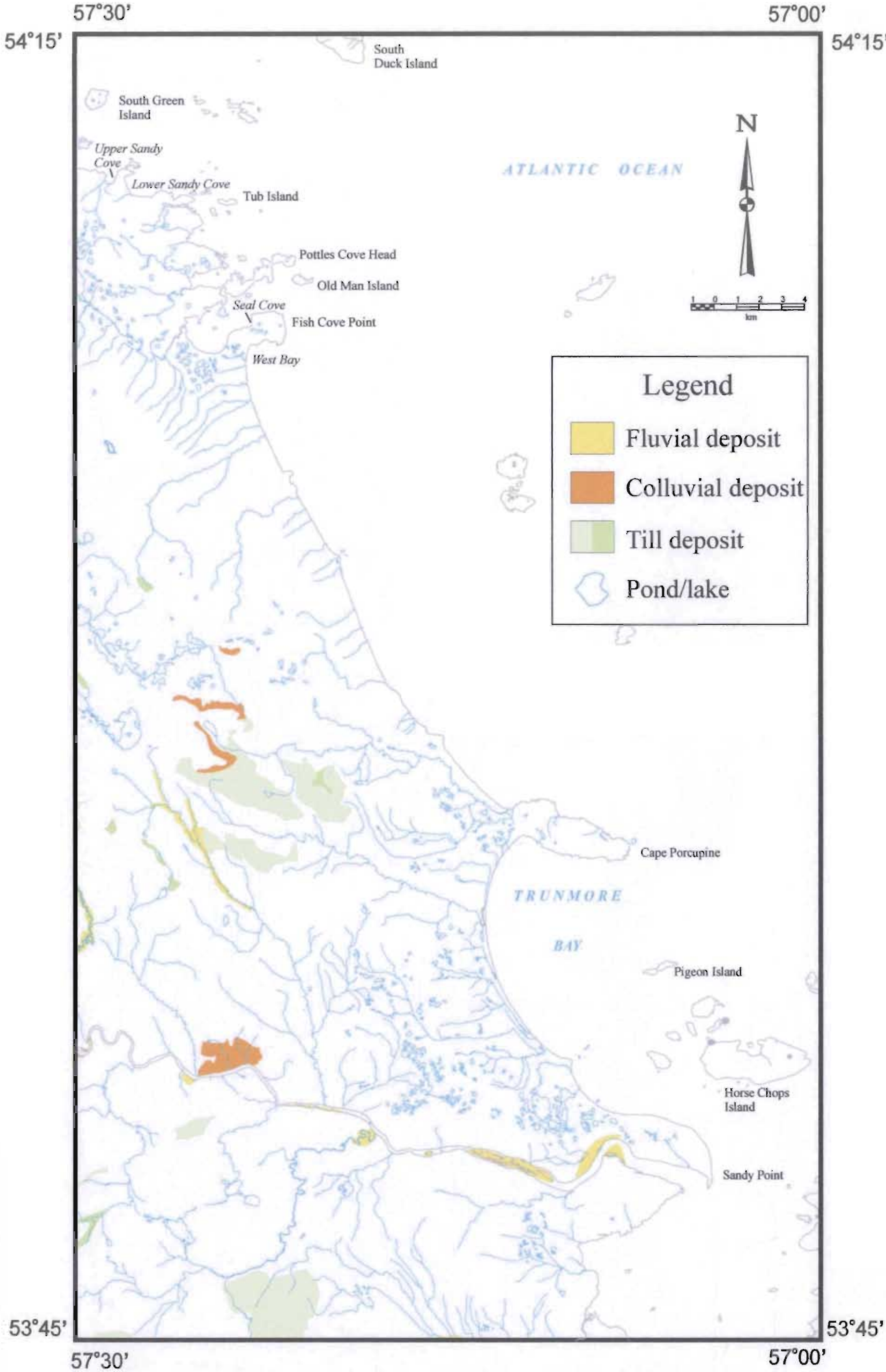


Fig. 3-9: Distribution of fluvial, colluvial and till deposits within the study area. These polygons represent areas characterized by more than 60% of the surficial unit.

Woolfreys Brook, Big Brook, South Feeder Brook, Fancies Brook, Porcupine River and North River, had fluvial deposits large enough to be distinguished on the surficial maps.

Fluvial bars composed of sand and gravel were identified in North River, and were classified on the surficial map as fluvial plains (Fp). Fluvial terraces (Ft) are located on both sides of North River. These are identified approximately 8 km upstream and range from 0.1 to 1.9 km long. Some of the larger, teardrop shaped bars are longitudinal bars.

Surficial Geology of Porcupine Uplands

The coastal uplands are located above 60 m asl and lie west of the coastal lowlands. Four surficial units are identified within the coastal uplands; the order of these units in the following section is based on the decreasing percentages of coverage these units have throughout the map area.

3.1.5 *Glaciofluvial Deposits*

Glaciofluvial sediments are the most widespread deposits covering approximately 35% of the map area (Fig. 3-10). Glaciofluvial refers to glaciogenic material transported by glacial meltwater and deposited as outwash in front of the ice sheet. These deposits are found between 18 and 262 m asl and form in valley bottoms within the *Porcupine Hills* and *Local Mealy Mountains*. They also form extensive plains north of the *Porcupine Hills*. These deposits were characterized on aerial photographs by light grey tones, a coarse stippled texture, and low vegetation. Glaciofluvial deposits have a wide range of

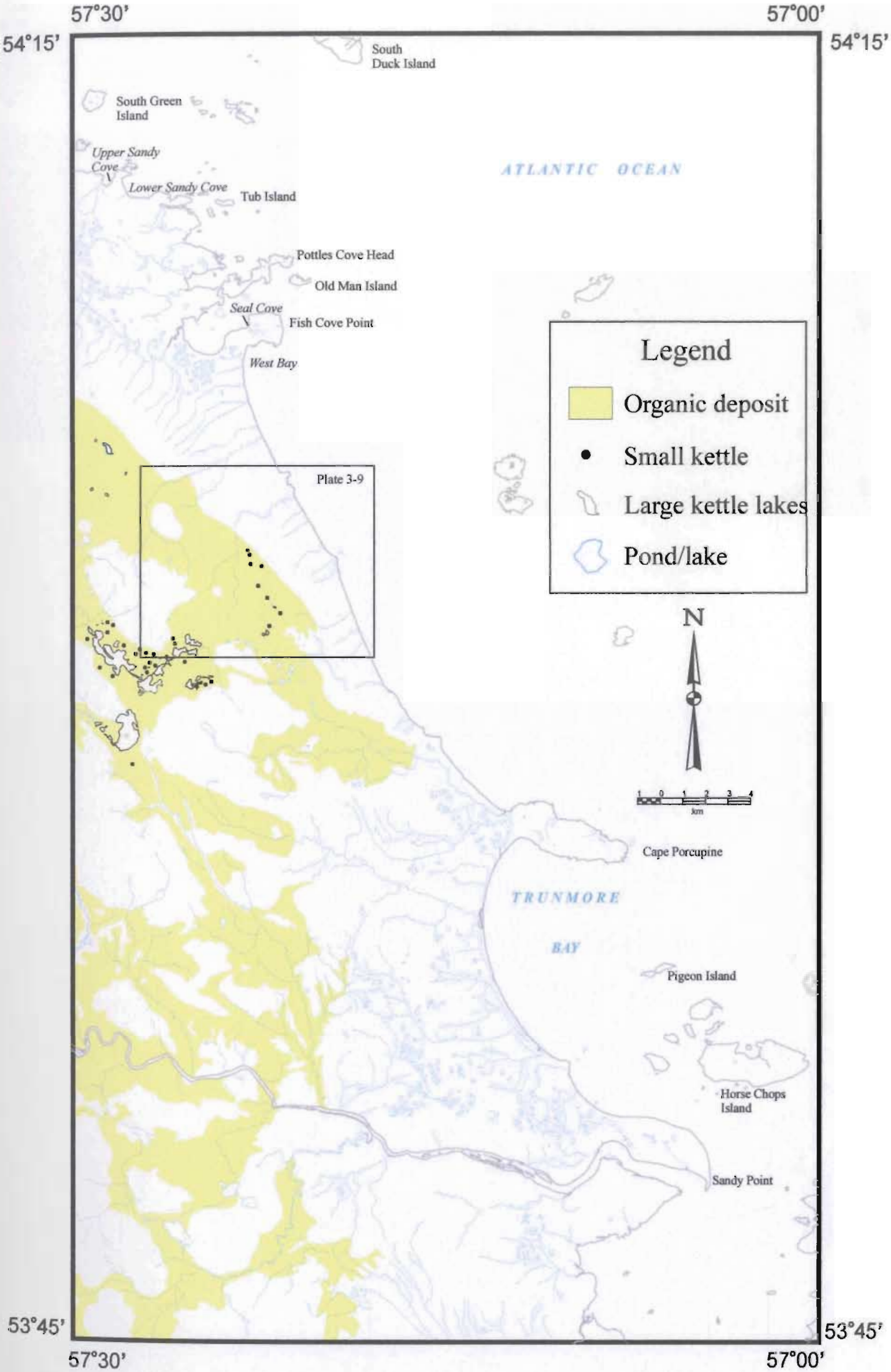


Fig. 3-10: Distribution of glaciofluvial deposits within the study area. Map also shows the distribution of kettle holes associated with this deposit.

surface expressions including: blanket (Gb), eroded (Ge), hummocky (Gh), kettled (Gk), plain (Gp), ridge (Gr), terrace (Gt), veneer (Gv) and undivided (Gx).

The most common surface expression identified in the map area is glaciofluvial plains. North of the *Porcupine Hills*, a more or less continuous outwash plain occurs between 70 and 115 m asl (Plate 3-9). The surface of the outwash plain has distinct terraces, abandoned channels and kettle holes. Kettles are typically steep sided and have diameters that range from tens to hundreds of metres. They often contain water, forming kettle lakes. Small valley outwash plains within the *Porcupine Hills* contain many of the same features.

A prominent raised beach identified at 92 m asl is located on the eastern edge of the large glaciofluvial plain south east of *West Bay*.

Interpretation

As ice retreated westward, glacial outwash formed sandur plains, along the northeast side of *Porcupine Hills* and within the valleys of the *Porcupine Uplands*. These outwash plains extended into the sea depositing the glaciomarine deltaic sands discussed in Section 3.1.1. During ice retreat, blocks of ice were buried in the glacial outwash. The ice blocks melted to form kettle holes. As meltwater generally graded to progressively lower base levels during postglacial emergence, terraces and abandoned channels were preserved on the outwash surface.

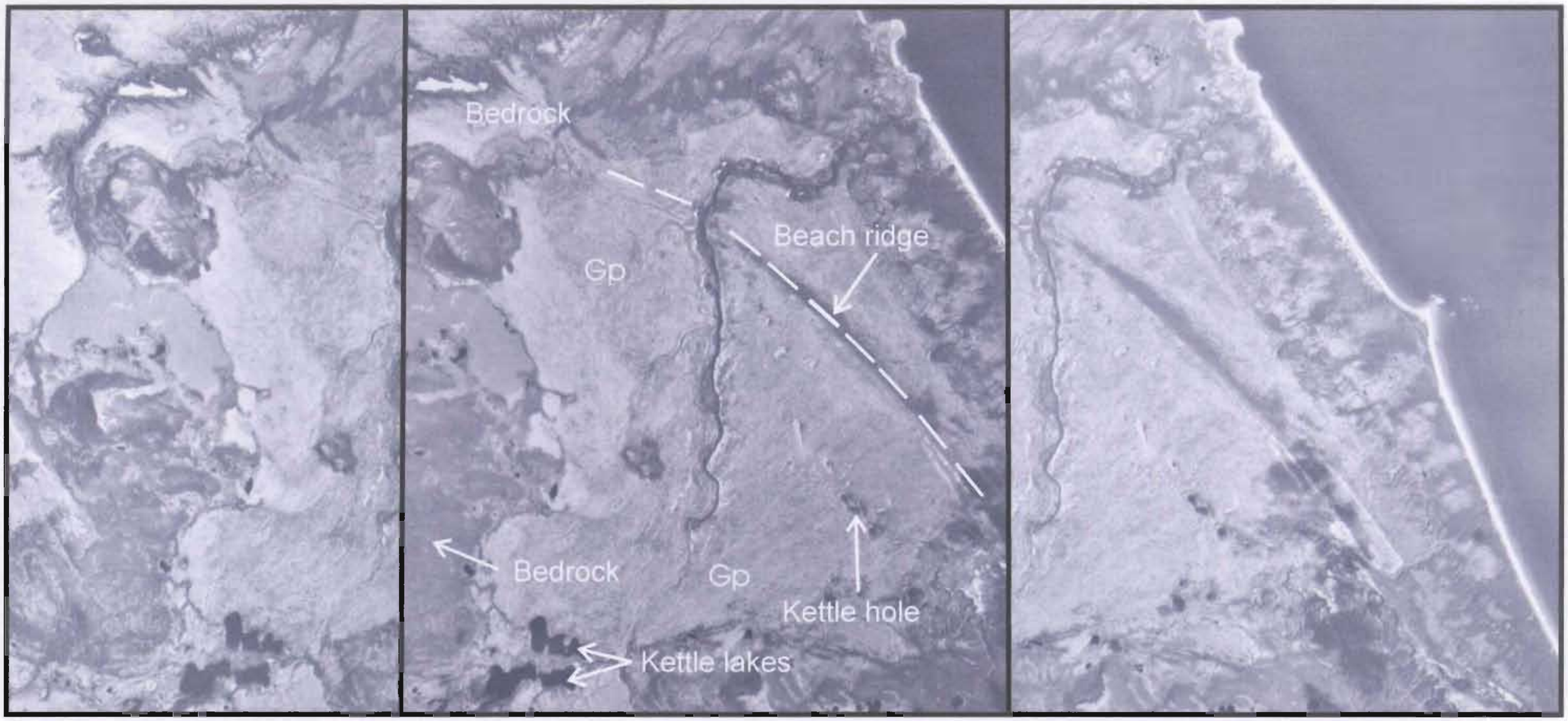


Plate 3-9: Large glaciofluvial outwash plain on NTS 13I/3. A prominent raised beach is located on the seaward edge of the glaciofluvial plain at an elevation of 92 m asl. Kettle holes and lakes are located to the west of the raised beach. Aerial photographs obtained from the Department of Environment and Conservation, flight line A21894, frame 36 and 37, scale 1: 50,000.

3.1.6 *Till*

Till forms only 7% of the surficial geology of the study area (Fig. 3-9). Till is material carried by glacial ice and deposited in direct contact with the ice. These deposits are mainly located on the southern map sheet (13H/14) in the Porcupine Hills as well as on the uplands northeast of the *Local Mealy Mountains*. Till was mapped overlying bedrock between 110 and 400 m asl and was not identified overlying any other surficial unit. Till blanket (Tb) and till veneer (Tv) are the only sub-units used from the GSNL landform classification legend.(Table 2-2) These sub-units refer to only the thickness of the deposit ($\geq$1.5 m and $<$ 1.5 m respectively). Till observed in the field area was limited to one poorly exposed section at the north end of the Strand. Near *West Bay*, a fine-grained stony diamicton outcropped adjacent to striated bedrock (striations oriented at 105°) and was overlain by glaciomarine mud. Upper and lower contacts were obscured by slumped material.

3.1.7 *Colluvium*

Approximately 0.5% of the study area contains colluvium (Fig. 3-9). These deposits are generally confined to the north side of the Porcupine Hills at the bottom of steep bedrock slopes. They consist of coarse rocky material and are considered to be rockfalls. Colluvium is identified between 103 and 303 m asl.

3.1.8 *Bedrock*

Bedrock primarily (15%) occurs within the *Porcupine Hills* and *Local Mealy Mountains*, and to a lesser extent along Porcupine Strand (Fig. 3-11). Generally, bedrock is more prominent on the landscape north of *West Bay*, where it separates pockets of marine sediment. Along the South Strand bedrock was mapped only around Cape Porcupine and offshore islands. Bedrock is subdivided into exposed bedrock (R) and bedrock that is concealed by vegetation (Rc).

Eight glacial ice flow indicators were identified on bedrock exposures, mainly within the northern part of the field area (Table 3-3). These indicators include polished stoss and lee forms, striations, grooves and chattermarks. The presence of these features provides evidence for glacial ice extending to the coast and indicates that ice generally flowed from west to east.

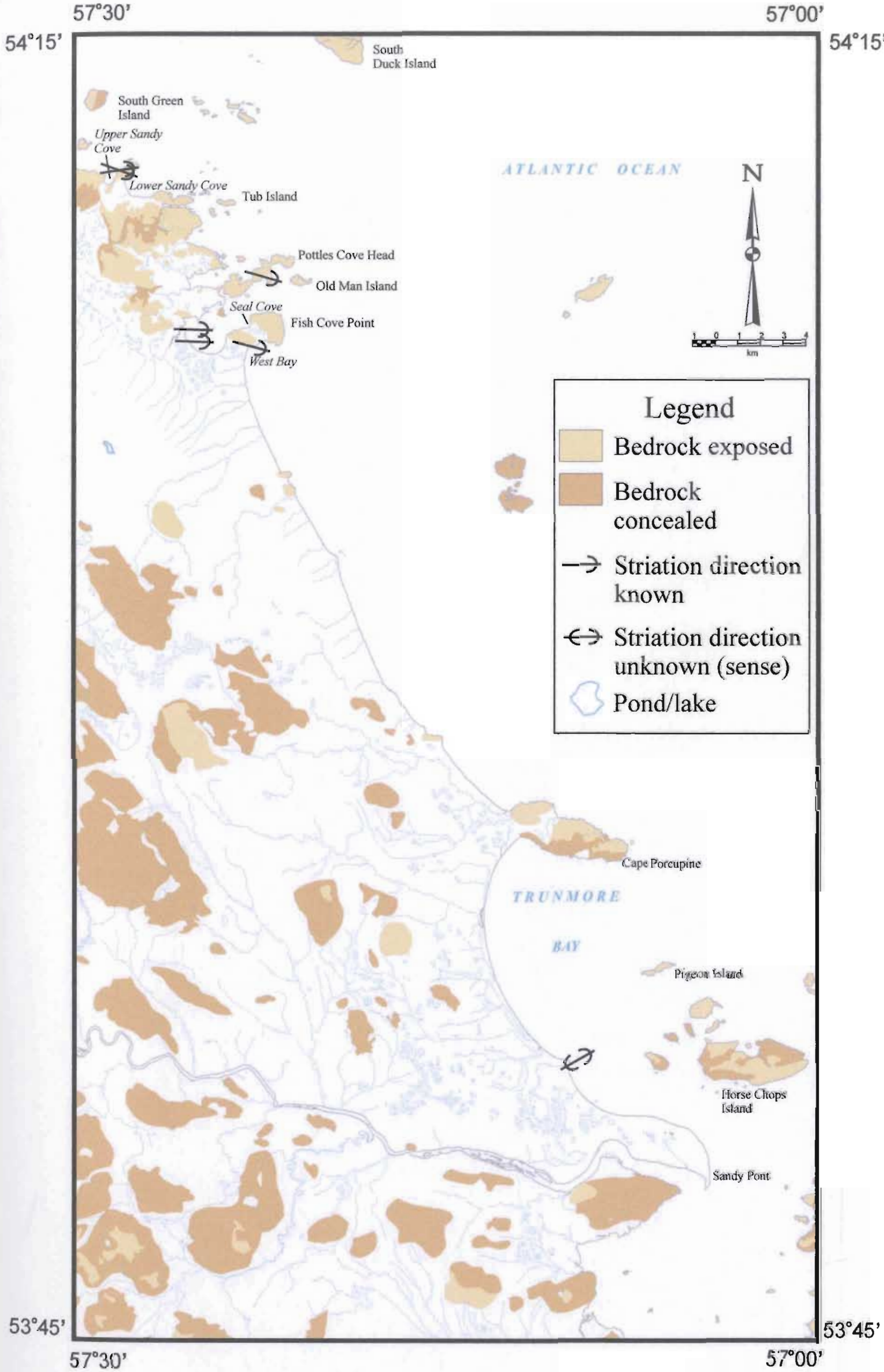


Fig. 3-11: Distribution of areas containing more than 60% of bedrock concealed and exposed within the study area. Ice flow indicators are also identified (see Table 3-3 for more information).

Table 3-3: Location, type and direction of ice flow indicators from the field area.

LOCATION	SITE NUMBER	DATE	UTM	DIRECTION/ SENSE* (°)	CONFIDENCE	TYPE
Trunmore Bay	PS-067	7/25/02	490228E 5965754N	30-210*	Low	Polished Stoss and Lee/ few striations
Sandy Cove	PS-121	8/12/02	469059E 6004627N	78	Moderate	Polished Stoss and Lee/ Chattermarks
Sandy Cove	PS-122	8/14/02	469126E 6005419B	60	Moderate	Polished Stoss and Lee/ Chattermarks – Side of Bedrock
Sandy Cove	PS-122	8/14/02	469121E 6005449N	1) 82; 2) 110	1) High; 2) low	Polished Stoss and Lee/ Chattermarks/ Grooves and Striations
West Bay	PS-079	7/30/02	475038E 5998058N	105	High	Grooves and Striations
Plances Bight	PS-126	8/15/02	472380E 5998184N	92	High	Grooves and Striations
Plances Bight	PS-128	8/15/02	472776E 5998957N	92	High	Striations
Fish Cove	PS-129	8/16/02	475866E 6006930N	106	Moderate	Striations

* The sense of an ice flow indicator implies the orientation of ice flow is known that is ice movement was towards 30 or 210°, but the actual direction of ice flow cannot be determined.

3.2 Data Used in the Reconstruction of Sea Level

Introduction

Two relative sea-level curves are constructed for Porcupine Strand using 16 new radiocarbon dates, 12 previously published radiocarbon-dated samples and six archaeological sites, the ages of which are assigned through identification of culturally diagnostic artifacts (Tables 3-4, 3-5, and Fig. 3-12). New sample sites are confined to Trunmore Bay and north of *West Bay* (outer Groswater Bay) due to limited field access. Archaeological sites and previously published dates by previous workers are located between Trunmore Bay and Sandwich Bay, and within outer Groswater Bay. Two separate curves were constructed due to the clustering of sea-level data at the extreme north and south of the Strand and because previous interpretations recorded a highly variable sea-level history for the area (Rogerson 1977; Clarke and Fitzhugh 1992). This section focuses on how the geological data and archaeological data constrain the two sea-level curves for Porcupine Strand.

3.2.1 *Reconstructing Sea Level*

The sea-level curve is generated through the identification and dating of deposits that identify former sea levels. These dates provide the temporal basis for reconstructing postglacial sea-level change. Marine limit is the highest elevation shown on the sea-level curve and is the starting point from which the remainder of the curve is reconstructed. The end of the sea-level curve is anchored by modern sea level. The form of the curve is dictated by the presence of sea-level index points, that place sea level at a known time

Table 3-4: Details of dated geological and archaeological data used in the construction of the Groswater Bay and Trunmore Bay sea-level histories identified in Fig. 3-12.

Sample no.	Age	Sample lab no.	Sample type	Elevation (m)	Enclosing material	Location	Reference
1	8820±70	TO-10948	*Macoma calcarea* [a]	0.5	clay	Big Brook	This study
22	8155±405	SI-1739	gyttja	100	above clay	Sandy Cove Pond, Groswater Bay	Jordan 1975
23	7840±100	GSC-2196	*Clinocardium ciliatum*	2	sand	Dove Brook	Rogerson 1977
24	7590±160	GSC-1284	*Mya arenaria*	1.5	silty clay	Sandy Point	Fulton 1986
2	7430±100	GSC-6677	*Hiatella arctica* [b]	1.8	sand	South of Rocky Point	This study
25	7170±180	SI-1531	gyttja	25	above clay	Aluik Pond, Groswater Bay	Jordan 1975
26	6750±190	GSC-2465	*Hiatella arctica* [c]	1.5	silt/clay	The Backway	Rogerson 1977
27	5640±100	GSC-2480	freshwater peat	9	sand	Woolfreys Brook	Rogerson 1977
3	5580±80	GSC-6675	freshwater peat	7.4	peat	South of Rocky Point	This study
35	5150±40	Beta-198381	charcoal	8	sand	Sandy Cove	Rankin Pers. Comm. 2005
28	5130±110	SI-1270	charcoal	15	?	Sandy Cove, north shore Groswater Bay	Fitzhugh 1972
40	4050±60	Beta--198382	charcoal	7.6	organics	Sandy Cove	Rankin Pers. Comm. 2005
29	4000±65	SI-2515	plant remains	6.7	?	Rattlers Bight, Groswater Bay	Fitzhugh 1972
4	2910±45	BGS-2455	freshwater peat	11.4	peat	North of Rocky Point Little Sahara	This study
5	2590±60	Beta-175379	palaeosol	6.4	peat	Sandy Point	This study
30	2520±160	GSC-1367	charcoal	7.1-8.5	?	East Pompey Island, Groswater Bay	Fitzhugh 1972
7	2040±40	Beta-191933	wood	5.65	peat	South of Rocky Point	This study
31	1890±60	Beta-173907	charcoal	7	?	Snack Cove, Huntingdon Island	Wolff 2003
9	1568±40	BGS-2454	freshwater peat	5.7	peat	Sandy Point	This study
10	1430±50	GSC-6723	wood	1.3	sand and cobbles	South of Rocky Point	This study
32	1050±50	Beta-56253	charcoal	4.9	?	Horse Chops Island	Stopp 1997
33	760±130	GSC-1196	charcoal	2.7	sand	Big Island, Groswater Bay	Fitzhugh 1972
12	390±60	Beta-175380	palaeosol	4.9	peat	Sandy Point	This study
14	290±50	GSC-6750	wood	5.5	peat	Sandy Cove	This study
17	130±80	GSC-6758	wood	8.25	peat	Seal Cove	This study
18	80±70	GSC-6683	*Mya* sp. [d]	1.3	sand and cobbles	South of Rocky Point	This study
20	40±60	GSC-6766	wood	intertidal zone	sand	North of Big Brook	This study
21	30±60	GSC-6685	*Mytilus edulis* [e]	0.5	sand and gravel	Seal Cove	This study

[a] Shell sample collected also contained: *Balanus* sp., *Clinocardium Ciliatum*, *Macoma calcarea*, *Nucula tenuis*, and *Yoldia hyperborea*

[b] Shell sample collected also contained: *Astarte* sp., *Astarte borealis, Astarte elliptica, Astarte undata, Balanus* sp., *Balanus crenatus, Clinocardium ciliatum, Cockle, Macoma balthica, Macoma calcarea, Mya* sp., *Mya arenaria, Mya truncata, Serripes groenlandicus, Trichotropis borealis,* and *Turridae*

[c] Shell sample collected also contained: *Macoma balthica, Balanus* sp., and *Mytilus* sp.

[d] Shell sample collected also contained: *Mytilus edulis s.l*

[e] Shell sample collected also contained: *Mya arenaria, Mytilus edulis s.l., Mytilidae,* and *Volsella modidus*

Table 3-5: Details of archaeological sites used in the reconstruction of sea level in which an age range was assigned.

Sample no.	Age ^{14}C BP	Cultural affiliation	Archaeology Borden no.	Elevation (m)	Enclosing material	Location	Reference
34	6770-7255*	LAI"	FkBg-13	3.4	sand	Sandy Point	Rankin pers. Comm. 2004
35	6000-4700 (5150 ± 40 ^{14}C BP)**	LAI (Sandy Cove Complex)	GbBi-07	5	sand	Sandy Cove	Rankin pers. Comm. 2005
36	4000-3800	LAI (Rattlers Bight Complex)	GbBi-16	6.5	sand	Sandy Cove	Rankin pers. Comm. 2004
37	3800-1500	Intermediate Indian	FkBg-12, FkBg-11	3.2	sand	Sandy Point	Rankin pers. Comm. 2004
38	2800-2100	Groswater Palaeoeskimo	FkBg-15	5	sand	Sandy Point	Rankin pers. Comm. 2004
39	2500-600	Dorset Palaeoeskimo	FkBg-14, FkBg-30, GaBi-03, GaBi-06, GaBi-19, FIBg-3, USC-11^	4.9-14	sand	Sandy Point, Seal Cove	Rankin pers. Comm. 2004

* Radiocarbon ages from Arrowhead Mine site, (SI-1799 and SI-1800 B) see text.

** Radiocarbon date (Beta-198381) from only one longhouse in Sandy Cove.

" There are five additional sites (GbBi-3, GbBi-4, GbBi-17, New Harbour 8 and 9) that have not been assigned to one of these 3 complexes (sample 34, 35, 36). These sites span the entire LAI age range 7255 and 3800 ^{14}C BP. These sites are not shown on Fig. 3-12.

^ USC = Upper Sandy Cove

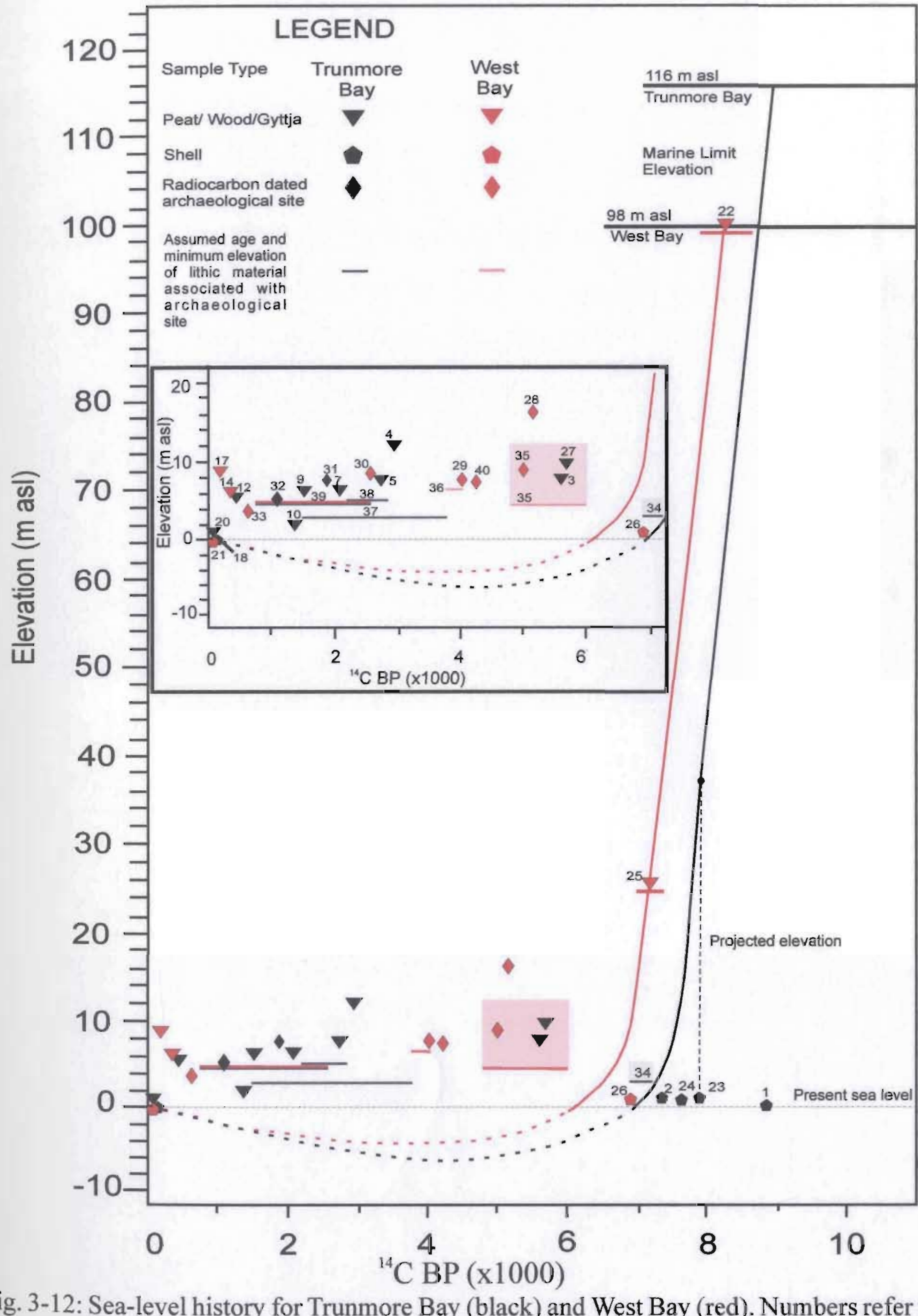


Fig. 3-12: Sea-level history for Trunmore Bay (black) and West Bay (red). Numbers refer to samples in Tables 3-4 and 3-5 that provide detailed information on geological and archaeological data. The dotted lines represent speculative portions of the curves. The elevation of each sample type is indicated by the lowermost point of both the diamonds and triangles and the uppermost point of the polygons. The colored boxes paired with the archeological sites represent the elevation error associated with each site.

and elevation. For example, marine shells collected from the delta front may provide an approximate timing for when sea level was located at the foreset/topset boundary. The projected sea level position at the elevation of the delta top would be the elevation the relative sea-level (RSL) curve would pass through, not the shell collection site.

Former sea-level positions may also be located by freshwater organic rich mud called gyttja, where it overlies marine sediments resulting in a marine-freshwater transition. Gyttja usually begins to accumulate in a marine inundated basin during a fall in sea level, as the influx of seawater into the basin becomes less. The result is a gradual change to freshwater processes once sea level falls below the sill of the basin, isolating it from the sea. This is recorded in the sediment by the disappearance of marine fauna and the appearance and increased abundance of freshwater gyttja. The dating of a bulk gyttja sample taken immediately above the transition provides an age estimate for when sea level was at that elevation. Age estimations from bulk gyttja samples are often problematic as these dates may be associated with large errors and contamination. This is partly because bulk samples require a large amount of organic material that may have accumulated over a long time period. Another source of error in dating organics from gyttja is the sample being contaminated with older carbon, resulting in a reported age that is older than the true age (King 1985). This type of contamination is most significant when the sample contains low amounts of organic material (King 1985). As a result, each sample and resulting date must be critically examined when making interpretations from these samples.

Marine shells identified in raised littoral sediments are derived from material on the sea floor, and reworked into beaches during emergence. They therefore represent the maximum ages for beach formation and are located below the RSL curve. Shells found in life position within deepwater sediments provide minimum estimates of sea-level elevation for the period of shell growth.

Maximum age constraints on the timing of emergence at a particular elevation are given by radiocarbon dated freshwater peat, wood, palaeosols, and charcoal from archaeological sites. Archaeological sites that do not have associated radiocarbon dates have both an associated age and elevation error. These sites have been assigned an age range based on the identification of culturally diagnostic artifacts (Table 3-5). The occupation of a site on Porcupine Strand could fall anywhere within the known age range of that culture. A range is also associated with the elevation of such sites. Many of these sites were identified on the floors of dune blowouts and this represents a minimum elevation. The maximum elevation is given by the elevation representing the top of the dune deflation surface. Thus, the associated elevation range is between the minimum and maximum elevations suggested by the shaded box that extends the length of the age range for the site (Fig. 3-12). Clark and Fitzhugh (1992) propose that archaeological sites are generally found 3 m above sea level corresponding to the period of occupation, and thus the RSL curve would fall below these sites.

The following is a description of how sea-level history was reconstructed for Porcupine Strand beginning with marine limit, as well as how both curves are constrained by both the new and published data.

Marine Limit

Aerial photography was used to determine marine limit along Porcupine Strand. As a result, the elevation of features discussed below are interpolated from topographic maps and have an associated ±3 m error range that is derived from the contour interval. Mapping of raised beaches between 0.5 and 92 m asl indicated that sea inundated to at least these elevations. South of Cape Porcupine glaciomarine/marine sediments form a raised delta, along *South Feeder Brook,* that is 116 m asl. This delta likely relates to the maximum post-glacial sea level. The timing of this inundation remains undated, as shell fragments collected by Rogerson (1977) related to this delta were insufficient for radiocarbon dating. The 8820±70 ^{14}C BP (TO-10948; sample 1; Table 3-4) assigned age for marine limit in Trunmore Bay represents minimum age estimates for marine limit/deglaciation; it is the oldest date representing deposition of glaciomarine muds in the area.

In the northern part of the field area higher sea levels are noted by the presence of raised beaches that range from 0.5 to 92 m asl. The highest raised beach, at 92 m asl, is also the highest extent of glaciomarine/marine sediments mapped for this area. As a result the best estimate of marine limit is that it is greater than 92 m asl. There is no radiocarbon date associated with this feature, therefore marine limit for the northern part of the study area remains undated. Using previously published dates for the surrounding area, one clay gyttja transition date recorded from a lake sediment sample by Jordan (1975) may be used to identify the timing and elevation of marine limit at a location on the north side of Groswater Bay. The clay gyttja transition sampled from Sandy Cove Pond is at an elevation of 98 m asl (Section 2.2.8). Dated at 8155±405 ^{14}C BP (SI-1739; Jordan 1975) this sample records a generalized age for this transition. The clay records the presence of two diatom species that range from freshwater to brackish water environments as well as a rare benthonic freshwater species (Jordan 1975). At the time of deposition Jordan (1975) suggested that the basin experienced partial salinity indicating at the time of deposition the basin was at or slightly above marine limit. The identification of a 98 m asl marine limit on the north side of Groswater Bay is comparable to a 92 m asl estimated marine limit that is currently undated on the south side of Groswater Bay. As a result of this similarity in elevation, the radiocarbon date and elevation from Sandy Cove Pond is used to estimate the timing of marine limit within the field area.

3.2.2 *Radiocarbon Dated Samples*

The 28 samples used to reconstruct the postglacial sea-level history of Porcupine Strand consist of marine shell (7), charcoal (7) wood (5), peat (4), gyttja (2), palaeosol (2), and plant remains (1; Table 3-4)[6]. Nineteen of the samples were collected from

[6] There are a total of 35 radiocarbon dates from the region as well as five age estimates from archaeological sites that relate to sea level and aeolian activity. These are each assigned a sample number that is kept constant throughout the thesis (Table 2-3). As a result numbers in Table 3-4 are only those samples that relate to sea level and numbers are therefore not consecutive.

terrestrial/freshwater environments, thus providing upper constraints on the sea-level history. The remaining samples represent shallowing marine environments and provide lower constraints on the relative sea-level position. Of these samples, 16 are from Trunmore Bay, while the remaining 12 samples are from the *West Bay* area.

Trunmore Bay

Radiocarbon dated shells from the deltaic sediments at *Dove Brook* (located to the southeast of the map area) indicate that at 7840±100 ^{14}C BP (GSC-2196; sample 23), sea level was 37 m asl (Rogerson 1977). This is the only known palaeo sea-level index point for the Trunmore Bay area. Collected from beneath the delta foresets at 2 m asl, sea level at the time these shells were deposited would have been located at the upper delta surface identified at 37 m asl. As a result the sea level at 7840±100 ^{14}C BP (GSC-2196; sample 23; Table 3-4 and Fig. 3-12) is projected to 37 m on the sea-level curve.

Four shell samples, ranging in age from 7430±100 ^{14}C BP (GSC-6677) to 8820±70 ^{14}C BP (TO-10948), were collected from sub-littoral sediments within the Trunmore Bay area (samples 1, 2, 23, 24; Table 3-4 and Fig. 3-12). These shell samples were not found in living position and therefore have little stratigraphic context in relation to the relative position of sea level. However, the ecological preferences of these marine fauna found both within the mud and the overlying sand may provide minimum estimates as to how high sea levels were at the time of deposition. For example, the species *Macoma calcarea* identified in sample 1 (8820±70 ^{14}C BP; TO-10948) is often associated with muddy substrates and is commonly identified in water depths of less than 80 m (Abbott 1968; Peacock 1993). Other species identified within the muds at Big Brook (sample 1) including *Clinocardium ciliatum*, *Nucula tenuis* and *Yoldia hyperorea* are associated with common water depths of 5 to 40 m (Abbott 1968; Peacock 1993). This suggests that the muds were likely deposited in relatively shallow waters up to a maximum of 80 m water depth. Deposition of massive muds within shallow marine waters can occur when currents and tidal influences are minimal (Benn and Evans 1998). The sedimentology of the overlying marine clays is suggestive of a shallowing upward sequence that began as early as 7590±160 ^{14}C BP (GSC-1284; sample 24; Table 3-4 and Fig. 3-12). The marine shells found within the sands are suggestive of shallower waters. For example common water depths as suggested by Peacock (1993) for *Mya arenaria, Mya truncata, Mya edulis* s.l., and *Serripes groenlandicus* range from intertidal to 50 m. Water depths of other species such as *Astarte* sp., *Astarte borealis, Astarte ellipica, Astarte undata, Balanus crenatus, Mytilidae, Trichotropis Borealis, and Turridae* are also found within this range, but also may occur in deeper waters (Abbott 1968; Peacock 1993; Table 3-2).

Although numerous raised beaches were identified along Trunmore Bay, organic material was collected from just one beach on the north side of Sandy Point (Fig. 3-4). The raised beach is located only metres from the present shoreline and was eroded exposing both sand and rounded cobble gravel. Samples of shells (sample 18) and driftwood (sample 10) were collected at an elevation of 1.3 m asl (Table 3-4). The shells yielded an age of 80±70 ^{14}C BP (GSC-6683) while the driftwood was dated at 1430±50 ^{14}C BP (GSC-

6723). The better estimate age of the beach likely is provided by the shell sample as it determines the youngest time the beach could have formed. The driftwood associated with the beach represents the minimum age of formation and is not directly related to sea-level change. The driftwood indicates that during the formation of the beach, wood was eroded into the sea and washed ashore.

Nine radiocarbon dates provide upper limits or constraints on the relative sea-level curve. The bottom ten centimetres of three freshwater peat exposures (samples 3, 9, 27; Table 3-4 and Fig. 3-12) were collected from the top of the coastal cliff overlying marine sediments. The age of the freshwater peat ranges from 5640±100 ^{14}C BP (GSC-2480; sample 27), 5580±80 ^{14}C BP (GSC-6675; sample 3), 1568±40 ^{14}C BP (BGS-2454; sample 9; Table 3-4 and Fig. 3-12). Small pieces of wood identified in a basal peat sample were dated at 2040±40 ^{14}C BP (Beta-191933, sample 7). The variation in elevation of the dated peat horizons might explain the range seen in the age of the peat samples. This range in age might be suggestive of two phases of peat development, one on the main coastal plain (7-9 m asl) between 5640±100 ^{14}C BP (GSC-2480; sample 27) and 5580±80 ^{14}C BP (GSC-6675; sample 3) and the fronting terrace (5.6-5.7 m asl) between 2040±40 ^{14}C BP (Beta-191933, sample 7) and 1568±40 ^{14}C BP (BGS-2454; sample 9). A tree stump identified in the substrate of the intertidal zone had an age of 40±60 ^{14}C BP (GSC-6766; sample 20). This *Picea* tree stump was located in an upright position extending 65 cm above the beach sand. With a small portion of the main roots uncovered the stump appeared rooted in sandy gravel that was overlain by finer beach sediments. Aeolian sand overlaid two collected palaeosols samples from Sandy Point both of which were dated at 2590±60 ^{14}C BP (Beta-175379, sample 5) and 390±60 ^{14}C BP (Beta-175380, sample 12). In addition, radiocarbon dated charcoal collected from archaeological sites on Huntingdon Island (1890±60 ^{14}C BP; Beta-191933; sample 31) and Horse Chops Island (1050±50 ^{14}C BP; Beta-56253; sample 32) were used to constrain sea level. Of the 100 new sites identified on Porcupine Strand by PSAP only 18 sites contained lithic material that was diagnostic of a particular cultural occupation time period (Table 3-5). The age associated with these sites spans the period from 7200 to 600 ^{14}C BP. Four of these sites are identified on Sandy Point (the remaining are from Sandy Cove and will be discussed below). These sites include the Labrador Archaic Indian (LAI), Intermediate Indian, Groswater Palaeoeskimo and Dorset Palaeoeskimo. The LAI site (FkBg-13) is identified on the blowout floor at an elevation of 4.8 m asl and can be well constrained to approximately 7000 ^{14}C BP based on similarities with the Arrowhead Mine Site (EjBe-16), which has been radiocarbon dated to between 7255 and 6770 ^{14}C BP (SI-1799 and SI-1800 B; Rankin 2003 personal communication).

West Bay

Twelve radiocarbon-dated organic samples were used to constrain the *West Bay* curve. These organic samples included: marine shells (2), gyttja (2), wood (2), charcoal (5) and plant remains (1). However, only three of these samples (samples 14, 17, 21; Table 3-4 and Fig. 3-12) were collected during this study.

Two gyttja samples collected by Jordan (1975) were dated at 8155±405 ^{14}C BP and 7170±180 ^{14}C BP (SI-1739, sample 22 and SI-1531, sample 25). These were interpreted by Jordan (1975) to be generalized dates that mark the marine to freshwater transition at 100 m asl and 25 m asl respectively. The use of the gyttja sample from Aliuk Pond (sample 25) represents a good marine-freshwater transition and while the date is only considered to be a generalized one, it allows the upper part of the curve to be constrained.

The only sub-littoral shell (*Hiatella arctica*) sample constraining sea level was collected from a site located 30 km to the west of *West Bay* in The Backway. This sample was described by Rogerson (Blake 1983) as a marine silt/clay bed located 1.5 m asl. *Hiatella arctica* indicted that this unit formed 6750±190 ^{14}C BP (GSC-2465, sample 26). These sediments were believed to be the earliest postglacial sediments identified at the head of The Backway and were associated with a sandur surface containing a beach ridge on its eastern edge (90 m asl) approximately 7 km to the east (Rogerson 1977). In addition to the dated *Hiatella arctica* sample this location also included *Macoma balthica,* and fragments of *Balanus* sp. and *Mytilus* sp. all of which were not found in life position. Shells were collected from only one beach north of *West Bay*. In *Seal Cove*, a gravel beach with an elevation of 0.5 m asl lies metres from the present shoreline (sample 21). Shells from the beach were dated at 30±40 ^{14}C BP (GSC-6685; Table 3-4 and Fig. 3-12).

All of the remaining samples provide upper constraints on sea-level history. Three charcoal samples were collected from archaeological sites in Groswater Bay and dated by

Fitzhugh (1972, samples 28, 30, 33). These samples have ages of 5130±110 ^{14}C BP (SI-1270, sample 28), 2520±160 ^{14}C BP (GSC-1367, sample 30), 760±130 ^{14}C BP (GSC-1196, sample 33) and have elevations that become progressively lower with decreasing age. Two charcoal samples were dated by Rankin (Personal Communication 2005, samples 35 and 40) from *Sandy Cove*. The oldest age, 5150±40 ^{14}C BP (Beta-198381, sample 35), was associated with a hearth in the bottom of a blowout. The remaining age, 4050±60 ^{14}C BP (Beta-198382, sample 40) was derived from charcoal taken from a buried soil that had no affiliation with artifacts. Wood was collected from two separate peat beds (*Sandy Cove* and *Seal Cove*) buried by aeolian sand. These were dated at 290±50 ^{14}C BP (GSC-6750, sample 14) and 130±80 ^{14}C BP (GSC-6758, sample 17). Fitzhugh (1972) dated plant remains (4000±65 ^{14}C BP; SI-2515, sample 29) from an archaeological site in Rattler's Bight that also provide upper constraints on sea-level history.

Two archaeological sites identified in *Sandy Cove* contained lithic material that was culturally diagnostic of the LAI. These sites contain two different complexes of the LAI, that include the Sandy Cove Complex that has been since radiocarbon dated at (5150±40 ^{14}C BP (Beta-198381, sample 35) and the Rattlers Bight Complex (4000 to 3800 ^{14}C BP, sample 36). Further details regarding these archaeological sites is given in Table 3-5.

3.2.3 *West Bay Sea-Level Curve*

The radiocarbon data along with the archaeological data identified north of *West Bay* defines a Type-A or -B sea-level curve (Quinlan and Beaumont 1981). Samples 22 (8155±405 ^{14}C BP; SI-1739) and 25 (7170±180 ^{14}C BP; SI-1731A) date marine-freshwater transitions, and as a result the curve is drawn through these points. Rogerson's (1977) shell sample from The Backway, sample 26 (6750±190 ^{14}C BP; GSC-2465; Table 3-4 and Fig. 3-12), constrains sea level to at least 1.5 m above present at 6800 ^{14}C BP. While the shell assemblage identified at this location (*Balanus* sp., *Hiatella arctica, Macoma balthica, and Mytilus* sp.) did not appear in life position, it is indicative of estimated water depths ranging from 5 to 80 m. *Mytilus* sp. and *Balanus* sp. are commonly found in less than 20 m of water, suggesting that the deposition of the mud was likely limited to water depths of this range. The archaeology site in *Sandy Cove* that represents the Sandy Cove Complex of the LAI (35) indicates that by 6000 ^{14}C BP sea level was likely close to present levels. During the occupation of one longhouse, 5150±40 ^{14}C BP (Beta-198381; sample 35) sea level was likely 2 m below present. The shells from *Seal Cove* (sample 21) imply sea level approximately 80 years ago was close to present (Table 3-4, Fig. 3-12).

The sea-level curve is not tightly defined from 6000 ^{14}C BP to present and as a result either a Type-A or Type-B curve can be suggested for *West Bay*. A Type-B curve is favoured and is shown on Figure 3-12 as a dotted line after 6000 ^{14}C BP. This curve is preferred as the present coastal geomorphology in Trunmore Bay and *West Bay* indicate actively eroding beaches and coastal cliffs suggesting rising sea levels. A similar Type-B curve is constructed for Trunmore Bay. In addition the *Sandy Cove* archaeology site (sample 35) suggests sea level was close to present levels by at least 5150±40 ^{14}C BP (Beta-198381; sample 35).

3.2.4 *Trunmore Bay Sea-Level Curve*

The Trunmore Bay curve is a Type-B curve (Quinlan and Beaumont 1981) in which sea level fell more than 116 m to below current sea level and then rose. The exact timing of the sea level low-stand is unknown.

The timing of marine limit as defined by the upper delta surface identified at 116 m asl along *South Feeder Brook* is unknown. The minimum time estimates for the marine limit are derived from the oldest radiocarbon date from glaciomarine mud, 8820±70 ^{14}C BP (TO-10948, sample 1). This elevation and age serves as the starting point for the Trunmore Bay sea-level curve (Table 3-4, Fig. 3-12).

A projected elevation of 37 m asl to the upper surface of the *Dove Brook* delta represents sea levels in which marine shells were deposited in at 7840±100^{14}C BP (GSC-2196; sample 23). As a result sea level falls through this sea-level index point.

The lower-most part of the emergence curve is constrained by the presence of the LAI site (FkBg-13, sample 34) from Sandy Point that dates between 7255 and 6770 ^{14}C BP

(SI-1799 and SI-1800 B). As a result, the sea-level curve falls below the elevation of this archaeological site, identified at 3.4 m asl and above the minimum sea-level position given by marine shells from the *Dove Brook* delta (sample 23). The slight differences in the ages of sample 23 and sample 34 along with the minimum elevation of the artifacts constrain the position of the sea-level curve.

It is proposed that the curve falls below present sea level as a result of the confinement of the curve between sample 23 and 34 and due to the absence of dated marine shells found above modern sea level between 7000 and 100 ^{14}C BP (c.f Liverman 1994). A Type-B curve indicates that there should be a succession of raised features, but none should be younger than the date marking submergence below present sea level (Liverman 1994). If archaeological sites are solely tied to sea level as suggested by Clark and Fitzhugh (1992) than a period of submergence as indicated by this curve, may result in an absence within cultures identified in the archaeological record. The exact timing of the sea level low-stand is unknown and as a result of these lack of constraints sea level after 7000 ^{14}C BP is denoted with a dotted line. Sample 18, *Mya* sp., collected from the raised beach in Trunmore Bay indicates that sea level was close to present levels at 80±70 ^{14}C BP (GSC-6683).

The upper constraints of sea level during the last 6000 ^{14}C BP relies heavily on relatively dated archaeological sites (samples 34, 37, 38, 39), radiocarbon dated archaeological sites (samples 31, 32), freshwater peat (samples 3, 9, 27), wood (samples 7, 10, 20) and palaeosol samples (samples 5, 12, Table 3-4, Fig. 3-12). The elevation of these samples provides maximum constraints on sea-level elevation. In order for soils and vegetation (trees) to grow and for organic material (freshwater peat) to accumulate in these areas, sea level would have to be a few metres lower so that the roots of growing vegetation would not encounter salt water or would not be affected by tidal or storm surges. Similarly, archaeological sites should also be located a few metres above sea level as people would have likely been seeking shelter from high seas and onshore winds.

The curves produced for Trunmore Bay and *West Bay* show similar sea level trends since deglaciation. The presence of a tree stump in the intertidal zone (sample 20) was thought to be evidence of rising sea level; however, its young age of 40±60 ^{14}C BP (GSC-6766) suggests that it is modern. No other upright stumps were identified along the intertidal zone. The exterior of the stump is weathered grey and no bark was preserved on the stump including the roots, leaving a smooth surface. Driftwood is abundant along the Strand particularly where the coastal cliffs and back beaches are being eroded. In consideration of its young age, this tree stump is likely to be a piece of driftwood that was placed in an upright position. As a result, it is not directly indicative of a rise in sea level. However, the presence of actively eroding beaches and coastal cliffs, as well as the closeness of high-tide lines to the bottom of these eroding features, indicate that rising sea levels are likely the cause of such erosion. There is no direct evidence, terrestrial or marine data, identified constraining sea level above present in the last 7000 ^{14}C BP, in either Trunmore Bay or *West Bay*. As well there is good archaeological evidence from both Trunmore Bay and *West Bay*, for 7000 ^{14}C BP and 6000 ^{14}C BP respectably, that sea level was close to present. This evidence suggests that a Type-B curve is more likely than a Type-A curve and that a period of submergence from 7000 ^{14}C BP to present is possible. The amount of submergence is estimated between 4 and 6 m, based on the general shape similar sea level curves suggested by Quinlan and Beaumont (1981) and Liverman (1994). The suggestion of a Type-B coastline for Trunmore Bay has major implications for the identification and preservation of coastal archaeological sites. These curves will be further discussed in Chapter 4 along with the implications that this sea-level history has on the archaeological record.

3.3 Aeolian Sediments and Buried Organic Material

Introduction

Aeolian deposits are located on top of the coastal lowlands, fronting the coastal cliff, and within bayhead locations in the northern part of the study area. Dunes and veneers are found at a range of elevations and have both stable and active forms. Buried soils and peat horizons were identified (in all these locations), demonstrating that aeolian deposition was discontinuous. Over 60% of archaeological sites found by PSAP were on the floors of blowouts within aeolian deposits. These archaeological sites are effectively a lag deposit on the blowout surface that occurred as the result of wind erosion. This erosion removed both the context and stratigraphy in which these sites were placed. As a result it is hard for archaeologists to determine the true meaning of these sites. Buried soil horizons and peats identified along the walls of the blowouts may provide some insight to site context, if the archaeological sites can be correlated with these horizons. Radiocarbon dating palaeosols and buried peat horizons may provide a way in which to correlate archaeological sites located on the blowout floors to these buried soils, thus potentially reconstructing the archaeological site stratigraphy and showing that prehistoric peoples were occupying vegetated surfaces along the Strand.

Fifteen samples of organic material from eight sites located on Sandy Point, *Little Sahara*, *Seal Cove*, and *Sandy Cove* were radiocarbon dated (Fig. 3-13 and Table 3-6). These samples include eight O horizons and two wood samples collected from buried palaeosol horizons and five samples from three peat deposits. All of these samples are

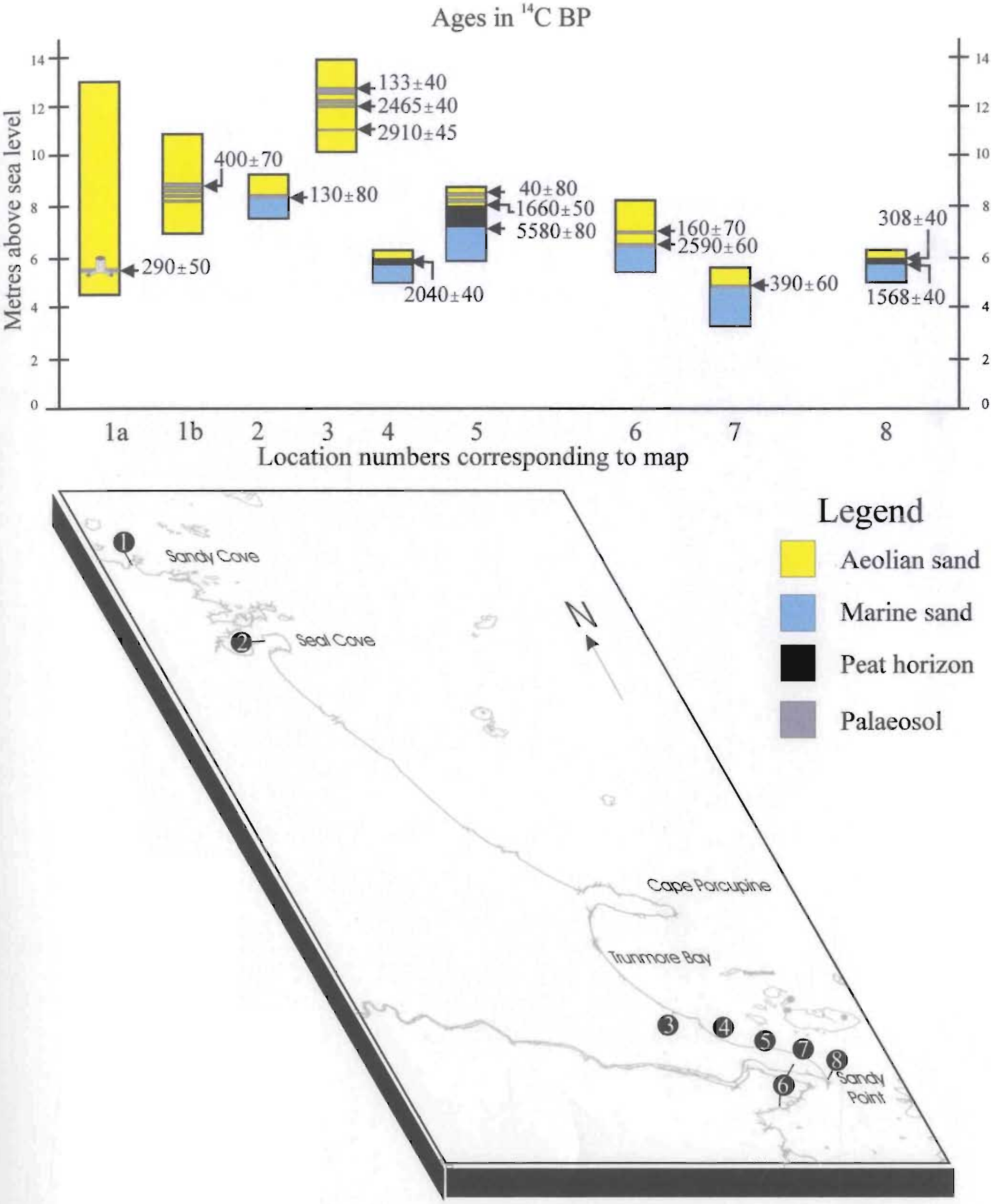


Fig. 3-13: Diagram showing the distribution of dated peat, palaeosol and wood samples collected from palaeosol (grey) and peat (black) horizons along with the stratigraphic context of each sample. Sample details are located in Table 3-6.

Table 3-6: Table identifiying the characteristics of soils dated along the Strand. Sample locations are identified on Figure 3-13.

Sample No.	Lab No.	Radiocarbon date (years ^{14}C BP)	Calibrated age (cal years BP)[a]	Elev. (m)	Location[b]	Number of palaeosols	Peat horizon[c]	Horizon thickness (cm)	Organic texture	Charcoal	Underling unit	Aeolian sand thickness above (cm)	Associated cultural group
3	GSC-6675	5580±80	6370	7.4	SP		2 dates; lower (8)	100	medium grained	N	marine		none
4	BGS-2455	2910±45	3048	11.5	LS	3		2.5	fine grained	Y	aeolian / marine	70	none
5	Beta-175379	2590±60	2675	6.4	SP	2		3	fine grained	Y	marine	40	none
6	BGS-2456	2465±40	2546	12.3	LS	3		9.5	fine grained	N	aeolian	12	none
7	Beta-191933	2040±40	1990	5.5	SRP		lower peat sample	75	medium grained	N	marine	none	none
8	GSC-6714	1660±50	1560	8.35	SP		2 dates; upper (3)	100	medium grained	Y	marine	60	none
9	BGS-2454	1568±40	1460	5.7	SP		2 dates upper (13)	20	medium grained	N	marine	20	none
11	Beta-175380	400±70	438	9.8	SC	4 (uppermost)		6	fine grained with wood	Y	aeolian	100	LAI Sandy Cove Complex
12	Beta-175377	390±60	434	4.9	SP	1		3	medium grained	Y	marine	88	LAI Arrowhead Complex
13	BGS-2453	308±40	390	5.9	SP		2 dates; upper (9)	20	medium grained	N	marine	20	Dorset Palaeoeskimo
14	GSC-6750	290±50	379	5.5	SC	1		10	wood	Y	marine	800	LAI
15	Beta-175378	160±70	162	6.9	SP	2		1	fine grained	N	aeolian	120	none
17	GSC-6758	130±80	146	8.25	Seal Cove	1		8	medium grained	Y	marine	20	none
16	BGS-2457	133±40	135	12.7	LS	3		14	medium grained	Y	aeolian	130	none
19	GSC-6716	40±80	115	8.5	P	1 and 2 peat		7	medium grained	Y	aeolian	29	none

[a]Calibarated age is given as median probability in the 95% confidence interval (2 sigma)
[b] LS: Little Sahara, SP: Sandy Point, SC: Sandy Cove, P: Parabolic dunes, SRP: South of Rocky Point
c Numbers in brackets refer to the sample number of the other radiocarbon date associated with that peat horizon.

associated with aeolian sand, except three basal peat samples. Prehistoric cultural debitage is found in blowouts at four sites. The following sections summarize the stratigraphy, age and archaeological significance for sites containing peat and palaeosol horizons.

3.3.1 *Peat Deposits*

As described in Section 3.1.3, organic deposits cover a large part of the coastal lowlands, often surrounding aeolian deposits. Sections through these organic deposits can be viewed and studied (only along the coastal cliffs). Five peat samples were taken from three coastal sites located south of *Rocky Point* (sites 4, 5, 8, Fig. 3-13).

The base of the peat in all three of these sites overlies glaciomarine/marine sediments and ranges in elevation from 6 to 7.2 m asl. Peat ranged from 20 cm to 100 cm thick. The composition of peat at all three sites consisted of fine to medium organic debris with wood only identified in site 5. Peat horizons at sites 5 and 8 are overlain by 20 cm and 64 cm of aeolian sand respectively. Both the top and bottom 3 cm of the peat bed were sampled at sites 5 and 8, while only the bottom 3 cm of the peat was sampled at site 4 (Fig. 3-13). Calibrated radiocarbon dates from these samples indicate that peat was accumulating at site 5 between 6370 (GSC-6675) and 1560 cal BP (GSC-6714), and at site 8 between 1460 (BGS-2454) and 390 cal BP (BGS-2453), and peat had started to accumulate at site 4 by 1990 cal BP (Beta-191933; Table 3-6). Peat at site 5 and 8 thus accumulated at approximately 2.0 cm/century. Charcoal is present at the top of the peat deposit at both sites 4 and 5 (Fig. 3-13).

3.3.2 *Palaeosol Horizons*

Most of the 50 palaeosols identified along the Strand were found within 1.5 km of the coastline, exposed in the sides of blowouts. Some were also observed in test pits or coastal sections. In many cases the uppermost horizon (organic horizon) of these palaeosol layers were sampled, however, where the organic horizons were very thin less than 1 cm the entire layer were sampled. Organic material from these uppermost horizons accumulate over time and are subjected to a number of processes, that are not limited to, varying degrees of decomposition, humification and translocation (Matthews 1985). The result of these processes is the production of organic material with a mixed age (Matthews 1985; Catt 1990). Radiocarbon dating of bulk organic samples from buried soils is therefore an average age for the soil development and represents minimum estimates for the initiation of soil development. However, the age also represents maximum estimates of the time period for which the soil has been buried (Matthews 1985). The location and age of 15 radiocarbon dated palaeosols and buried peats are identified in Figure 3-7.

The distribution of dated soils and their simplified stratigraphy is shown in Figure 3-13. Detailed sedimentary descriptions of all of these sites were made (Appendix 1). The following is a brief summary of palaeosol characteristics, and their relationship to archaeological sites.

Buried soil horizons were generally identified overlying fine marine littoral or sub-littoral sediments between 4.5 m and 24 m asl and within aeolian sediments. The thickness of organic horizons commonly ranged from 1 to 14 cm. These horizons were composed of fine- to medium-grained organic material and sometimes included wood. Palaeosols in *Sandy Cove* (GSC-6750) and *Seal Cove* (GSC-6758) contained *in situ* tree stumps (*Picea* and *Abies* respectably) rooted in the palaeosol (Table 3-6). These stumps extended a maximum of 100 cm into the overlying sand. This suggests that palaeosols in these locations were forested prior to being buried by aeolian sand. Of the 51 palaeosol samples collected 71% contained charcoal (Appendix 5). The presence of charcoal suggests that fires may have been a mechanism for the reactivation of sand movement and deposition. Along the Strand, palaeosols are always buried by varying amounts of aeolian sand. On Sandy Point and *Little Sahara* the amount of aeolian sand overlying palaeosols ranged from 0.3 m to 3 m, while in *Sandy Cove* and *Seal Cove* upwards of 4 to 5 m were seen. The relationship between modern vegetation and the underlying aeolian sand generally ranged from sparse marram grass to completely vegetated with a relatively thick mat of low growing shrub vegetation. Modern roots are commonly associated with the aeolian sand and often obscure sedimentary structures within the deposit.

Most of the blowouts contained only one palaeosol layer. Ten sites contained between two and four palaeosols. Varying amounts of aeolian sand separated these horizons. The thickness of the sand found between and above these horizons is variable due to proximity to source, vegetation present and if aeolian sand is forming a dune. Sites containing multiple palaeosols were found within 1 km of the coast and were at higher elevations than sites that contained only one horizon. Those sites at higher elevations are likely more susceptible to changes in moisture conditions and wind erosion and as a result had a longer period of aeolian activity.

Buried soils should follow the law of superposition, in which older palaeosols are always found at the lowest stratigraphic elevation while younger horizons are identified higher in the section (Boggs 1995; Matthews 1985). Radiocarbon dates from Sandy Point, 2590±60 ^{14}C BP (Beta-175379) and 160±70 ^{14}C BP (Beta-175378) and *Little Sahara*, 2910±45 ^{14}C BP (BGS2455), 2465±40 ^{14}C BP (BGS-2456) and 133±40 ^{14}C BP (BGS-2457) confirm that there are no reversals seen in the section and as a result the law of superposition holds true.

Four of the five remaining dates on palaeosols were derived from sites that contained only one palaeosol. These included two sites from Sandy Point that yielded dates of 390±60 ^{14}C BP (Beta-175377; site 7) and 40±80 ^{14}C BP (GSC-6716, site 5); and wood collected from sites in *Seal Cove* and *Sandy Cove* was dated at 130±80 ^{14}C BP (GSC-6758, site 2) and 290±50 ^{14}C BP (GSC-6750, site 1(a)) respectively. The uppermost of four palaeosols in *Sandy Cove* was dated at 400±70 ^{14}C BP (Beta-175380, site 1b).

3.3.3 *Interpretation of Buried Peat and Palaeosol Horizons*

The 15 radiocarbon dated buried soil/peat samples indicate that there has been peat accumulation during the last 5600 ^{14}C BP as well as soil development over the last 3000 ^{14}C BP. Both peat and soil development have been interrupted numerous times by sand deposition. Aeolian activity has been present on the landscape, particularly on the coastal lowland for the last 3000 ^{14}C BP. However, the majority of both the soil development and aeolian activity has taken place in the last 500 ^{14}C BP.

Aeolian activity on the coastal lowlands has been taking place for at least 2910±10 ^{14}C BP (BGS-2455) as suggested by the oldest dated palaeosol from *Little Sahara.* Periods of sand deposition have been interrupted at least two other times. Based on these three dates from the coastal lowlands it cannot be determined if these periods of aeolian sedimentation were localized or widespread. Currently aeolian activity along the coastal lowlands is only seen in localized areas; therefore one might speculate that these past periods of sedimentation were localized as well. The sand source of these deposits based on grain size analysis (Appendix 3) was the underlying marine/glaciomarine sediment.

Approximately half of the radiocarbon dates for palaeosol and peat horizons have ages that are younger than 500 ^{14}C BP. These are found on Sandy Point, *Seal Cove* and *Sandy Cove*. This indicates that the aeolian deposits in these areas are relatively young features, having been formed after the ages of the respective soil horizons. The exception is Sandy Point where aeolian activity occurred, in one location, as early as 2590±60 ^{14}C BP (Beta-

175379) and continued until 160±70 (Beta-175378). Despite this period of aeolian activity, the remaining dates from Sandy Point indicate that aeolian activity was more active in the last 500 ^{14}C BP. Many of these palaeosols developed on the surface of raised beach sediments, indicating that stable vegetated surfaces existed in these areas prior to aeolian deposition. In all three locations aeolian material was derived locally. Small shallow blowouts occurred in places where vegetation was sparse, or had died. The underlying marine sand was the source of all of the aeolian material. Over time the wind eroded more material creating deeper, longer and ultimately larger blowouts. The eroded sand was deposited at the end of the blowout over the vegetation creating buried soils and forming dunes. The mechanisms thought to be responsible for forming series of buried soils and aeolian sands will be discussed in Chapter 4.

3.3.4 *Archaeology and Aeolian Sand*

Sixty percent of archaeological sites were associated with aeolian sediments, but only a fraction of these were examined in detail. Particular attention was paid to 13 sites in which the cultural affiliation was known. These sites are located in *Sandy Cove* (4), *Tub Harbour* (1), *Seal Cove* (2) and Sandy Point (6; Fig. 2-3; Table 2-1). Within these archaeological sites, cultural debris was identified on the blowout floor and palaeosol or peat horizons were located in the blowout wall. Artifacts were traceable to the buried palaeosol/peat layer in only two sites (both of which were dated). Thirteen sites contained both evidence of prehistoric occupation and buried palaeosol/peat, however, only four were radiocarbon dated.

A Dorset Palaeoeskimo site was identified on the east side of Sandy Point (site 8, Fig. 3-13, FkBg-30). Artifacts associated with this culture were found both on the blowout floor as well as in the upper part (5 cm) of a peat horizon (personal observation). The top and bottom of this horizon was dated approximatly10 m to the north in an adjacent blowout. Dates show that peat accumulated from 1568±40 ^{14}C BP (BGS-2454) to 308±40 ^{14}C BP (BGS-2453). This indicates approximately 1200 years of peat accumulation that generally corresponds to the last 900 ^{14}C BP of Dorset Palaeoeskimo occupation, with peat accumulation continuing for 300 years after the disappearance of the group.

The oldest LAI (FkBg-13) site identified along the Strand (6900-7200 ^{14}C BP) is located on Sandy Point (site 7, Fig. 3-13, Table 3-5). This site contained artifacts that were located in the bottom of the blowout. A piece of fire-cracked rock was identified on a buried soil located in the blowout wall. While no other artifacts were identified on top of the palaeosol, the presence of the fire-cracked rock both in the blowout and on top of the buried soil may suggest the LAI were living on this vegetated raised beach. However, the palaeosol was dated at 390±60 ^{14}C BP (Beta-175377; site 7), thus the soil appears to be much younger than the artifacts found in the same locality.

Two archaeological sites containing dated palaeosols are found in *Sandy Cove*. An early LAI site (GbBi-17; site 1a on Fig. 3-13, Fig. 3-14) is located on the floor of a large blowout in *Sandy Cove*. In this blowout only one palaeosol was identified.

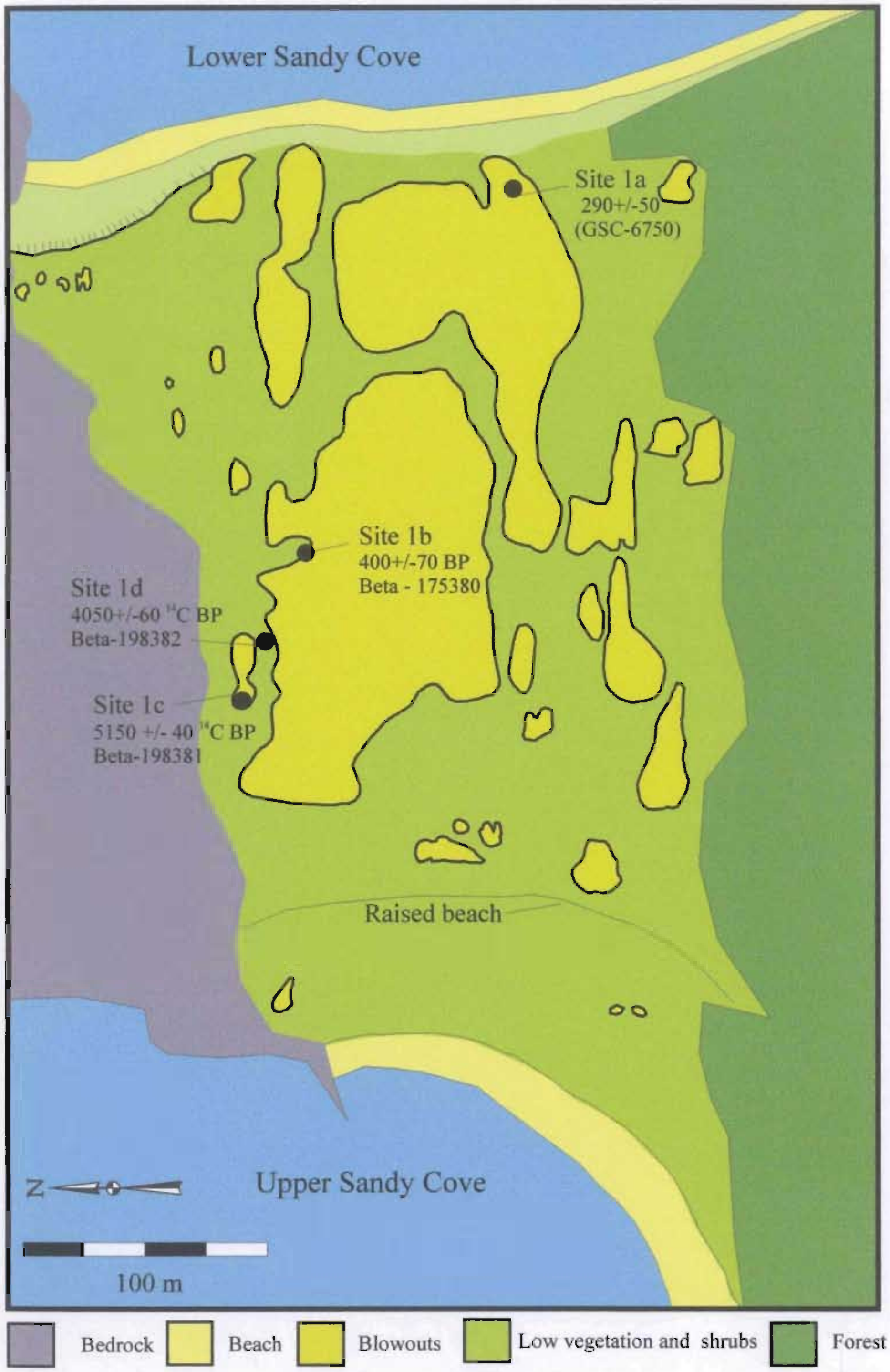


Fig. 3-14: Map of blowouts identified between Lower and Upper Sandy Cove. Map also shows site location and age of radiocarbon dated samples. Sites are referred to in Fig. 3-13 and Fig. 4-10.

Wood from this palaeosol horizon recorded an age of 290±50 ^{14}C BP (GSC-6750). This site also indicates that the palaeosols are younger than the artifacts associated with them.

The remaining archaeological site is located approximately 50 m north of site 1a (Fig. 3-14). This site was interpreted as the Sandy Cove Complex of the LAI (GbBi-07) based on the tool assemblages associated with the remains of three longhouses. The distribution of cultural debris was spread over approximately 50 m^2 that includes two blowouts. The majority of the material was found in a large, deep blowout. In this location the archaeological material was identified on the floor of the blowout as well as eroding from sand in the north side of the blowout. Located approximately 15 m to the north was a smaller shallower blowout containing a hearth associated with characteristic artifacts on the blowout floor. The hearth was located at approximately 55 cm below the present surface, and below two palaeosol horizons in the blowout sides. No artifacts were found in either of the buried soils. The charred material associated with the hearth was radiocarbon dated using the AMS method at 5150±40 ^{14}C BP (Beta-198381; Rankin 2005 personal communication). A test pit dug between the two blowouts revealed a buried soil horizon that was overlain by 93 cm of sand (Rankin 2005 personal communication). No artifacts were identified within the test pit or the buried soil. Radiocarbon dating of charred organics from this palaeosol yielded an age of 4050±60 ^{14}C BP (Beta-198382; Rankin 2005 personal communication). It was not determined if marine sand underlay either the palaeosol found in the test pit or the artifacts located in the small blowout. Examination of the larger blowout identified four buried palaeosols along the northeast along the northeast wall of the blowout (site 1b, Fig. 3-13, Fig. 3-14). Not all of these horizons were continuous, in places only two horizons could be seen and along the northwest side no palaeosols were identified due to slumping and revegetation of the slopes. At site 1b the uppermost palaeosol located at 10 m asl was buried by one meter of aeolian sand. A large Ramah flake was identified within the aeolian sand between palaeosols one and two. The uppermost palaeosol was dated at 400±70 ^{14}C BP (Beta-175380). This age is much too young to be associated with any archaeological remains. Thus, the two radiocarbon dates from this study along with the two associated with the archaeological sites, suggest that this area had a complex aeolian history.

CHAPTER 4 - DISCUSSION

4.1 Environmental History - Introduction

The modern landscape of Porcupine Strand has been influenced by deglaciation, changing sea levels and shifting sands. It is possible to reconstruct a picture of landscape changes that have occurred along Porcupine Strand over the last 8000 ^{14}C BP through detailed mapping and interpretation of the surficial geology, along with radiocarbon dating of organic material. Changes occurred quite rapidly during the two or three millennia following deglaciation, and must have been witnessed by prehistoric cultures who first inhabited this area between 7500 and 7000 ^{14}C BP. Perhaps the most notable of these were changes in sea level; coastline displacement; climate variability and its impact on landscape processes (e.g., coastal erosion and aeolian stabilization); and vegetation change. It may be possible to determine the relationship prehistoric cultures had with the changing environment through the integration of data on landscape change with the archaeological record. By understanding this relationship, it may also be possible to develop strategies for site surveys and to assess how environmental change affected the settlement patterns of prehistoric cultures along Porcupine Strand. The following discussion documents landscape change by providing "snapshots" through time documenting how Porcupine Strand has evolved over the last 10,000 ^{14}C BP.

4.2 Glacial and Post Glacial History

The surficial geology and stratigraphy of Porcupine Strand is the product of a changing environment that evolved from being influenced by glacial ice (a tidewater ice margin to ablation on land), changing sea levels, vegetation and soil forming processes as well as aeolian activity. Radiocarbon dated marine shells derived from glaciomarine muds and sands allow the time of deglaciation and the pattern of retreat to be determined. The timing of deglaciation is particularly important as it identifies when land would have been ice-free and available for migration and occupation by prehistoric cultures.

The identification of till at the base of the coastal cliffs at the northern end of the Strand suggests that till may underlie the wedge of glaciomarine sediments that dominate the coastal lowlands (Section 3.1.1). Thick sequences of till found to the east on the inner Labrador Shelf (Josenhans *et al.* 1986) as well as to the west within Lake Melville were deposited during the Wisconsinan glaciation (Syvitski and Lee 1997). The ice contact margin that deposited the till occurred prior to 10,000 ^{14}C BP as ice was at the eastern end of Lake Melville by this time (Syvitski and Lee 1997).

The stratigraphic relationship of the till and overlying glaciomarine sediments indicates that ice was replaced by water upon deglaciation of a tidewater margin in which the ice margin eventually became unstable and retreated. During this time glaciomarine mud was deposited. Syvitski and Lee (1997) interpreted the deposition of sorted sands and mud containing ice-rafted dropstones as forming in an ice-proximal environment during the retreat of the Laurentide ice front. A similar environment can be suggested for the deposition of massive muds that underlie the Strand. Shells collected from the glaciomarine mud are dated at 8820±70 ^{14}C BP (TO-10948) a minimum age for the deposition and deglaciation. Based on faunal environmental preferences, water depths are likely on the order of 10's of meters, and are no more than 80 m (Abbott 1968; Peacock 1993).

The sea inundated the isostatically-depressed coastline up to a marine limit of 116 m asl. As ice retreated on to land, the melting ice discharged debris-rich meltwater. Debris, carried in the meltwater as bedload, was deposited as meltwater flow decreased forming glaciofluvial outwash deposits. Glaciomarine sand was deposited at the distal end of these sandur deposits where meltwater carrying suspended load entered the sea. These glaciofluvial and sandy glaciomarine sediments were deposited over the glaciomarine mud as the sandur prograded seaward. The fine-grained sands were deposited rapidly as meltwater entered the sea as suggested by dewatering structures at the base of the sand unit (Boggs 1995). Radiocarbon dates on marine shells found in the lowermost sand units identify the onset of this glaciomarine deposition to have occurred at 7430±100 ^{14}C BP (GSC-6677). This date is similar to other dates that were acquired from the lowermost sand units both on the Strand and in Sandwich Bay, at 7590±160 ^{14}C BP (GSC-1284) and 7840±100 ^{14}C BP (GSC-2196) respectively. The presence of slightly coarser material in the upper parts of the glaciomarine sand unit is typical of Hjulström type delta formation in which inverse grading with depth is the result of distal enlargement of the delta (Hjulström 1952). The minimum age for the onset of progradation of sandur deposits for the Porcupine Strand is 7800 ^{14}C BP.

The pitted surface of outwash plains along the North Strand and in the valleys of the uplands indicates ice-proximal environments. Kettle holes are more prominent in the western parts of these plains. Such kettles indicate the melting of buried stagnant ice. Detailed studies by Rogerson (1977) suggested that these outwash deposits formed in five phases, due to waning ice within the uplands that underwent periods of still stands followed by retreat.

The eastern edges of the main outwash plains are marked by raised beaches (Plate 3-9). These beaches are used to provide a minimum estimate of marine limit of 92 m asl for the northern Strand. Estimated to have formed at approximately 8000 ^{14}C BP, their curved NW-SE orientation suggests a different configuration than the modern shoreline configuration. As glacioisostatic rebound took place, the relative location of sea level fell in relation to the rising land creating new palaeoshorelines.

Examination of regional patterns of ice retreat allows a better understanding of deglaciation along Porcupine Strand. The retreat of the ice margin by 10,000 ^{14}C BP as indicated by an overstepping sequence of ice distal mud in Lake Melville suggests that outer Groswater Bay was deglaciated by this time (Syvitski and Lee 1997). Between 10,000 and 9000 ^{14}C BP, the ice margin underwent a short-lived stillstand with minor fluctuations of retreat or readvance (Syvitski and Lee 1997). To the southwest of Groswater Bay, this period is marked by the formation of the Paradise Moraine. The moraine is composed entirely of glaciofluvial sediment and is interpreted as marking a landward stillstand of the Laurentide Ice Sheet at 9700 ^{14}C BP (Fulton and Hodgson 1979; King 1985; Vincent 1989; McCuaig 2002a). This regional picture of deglaciation indicates that the Porcupine Strand must have been deglaciated some time prior to the formation of the Paradise Moraine. The dates on marine shells obtained in this study (8820±70 ^{14}C BP, TO-10947 and 7430±100 ^{14}C BP GSC-6677) provide evidence that deglaciation occurred earlier than previously suggested in this area (c.f. Rogerson 1977).

The timing of deglaciation would have influenced the migration of prehistoric peoples. As a result of early deglaciation of the Strand, prior to 8820±70 ^{14}C BP (TO-10947) ice was not present to hinder the migration of the earliest potential prehistoric cultures at approximately 8000 ^{14}C BP. The landscape encountered at this time differs considerably than the modern configuration (Fig. 4-1). Inhabitants standing on the beach (92 m asl) would have been able to see glaciers in the uplands. They would have witnessed changing flows of the meltwater rivers crossing the large sandur plains as a result of the draining of the inland continental ice sheet. Most importantly they would have experienced higher sea levels that would have covered the extensive coastal lowland forming a shoreline in front of the *Porcupine Hills* and *Uplands*. As sea level fell, occupants would have moved from this location, following the shoreline as new beaches formed in the falling sea. These raised beaches are therefore potential areas where new archaeological remains may be located. This will be further discussed following a discussion of the sea-level history of Porcupine Strand.

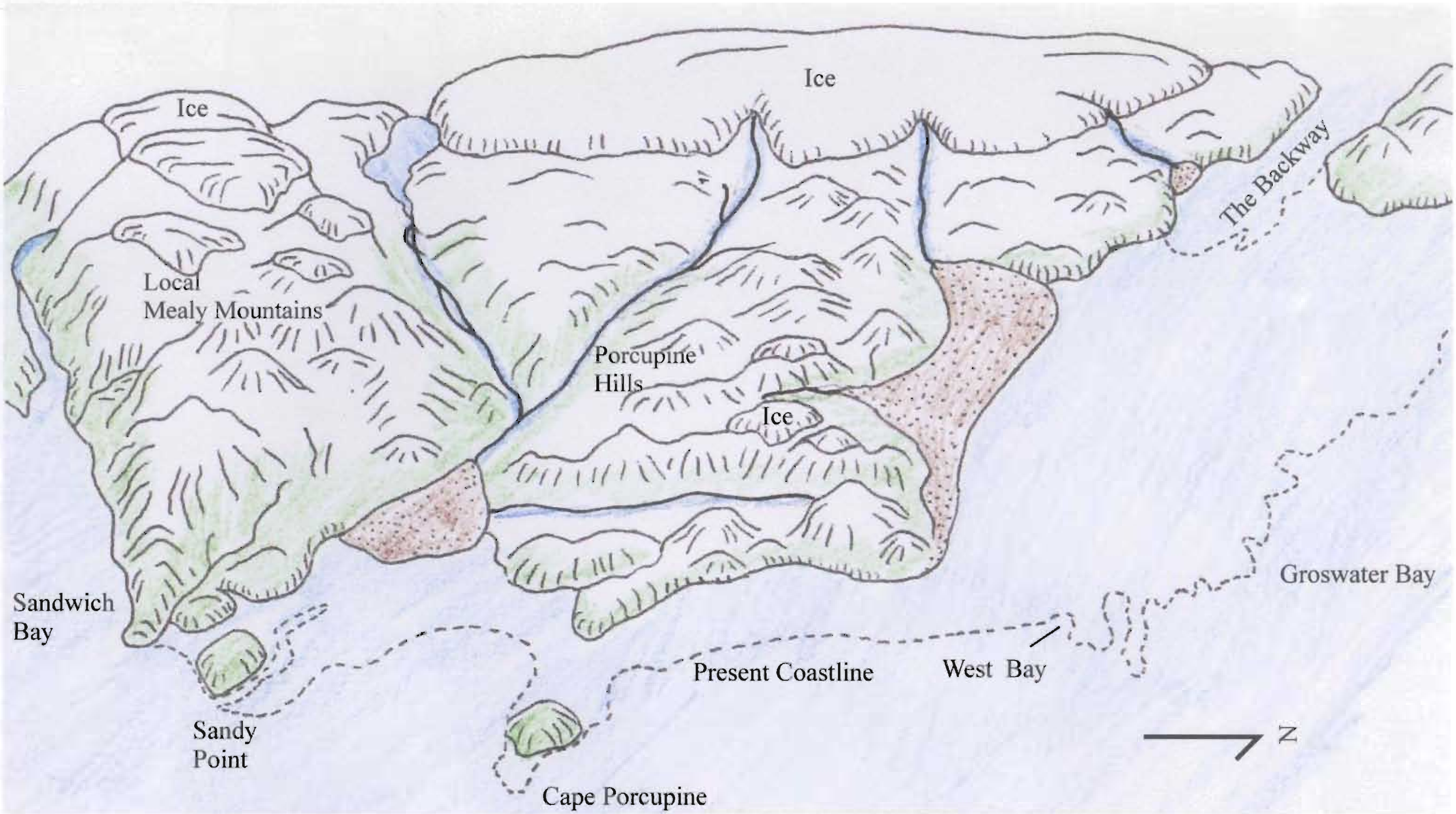


Fig.4-1: Schematic sketch showing the landscape the first prehistoric peoples may have seen at 8000 ^{14}C BP. Notice the remnant ice in the Uplands, and west of Porcupine Strand. The shoreline at this time is approximately 88 m asl.

4.3 Sea-Level History – A Comparison of Models

Introduction

Sea-level history is represented by two similar curves for Trunmore Bay and *West Bay* (Fig. 3-12). The general shape of the curves is the same, however the differences lie in the height and age in marine limit. Both curves have a steep sloping form showing a rapidly emerging coastline for the first 1000 ^{14}C BP, after which time emergence slows considerably until 4500 ^{14}C BP and is eventually replaced by submergence. The timing and estimated depth of submergence for the two curves differs (4 to 6 m) and is related to the differences in the timing of marine limit. The result is that submergence occurs earlier in Trunmore Bay at approximately 6900 ^{14}C BP, followed by *West Bay* at 5500 ^{14}C BP. These curves are characteristic of a Type-B sea-level history that records initial coastal emergence that is greater than the subsequent submergence (Quinlan and Beaumont 1981; Liverman 1994). This type of curve has not been proposed for the southeast Labrador coast prior to this study.

These curves differ significantly from those proposed by Rogerson (1977) and Clark and Fitzhugh (1992) for the same area. Rogerson's (1977) curve can be compared to both proposed curves as samples used to construct his curve have a wide spatial distribution from Sandwich Bay to Groswater Bay. The curve of Clark and Fitzhugh (1992) is for the area north of *West Bay* and cannot be compared to the Trunmore Bay curve.

4.3.1 *Comparison of the Proposed Models and Rogerson's (1977) Model*

The sea-level curves shown here incorporate the same data presented by Rogerson (1977), but this data is interpreted differently (Fig. 4-2). Rogerson's (1977) sea-level history envelope showed an oscillation of sea level during the overall emergence of the Strand (a modified Type-A curve). The curve proposed here shows a Type-B sea-level history of emergence followed by submergence. The differences in interpretation stem from the collection of new data, specifically the identification of new archaeological sites and differing interpretations of a section at *Woolfreys Brook.*

Rogerson (1977) constructed one preliminary emergence envelope for Porcupine Strand based on limited data. This curve used a median value of marine limit along the Strand. Use of this median estimate of marine limit along with an early estimate of deglaciation gives the curve a lower gradient than the proposed model.

Rogerson's (1977) envelope portrays a history of emergence with a brief oscillation sea level that occurs above present sea level. The models presented here are constrained by archaeological sites that are found within or below Rogerson's (1977) envelope. In Trunmore Bay the proposed curve is confined to a location between an old LAI site (sample 34; Table 3-4; Fig.4-2) and the 7430±100 ^{14}C BP (GSC-6677; sample 2; Table 3-4; Fig.4-2) age of glaciomarine sands. This suggests the curve extends below present sea level at approximately 6900 ^{14}C BP. The presence of this and other archaeological sites

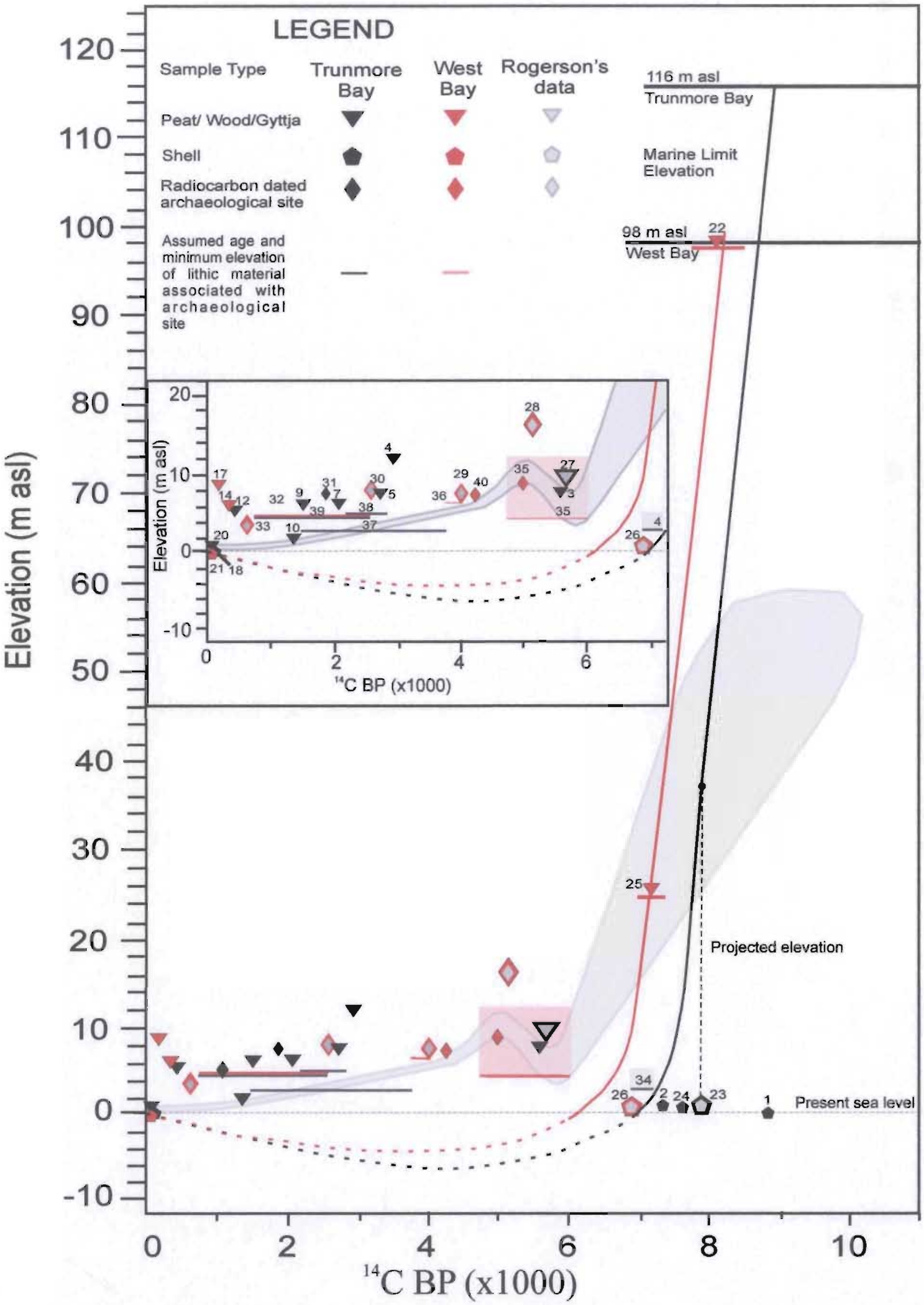


Fig. 4-2: Proposed sea-level history for Trunmore Bay (black) and West Bay (red) and Rogerson's (1977) sea-level history model for Porcupine Strand (grey). The dotted lines represent unconstrained portions of the curves. The elevation of each sample type is indicated by the lower most point of both the diamonds and triangles and the uppermost point of the pentagon. The colored boxes paired with the archaeological sites represent the elevation error associated with each site.

on Sandy Point indicates that Rogerson's (1977) curve may no longer be the best representation for sea-level history along Porcupine Strand.

The presence of a dated archaeological site (5150±40 ^{14}C BP; Beta-198381; Sandy Cove Complex of the LAI; sample 35) in *Sandy Cove*, also questions the validly of Rogerson's (1977) sea-level curve. Comparison of this site to Rogerson's (1977) model shows that the majority of the elevation range associated with the site falls below Rogerson's (1977) sea-level curve. Indicating that the archaeology site would have been submerged at the time of occupation. Therefore, in consideration of the new data, this indicates that Rogerson's (1977) curve for both *West Bay* and Trunmore Bay is no longer suitable and modifications are needed.

The oscillation in the sea level identified by Rogerson (1977) was based on the presence of a buried peat (5640±100 ^{14}C BP; GSC-2480) within a section at *Woolfreys Brook*. The buried peat is situated at 9 m asl in a former lagoon environment behind a number of beach ridges. The lowest sediments exposed in this section were described as faintly cross-bedded fine sand that contained occasional pebbles and lenses of gravel. Above this lower unit, moderately to well-sorted fine sand interpreted as marine beach sands underlay 5 cm of peat. The peat was dated at 5640±100 ^{14}C BP (GSC-2480) and was overlain by a 1 m thick bed of mottled sand and pebbles. Rogerson (1977) suggested that the unit overlying the peat was not aeolian and was unlikely to be fluvial because the presence of the peat indicated that stream levels were below 9 m asl at this time. He interpreted this uppermost sand unit as beach sand and gravel that was deposited during a brief marine transgression. Rogerson proposed that the height of the transgression is given by the height of a cliff face, 12 m asl, that cuts across older raised beaches south of Cape Porcupine (Blake 1983). Raised beaches formed since the transgression, during emergence, have orientations similar to the present shoreline. Buried peats were identified during the present study, but were all overlain by aeolian sand. None appear similar to the description given by Rogerson (1977) for the *Woolfreys Brook* site. The *Woolfreys Brook* site was not examined during the present study and no other evidence was collected during the present study to indicate a rise in sea level at this time.

The oscillation in Rogerson's (1977) curve is dependent on the understanding and interpretation of the *Woolfreys Brook* site. The sediments described by Rogerson (1977) do not reflect a typical transgressive – regressive sequence (Boggs 1995). The description given by Rogerson (1977) is not sufficiently detailed to effectively rule out other mechanisms for deposition of the upper sand unit without investigating the *Woolfreys Brook* site. Rogerson's (1977) interpretation, of *Woolfreys Brook*, is just one of several alternative hypothesis that may result in similar beds of fine-grained sand containing pebbles. Comparable deposits may be generated in a fluvial or storm setting or perhaps the result of a tsunami (Foster *et al.* 1991; Boggs 1995; Tuttle *et al.* 2004).

Rogerson's (1977) brief sea-level oscillation has not been incorporated into the present models as a result of 1) not identifying any other evidence to support a marine transgression, 2) not visiting the site, 3) not being able to use the sedimentary description to conclude that it is a marine deposit as well as 4) being incompatible with newly recognized archaeological sites present along the Strand.

4.3.2 *Comparison of the West Bay Model to Clark and Fitzhugh's (1992) Model*

The Type-A sea-level history proposed for outer Groswater Bay by Clark and Fitzhugh (1992) has both similarities and differences to the proposed Type-B (*West Bay*) sea-level curve (Fig. 4-3).

Although the two curves initially record emergence, the slope of the curves are quite different. This is largely due to the way in which Clark and Fitzhugh (1992) constructed their curve. The curve is constrained by marine shells as the lower constraints and archaeological sites as the upper constraints. Due to the absence of geological data used to constrain the age of marine limit for the older portion of the curve, Clark and Fitzhugh (1992) used a physical mathematical model to extrapolate the age of marine limit. The model was based on smoothly decelerating exponential curves identified in the Arctic. Using an exponential decay constant 'k' (0.39) in the exponential decay equation, Clark and Fitzhugh (1992) were able to produce a smooth extrapolated curve extending from the constrained portion of the curve to the elevation of marine limit. The 11,000 ^{14}C BP age of marine limit at 75 m is considered an early estimate of marine limit for Groswater Bay (Clark and Fitzhugh 1992).

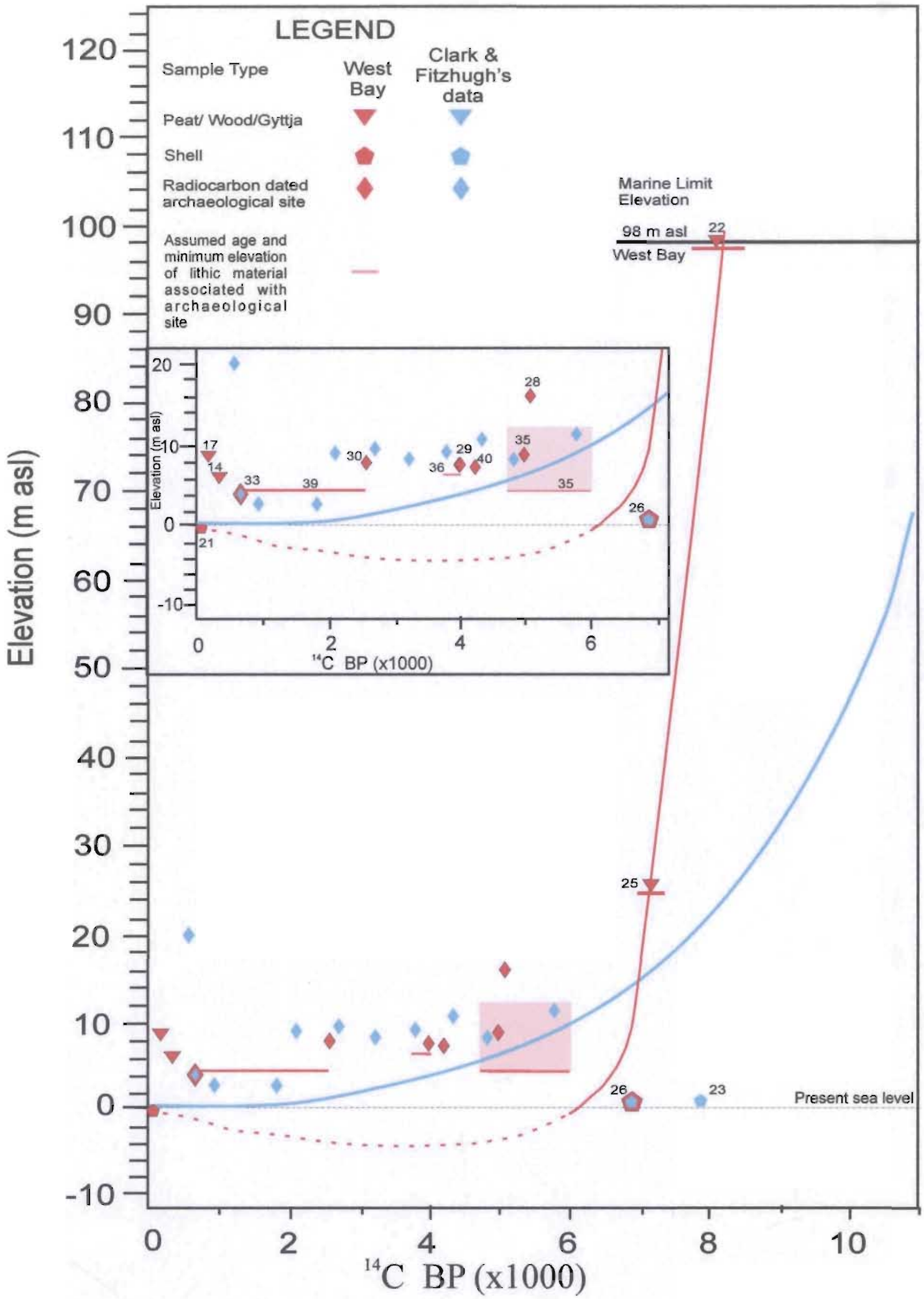


Fig. 4-3: Proposed sea-level history for West Bay (red) and Clark and Fitzhugh's (1992) sea-level history model for outer Groswater Bay (blue). The dotted line represent unconstrained portions of the curve. The elevation of each sample type is indicated by the lower most point of both the diamonds and triangles and the uppermost point of the pentagon. The colored boxes paired with the archaeological sites represent the elevation error associated with each site.

The proposed curves differ significantly after 7000 ^{14}C BP. The Clark and Fitzhugh's (1992) model represents a Type-A sea-level history of continual emergence. The curve proposed here is a Type-B sea-level history of initial emergence followed by submergence. Clark and Fitzhugh's (1992) curve remains above present sea level because it is constrained by the presence of archaeological structures and assemblages within sites that suggest a close association to sea level at that time. New geological and archaeological data presented here is compatible with Clark and Fitzhugh's (1992) model of sea-level history. This suggests that Clark and Fitzhugh's (1992) model is still a valid alternative, particularly the part of the curve that is younger than 7000 ^{14}C BP. The part of Clark and Fitzhugh's (1992) curve younger than 7000 ^{14}C BP represents the uppermost position in which the curve could be placed and still remain valid sea-level history. The proposed sea-level curve is preferred because it uses geological data to produce the entire curve instead of using geophysical models to extrapolate the sea-level history. The age of marine limit and deglaciation are likely much older than those identified on the proposed curve, however, these represent the minimum estimates using the available data from the area. Clark and Fitzhugh (1992) did not use Jordan's (1975) elevation of the gyttja/clay transition or the resulting dates from these features in the construction of their curve. Diatom assemblages from the Sandy Cove Pond gyttja/clay transition at 98 m asl suggest that the depositional environment was freshwater to brackish water and sea level was at or slightly above this elevation (Jordan 1975). Raised beaches on the southern shore of Groswater Bay have a similar elevation, 92 m asl, for marine limit in this area. Sea-level changes at these two sites most likely occurred at roughly the same time due to similar elevations. However, the marine limit used in the extrapolated part of the curve by Clark and Fitzhugh (1992) was much lower. While the acceptance of Jordan's (1975) ages for marine limit are based on bulk samples with low organic content that result in ages with large error bars, it does provide minimum age estimates for marine limit within the area. This allows for an original curve to be drawn that takes into consideration the available data, with acknowledgements that it is based on dates that are likely much older.

4.3.3 *Palaeoshorelines and Prehistoric Peoples*

Carvings of marine mammals along with faunal remains of whales, seals, and sea birds in the archaeological record indicate that Labrador's prehistoric cultures had a close relationship to the sea. The sea was an important resource as it was a source of food, clothing, and tools; as well as a potential means of transportation. The location of archeological sites on raised beaches and terraces is further evidence of the relationship these cultural groups had with the sea. Clark and Fitzhugh (1992) indicated that summer sites of historic and modern Labrador Inuit are found within 1-3 m of high-tide, while winter sites have little reliable shoreline association. The work of Andrews *et al.* (1971) in coastal Arctic Canada determined a close relationship between the known age of the site and the site age predicted from the relative sea-level history. This demonstrates that most sites (summer) are located within a few meters of the predicted elevation determined from the relative sea-level history, while higher elevation sites are generally associated with winter sites.

Changes in sea level have likely affected the distribution of archaeological sites. Temporal and spatial changes identified within the sea-level history enables the palaeoshoreline configuration to be constructed, thereby locating areas likely to have been used by prehistoric peoples. This section examines the relationship between prehistoric site distribution and changing sea level, identifying the potential of using sea-level history as a tool for archaeological exploration. These relationships are based on using the preliminary sea-level history proposed in this study.

A rapid rate of emergence is identified for the Groswater Bay and Trunmore Bay curves until 7000 and 7500 ^{14}C BP respectively. During this time, sea level fell over 88 m in the Groswater Bay area and more than 106 m in Trunmore Bay. Between 7500 and 4500 ^{14}C BP, sea level fell more than 10 m, and in the last 4500 ^{14}C BP sea level has risen to present levels.

There are two distinct site distribution patterns that can be predicted from the sea-level history. The earliest cultures (e.g. LAI) to occupy Porcupine Strand would have occupied sites on palaeoshorelines that were higher than present and associated with the emergence phase of sea-level history. The sites of these earliest cultures would have occupied a large range of elevations, moving progressively to lower elevations as sea level fell, owing to the fast rate of emergence. Cultural groups present during the period of submergence may have occupied palaeoshorelines that are now below the present shoreline configuration. As a result of sea level rising at an extremely slow rate during this time period, low elevation areas close to the modern coastline may have been occupied by more than one culture. There is no distinctive pattern identified on the Strand, particularly on Sandy Point where sites for four cultural groups appear to be randomly distributed. Sites that are located close to the coast, for example the Dorset Palaeoeskimo site (FkBg-30) on the east side of Sandy Point, are subject to erosion caused by rising sea level.

During a fall of sea level, topography influences the area emerged and the configuration of palaeoshorelines. Sea-level changes in areas that have a steep gradient, e.g. *Porcupine Hills*, are less apparent because large changes in sea level are needed to expose large areas of land. For areas that have low gradients, e.g. the coastal lowlands, small changes in sea level expose large areas of land and result in more dramatic changes in palaeoshoreline configuration.

4.3.4 *Palaeoshoreline Reconstructions*

The LAI were the first culture to have reached Groswater Bay. Jordan (1975) reported that this had occurred by 7500 ^{14}C BP, 500 years after LAI sites are found in the Straits of Belle Isle (Tuck and McGhee 1975). With sea level falling rapidly between 8000 and 7500 ^{14}C BP, the changes in the paleoshoreline configurations are dramatic and would have been important to the location of LAI sites. The sea-level curves for Trunmore Bay and *West Bay* differ and as a result there are variations in the elevation of palaeoshorelines between the two areas. Palaeoshoreline configurations that were reconstructed for the two areas show substantial change at the following times, 8000, 7500, 7000 and 6000 ^{14}C BP (*West Bay* only). In addition, a palaeoshoreline reconstruction is also identified for the lowstand that may have occurred around 4500 ^{14}C BP. The earliest LAI settlers would likely have used the oldest shorelines identified at higher elevations. The remaining palaeoshoreline reconstructions identify how prehistoric cultures may have shifted their sites with changing sea levels.

Sea-level curves allow for elevations of palaeoshorelines to be predicted. For example, at 8000 ^{14}C BP, sea level in *West Bay* is at 88 m asl, while the elevation in Trunmore Bay is only 43 m asl. Tracing the corresponding contour, on the 1:50,000 scale topographic map identifies the configurations for the palaeoshoreline at 8000 ^{14}C BP. Shorelines are only constructed for areas where the sea-level history is well constrained.

The delineation of palaeoshorelines points to areas where archaeological sites of similar age might be found. This allows archaeologists to plan site surveys along a narrow range of elevations and search for a prehistoric culture that might have occupied these elevations at a particular time. For example, LAI occupations along the Strand span approximately 7500 to 3500 ^{14}C BP. During this time the palaeoshoreline elevation would have decreased progressively from 88 m asl to below present sea level and archaeological sites might be found throughout this range. This large elevation range suggested for the LAI can be divided into smaller parts using the cultural complexes associated with the LAI. For example, the Sandy Cove Complex (6000 to 4700 ^{14}C BP) identified north of *West Bay* would be located between -4 and 12 m asl, while the Rattlers Bight Complex (4000 to 3800 ^{14}C BP) would be found between -4 and 6 m asl. These elevation ranges are predicted using the sea-level curve proposed here and that of Clark and Fitzhugh (1992). The reconstruction allows for the identification of particular elevations but also indicates areas such as sheltered bays, headlands or islands that would be favoured by prehistoric peoples based on the amount of shelter, the view and the proximity to freshwater. This directs the planning of archaeological surveys to an elevation range for a particular time period or cultural group, as well as focusing on areas that may contain raised beaches and terraces that are more likely to have been occupied by prehistoric peoples. This may allow for a higher success rate in identifying new archaeological sites.

8000 ^{14}C BP Palaeoshoreline

The 8000 ^{14}C BP palaeoshorelines identified for *West Bay* and Trunmore Bay differs by approximately 40 m.

The elevation of the palaeoshoreline within Trunmore Bay is approximately 43 m asl. Numerous beaches are found above this elevation, but two correspond to the 43 m palaeoshoreline. As Fig. 4-4 indicates, the 8000 ^{14}C BP shoreline is much different from the present configuration. This palaeoshoreline is located approximately 5 km inland of the modern shoreline and has two small embayments in the areas of *Big Brook* and North River, one major headland south of North River, and three islands appear offshore.

The *West Bay* palaeoshoreline is much higher, located at 88 m asl. Four small islands on the hill southwest of *Sandy Cove* is the only exposed land (north of *West Bay*) at this time.

8000 ^{14}C BP Palaeoshoreline

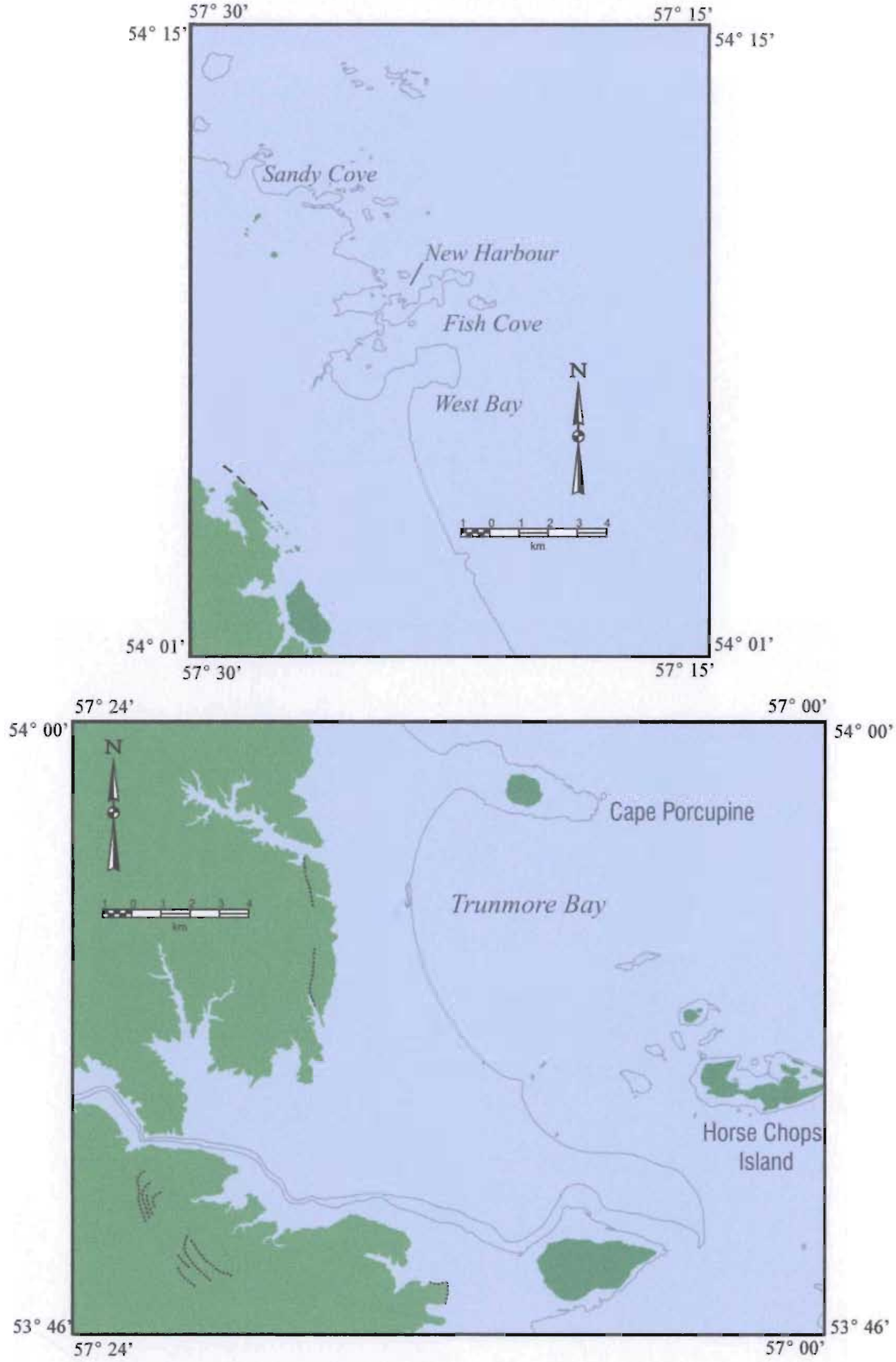


Fig. 4-4: Position of the 8000 ^{14}C BP palaeoshoreline in West Bay and Trunmore Bay (green). At this time sea level is 88 m asl (300 ft contour) in West Bay and 43 m asl (140 ft contour) in Trunmore Bay. Dashed lines indicate raised beaches.

7500 ^{14}C BP Palaeoshoreline

Sea level fell over 30 m in 500 years within Trunmore Bay (Fig. 4-5). The 7500 ^{14}C BP paleoshoreline is located at 12 m asl. By this time, the shoreline had migrated up to 12 km seaward north of North River. This palaeoshoreline corresponds to the location of the prominent coastal cliff and has a similar configuration to the modern coastline. At this time the majority of the modern coastal lowlands had emerged above sea level. The coastline line was relatively straight and had very few embayments. Cape Porcupine was attached to the mainland and the lagoon formed at *Woofreys Brook*. Horse Chops Island formed the largest island in Trunmore Bay. Sandy Point was the only portion of the Strand that still remained submerged.

In this time frame sea level within the *West Bay* area fell approximately 34 m. Despite this large change, the palaeoshoreline remained similar to the 8000 ^{14}C BP palaeoshoreline. The only emerged land north of *West Bay* was an expansion of the islands exposed at 8000 ^{14}C BP.

7000 ^{14}C BP Palaeoshoreline

The coastal configuration in Trunmore Bay at 7000 ^{14}C BP was very similar to the modern coast as at this time sea level was approximately 1 m above present (Fig. 4-6). At this time Sandy Point had emerged, as well as the remainder of the smaller islands. Emergence continued after this time to some unknown elevation below present sea level.

$7500^{14}C$ BP Palaeoshoreline

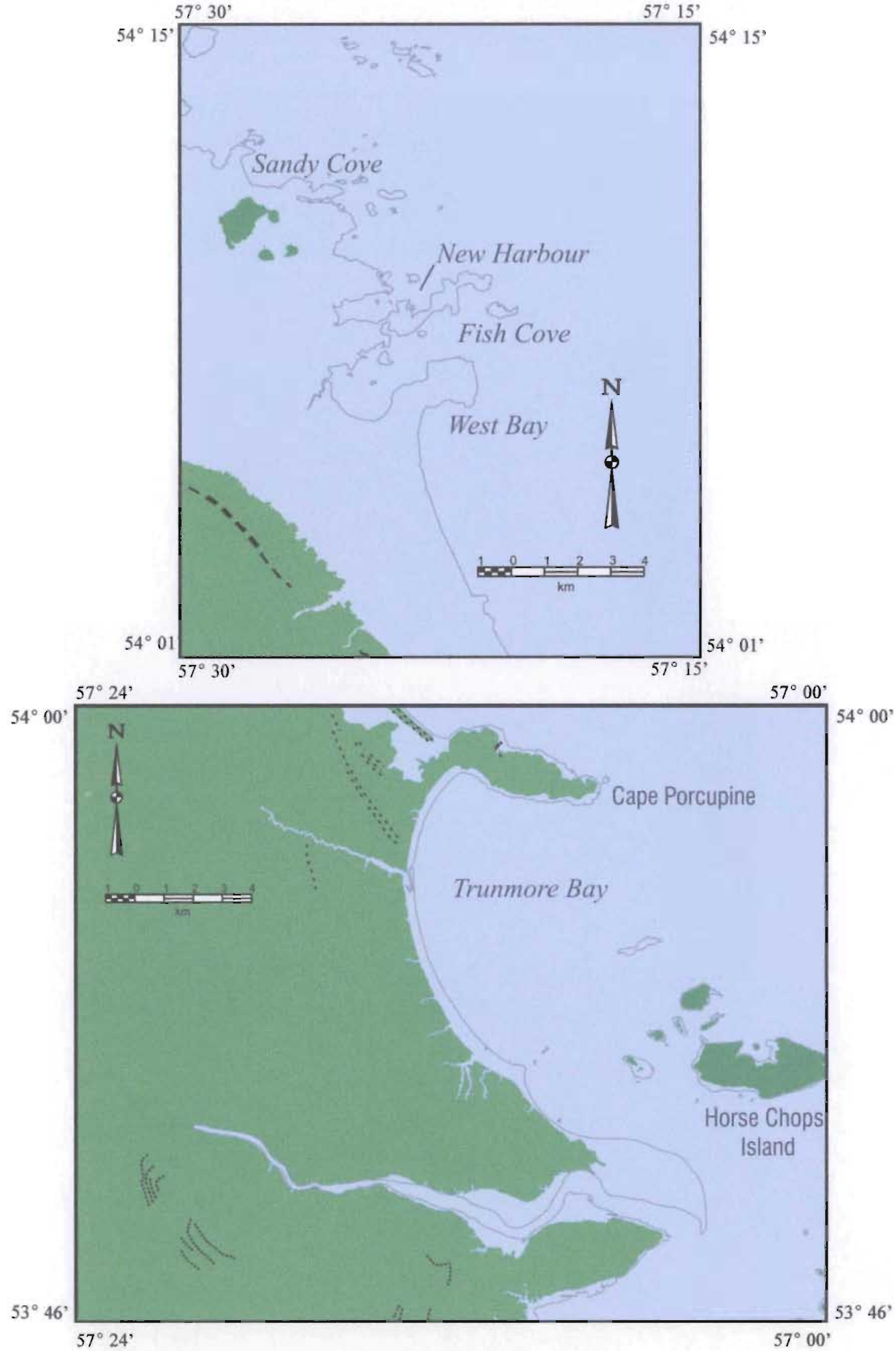


Fig. 4-5: Position of the 7500 ^{14}C BP palaeoshoreline for West Bay and Trunmore Bay (green) in relation to the modern coastline (black). At this time sea level is 55 m asl (180 ft contour) in West Bay and 12 m asl (40 ft contour) in Trunmore Bay. Dashed lines indicate raised beaches.

7000 ^{14}C BP Palaeoshoreline

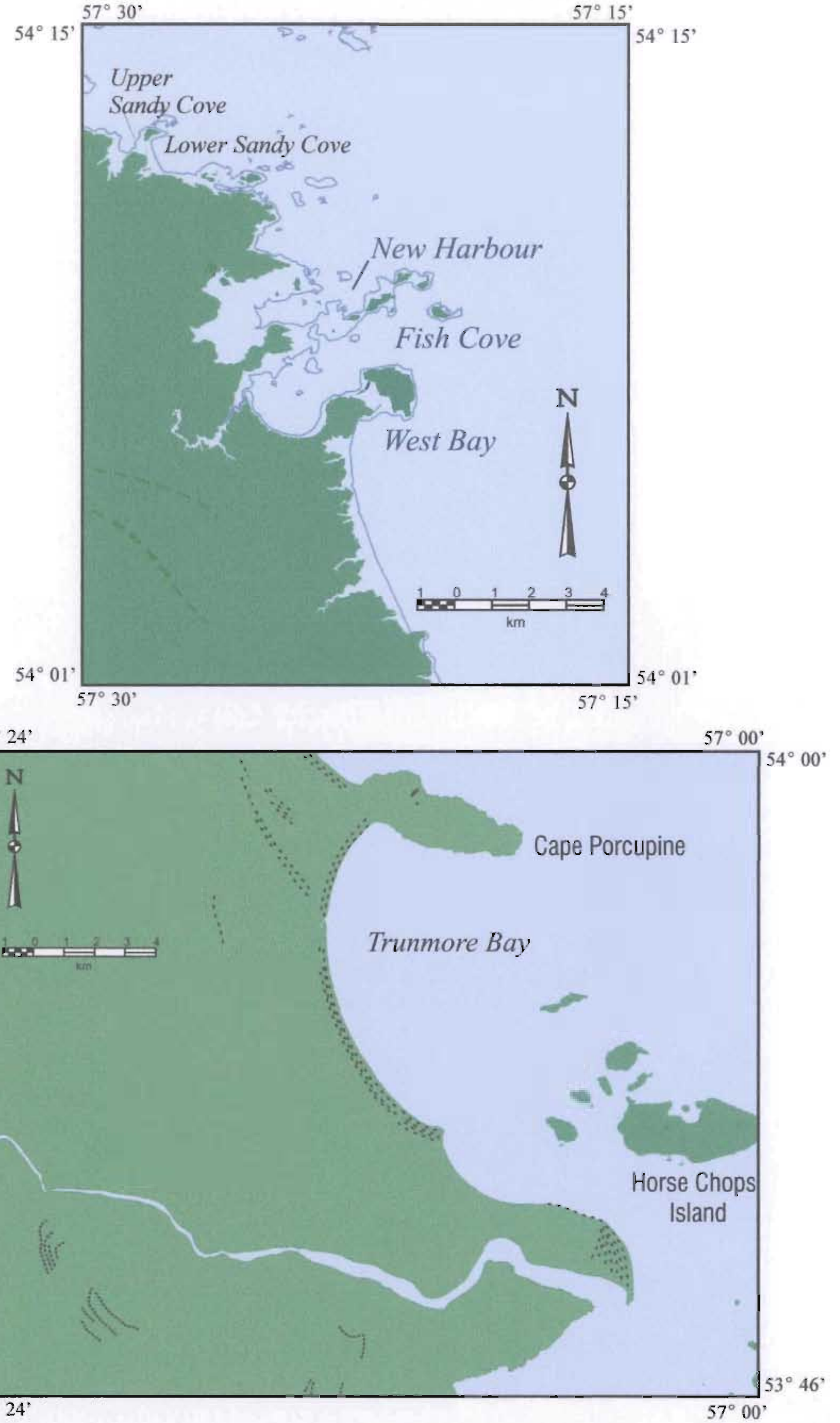


Fig. 4-6: Position of the 7000 ^{14}C BP palaeoshoreline for West Bay and Trunmore Bay (green) in relation to the modern coastline (black). At this time sea level is 12 m asl (40 ft contour) in West Bay and 1 m asl (0 contour) in Trunmore Bay. Dashed lines indicate raised beaches.

By 7000 ^{14}C BP sea level was approximately 12 m above present in *West Bay*. This palaeoshoreline differs notably from the 7500 ^{14}C BP configuration. The majority of the land north of *West Bay* emerged within 500 ^{14}C BP. Bays separated by a small headland formed in the vicinity of *Plances Bight* and *New Harbour*. Both *Sandy Cove* and *Seal Cove* remained submerged at this time.

6000 ^{14}C BP Palaeoshoreline

By 6000 ^{14}C BP sea level in *West Bay* was within 1 m of contemporary sea level (Fig. 4-7). *Sandy Cove* and *Seal Cove* had formed and the coastline resembled the modern configuration, with the exception of the headland separating *Plances Bight* and *New Harbour*. This area appears as a number of islands.

4500 ^{14}C BP Palaeoshoreline

Sea level was likely between 4 and 6 m below present sea level at 4500^{14}C BP. This is an estimate based on extrapolation of the well constrained parts of the curves and typical shapes of Type-B Curves (Quinlan and Beaumont 1981). The palaeoshoreline can be reconstructed using preliminary bathymetric charts obtained from the Canadian Hydrographic Service (1983). The limitation of these preliminary maps is that the bathymetry is constructed in 10 m intervals. The 4500 ^{14}C BP palaeoshoreline configuration (-6 m) is extrapolated from the 10 m bathymetry and is shown in (Fig. 4-8). There is less land exposed north of *West Bay* and as a result the shoreline looks much different than that in Trunmore Bay (Fig. 4-8). Land is emerged to half way along Cape

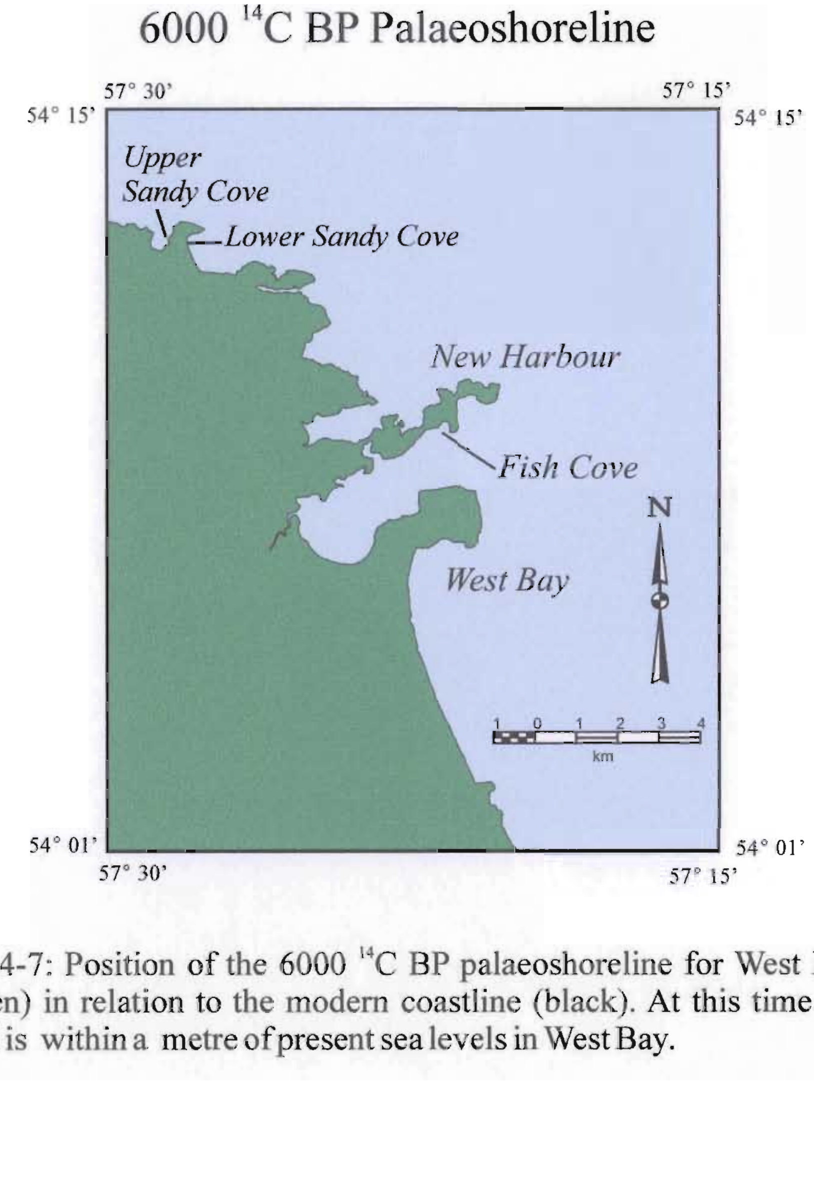


Fig. 4-7: Position of the 6000 ^{14}C BP palaeoshoreline for West Bay (green) in relation to the modern coastline (black). At this time sea level is within a metre of present sea levels in West Bay.

4500 ^{14}C BP Palaeoshoreline

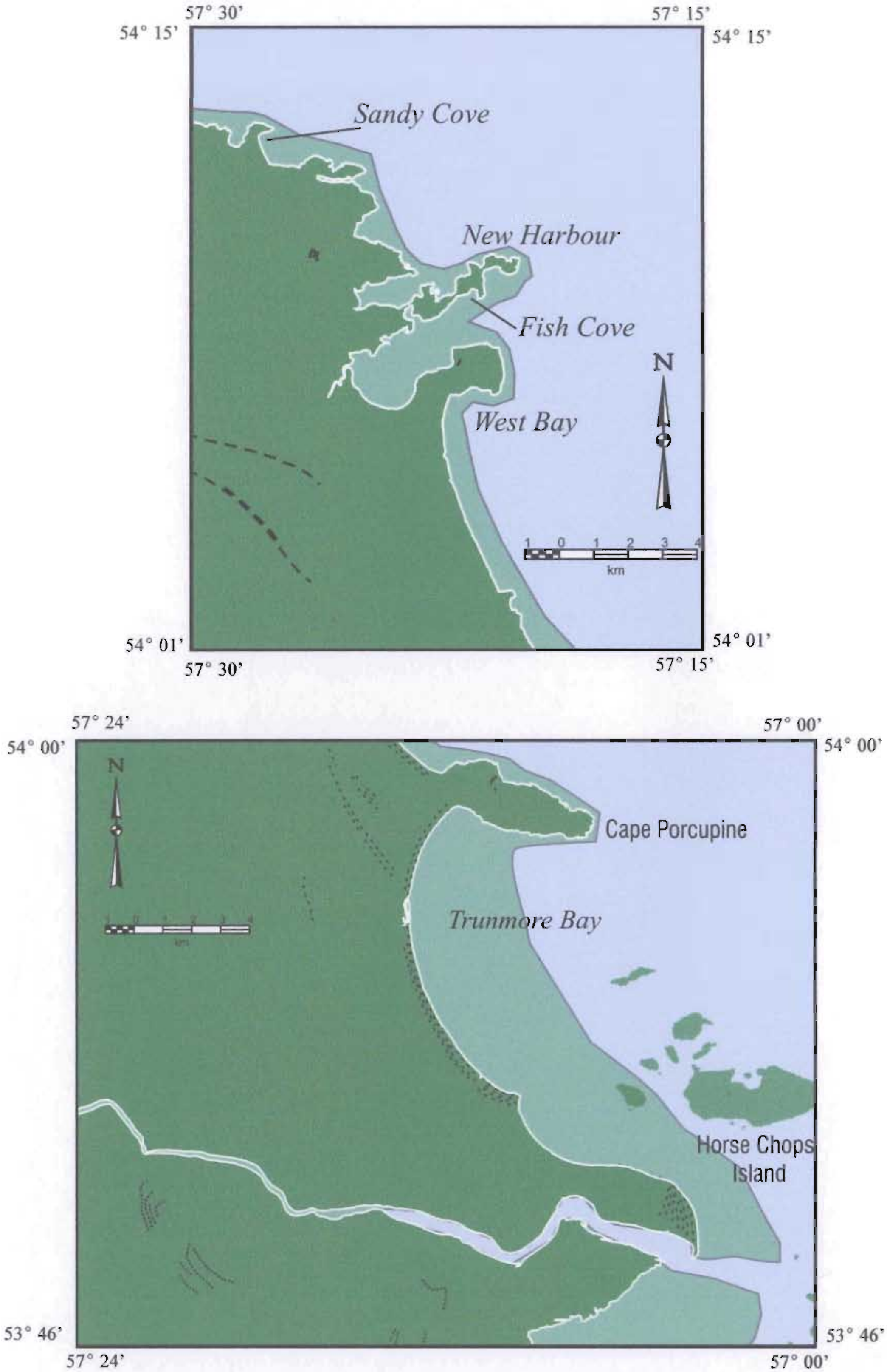


Fig. 4-8: The 4500 ^{14}C BP lowstand palaeoshoreline for West Bay and Trunmore Bay estimated at 4 to 6 m below present.

Porcupine, encompassing a number of the present near shore islands. A large portion of this area is exposed today during spring low tides.

4.3.5 *Sea-Level History and Archaeology*

The three early LAI sites are thought to have been occupied between 7000 and 4000 ^{14}C BP. The coastline for these times is portrayed by the 7000, 6000, 4500 ^{14}C BP palaeoshorelines. The position of three early LAI sites can be compared with the proposed palaeoshorelines. The LAI site on Sandy Point was occupied between 7200 and 6700 ^{14}C BP. The 7000 ^{14}C BP plaeoshoreline (Fig. 4-6) suggests this site was close to the active shoreline at that time.

In the *Sandy Cove* area, the older LAI site has a suggested range of 6000 and 4700 ^{14}C BP. This site would have been situated approximately 150 m from the 6000 ^{14}C BP reconstructed shoreline at this time. The younger site has a suggested range of 4000 and 3800 ^{14}C BP. At this time sea level would have been rising from the low-stand elevation of approximately -4 m at 4500 ^{14}C BP. With sea level at an estimated elevation of -4 m, these sites would have been approximately 500 to 1000 m away from the active shoreline.

The distribution pattern of archaeological sites is best assessed on Sandy Point, where sites of all four known cultural groups were found (Plate 4-1). Sandy Point contains 15 prehistoric sites, with six corresponding to a particular culture. As discussed above, the oldest LAI site was occupied during the period of emergence and may relate to when the

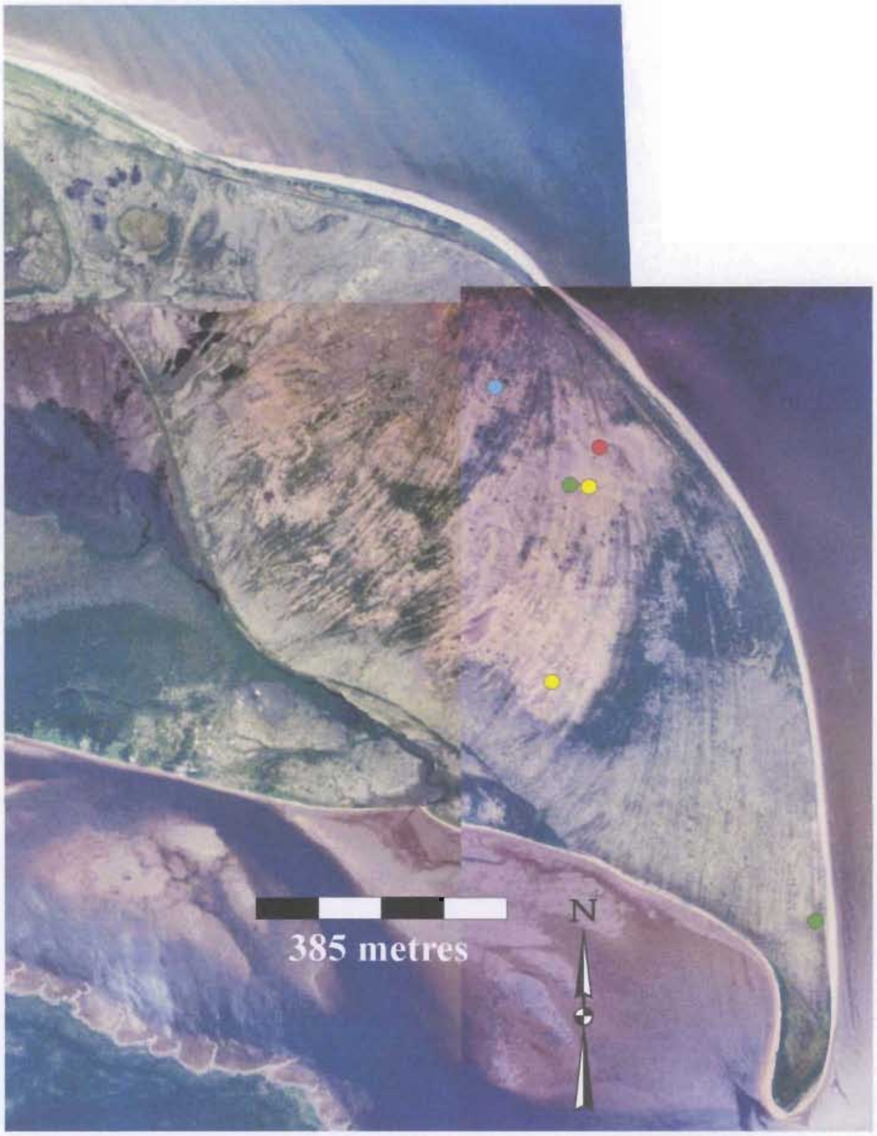


Plate 4-1: The photograph is a composite of three 1:12,500-scale aerial photographs that shows the known prehistoric cultures which occupied Sandy Point (circles). These cultures include LAI (red), Intermediate Indian (yellow), Groswater Palaeoeskimo (blue), Dorset Palaeoeskimo (green). Aerial photographs obtained from the Department of Environment and Conservation, flight line 92005, frames 190 and 192, and flight line 92006, frame 3.

active shoreline was close to this site. The other sites show cultural affiliations younger than 3800 ^{14}C BP and thus were occupied during the period of submergence. The type of site or site function may explain the location of these sites away from the active shoreline during the period of submergence.

Rising sea level after approximately 4500 ^{14}C BP has important ramifications for site identification and preservation. Due to sea level falling below present between 7000 and 4500 ^{14}C BP and the slow rise in sea level after 4500 ^{14}C BP, sites situated adjacent to the coastline during this time may have been eroded by rising sea levels or are submerged. It is possible that the early record of the prehistoric groups younger than 3800 ^{14}C BP on the Strand has been eroded. The sites on Sandy Point may represent the late occupation within each of the cultural groups identified or sites that were located well above the shoreline and were not related to changing shorelines.

The sea-level history is well constrained for north of *West Bay* thus there are a number of possibilities for the identification and preservation of archaeological sites in the area. If sea level shows a Type-A sea-level history, all of the archaeological record should be present above sea level. However, if sea level extends below present as suggested here, the early part of the record for the Intermediate Indian, Groswater and Dorset Palaeoeskimo may have been submerged or eroded due to rising sea levels. A third possibility for both the Trunmore Bay and *West Bay* curves is that if the amount of submergence was only a few metres, then the coastline over the last 6000 ^{14}C BP has remained relatively stable. This sea-level pattern would result in a mix of cultural groups of different time periods occupying the same locations without any separation in elevations, i.e. *Sandy Cove*, and Sandy Point.

4.4 Relationships Between Aeolian Sand and Dated Organics

Introduction

Aeolian sediment characterizes only 4% of the surficial geology of the area as a whole. Wind blown sand, sand dunes and large deflation areas along the Strand are distinctive features on the landscape. The evolution of these features may be linked to sea-level change, climatic variability, palaeosol and peat formation, and the occupation of prehistoric groups.

4.4.1 *Sea level and Aeolian Sand Deposition*

Most aeolian sediments and dunes are located on the coastal lowlands. The oldest dated palaeosol overlain by aeolian sand indicates that Porcupine Strand has been subject to aeolian sedimentation for at least 2910±45 ^{14}C BP (BGS-2455).

Models of dune formation coinciding with falling sea level are documented in NW Jutland, Denmark (Clemmensen *et al.* 2001), the central St. Lawrence Lowlands (Filion 1987), and South Erradale Peninsula, Wester Ross, Scotland (Wilson 2002). These studies show a continual source of sediment for forming dunes as sea level fell. However, coastal sections and test pits identified along Porcupine Strand do not show a transition from marine sediments through to aeolian sand. Instead, many sections contain buried soils that separate the marine sediments and overlying aeolian sediments. Indicating that the majority of beaches were stabilized prior to wind erosion. While the source of the aeolian is derived from marine and glaciomarine sediments, aeolian sedimentation likely did not occur as sea level fell.

The orientation of the vegetated dunes on the coastal lowlands (particularly the parabolics) indicate dominant west to west-northwest palaeowinds. Some dune orientations appear to parallel palaeoshoreline configuration. Such linear dunes may form in the coastal environment with beach sand forming the source.

Active dunes on Sandy Point, *Little Sahara, Tub Harbour* and *Sandy Cove* appear to be migrating eastward as a result of westerly winds. Local northerly winds are influencing dune formation in *Seal Cove*. In all of these areas, removal of vegetation allows deflation of underlying marine sands, producing a source of sediment to the dunes. Aeolian sands identified overlying the buried soils within the coastal cliffs sections and in the backshore dunes north of *Rocky Point* may be related to sediment derived from the eroding cliffs. In one location south of *Rocky Point,* a soil buried by 29 cm of aeolian sand dated 40±80 ^{14}C BP (GSC-6716; site 5; Fig. 3-13). Active erosion of the coastal cliffs, from storms and the proposed sea level rise, is the most likely source of the aeolian sediments. These sediments are deposited by onshore winds that transport the sandy material upslope depositing the material on top of the coastal cliffs. The formation of dunes located in Fonte de Telha, Portugal and Lodbjerg, NW Jutland, Denmark described by Jackson and

Nevin (1992) and Clemmensen *et al.* (2001) indicate that these features were the result of landward upslope movement of sand from the eroding coastal cliffs. The erosion and movement of sand by katabatic winds up a cliff slope formed cliff top dunes along Mountain River, NWT (Bégin *et al.* 1995).

4.4.2 *Climate Variability and Aeolian Sand*

Accumulation of soil, peat and aeolian deposits is highly variable and depends on changing environmental conditions. Soil and peat development generally are slow processes that accumulate on the order of centimetres per century in comparison to aeolian deposition that may accumulate tens to hundreds of centimetres per century. In northern Quebec the movement of aeolian sand and the burial of soil and peat horizons generally occurs under dry, cool conditions in comparison to the warm, humid conditions that are associated with soil development (Filion 1984). Regional temperature and precipitation trends can be obtained from proxy climatic indicators from Labrador. It can then be determined if periods of aeolian activity were triggered by changes in regional climate, or if they were the result of local conditions.

Broad vegetation changes are interpreted from fossil pollen (Jordan 1975; Lamb 1980; Macpherson 1985). This record covers most of the post-glacial period. Proxy climate data for the last four centuries are derived from high-resolution tree ring data (Diaz *et al.* 1989; D'Arrigo *et al.* 2003).

Climate record

Fitzhugh (1972) expanded a summary of climate conditions in the eastern Arctic compiled by Dekin (1969, 1970) to include Labrador data and ice core data from Camp Century (Dansgaard *et al.* 1969). Pollen and tree ring data were compared to the summarized model by Fitzhugh (1972) in order to reconstruct a more detailed record. Comparison of Fitzhugh's (1972) model to pollen records from Hamilton Inlet (Jordan 1975), southeast Labrador (Lamb 1980), and northern Labrador (Diaz *et al.* 1989) show similar warming and cooling trends with slight offsets in timing due to location. The main difference in the timing of these changes lies within the last 1000 years. Jordan (1975) records a warming trend, while Lamb (1980) and Diaz *et al.* (1989) indicate that this period was characterized by cooling. In comparing the pollen record with the tree ring data, both show a cooling trend in the last 500 Cal BP. However, the tree ring data also indicate brief warming periods occurring during this time (Diaz *et al.* 1989; D'Arrigo *et al.* 2003).

The data presented by Fitzhugh (1972), Jordan (1975), Lamb (1980), Diaz *et al.* (1989) are compiled to give a composite record of climate changes for southern Labrador (Fig. 4-9).

During peat accumulation between 6370 and 1560 Cal BP (site 5; Fig. 3-13) as well as between 1460 and 390 Cal BP (site 8; Fig. 3-13) the climate record suggests changes in

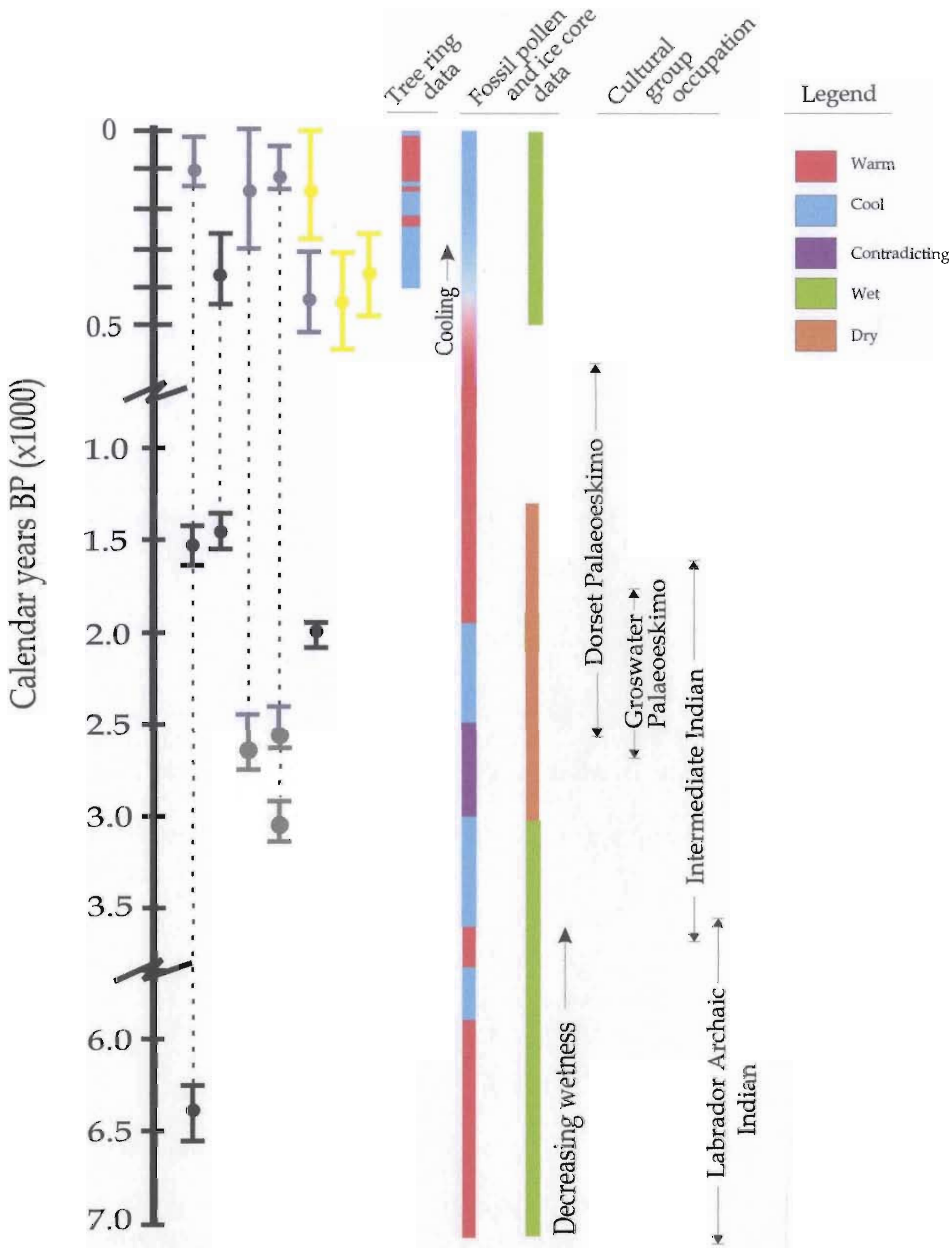


Fig. 4-9: Comparison of climate proxy data from Labrador to fifteen calibrated dates from buried peats and palaeosols collected from the Strand. Two sigma median probability ages are identified by the dots, while the associated minimum and maximum range is noted by the bars. Dotted lines connect samples taken from the same section. Black bars indicate peat samples. Grey bars show palaeosols south of Cape Porcupine; and yellow bars palaeosol samples from north of Cape Porcupine.

both temperature and moisture regimes. These changes may have caused reduced accumulation of organics at certain periods. However, no obvious breaks or sand beds were identified during examination of the peat beds (sites 5 and 8; Fig. 3-13). Regional temperature and precipitation conditions at approximately 2500 Cal BP were warm to cool and dry. This appears to correspond with the burial of soils collected from *Little Sahara* (3050 Cal BP, BGS-2455 and 2550 Cal BP, BGS-2456) and Sandy Point (2680 Cal BP, Beta-175379; Table 3-6). Palaeosols dating within the last 500 Cal BP appear to have formed during a period of regional fluctuations in temperature regime and under increased moisture conditions. Charcoal was present in six of seven horizons identified along the Strand. Filion (1984) suggested that charcoal identified in buried organic horizons in northern Quebec is indicative of a close relationship between fire and aeolian activity. Charcoal suggests that there may be a close relationship between fire and aeolian activity for the Strand, the climatic regime during these periods is harder to determine. It may be suggested that the occurrence of fires relate to dry periods in climate. However, it is difficult to make a direct connection without further information, as fire can occur at any time and be representative of a relatively short time period. The presence of forest fire activity in southern Labrador according to Foster (1983) increased in the last 50 to 100 Cal BP. In comparing precipitation records from Cartwright to years of major forest fire activity (1950-1959 and 1970-1979), a strong but not always exact correlation between low summer precipitation and forest fire occurrence is identified (Foster 1983).

Regional climate variation shows no clear relation with aeolian deposition along the Strand. Changes in local temperature and moisture regimes are most likely responsible for triggering periods of aeolian deposition. The presence of charcoal in many of the samples suggests fires may be the local event that helped initiate aeolian activity by removing vegetation and exposing underlying sediment.

4.4.3 *Archaeology and Dated Organic Horizons*

The dating of 15 buried soil and peat samples from along Porcupine Strand provides the first attempt to understand the relationship between aeolian sand, buried soils and cultural occupations. In the last 3000 ^{14}C BP, sand accumulation was episodic as suggested by the dated soil horizons, with the majority of these periods occurring within the last 500 ^{14}C BP. In sections where more than one palaeosol was dated, the resulting ages correlate to the stratigraphic position in which they were found and no age reversals are noted. This record of landscape change appears relatively simple and straightforward. However, comparison of archaeological data with the buried soil/peat record revealed that in general the ages associated with peat appear to correlate with the archaeological record, while ages obtained from the buried soils are much younger (on the order of 1000's of years) than the artifacts found in the same locality (see Section 3.3.4). The younger ages associated with the buried soils may result from the type of radiocarbon dating technique used, type of organic sample, contamination of radiocarbon dates, an error in the relationship between artifacts and buried soil horizons, differential erosion of older soils or perhaps the result of a more complex surface history. These are briefly examined with examples from the literature and are discussed in reference to the four archaeological sites from the Strand.

Literature Review

Buried soils are often associated with archaeological material. The use of dated buried soil/peat horizons is a useful tool in reconstructing many different landscapes of prehistoric cultures. However, dating of palaeosols can prove problematic due to the complex nature of the soil organic matter (Matthews 1993). Matthews (1993) summarized the problems associated with radiocarbon dating of soils, some of which arise from the lack of horizontal variability in ages, root contamination due to shallow burial, bioturbation of the soil, soil erosion prior to and during burial, continued decomposition of organic material after burial, as well as errors associated with radiocarbon dating. These problems can generally be solved with proper understanding of soils, proper sampling techniques and appropriate laboratory procedures (Matthews 1993). Dating of palaeosols was effective in understanding archaeology in the Great Plains region of the United States (Blair *et al.* 1990; Mayer 2002 and 2003; May and Holen 2003), the Canadian Prairies (Turchenek *et al.* 1974, Klassen 2004), the Peace River Valley (Valentine *et al.* 1980) and central Alaska (Hoffecker 1988; Powers and Hoffecker 1989).

The dating of humus from the buried soil horizons was generally limited (Turchenek *et al.* 1974; May and Holen 2003), or was used in addition to other radiocarbon techniques (Mayer 2002; see below). Instead, macro-remains such as wood, charcoal or bone removed from the bulk sample were used for radiocarbon dating (Valentine *et al.* 1980; Hoffecker 1988; Powers and Hoffecker 1989; Blair *et al.* 1990; May and Holen 2003; Klassen 2004). By separating organic material into fractions of wood, charcoal or bone, a more accurate age for the soil can be deduced (Catt 1990; Matthews 1993). This also eliminates contamination from modern rootlets. These fractions are often too small to be dated by conventional radiocarbon means and instead they are dated using the AMS method (accelerator mass spectrometry). AMS dating is generally considered more reliable than conventional dating as the quantity of ^{14}C is measured directly by measuring individual carbon ions (Litherland and Beukens 1995).

A buried palaeosol, at Krmpotich Folsom site in Wyoming, contained Folsom Palaeoindian (10,900 to 10,200 ^{14}C BP) artifacts (Mayer 2002). This palaeosol was separated by two aeolian units. Radiocarbon dating of this soil, as well as optical dating of sand units above and below the soil revealed a Holocene aged soil, indicating that the artifacts occurred across an unconformity. Grain size analysis shows that the artifacts are associated with coarser material forming an erosional contact that was not identified in the field. This unconformity indicates that the relationship between Folsom artifacts and the palaoseol was erosional in nature and that the artifacts were displaced during the Holocene (Mayer 2002).

Sandy Point Environment

As the sea-level curve suggests the formation of beach ridges on Sandy Point was complete by 7000 ^{14}C BP. The identification of indurated and stained sand making up the beach ridges is indicative of the soil forming process. Known as hardpan, coffee rock, or iron soils, these hardened layers are the result of reactions between humic acids, leached from the organic portion of the soil to the B horizon, and mineral grains contained within the sand (Soil Classification Working Group 1998; Lascelles *et al.* 2000). The result of these reactions is the formation of iron oxides that bind and give the sediment a reddish hue. These ironpan layers are common in Ferro-Humic Podzols, and Humo-Ferric Podzols soils which are common in southeastern Labrador (SLCWG 2001). Acton (1980) demonstrates the formation of podozolic soils associated with fine-grained sand in Northern Saskatchewan take a minimum of 1670±150 ^{14}C BP. Lascelles *et al.* (2000) used radiocarbon techniques to date stagnopodzols with ironpan formation in the UK. While the application of radiocarbon dating ironpans is relatively new, it gives preliminary ages of 2000 years for the formation of these soils (Lascelles *et al.* 2000). This suggests that beach ridges on Sandy Point were vegetated after their formation prior to the start of aeolian sedimentation. This stratigraphy is identified in many blowout walls, where fine- to medium-grained sand contains horizontal laminations highlighted by heavy minerals and occasional clasts. These sediments are strongly indurated and are overlain by palaeosols and varying amounts of aeolian sand. Pollen analysis of the uppermost-buried soil, conducted by Rogerson (1977), indicated that Sandy Point at one time was colonized with spruce and birch forest. The oldest buried soil interpreted as representing a marine/aeolian transition was dated 2590±60 ^{14}C BP (Beta-175379). This is a minimum age for the onset of soil formation and a maximum age for the burial of aeolian sand (Matthews 1993). It suggests the earliest time for aeolian activity on Sandy

Point was approximately 2600 ^{14}C BP. However, the majority of aeolian activity has taken place in the last 400 ^{14}C BP based on three other radiocarbon dated palaeosols.

Sandy Point: Palaeosols, Aeolian Activity and Prehistoric Peoples

The ages of these palaeosols along with the relationship of associated cultural artifacts are indications to where these groups were living. The following is a discussion that outlines the preliminary interpretation, based on the available radiocarbon dates, of the environment prehistoric groups experienced.

Labrador Archaic Indian (7200 to 3500^{14}C BP)

The LAI site (FkBg-13) located in the bottom of a blowout on Sandy Point is adjacent to a dated palaeosol that records an age of 390±60 ^{14}C BP (Beta-175377). This young age of the palaeosol raises a number of concerns regarding the confidence in the age of the soil, the confidence in the relationship between the palaeosol and the associated artifacts, as well as the reconstruction of the environment and striatgraphic position in which these artifacts were originally deposited.

The young age of the palaeosol may be due to sample contamination. The palaeosol was overlain by 90 cm of aeolian sand that contained abundant modern roots. While the sample was cleaned of all visible modern roots, some may have remained and caused contamination of the sample. However, in consideration of the other dated peat and soil horizons on Sandy Point that recorded similar young ages 308±40 ^{14}C BP (BGS-2453) and 160±70 ^{14}C BP (Beta-175378), this age is likely valid.

The LAI site was comprised of a large collection of artifacts that include two red sandstone points, two blades, a burin, a scraper, flakes and fire-cracked rocks. While these artifacts are largely confined to the blowout floor, a fire-cracked rock was identified on top of the palaeosol and buried by aeolian sand. This suggested that this might have been the horizon from which the site was derived. However, no artifacts were identified with the buried soil and the presence of fire-cracked rock may be the result of a younger occupation. This low confidence of palaeosol/artifact association, along with the young age of the soil implies that this horizon was not the original location of this site.

This LAI site is likely not associated with the buried soil. The geomorphology may be used to suggest two other possibilities regarding the origin of these artifacts. The presence of an ironpan below a 390±60 ^{14}C BP (Beta-175377) palaeosol indicates that the development of the ironpan is not likely the result of the formation of this soil horizon due to the long time associated with ironpan formation (Acton 1980; Lascelles *et al.* 2000).

This may suggest that the original soil development associated with the formation of the indurated soil was eroded and that the artifacts may have been associated with this former older horizon. Buried soils are often subjected to erosion prior to or during burial (Matthews 1993). No cultural material was associated with the palaeosol and no deflation surface was found immediately below the soil suggesting the artifacts may have been associated with unvegetated raised beach sediments. Radiocarbon and optical dating as well as grain size analysis could be used to test whether the artifacts are associated with the formation of the ironpan. Methods associated with testing this hypothesis include: (1) Redating the palaeosol using the AMS method to confirm that the young age is not the result of contamination. If a similar age results, then no contamination has taken place and the soil is not related to the underlying indurated sediment. Conversely, an older age might relate to both the induration and the artifacts. (2) Radiocarbon dating and perhaps optical luminescence dating the sediment underlying the buried soil could determine how long ago the sediments became buried. This will indicate whether or not the artifacts fall above or below this stratigraphic point. The date should also represent a minimum age of soil formation. Lascelles *et al.* (2000) used the AMS radiocarbon dating method to date ironpan samples that contained prehistoric artifacts in Clwyd, North Wales, UK. (3) Detailed grain size analysis will determine if any subtle change in grain size occurs below the 400 ^{14}C BP palaeosol, that may be indicative of a lag or deflation deposit. If no change in grain size is noted, then artifacts were originally deposited on the vegetated surface associated with the beach ridge. Conversely, if a change in grain size is present, then this could represent a lag or deflation surface (an unconformity) where the LAI may have been occupying. Similar techniques were used in determining the source of Palaeoindian artifacts (10,900-10,200 ^{14}C BP) that were located on a Holocene aged palaeosol in Wyoming (Mayer 2002).

Dorset Palaeoeskimo (2500 to 600 ^{14}C BP)

Two Dorset Palaeoeskimo sites were identified on Sandy Point. Both were located in the bottom of shallow blowouts approximately one kilometre apart. In the northern site

(FkBg-14) a cultural layer was identified within the blowout wall, but was not dated. The other site (FkBg-30) contained a buried peat horizon that was dated between 1568±40 ^{14}C BP (BGS-2454) and 308±40 ^{14}C BP (BGS-2453). This horizon contained similar artifacts to that identified in the adjacent blowout. The dates associated with this horizon generally correlate with the last 900 ^{14}C BP of Dorset Palaeoeskimo occupation in Labrador (2500 to 600 ^{14}C BP). The close connection between this buried horizon and the artifacts present is a strong indication that the Dorset Paleoeskimo culture was living on a vegetated surface at this site. It can be speculated that the Dorset were likely occupying a vegetated surface at the northern site, as a cultural layer is also identified there.

Intermediate Indian (3800-1500 ^{14}C BP)

The only two Intermediate Indian sites identified were located on Sandy Point. These sites were not radiocarbon dated. The relationship between cultural material and a buried soil was identified at one of the site. At this site, cultural material is eroding out of a palaeosol that overlies marine sediment. This indicates that at the time of Intermediate Indian occupation on Sandy Point, the inhabitants were likely living on a vegetated surface prior to aeolian activity. A dated palaeosol, (2590±60 ^{14}C BP; Beta-175379) unrelated to any cultural material, located approximately 700 m to the northwest of this site also reveals that a vegetated surface was present during the occupation of this prehistoric group. Other dated palaeosols and peat horizons from the *Little Sahara* and on the terrace fronting the north end of the parabolic dunes have ages, 2910±45 ^{14}C BP (BGS-2455) 2465±40 ^{14}C BP (BGS-2456) and 2040±40 ^{14}C BP (Beta-191933; Table 3-6 and Fig. 3-13), that fall within this period of occupation but are not associated with archaeological sites. The presence of additional vegetated surfaces that date within the period of occupation for the Intermediate Indian suggests that it is likely these people were associated with vegetated surfaces.

Groswater Palaeoeskimo (2800 to 2100 ^{14}C BP)

Only one Groswater Palaeoeskimo site was identified on Sandy Point. Artifacts were identified in the bottom of the blowout and below the buried soil. The palaeosol associated with this blowout was not radiocarbon dated. Other dated palaeosols and peats not associated with archaeological sites are identified within the time range of the Groswater Palaeoeskimo. These dated horizons, found at Sandy Point, *Little Sahara* and on the terrace fronting the north end of the parabolic dunes, have ages of 2590±60 ^{14}C BP (Beta-175379), 2465±40 ^{14}C BP (BGS-2456) and 2040±40 ^{14}C BP (Beta-191933) respectively (Table 3-6 and Fig. 3-13). Although artifacts belonging to the Groswater Palaeoeskimo are found associated with aeolian sand, it is likely that these people were living on a vegetated surface above the active shoreline.

Sandy Cove Environment

Raised beaches identified in Sandy Cove were formed between 7000 ^{14}C BP and 6000 ^{14}C BP as sea level fell below 12 m. Multiple buried soils horizons indicate that Sandy Cove experienced at least four periods of aeolian activity. The most recent period of aeolian activity resulted in the burial of trees and the formation of at least one large coastal dune. The upper most palaeosols from two sites have been radiocarbon dated. The results indicate the most recent aeolian activity occurred between 400 ^{14}C BP and 290 ^{14}C BP.

Sandy Cove: Palaeosols, Aeolian Activity and Prehistoric Peoples

LAI site (GbBi-07)

A section in a large blowout in Sandy Cove contained multiple buried soils as well as LAI (Sandy Cove Complex) artifacts (Section 3.3.4, Fig. 3-14). The site included three longhouses, parts of which were also identified in a small shallow adjacent blowout. Geomorphological and archaeological investigations recorded three radiocarbon dates from this site. Two buried soil horizons were associated with the small blowout. These were located above the artifacts identified on the blowout floor. However, the larger blowout contained four thin palaeosols, of which only the uppermost palaeosol was dated (400±70 ^{14}C BP; Beta-175380, Table 3-6 and Fig. 3-13) as a part of this study. At the time of the investigation, archaeologists were only beginning to survey this site and as a result the author was unable to examine the relationships between the artifacts and the palaeosols in detail. In clearing the section (site 1b, Fig. 4-10) that contained the four palaeosols, a Ramah chert flake was collected from the sand between the two uppermost buried soils. A detailed archaeological survey of the site was unable to determine if the artifacts were associated with the palaeosols.

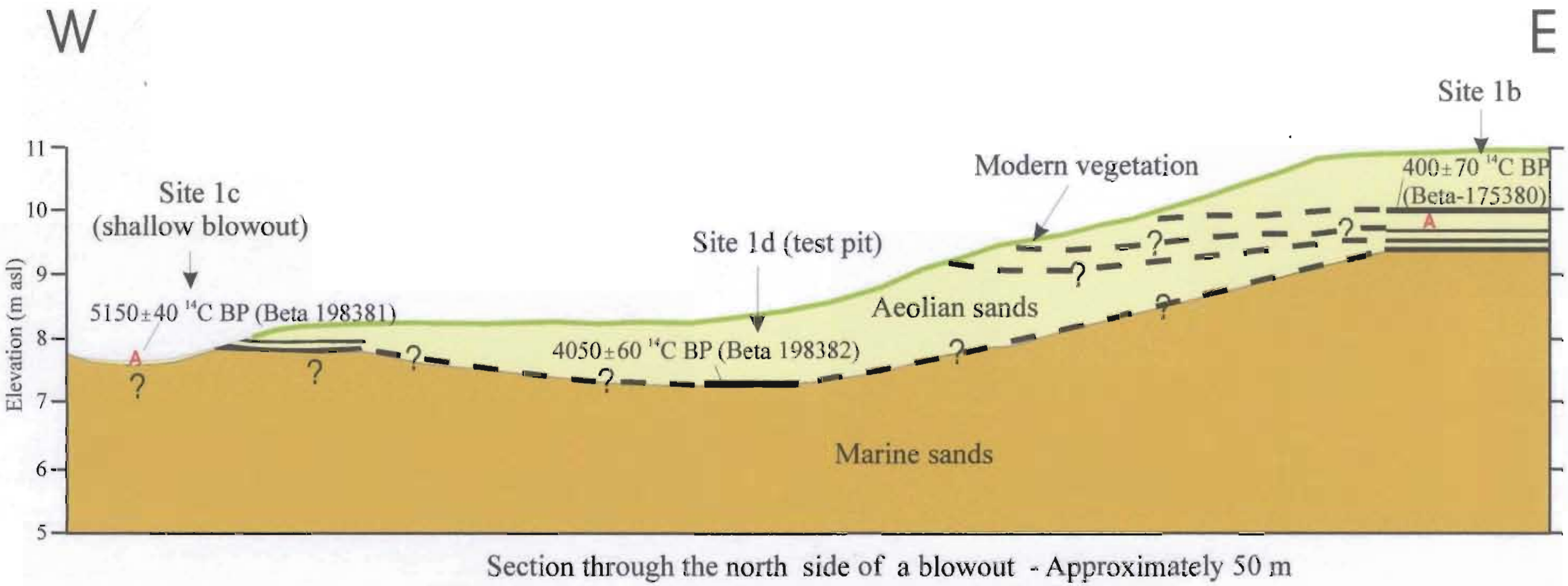


Fig. 4-10: Interpreted section through the north side of a large blowout in Sandy Cove based on three separate sites. This blowout contains the remains of three LAI longhouses (Sandy Cove Complex). Artifacts are noted by red A's. Black boxes are representative of buried soils. Sites correspond to Fig. 3-13 and Fig. 3-14.

During the excavation of the longhouses in 2003, charred material from a hearth associated with LAI artifacts was sampled and dated (5150±40 ^{14}C BP; Beta-198381, site 1c Fig. 3-14), along with charred material within a palaeosol from a test pit that had no associated artifacts (4050±60 ^{14}C BP; Beta-198382, site 1d, Fig. 3-14, Fig. 4-10). The buried soil identified in the testpit was not correlated to any of the palaeolsols recognized in the large blowout. The uncertainty regarding the sediment underlying the dated archaeological samples, the lateral extent of the palaeosols, and the lack of stratigraphic correlation between the radiocarbon dated samples makes the relationship the LAI had with the environment hard to determine without further investigation. Using the knowledge of the present environment along with the known stratigraphy identified in Figure 4-10, a preliminary interpretation may be determined.

Topography of the area north of the two blowouts containing LAI artifacts gently slopes towards the west. Sand movement is identified by the presence of sand dunes in the east end of the blowout. Elevations of marine sediments within *Sandy Cove* identified in blowout walls and test pits range from 6.3 to 8 m asl. Little is known about the site stratigraphy for the samples collected by the archaeologists. Artifacts identified in the shallow blowout are found beneath two palaeosols that are separated by aeolian sand. The presence of clasts ranging from 0.2 to 5 cm suggest that these could not be wind blown and that they are the result of deflation of the marine sediments presumed to underlie the lowermost palaeosol and artifacts. This LAI site was occupied 5150±40 ^{14}C BP (Beta-198381; Rankin 2005 personal communication).

The relationship these two palaeosols (small blowout) have with the palaeosol identified in the test pit is not known for certain. However, the fact that no artifacts were associated with the palaeosols identified in the small blowout suggests that these are younger than the artifacts and may correlate to the palaeosol identified in the test pit that dated 4050±60 ^{14}C BP (Beta-198382; Rankin 2005 personal communication). The difference in elevation between the palaeosols associated with the small blowout (8.2 m asl) and the palaeosol in the test pit (7.6 m asl) is perhaps due to a more undulating topography associated with the marine sediment or the result of differential erosion of this sediment during aeolian activity.

The four palaeosols separated by aeolian sand in the large blowout (site 1b) are located approximately 2 m higher than the palaeosol identified in the test pit (site 1d). The uppermost palaeosol has been dated at 400±70 ^{14}C BP (Beta- 175380). The presence of a Ramah chert flake identified below the 400 ^{14}C BP palaeosol and the second palaeosol suggests the one of the remaining palaeosols could correlate with the 4050±60 ^{14}C BP (Beta-198382; Rankin 2005 personal communication) palaeosol. The absence of the 400 ^{14}C BP palaeosol along with any others in the test pit may be the result of differential erosion prior to or during burial. Valentine *et al.* (1987) reports that buried soils may be severely disrupted during burial resulting in partial profiles and palaeosols that are not laterally continuous.

Considering the earliest date for aeolian activity in *Sandy Cove* is not until 4000 ^{14}C BP, it is most likely that LAI built their longhouses on the raised beaches and were not associated with aeolian activity. This hypothesis can be confirmed through a more comprehensive investigation of the site stratigraphy, and radiocarbon dating of the remaining buried soils.

LAI site (GbBi-17)

The youngest radiocarbon date was derived from an *in situ* tree stump rooted in a buried soil (site 1a, Figs. 3-13 and 3-14). The buried soil was identified along the majority of the blowout edges. Artifacts identified at this site (GbB9-17) are associated with the early LAI, but the complex could not be determined. LAI artifacts are situated on the bottom of the blowout and it was not determined how these artifacts relate to the buried soil. The cultural affiliation of the artifacts is much older than the 290±50 ^{14}C BP (GSC-6750) *Picea* tree stump. The recorded age associated with the tree stump is a reliable estimate of the age of the palaeosol. Dating of wood is considered to be more reliable than bulk organic dating as there is only one type of organic material forming the sample (Matthews 1985, 1993). The age of the tree stump represents the minimum age for the formation of the palaeosol (Matthews 1985, 1993). The palaeosol would have had to been well developed in order to maintain rooted trees. Dating of the lower portion of the buried soil and perhaps the upper sediments may reveal ages that correspond with the occupation of the LAI. Until further dating can be accomplished, the presence of marine sediments underlying the buried soil, suggests the prehistoric peoples were likely occupying the beach ridges prior to aeolian activity.

The presence of buried soils younger than 4000 BP suggests the Ratter's Bight LAI complex and later LAI occupants may have been associated with aeolian sand deposition.

CHAPTER 5 – CONCLUSIONS

The underlying theme of the research on Porcupine Strand is changing landscapes and how these changes affected the settlement patterns of prehistoric cultures. The following briefly summarizes changes in the landscape and the resulting patterns as identified by the location and distribution of prehistoric sites.

5.1 Deglaciation

The two new dates on marine shells (8820±70 ^{14}C BP, TO-10947 and 7430±100 ^{14}C BP GSC-6677) presented here provide minimum estimates for deglaciation of Porcupine Strand. These dates are approximately 1000 years earlier than the two dates (7840±100 ^{14}C BP, GSC-2196 and 6750±190 ^{14}C BP, GSC-2465) presented by Rogerson (1977). The data presented here fits within the regional deglaciation model for southern and central Labrador indicating that much of the area was deglaciated by 10,000 ^{14}C BP as suggested by King (1985) and Syvitski and Lee (1997).

This early deglaciation indicates that there was a land corridor in front of the retreating ice sheet that was available as a transportation route for the earliest prehistoric occupants (LAI) migrating from the Strait of Belle Isle to Hamilton Inlet by 7500 ^{14}C BP (Jordan 1975). Peoples occupying the Strand, prior to 7500 ^{14}C BP, would have seen glacier fed rivers, small glaciers in the hills and uplands and a very different coastline than we see today. Due to higher sea levels, between 8000 and 7000 ^{14}C BP these earliest prehistoric peoples would have occupied coastlines that were as much as 88 m higher than present, along palaeoshorelines fronting the *Porcupine Hills* and *Uplands*. Over time, as sea level fell to lower elevations, archaeological sites would have been moved to progressively lower palaeoshorelines.

The sedimentary sequence produced during deglaciation consists of massive glaciomarine mud that is overlain by thick deposits of glaciomarine sands derived from glacial outwash deposited in a marine environment at the distal end of sandar plains. These sands were deposited as a result of progradation of gently sloping Hjulström Type deltas into the marine environment. The coarser sand identified in the upper parts of sections represents the edge of the sandar plains that were composed of sand and gravel. Radiocarbon dates on shells from the lower sand unit forming at the base of the delta slope record minimum estimates of 7840±100 ^{14}C BP (GSC-2196) for the onset of progradation of outwash deposits on Porcupine Strand.

Future Work

Within the Porcupine Strand further fieldwork may be done to determine the age of deglaciation. In particular, Rogerson's (1977) *South Feeder Brook* delta site could be revisited to search for shells that might provide a later age for deglaciation. In addition sections through other river valleys within the area could be investigated for datable organic material.

5.2 Sea-Level History

Preliminary Type-B sea-level histories are presented for Trunmore Bay and *West Bay* using 16 new radiocarbon dated geological samples as well as archaeology sites. Type-A sea-level curves were suggested for southeastern Labrador by previous studies. The models proposed in this study are the first to suggest that emergence was followed by submergence (Type-B).

The shape of the sea-level curve for Trunmore Bay is based on new geological and archaeological data as well as a different interpretation of Rogerson's (1977) *Woolfreys Brook* site. The Trunmore Bay sea-level curve is confined between the Porcupine Strand's oldest LAI site (7200 ^{14}C BP; FkBg-13) identified at 3.4 m asl and a date on shells from glaciomarine sand located at 1.8 m asl (7430±100 ^{14}C BP, GSC-6677). As a result of this confinement of the curve so close to present sea level as well as the general exponential form of sea-level curves, the Trunmore Bay Curve falls below present sea level at 7000 ^{14}C BP. The extent and timing of the sea level low-stand is not known. There is no dated geological material indicative of a currently rising sea level. However, the present geomorphology suggests that the area is influenced by rising sea level. For example, high tides meet the base of the coastal cliff, and erosion is occurring along the back beaches and coastal cliffs. Archaeological sites situated on the coastal cliffs and back beaches are being eroded into the sea.

The *West Bay* curve is less well constrained than the Trunmore Bay curve. There is almost a 1000 year gap between the dated marine shell from The Backway (6750±190 ^{14}C BP, GSC-2465) and the *Sandy Cove* LAI site (6000 and 4700 ^{14}C BP; GbBi-07). While a hearth within one of the longhouses at LAI site has been dated (5150±40 ^{14}C BP; Beta-198381), it is unknown if this date also represents the occupation of the remaining two longhouses. As a result, the age range associated with the Sandy Cove Complex is still included in the sea-level curve. Due to the lack of younger constraints the sea-level history for *West Bay* can be represented by a Type-A or Type-B sea-level curve, until further research is carried out.

Future Work

Further investigation of sea level along Porcupine Strand should include a reexamination of Rogerson's (1977) *Woolfreys Brook* site, as well as an examination of raised beaches located at higher elevations outside the field area, i.e. southwest of *West Bay* and offshore islands.

5.2.1 *Implications of Sea-Level History on the Archaeological Record*

The sea-level history affects the archaeological record. The Type-B sea-level curve indicates that while sites might correspond to emerging sea level between 8000 and 4500 ^{14}C BP, there may be gaps in the archaeological record after 7000 ^{14}C BP (6000 ^{14}C BP for *West Bay*) as sea level fell below present during this time. All likely cultures are present in the archaeological record, but it can be speculated due to the coarser resolution of the record, that parts of their occupation may be missing after 7000 ^{14}C BP when sea level fell below present. Presumably, prehistoric peoples would have also been associated with palaeoshorelines that formed below present sea level. However, as sea level rose, these potential sites would have been submerged creating an apparent gap in the occupation history. The identification of sites younger than 7000 ^{14}C BP (6000 for *West Bay*) along the Strand suggests that these sites may have had a site function that was unrelated to sea level. Alternatively, if sea level fell only a couple of metres after 7000 ^{14}C BP, the paleoshoreline configuration would be similar to the present, this would allow the same areas to occupied repeatedly by different cultural groups. While the function of archaeological sites on Sandy Point have yet to be determined, this alternative hypothesis would explain the random site pattern identified in this location. Archaeological sites located along the coastline, on the top of the coastal bluff (i.e Sandy Point, Dorset Palaeoeskimo site) are currently being eroded due to rising sea levels.

5.2.2 *Sea-Level Reconstruction: Use as an Archaeological Tool*

Sea-level reconstruction can be used for identifying the location of the archaeological sites, particularly those associated with the period of falling sea level. This is most useful for the LAI who have the longest period of occupation that correlates to emergence. Using the span of the human cultural period, the palaeoshoreline occupied by this group can be determined by noting the elevation at which the age meets the sea-level curve. The elevation deduced is the most likely area where sites relating to this culture may be found. For example, the 8000 ^{14}C BP palaoshoreline indicates that the potential area for locating new sites, is located at elevations higher than present (approximately 88 m in West Bay and 43 m in Trunmore Bay) and are kilometres inland. The configuration of these shorelines can also be used to narrow site surveys to areas like sheltered bays, headlands and islands where cultures would have sought shelter, freshwater, an unobstructed view or proximity to marine resources.

5.3 Aeolian Sand and Buried Organic Horizons

Aeolian sand deposits are confined to the coastal lowlands. These deposits contain different types of sand dunes including parabolic, linear and small hill-shaped sand mounds that are associated with varying amounts of vegetation. Surficial mapping and grain size analysis indicates the source of the aeolian sand is the underlying marine and glaciomarine sand. Sections and test pits have identified numerous palaeosols and buried peats that indicate the formation of aeolian sand was episodic during last 3000 ^{14}C BP. The dating of these soils shows that soil development was interrupted many times and as a result these soil horizons are likely discontinuous along the Strand. Interruptions to soil development are more pronounced during the last 400 ^{14}C BP. Based on the presence of buried soils between the indurated marine/glaciomarine sediments and the aeolian sediments, it can be suggested that aeolian activity occurred after the marine/glaciomarine sediments were vegetated. Regional climate variation shows no clear relation with aeolian deposition along the Strand. Changes in local temperature and moisture regimes are most likely responsible for triggering periods of aeolian deposition. The presence of localized areas that are active today suggests other local factors such as natural hazards (i.e. mass expansion of insects, forest fires), animal grazing, frost heaving, or human activity could have been triggers for aeolian activity (Seppälä 2004).

5.3.1 *Aeolian Sand, Buried Soil Horizons and Archaeology*

While the dating of buried soil horizons found in the same locality as cultural diagnostic material was useful in determining the relationship these cultures had with the buried soils, it was generally inconclusive in providing more information regarding the environment. Dating of soils at the LAI site (FkBg-13) on Sandy Point, and at the LAI sites (GbBi-07 and GbBi-17) in *Sandy Cove*, revealed ages that were younger than the artifacts believed to have been associated with them. This indicates that the LAI occupying these sites were living on the raised beaches. The indurated soils suggest that these beaches were likely vegetated some time after emergence prior to aeolian activity. Thus, it can be suggested that cultural groups were living on a previous buried soil that was subsequently eroded after the occupation of the site, after which time a younger soil developed. This hypothesis can be tested by using AMS dating, optical dating of the sands, as well as detailed grain size analysis. The site (GbBi-17) containing Rattlers Bight Complex artifacts in *Sandy Cove* has an age range (4000 to 3800 ^{14}C BP) that could be associated with the formation of the 4050±60 ^{14}C BP (Beta-198382) buried soil or the subsequent aeolian activity.

Intermediate Indian and Groswater Palaeoeskimo sites contained buried soils that were not dated. Therefore the environment in which they were living cannot be determined with any certainty until these buried soils are radiocarbon dated. The relationship of

Intermediate Indian artifacts to the buried soil is good. This buried soil was developed on marine sediments and indicates that the Intermediate Indians were likely living on a vegetated raised beach. The Groswater Palaeoeskimo site identified artifacts below a buried soil horizon formed on marine sediments. The location of the artifacts suggest that this group were living on raised beach sediments prior to vegetation. However, a dated soil (2590±60 ^{14}C BP; Beta-175379) unrelated to both the sites indicated that, during the time span of Intermediate Indian and Groswater Palaeoeskimo occupation, vegetated surfaces were present.

Dating of a buried peat horizon containing Dorset Palaeoeskimo artifacts (Fk-Bg30) indicates the use of radiocarbon dating buried soils is effective in reconstructing the site stratigraphy when the relationship between prehistoric occupation and buried soils is known. The dates associated with this horizon, 1568±40 ^{14}C BP (BGS-2454) and 308±40 ^{14}C BP (BGS-2453) corresponds with Dorset Palaeoeskimo occupation in Labrador between 1500 and 600 ^{14}C BP. The close connection between this buried horizon and the artifacts present is a strong indication that the Dorset Palaeoeskimo culture was living on a vegetated surface at this site.

Further Analysis

In a number of sites the age of buried soils and cultural occupations did not correlate to each other this may be the result of a more complex landscape history. It can be suggested that cultural occupation of these sites is associated with older soils that predate aeolian activity. However, further investigation is needed to test this hypothesis in order to determine the environmental context of these sites. Analysis would include further radiometric dating of palaeosols and peats, using both conventional and AMS methods. In addition, sands associated with the buried soil horizons could be dated using optical dating methods such as luminescence stimulated luminescence and infrared stimulated luminescence to provide further stratigraphic control. Detailed grain size analysis can be used to identify unconformable surfaces between aeolian and marine sediments, or within aeolian sediments that are not distinguishable in the field.

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APPENDIX 1:

DESCRIPTIONS OF MEASURED SECTIONS AND TEST PITS

Location of sections and test pits are given in Fig. A.

Test pit descriptions not identified in Fig. A are listed in Table A.

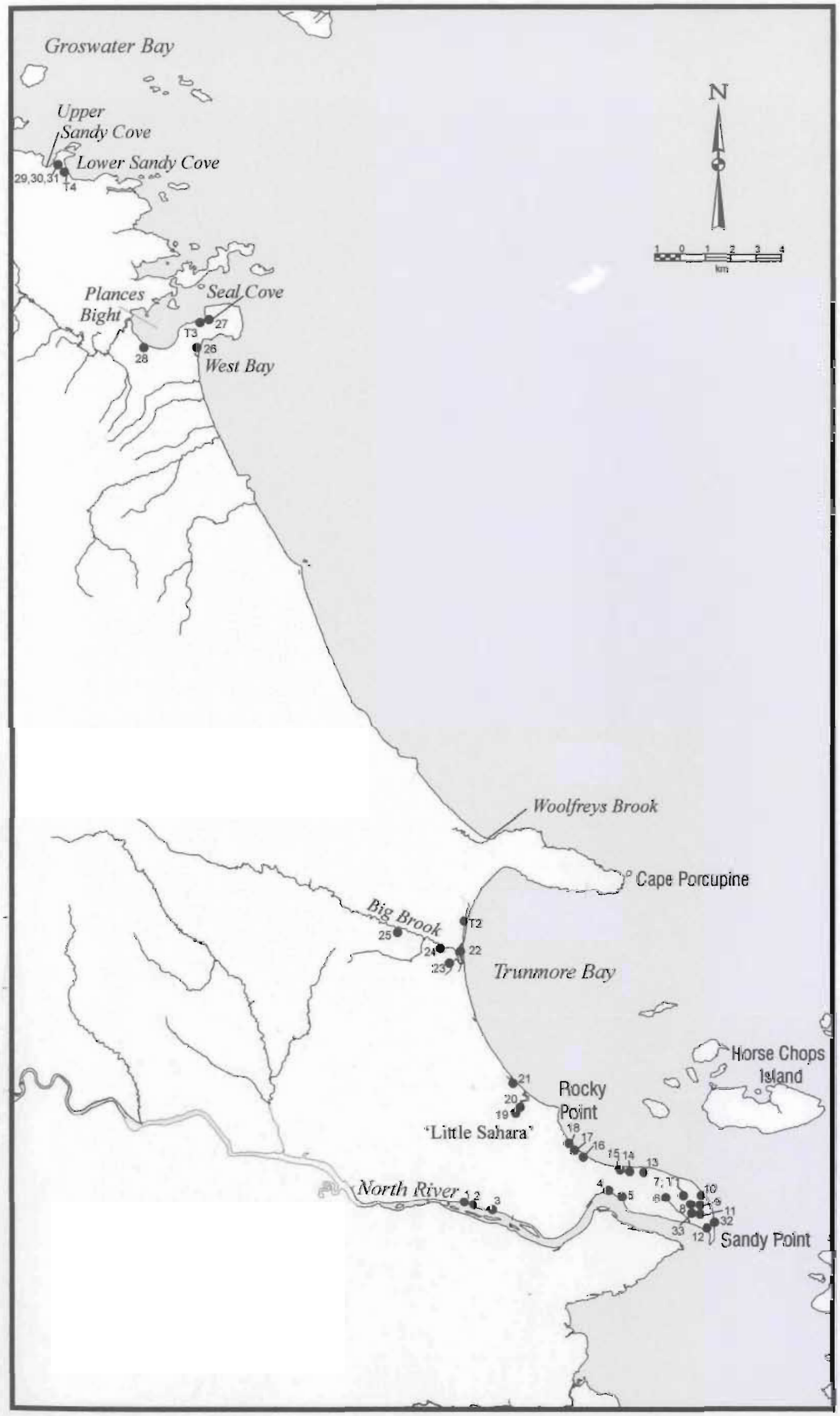


Fig. A: Map showing locations of drawn sections (numbered) and test pits (labeled as T1), which are described on the following pages. Test pits not shown here are recorded in a table in Table A.

LEGEND

Sediment types

- Organic horizon
- Clay and silt
- Sand
- Buried peat or palaeosol
- Granule bed
- Cobble bed

- Shells
- *In situ* tree stump (upright)
- Wood
- Modern roots
- 1660±50 ^{14}C BP Radiocarbon date

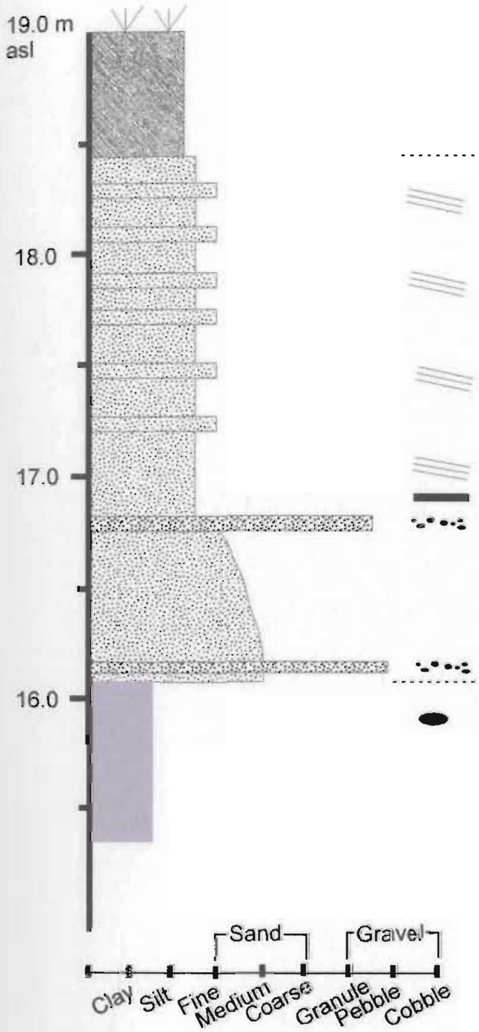
Sedimentary Structures

- Parallel dipping laminations
- Discontinuous dipping laminations
- Parallel laminations
- Discontinuous parallel laminations
- Heavy mineral laminations
- Discontinuous heavy mineral laminations
- Ripple cross-bedding
- Planar cross-bedding
- Trough cross-bedding
- Herringbone cross-stratification
- Convolute laminations

- Lens
- Wavy lamination
- Erosional contact
- Load casts
- Clay rip up clast
- Rip-up clast with parallel beds
- Granules
- Pebble
- Cobble
- Boulder
- Horizontal or vertical break in section

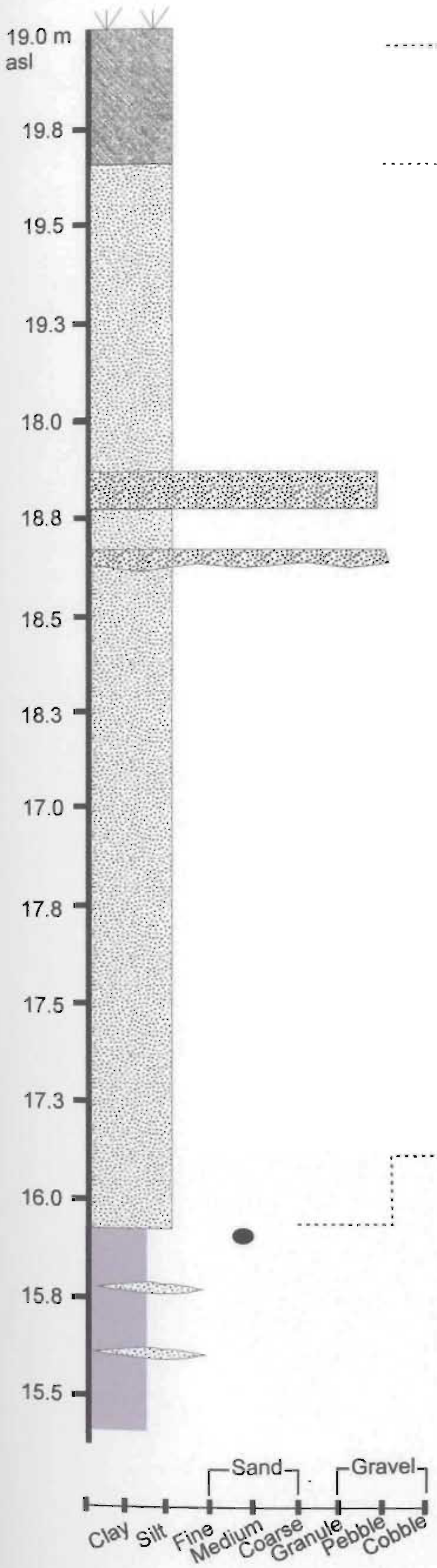
Note: Elevations marked with asterisks were estimated from topographic maps

Section:1 Site: PS-19-0216 UTM (Nad 27): 5963675 485250



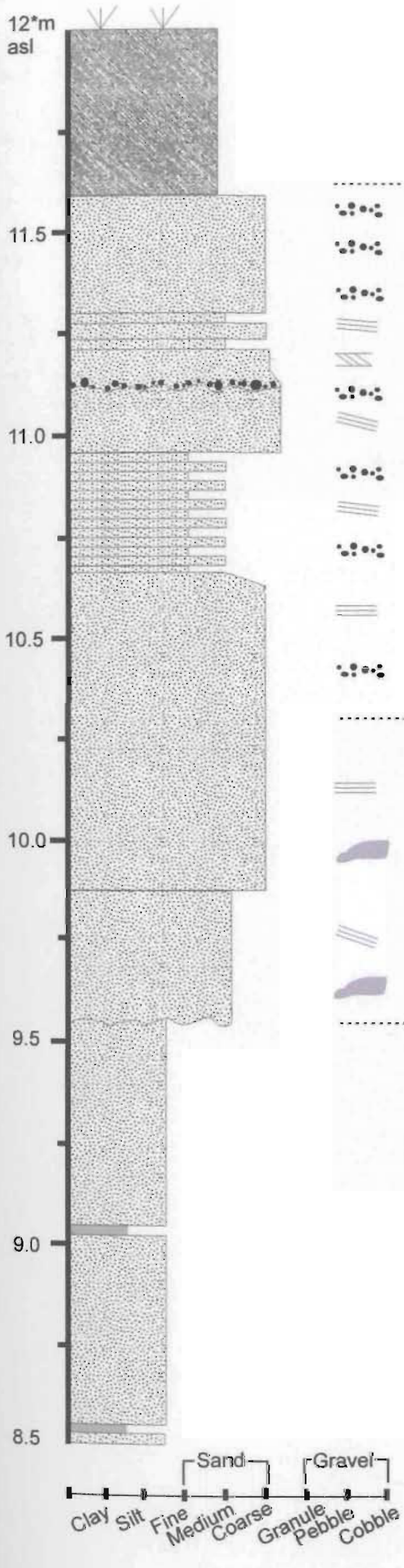
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Peat
Well-sorted very fine sand with interbeds of fine sand that dip 12° E	Glaciomarine deposit: Gently sloping beds of a Hjulström type delta
Medium sand containing pebble and granule beds Medium sand fines upwards to fine sand	Coarser sediment is the result of gravity-flows while finer material is the result of suspension settling
Mud composed of silt and clay; massive and well-sorted	Glaciomarine deposit: Sediment deposited through suspension settling in a shallow water basin in a location distal from the ice margin

Section: 2 Site: PS-18-0216 UTM (Nad 27): 5963690 485493



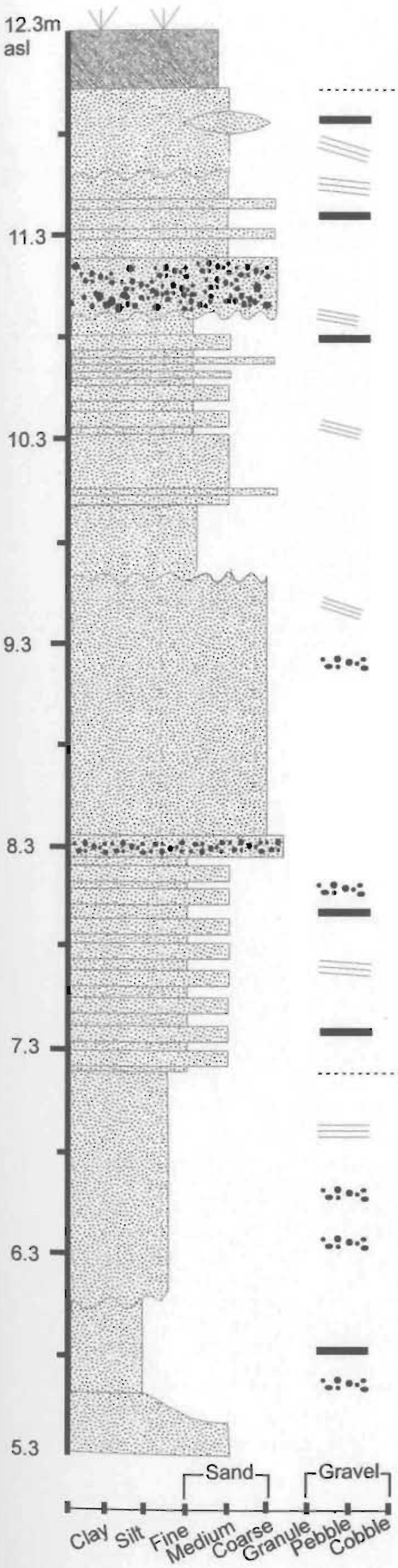
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Peat
Well-sorted, massive, very compact, very fine to fine sand with occasional irregular granule beds	Glaciomarine deposit: Massive sand deposited through interflows and suspension settling forming Hjulström type delta Coarser beds result from deposition in small channel s
Mud composed of silt and clay, massive and well-sorted Contains the occasional pebble and a few sand lenses	Glaciomarine deposit: Sediment deposited through suspension settling in a shallow water basin in a position distal to the ice margin Dropstones are the result of ice rafting

Section: 3   Site: PS-32-0218   UTM (Nad 27):5963392 486336



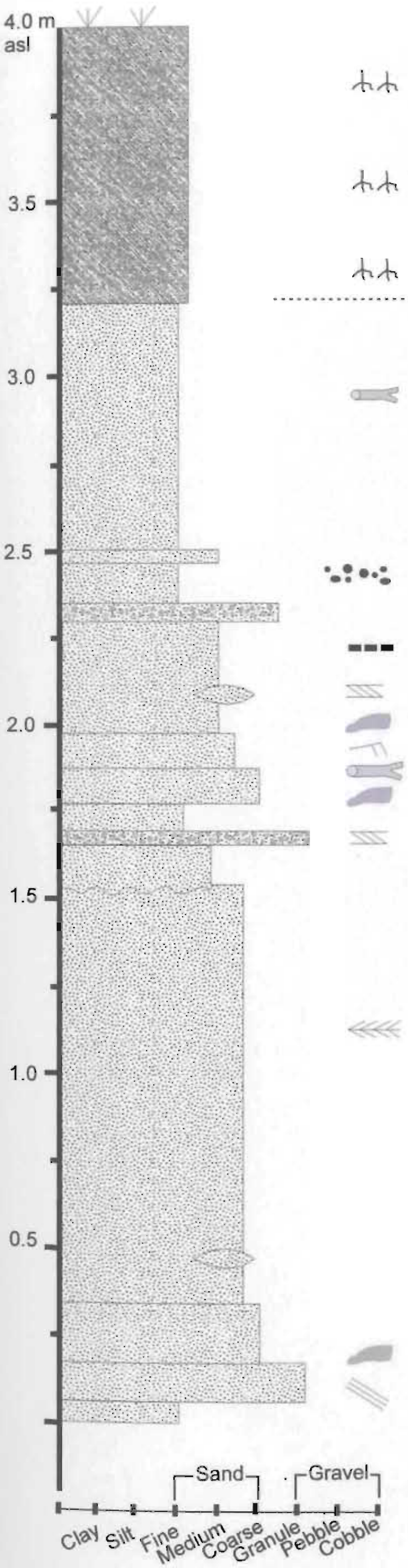
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Peat
Poorly sorted medium to coarse sand that contains granules and pebbles Bedded sand dips slightly to the east	Glaciomarine deposit: Slightly dipping beds form a Hjulström type delta
Pebbles concentrated along erosional contact Parallel beds dip 7-18° to east	Coarser material deposited as a result of higher meltwater input, likely by channel deposition or gravity flows
Moderately to well-sorted medium to coarse sand containing horizontal and dipping parallel beds Contains clay rip-up clast up to 4 cm long	Rip-up clasts likely eroded from isolated areas where settling of fine fraction took place
Well-sorted very fine sand Contains no visible structure other than two thin silty layers	Glaciomarine deposit: Suspension settling of very fine sediment in a shallow water basin in a location distal to the ice margin

Section: 4 Site: PS-33-0219 UTM (Nad 27): 5964186 491012



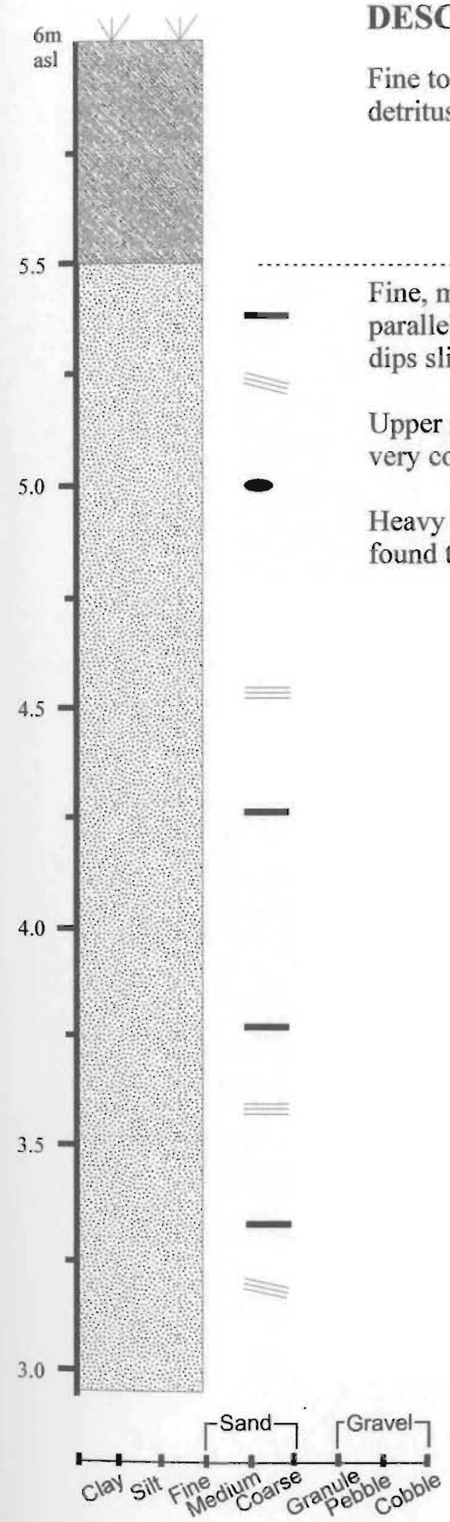
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Soil horizon
Beds of fine to coarse sand which dip 10-17° towards the east Erosional contacts common in upper part of section Granules and occasional pebbles common Heavy mineral lamination found throughout section	Glaciomarine deposit: Dipping beds form a Hjulström type delta Erosional contacts and granule beds the result of gravity flows and rapid sedimentation
Fine-grained sand containing horizontal beds, and minor heavy mineral laminations	Glaciomarine deposit: Distal beds of the Hjulström type delta

Section: 5 Site: PS-38-0219 UTM (Nad 27): 5963754 491627



DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Peat Horizon
Modern roots found throughout	
Fine to medium sand with beds of coarse sand and granule gravel	Fluvial deposit: Ancient North River deposit under a tidal influence
Two logs found on their sides identified in section first sampled PS-6-W-0219	Coarse material deposited in channels
A few discontinuous HML	Logs are likely driftwood deposited during as high flow regimes decreased
Cross-beds found in coarser beds	
Clay rip-up clasts common in medium to coarse sand	Rip-up clasts likely eroded from clay beds formed in abandoned channels, during periods of increased flow regime
Coarse sand often contains lots of granules and some pebbles	
Herring-bone like cross bedding	Herring-bone cross-beds indicative of a bimodal energy regimes, such as a tidal environment

Section: 6 Site: PS-23-0217 UTM (Nad 27): 5963906 493486



DESCRIPTION

Fine to medium organic detritus

INTERPRETATION

Peat horizon

DESCRIPTION

Fine, moderately sorted, parallel bedded sand that dips slightly towards the east

Upper metre of sediment very compact

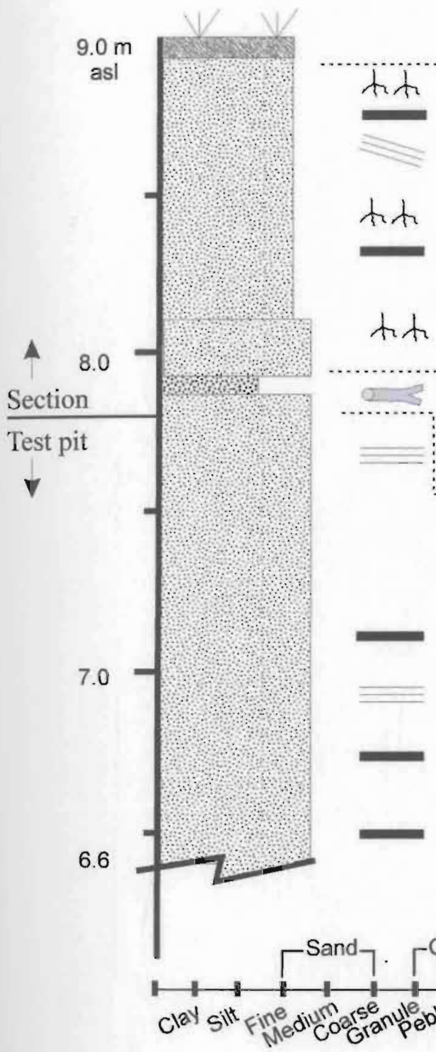
Heavy mineral lamination is found throughout section

INTERPRETATION

Marine deposits:
Beach sands sorted by swash and backwash wave action which separates sand grains from heavy mineral grains forming laminations

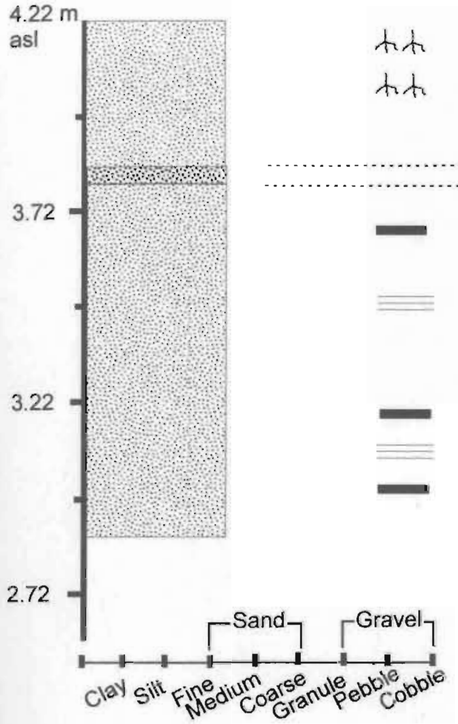
Compaction of upper metre the result of leaching of humic acids from the overlying organic horizon

Section: 7 Site: PS-15-0215 UTM (Nad 27):5963980 494084
Test pit:1



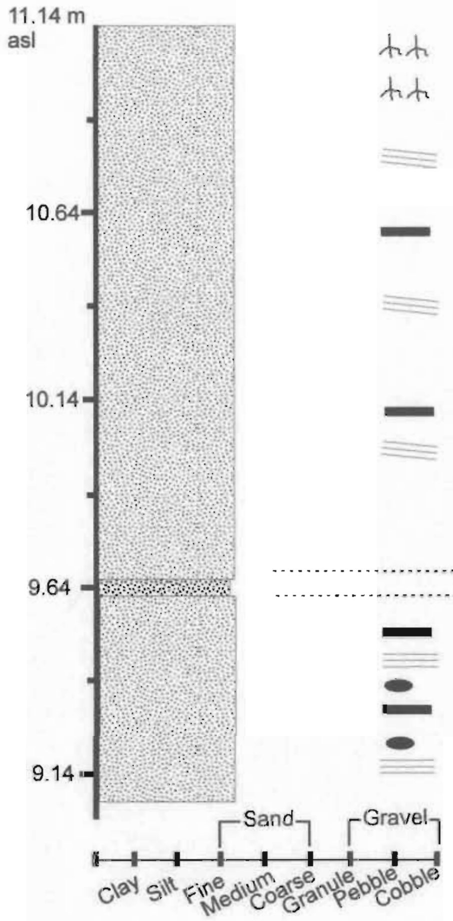
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of the soil profile
Well-sorted, steeply dipping beds of very fine- to fine-grained sand Dips highlighted by heavy mineral laminations Modern roots common	Aeolian deposit: Deposition by traction and grain flow
Fine-grained organic material containing wood	Palaeosol: Organic material of a former vegetated surface
Fine to medium sand generally horizontally bedded, moderately sorted High concentrations of heavy minerals	Marine deposit: Beach sand remobilized by marine processes, e.g swash and backwash wave action These processes effectively sort heavier mineral grains from fine-grained sand, forming layers of heavy minerals

Section: 8 Site: PS-99-0208 UTM (Nad 27): 5963360 494230



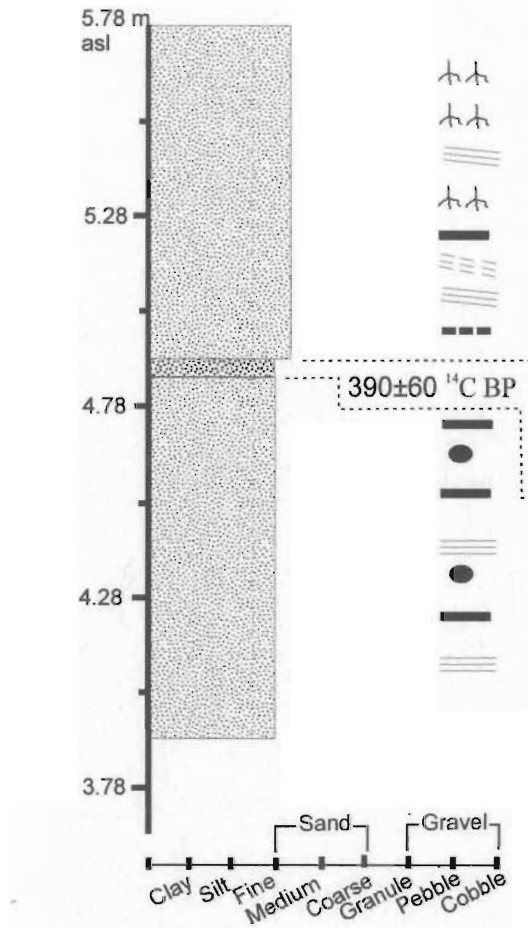
DESCRIPTION	INTERPRETATION
Well-sorted fine sand Modern roots common	Aeolian deposits: Deposited by traction and grain flow
Medium-grained organic material	Palaeosol: Organic horizon of a former vegetated surface
Well-sorted compact fine-grained sand, that is generally horizontally bedded	Marine deposit: Beach sands remobilized by marine processes, e.g. swash and backwash wave action Heavy mineral grains are sorted by these processes forming thin layers

Section: 9 Site: PS-92-0206 UTM (Nad27): 5963255 494380



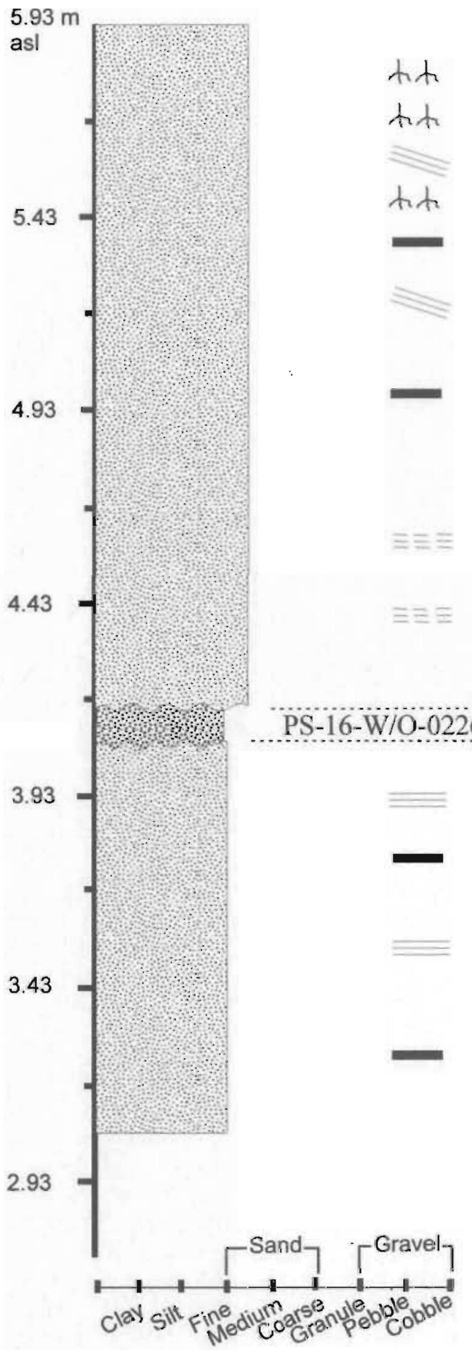
DESCRIPTION	INTERPRETATION
Well-sorted, dipping beds of fine- to medium- grained sand Marram grass roots identified in upper part of section Beds are highlighted by heavy mineral lamination	Aeolian deposits: deposition by traction and grain flow Heavy mineral laminations are remobilized by the wind and generally highlight sand beds
Medium-grained organic material that contains small amounts of charcoal	Palaeosol: Organic material of former vegetated surface
Well-sorted fine sand, generally horizontally bedded, that contains rare discoid shaped clasts	Marine deposit: Beach sands remobilized by marine processes, e.g. swash and backwash wave action Heavy mineral grains are sorted by these processes forming thin layers

Section: 10 Site: PS-74-0226 UTM (Nad 27): 5963729 494545



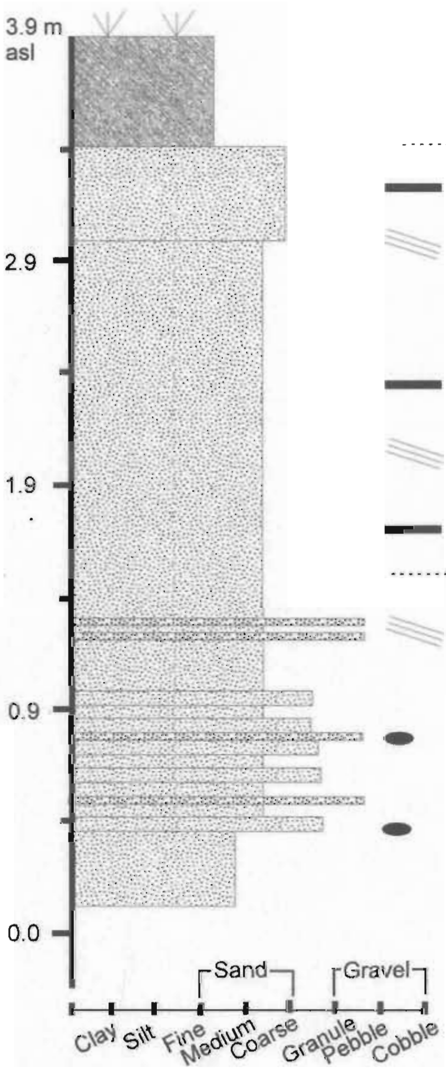
DESCRIPTION	INTERPRETATION
Well-sorted, dipping beds of fine to medium sand Modern marram roots found throughout Beds are highlighted by heavy mineral lamination, and are discontinuous in places	Aeolian deposit: Deposition by traction and grain flow Discontinuous heavy mineral laminations form from being remobilized by the wind
Medium-grained organic material (Beta-175377) that contains small amounts of charcoal	Palaeosol: Organic material forming an earlier vegetated surface
Well-sorted fine sand that is generally horizontally bedded Contains rare discoid shaped clasts	Marine deposit: Beach sand remobilized by marine processes, e.g. swash and backwash wave action Heavy minerals are sorted by these processes forming thin layers

Section: 11 Site: PS-71-0226 UTM (Nad 27): 5963241 494480



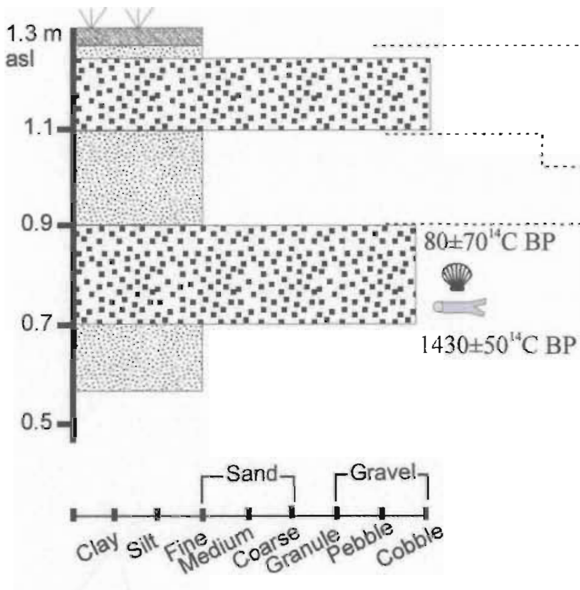
DESCRIPTION	INTERPRETATION
Well-sorted, steeply dipping fine to medium sand Marram roots common in upper part of section Parallel laminations are irregular and discontinuous in places Beds are highlighted by heavy mineral lamination	Aeolian deposit: Deposition by traction and grain flow Heavy mineral laminations form from being remobilized by the wind
Fine- to medium-grained organic material (sampled) that contained wood and charcoal	Palaeosol: Organic horizon Intermediate Indian cultural layer
Well sorted fine sand, horizontally bedded with heavy mineral laminations	Marine deposit: Beach sands remobilized by marine processes, e.g. swash and backwash wave action that separate heavy mineral grains from fine sand

Section: 12 Site: PS-11-0214 UTM (Nad 27): 5962607 494823



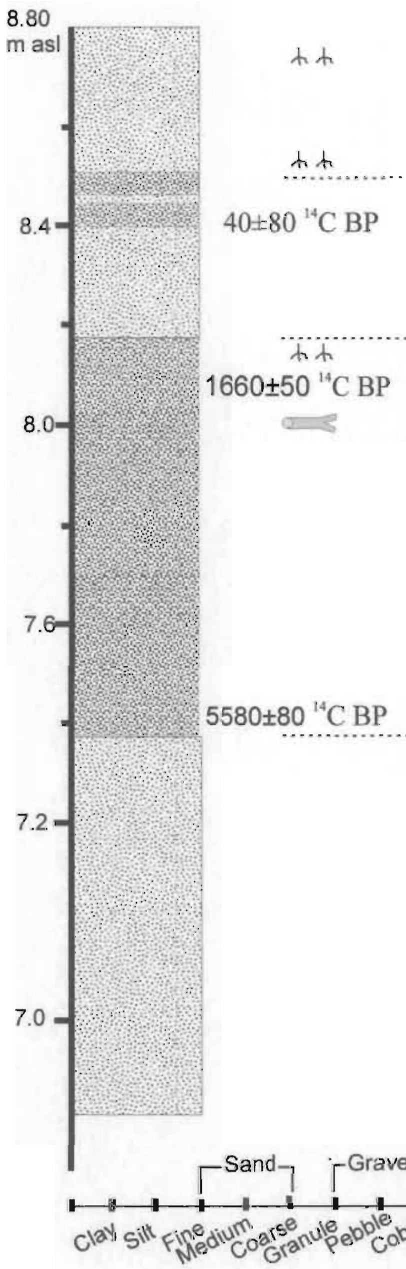
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Soil horizon (O)
Dipping medium to coarse sand that contains heavy mineral laminations	Marine deposit: beach sand remobilized by marine processes, e.g . swash and backwash wave action
Fine to medium sand with coarse sand and granule gravel beds	Glaciomarine deposit: Dipping beds form a Hjulström type delta
Occasional pebbles present	Variable sand beds resulting from channel and overflow deposition

Section: 13 Site: PS-88-0203 UTM (Nad 27): 5965111 492438



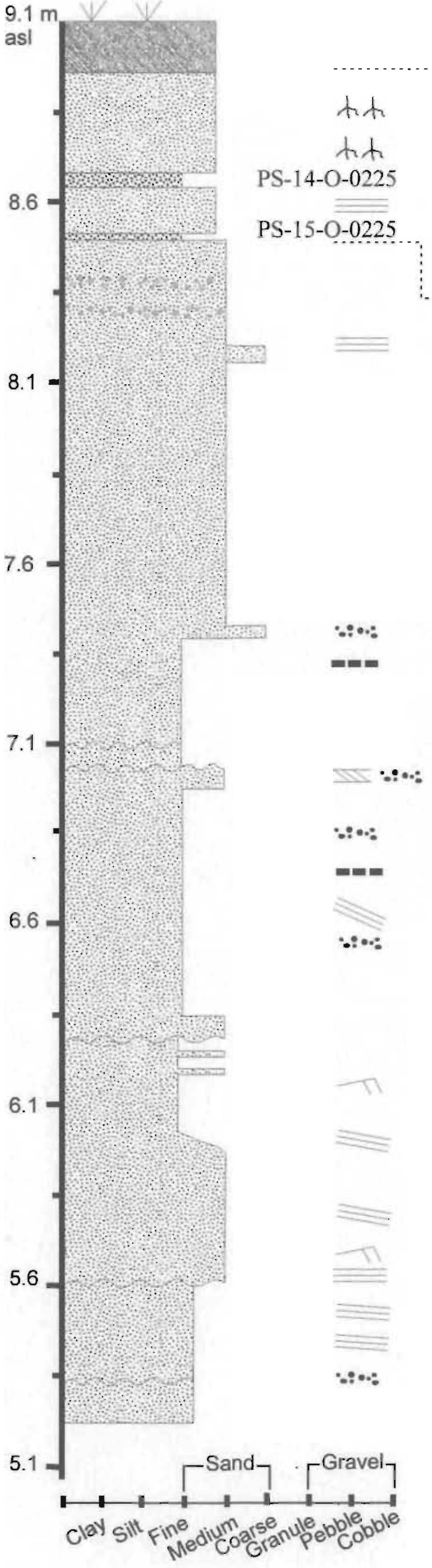
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of a soil profile
Fine sand overlaying a cobble bed with fine-grained matrix, clast-supported in places	Aeolian sand overlying a marine storm beach deposit
Well-sorted fine-grained sand	Aeolian sand
Flat discoid cobble bed with fine-grained matrix, clast-supported in places Contains dated broken shells (GSC-6683) and driftwood (GSC-6723)	Marine deposit: Storm beach composed of cobble gravel and fine sand that is underlain by fine beach sand
Well-sorted fine-grained sand	

Section: 14 Site: PS-89-0203 UTM (Nad 27):5965100 491598



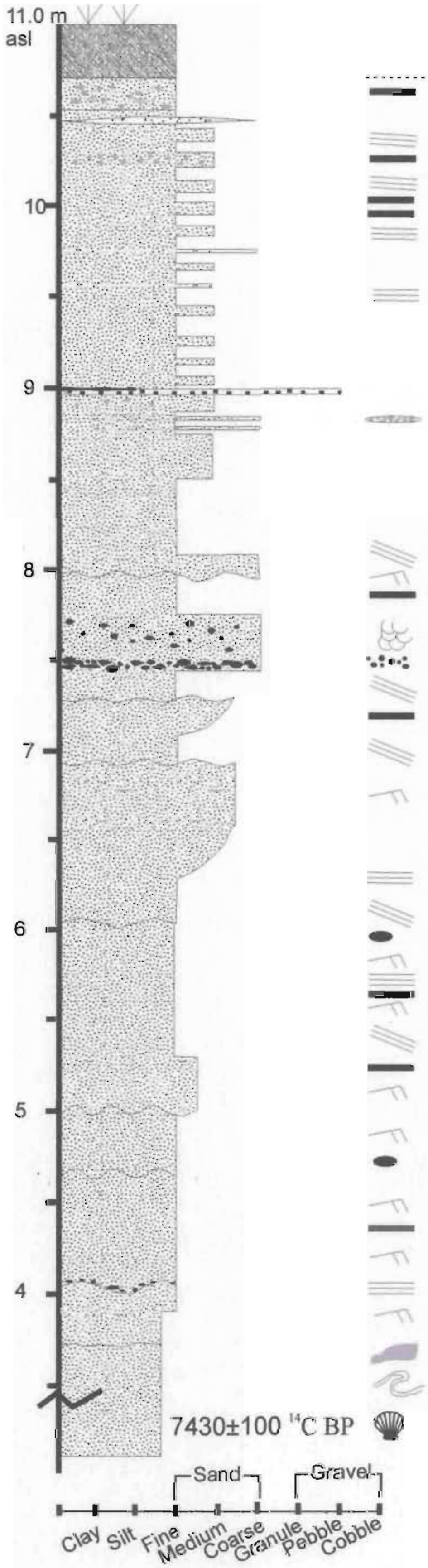
DESCRIPTION	INTERPRETATION
Well-sorted fine sand exposed at the surface Surrounding organic mat eroded	Aeolian deposit: Area of deflation exposing aeolian sand
Fine sand interbedded with thin medium to coarse organic material Uppermost organic material sampled (GSC-6716)	Aeolian sand deposited between thin palaeosol horizons
Thick deposit of medium to coarse organic material that contained wood Upper (GSC-6714) and lower (GSC-6675) 10 cm sampled	Organic deposit: Buried peat horizon
Fine well-sorted sand	Glaciomarine deposit: Sediments form a Hjulström type delta (Inferred from adjacent sections)

Section: 15 Site: PS-69-0224 UTM (Nad 27):5965139 491435



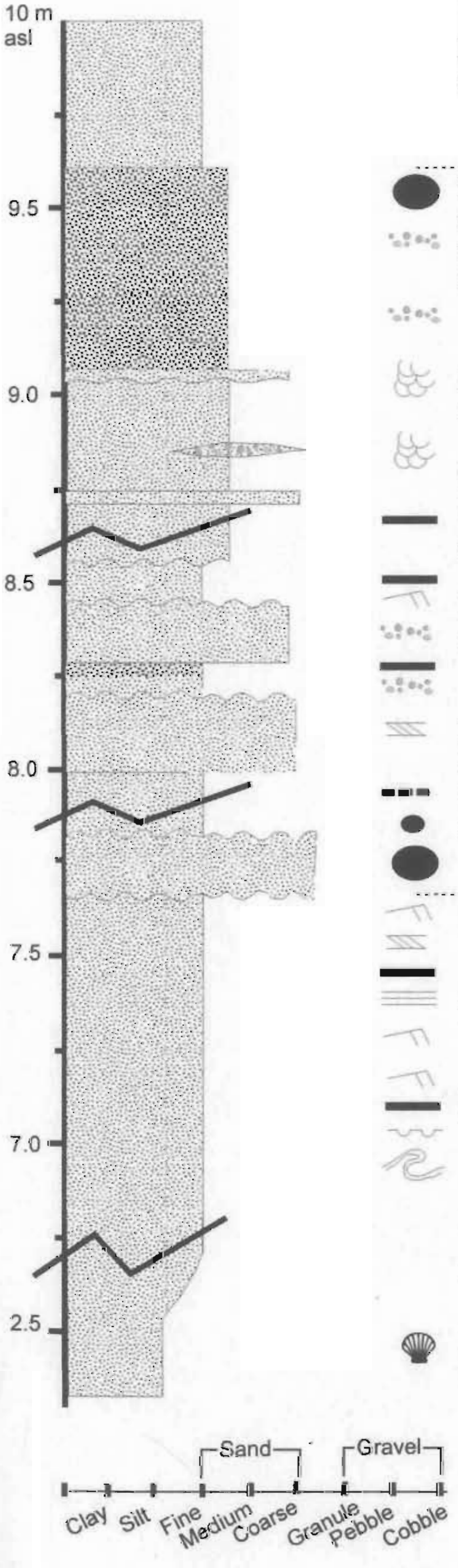
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Soil horizon (O)
Horizontally bedded fine to medium sand Modern roots present Two fine-grained organic horizons	Aeolian deposit: Aeolian sand overlying and interbedded with palaeosols Deposition of sand by traction and grain flow
Fine to medium sand with coarse sand beds Wavy and erosional contacts generally associated with the bottom of coarser beds and are overlain by finer sediment	Glaciomarine deposit: Moderately-sorted sand deposited on a gently sloping Hjulström type delta Erosional contacts the result of underflow and gravity flows
Granules common in lower portion of section	coarser material deposited in small channels
Rare discontinuous heavy mineral laminations found in fine sand	
Beds dip 10° towards the east	
Ripple cross lamination found toward the bottom of section	

Section:16 Site: PS-66-0224 UTM (Nad 27):5965648 489950



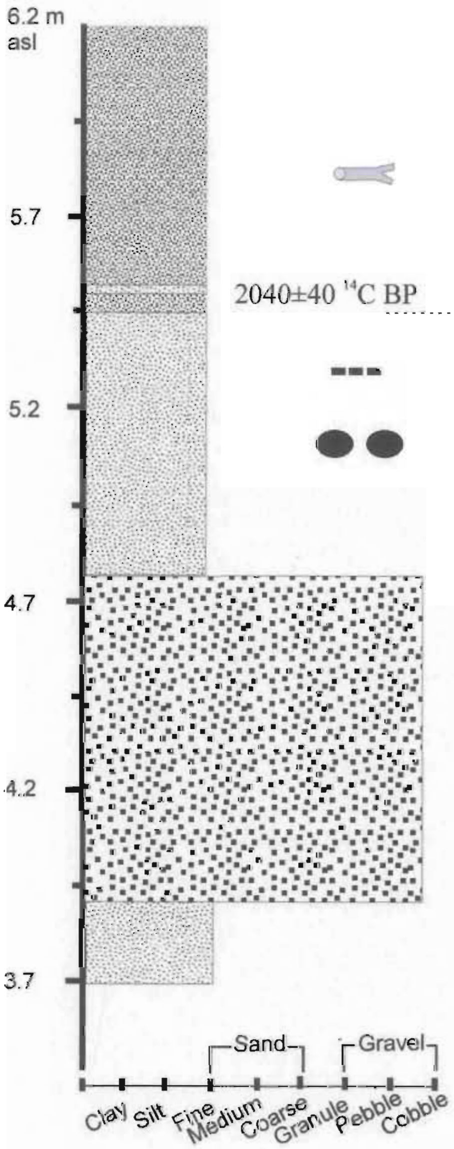
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of a soil profile
Fine to medium beds of sand that range from horizontally bedded to slightly dipping towards the east Beds dip 4-18° east and contain occasional pebble concentrations Wavy to erosional contacts common Concentrations of heavy mineral laminations decrease towards the bottom Some scour and fill structures Ripple cross lamination, and horizontal lamination Rare dipping beds and occasional discoid clasts found in lower part of section	Marine to glaciomarine deposit: Glaciomarine sediments reworked into beach sediments that grade into coarser outwash sediments deposited on a Hjulström type delta Coarser material is deposited in channels by underflow and gravity flows as the result of increased meltwater influx
Dewatering structures at bottom of section *Hiatella arctica* shells found as lag below measured section at 1.8 m asl (GSC-6677)	Rapid sedimentation rates are indicated by the presence of dewatering structures Environmental preferences of marine fauna suggest that deposition occurred in less than 80 m water depth

Section:17 Site: PS-149-0223 UTM: 5965926 489640



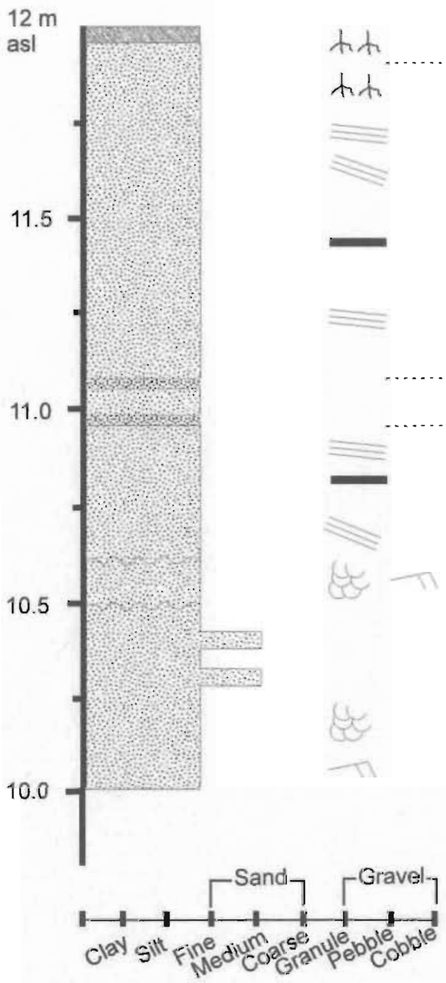
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Peat horizon
Fine to medium moderately-sorted cemented sand that contains few boulders and beds of pebbles and granules	Glaciomarine deposit: Uppermost portion of the section cemented by leaching of humic acids
Many scour and fill structures throughout Some heavy mineral laminations; discontinuous in places	Trough cross beds are indicative of migrating channels commonly associated with outwash sediments being deposited at the seaward end of a Hjulström type delta
Thin beds of pebble and granule gravel common Layer of pebbles and large boulders are found in the very coarse sand associated with the erosional contact	Pebbles and granule gravel deposited in channels during high energy flow events
Well-sorted ripple laminated fine sand containing heavy mineral laminations Lower portion contains many dewatering structures	Glaciomarine deposit: Sand rapidly deposited in a distal marine setting of a gently sloping delta
Mya arenaria, Mya truncata, were collected in sandy silt at 2 m asl (PS-152-S-0223) Pairs not found in living position	Shells species suggest deposition took place in shallow marine basin with water depths not exceeding 50 m

Section: 18 Site: PS-148-0223 UTM (Nad 27): 5965989 489593



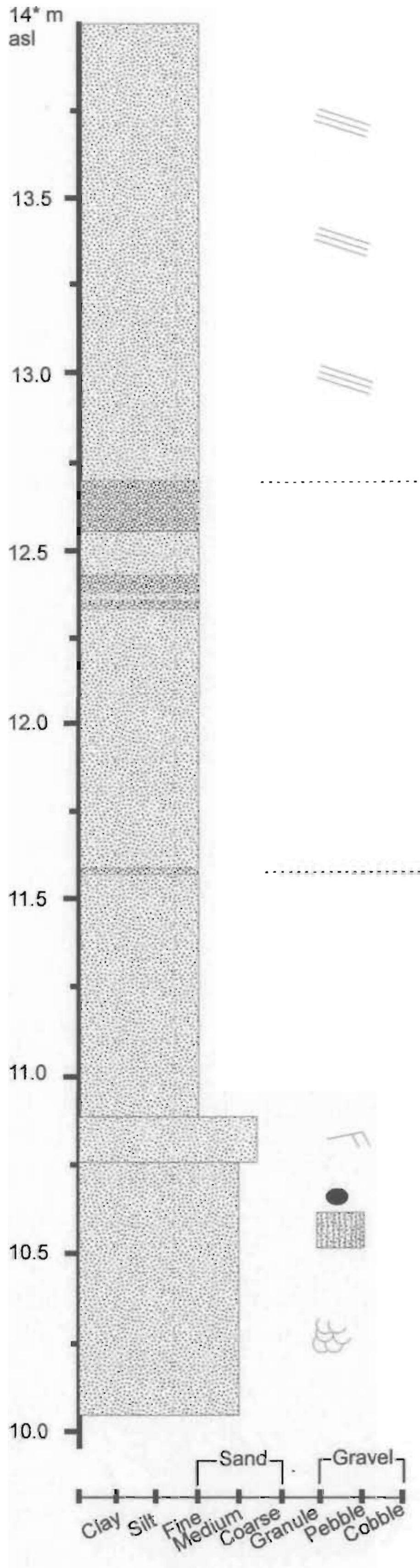
DESCRIPTION	INTERPRETATION
Fine- to medium-grained organic material including wood Thin layer of sand near bottom Bottom 10 cm of peat radiocarbon dated (Beta-191933)	Peat deposit
Fine- to medium-grained sand with discontinuous heavy mineral laminations and rare cobbles	Marine deposit: Moderately well-sorted beach deposit Sands remobilized by marine processes, e.g. Swash and backwash wave action
Clast-supported cobble bed Clasts have a discoid shape and are subround to well-rounded	Cobble beach deposit, formed during high energy event, such as a high magnitude storm

Section: 19 Site: PS-147-0222 UTM (Nad 27): 5967016 486940



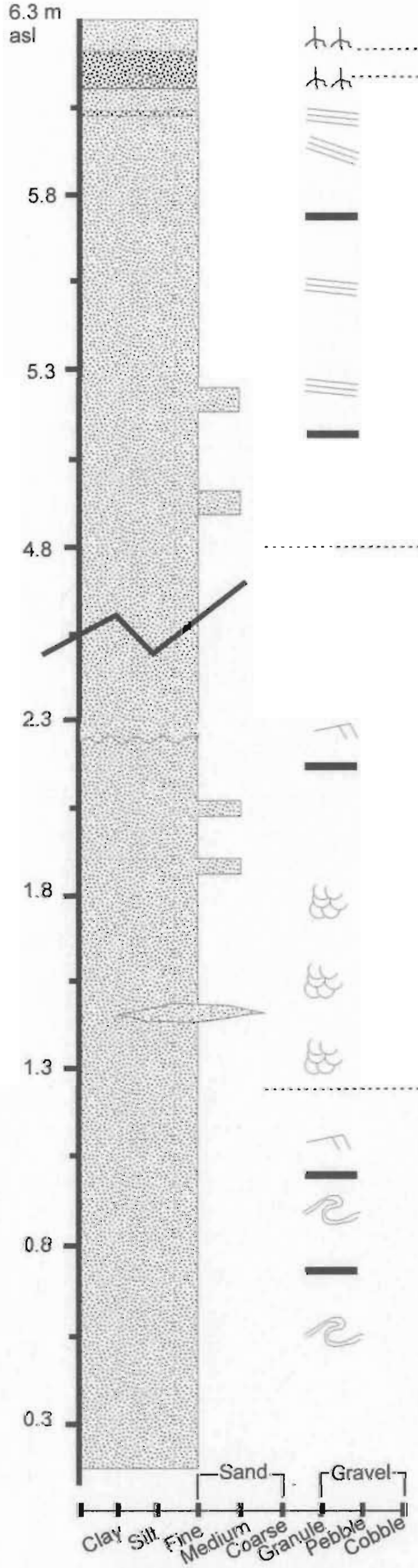
DESCRIPTION	INTERPRETATION
Fine organic detritus	Organic soil horizon
Well-sorted, fine-grained sand that dip slightly Some heavy mineral laminations present	Aeolian deposit: Deposition by traction and grain flow
Two thin organic layers separated by fine-grained sand	Palaeosols: Organic horizons separated by aeolian sand
Fine to medium sand containing beds that dip 18° SSE Scour and fill and ripple laminations common in lower section	Glaciomarine deposit: Dipping beds form a Hjulström type delta Coarser beds and channels formed as a result of gravity flow and overflow events associated with deposition at the seaward end of a Hjulström type delta

Section: 20 Site: PS-147b-0222 UTM (Nad 27): 5967444 487130



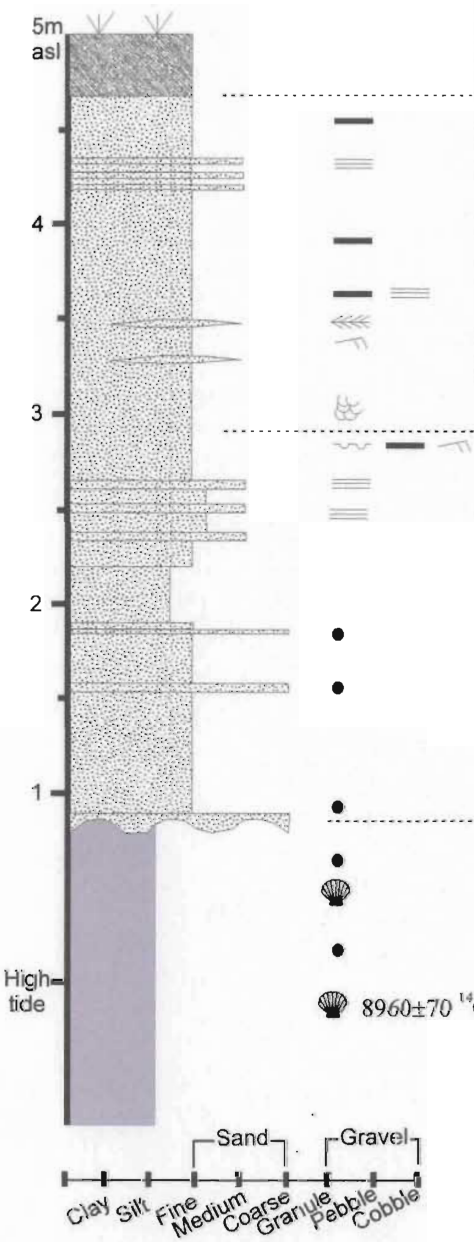
DESCRIPTION	INTERPRETATION
Well-sorted laminated sand which dips 10° N	Aeolian deposit: Sand deposition by traction and grain flow
Well-sorted fine sand Three buried organic layers comprised of fine- to medium-grained organic material	Palaeosol: Organic horizons separated by aeolian sand
Moderately-sorted fine to medium sand, that contained occasional pebbles, ripple cross lamination, trough cross beds, and rip-up clast with parallel beds	Glaciomarine deposit: Dipping beds form a Hjulström type delta Channels formed in association with gravity flow and overflow events at the seaward end of a Hjulström type delta

Section: 21 Site: PS-143-0221 UTM (Nad 27): 5968512 487178



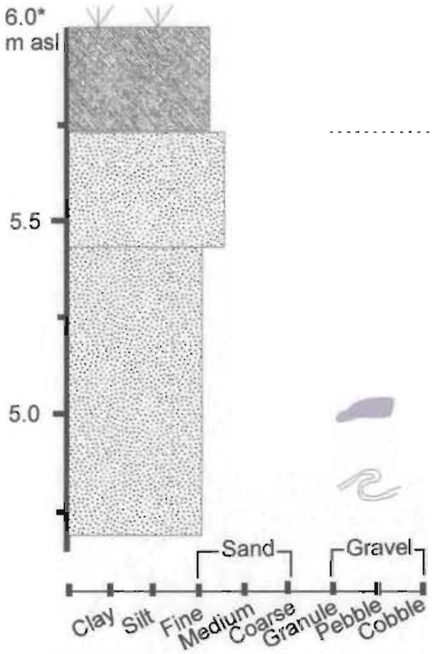
DESCRIPTION	INTERPRETATION
Well-sorted fine sand	Aeolian deposit:
Two layers of organic detritus separated by fine-grained sand	Peat deposits, separated by aeolian sand
Moderately-sorted fine to medium sand that contains heavy mineral laminations Dipping (6-9°) parallel laminations	Marine deposit: Gently dipping beach sands
Small scale trough cross beds common in lower portion of section	Glaciomarine deposit: Channel fills formed as a result of overflow and gravity flow at the seaward end of a Hjulström type delta
Dewatering structures highlighted by thin heavy mineral laminations	Glaciomarine deposit: Fine-grained sediment deposited rapidly on the distal end of a gently sloping delta

Section: 22 Site: PS-55-0224 UTM (Nad 27): 5974054 485120



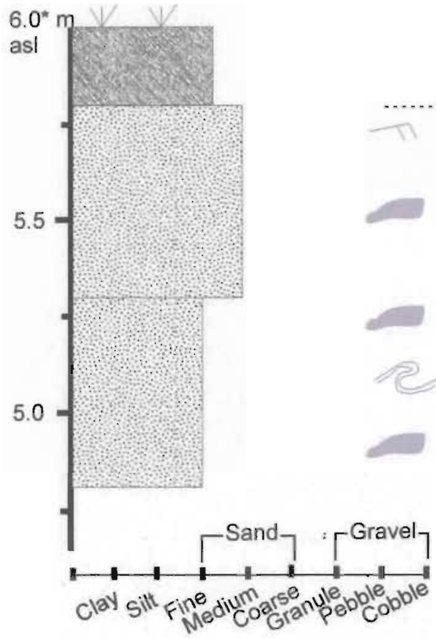
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Peat horizon
Fine to medium sand containing parallel horizontal laminations and herring bone cross laminations highlighted by heavy mineral laminations Small trough cross beds are also identified	Marine deposit: deposition in a littoral environment
Load casts in fine sediment Interbedded fine, medium and coarse sand, that is moderately- to well-sorted Erosional contact separating overlying coarse sand from mud Coarse sand contains few pebble size clasts	Marine to glaciomarine deposit: Rapid deposition in a shallowing deltaic environment Erosional contact and coarse beds are the result of gravity-flow and over-flow on a Hjulström type delta
Massive and well-sorted mud Contains rare pebbles and shells (TO-10948) 8960±70 ^{14}C BP	Glaciomarine deposit: Deposited in a shallow water basin in a distal ice margin enviornment Dropstones are the result of ice rafting

Section: 23 Site: PS-59-0224 UTM (Nad 27): 5973308 484828



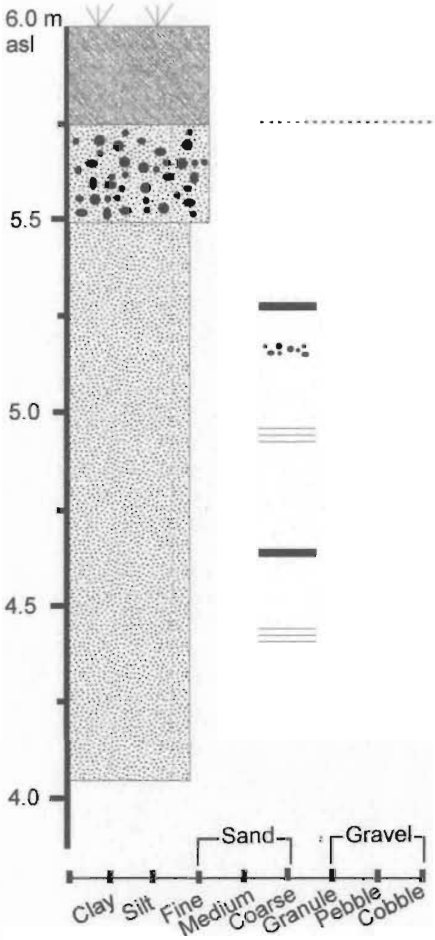
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of a soil
Fine to medium sand that is compact and oxidized	Glaciomarine deposit: Rapidly deposited sand on a Hjulström type delta
Contains rip-up clasts and convolute lamination	Rip-up clasts are suggestive of clay deposit that formed as a result of ponding on the delta top and was eroded and deposited by high energy flows

Section: 24 Site: PS-50-0222 UTM (Nad 27): 5973860 484517



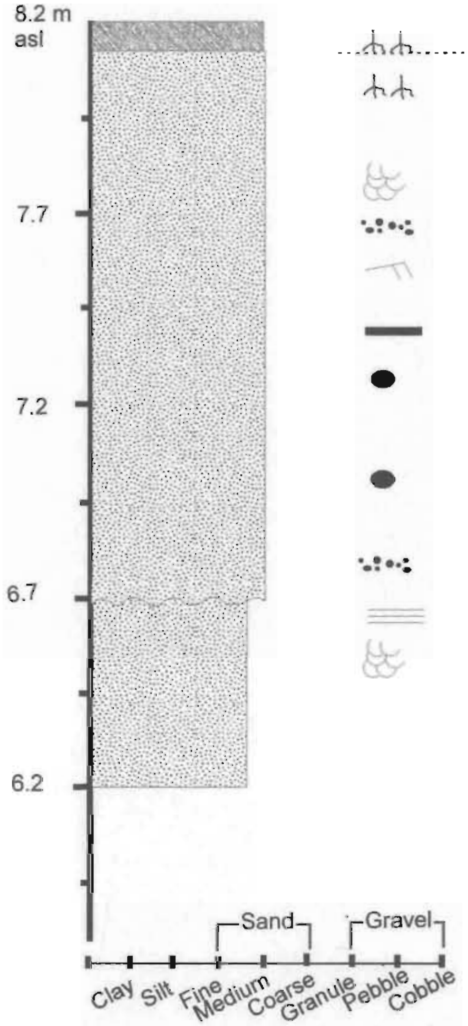
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of a soil
Fine to medium compact sand containing ripples and clay rip-up clasts	Glaciomarine deposit: Rapidly deposited sand in a distal Hjulström type delta environment
Convolute lamination present in the lower portion of the section	Clay rip-up clasts may be the result of ponding on the delta top that were eroded by high energy flows

Section: 25 Site: PS-46-0222 UTM (Nad 27): 5974465 482610



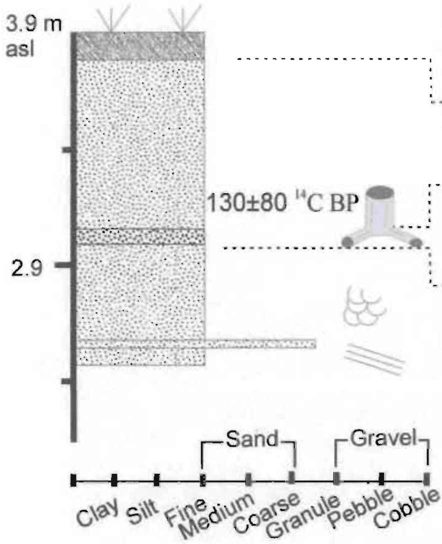
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of a soil
Fine compact sand with clasts ranging from granules to pebbles Very fine to fine compact sand containing heavy mineral laminations and horizontal parallel beds	Glaciomarine deposit: Coarser material deposited as a result of outwash prograding, out over finer-grained sands, at the seaward edge of a Hjulström type delta

Section: 26 Site: PS-80, 81, 82, 83 UTM (Nad 27): 5997468 474789



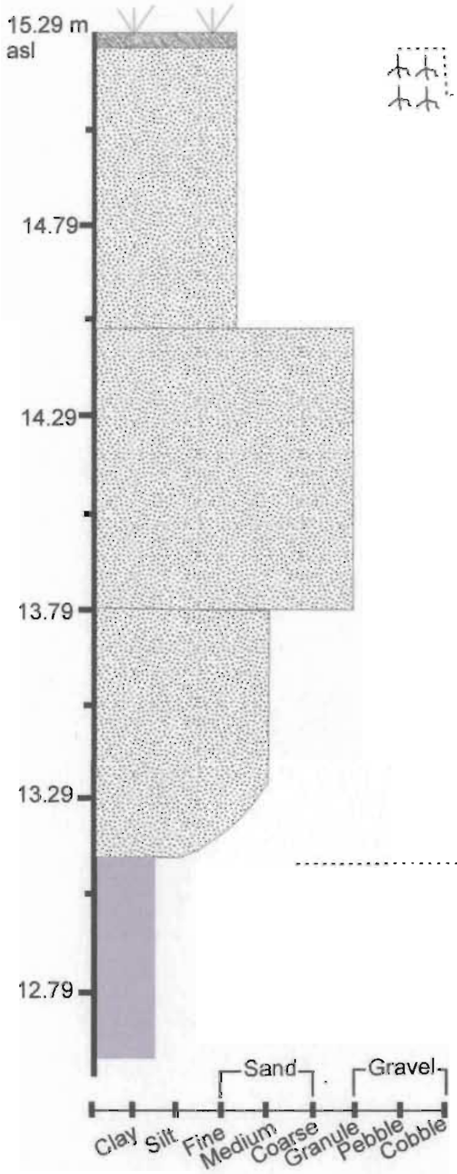
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Peat
Moderately sorted fine to medium sand containing large trough crossbeds and clast lags along erosional contacts	Glaciomarine deposit: Outwash sediment deposited at the seaward edge of a Hjulström type delta Coarser material associated with channels on the delta surface

Section: 27 Site: PS-87-0201 UTM (Nad 27): 5997468 474789



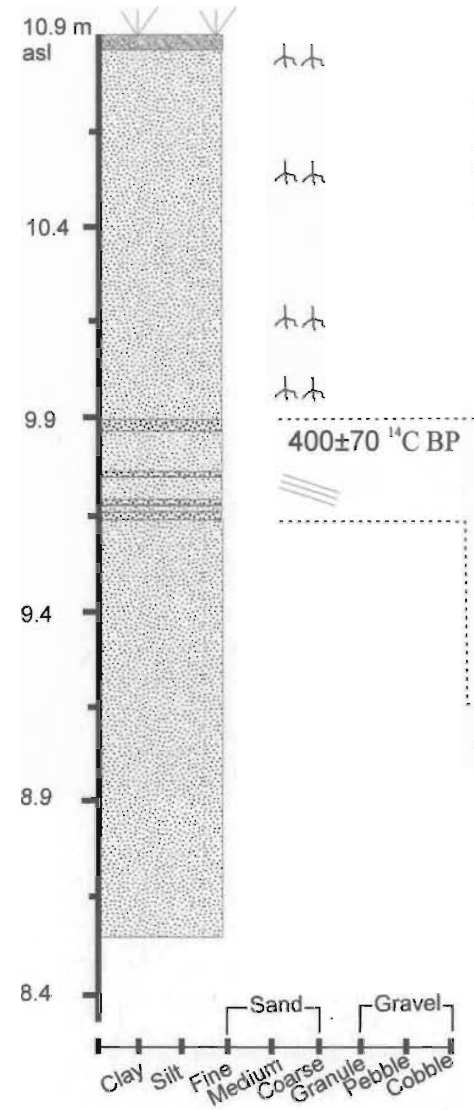
DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of a soil
Fine well-sorted sand	Aeolian Deposit
Fine- to medium-grained organics containing *in situ* wood (GSC-6758)	Palaeosol horizon, buried by aeolian deposits
Fine- to medium-grained sand, that contains trough crossbeds and dipping parallel laminations	Glaciomarine deposit: Sediment deposited at the seaward edge of a gently dipping delta
	Delta surface cut by small channels

Section: 28 Site: PS-125-0215 UTM (Nad 27): 5997659 473008



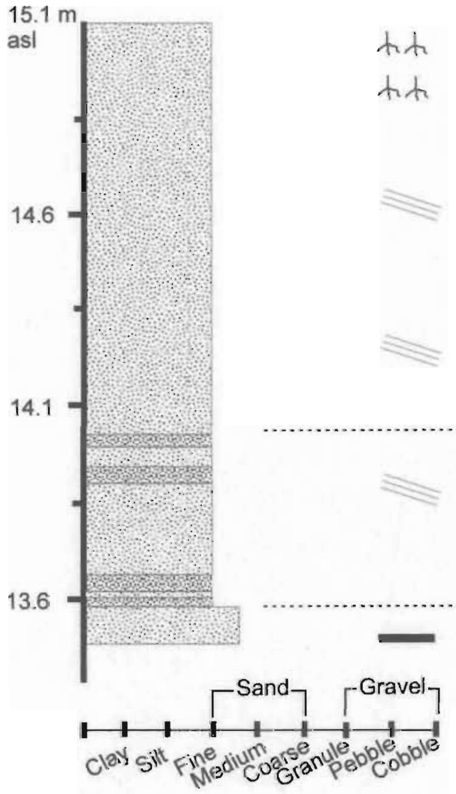
DESCRIPTION	INTERPRETATION
Fine-grained organic detritus	Organic horizon of a soil
Fine to coarse bedded sand No structures visible	Glaciomarine deposit: Sediment deposited in a marine setting forming a Hjulström type delta
Fine-grained mud No structures visible	Glaciomarine deposit: sediment deposited in shallow deltaic environment

Section: 29 Site: PS-122 Blowout D UTM (Nad 27): 6005094 469276



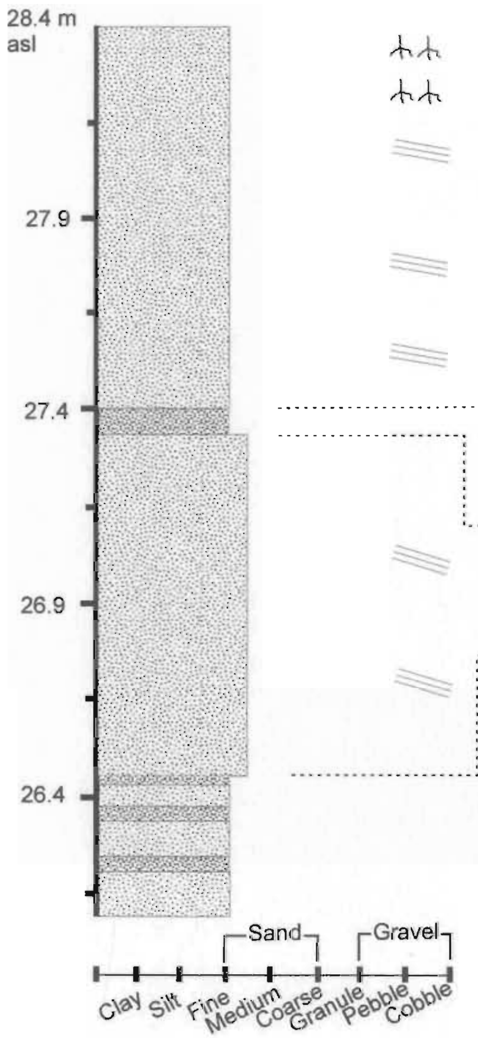
DESCRIPTION	INTERPRETATION
Well-sorted fine sand No structure seen due to abundant marrum grass roots	Aeolian deposit: Deposited by traction and grain flow
Four fine-grained organic horizons contained some wood fragments Uppermost sampled and dated (Beta-175380) Dipping parallel beds in fine sand	Palaeosol: O horizons separated by aeolian sand Sand deposited by traction and grain flow
Well-sorted fine sand	Marine raised beach sand

Section: 30 Site: PS-122 Blowout F UTMs not recorded, approx. 150 m east of section



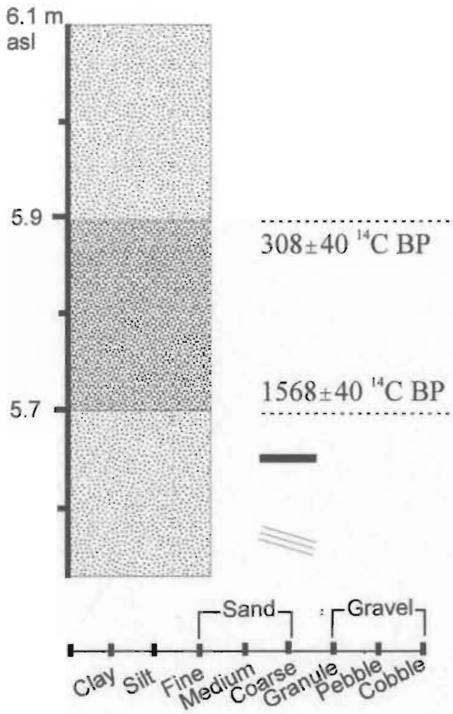
DESCRIPTION	INTERPRETATION
Well-sorted fine sand Dipping parallel beds common	Aeolian deposit: Deposited by traction and grain flow
Dry, fine- to medium-grained organic material that contained *in situ* wood stumps Sand contains dipping parallel beds	Palaeosol: O horizons separated by aeolian sand
Well-sorted fine to medium sand containing heavy mineral laminations	Marine deposit: Beach sands, heavy mineral grains sorted through swash and backwash action

Section: 31 Site: PS-121-0212 UTM (Nad 27): 6004595 469134



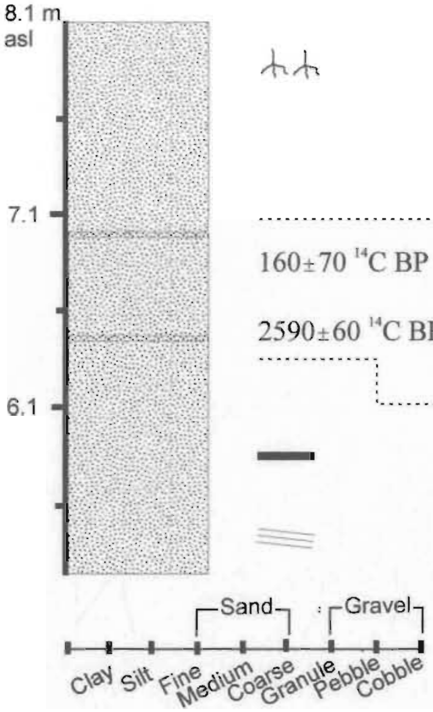
DESCRIPTION	INTERPRETATION
Modern roots in upper part of section Well-sorted,Fine sand that is parallel laminated, Laminatioinsdip 17°S	Aeolian deposits: Deposited by traction and grain flow
Medium-grained organic material that contained wood fragments	Palaeosol: O horizon of a former vegetated surface
Well-sorted, steeply dipping, fine- to medium-grained sand	Aeolian deposits: Deposited by traction and grain flow
Well-sorted fine-grained sand that separated three greasy textured beds of fine- to medium-grained organic material and small fragments of wood	Palaeosol:: O horizons separated by aeolian sand

Section:32 Site: PS-94-0205 UTM (Nad 27): 5963097 495124



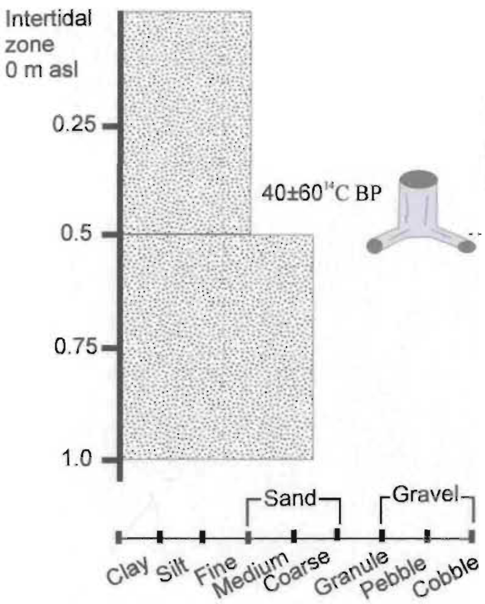
DESCRIPTION	INTERPRETATION
Well-sorted fine-grained sand	Aeolian deposit: Sand deposited by traction and grain flow
Fine- to medium-grained organic material Top (BGS-2453) and bottom (BGS-2454) sampled	Peat deposit: Associated with Dorset Palaeoeskimo artifacts
Fine- to medium-grained sand, moderately- to well-sorted containing easterly dipping parallel laminations, highlighted by heavy mineral laminations	Marine deposit: Beach sand, heavy mineral grains separated through swash and backwash action

Section: 33 Site: PS-107-0208 UTM (Nad 27): 5963679 493850



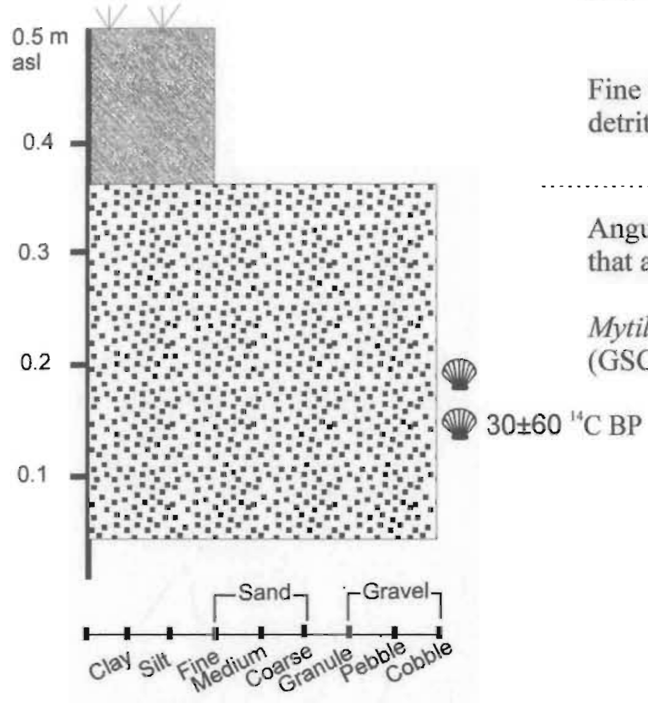
	DESCRIPTION	INTERPRETATION
	Well-sorted fine-grained sand	Aeolian deposit: Sand deposited by traction and grain flow
160±70 ^{14}C BP 2590±60 ^{14}C BP	Fine- to medium-grained organics layers Sampled and dated, top (Beta-175378) and bottom (BGS-175379)	Palaeosol: O horizons separated by aeolian sand
	Fine- to medium-grained sand, moderately- to well-sorted Easterly dipping parallel laminations, highlighted by heavy mineral laminations	Marine deposit: Beach sand, heavy mineral grains separated through swash and backwash action

Test Pit: 2 Site: PS-76-0229 UTM (Nad 27): 5974843 485401



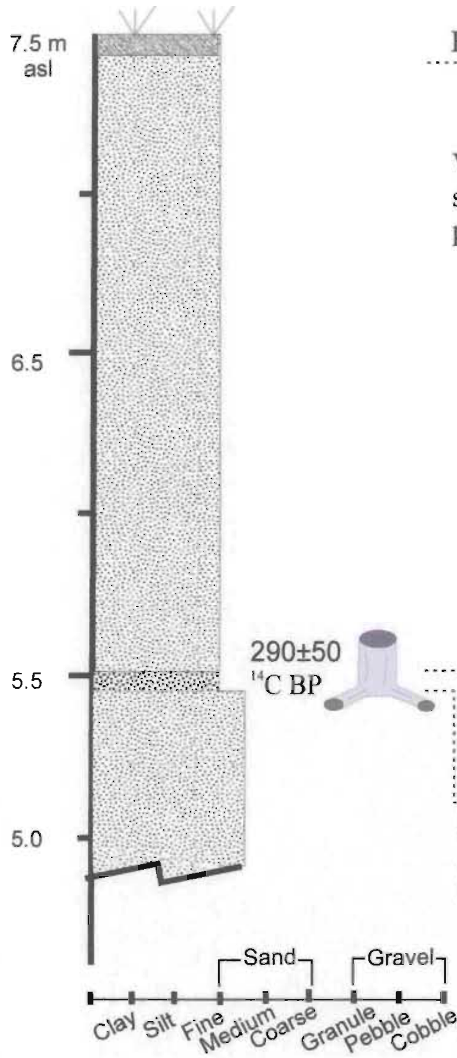
DESCRIPTION	INTERPRETATION
Well-sorted, fine-grained sand in a modern intertidal setting	Intertidal beach sand
Upright *Picea* tree stump in gravelly medium to coarse sand (GSC-6766)	Tree stump buried in reworked glaciomarine sediment

Test pit: 3 Site: PS-87-0215 UTM (Nad 27): 5998500 474700



DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of a soil
Angular pebbles and cobbles that are clast-supported *Mytilus edulis* sampled (GSC-6685)	Marine deposit: Relatively young raised beach derived from fracturing and wave reworking of adjacent bedrock

Test Pit: 4 Site: PS-85-0231 UTM (Nad 27): 6005046 469413



DESCRIPTION	INTERPRETATION
Fine to medium organic detritus	Organic horizon of a soil
Very well-sorted fine-grained sand, containing dipping parallel laminations	Aeolian deposits: Dipping beds deposited by traction and grain flow
Fine-grained organic material and *in situ* tree stumps (*Picea*; GSC-6750)	Forested palaeosol horizon
Fine- to medium-grained sand containing small clasts and horizontal lamination	Marine deposits: Beach sands

Table A: Location, description and interpretation of test pits along Porcupine Strand.

Site[a]	Northing	Easting	Elevation (m)[b]	Location	Depth (cm)	Grain size	Description[c]	Interpretation	Buried Soil	Samples Taken
PS-12-0215	5963395	493681	2	First terrace, south side of Sandy Point	100	Medium sand	HML, pebble layer at 70 cm, cobble sized clasts	Beach sediments	No	No
PS-13-0215	5963429	493692	7	Top of beach ridge Sandy Point	200	Fine sand	Compact, mottled apperance, no structures seen	Beach sediments	No	No
PS-14-0215*	5963468	493765	unknown	Bottom of blowout on Sandy Point	40	Fine sand	Dipping parallel beds, HML, no clasts	Beach sediments	No	No
PS-20-0217	5963375	484898	8.6	Between beach ridges on Sandy Point	100	Fine sand	HML parallel, but are slightly wavy in places	Beach sediments	No	No
PS-20-0217	5963415	493723	12*	Sandy Point	100	Fine sand	Oxidized, compact, no structures seen	Beach sediments?	No	No
PS-24-0217	5964355	493688	12*	Sandy Point	100	Fine sand	Oxidized, compact, no structures seen	Beach sediments?	No	No
PS-25-0217	5964339	493607	10*	Sandy Point	Unknown	Fine sand	No structures seen, sand overlying bedrock	Beach or aeolian?	No	No
PS-26-0217	5964360	493068	15*	Sandy Point	30	Fine sand	No structures seen, hit permafrost at 30 cm	Beach or aeolian?	No	No
PS-27-0217	5964377	493165	11*	Sandy Point	30	Fine - medium sand	No structures seen, hit permafrost at 30 cm	Beach or aeolian?	No	No
PS-30-0218	5963834	485788	22	North side of North River	43	Peat	Found permafrost at 43 cm	Not Known	No	No
PS-31-0218	5964736	485128	28.5	North side of North River	70	Fine - medium sand	No structures seen	Not Known	No	No
PS-36-0218	5964300	491721	20.4	North side of North River	300	Medium and coarse sand	Compact, erosional contact between medium and coarse sand, HML	Marine	No	No
PS-44-0222	5974357	481729		South of Big Brook	30	Fine - medium sand	Extremely compact, clasts 20%, Ave. 4 cm, SA-SR, boulders on surface	Raised beach ridge	No	No
PS-47-0222	5974497	482841	21*	South of Big Brook	75	Fine sand	Clasts 5%, Ave. 1.5 cm, SA-SR, no structure seen	Beach sediments?	No	No
PS-51-0223 A	5964988	493164	3.8	NE side Sandy Point	103	Fine sand	HML, oxidation to 45 cm, ripples	Beach sediments	No	No
PS-51-0223 B	5964988	493164	2.3	NE side Sandy Point	110	Fine sand	HML, dipping parallel beds, wavy HML	Beach sediments	No	No

Cont. of Table A

Site[a]	Northing	Easting	Elevation (m)[b]	Location	Depth (cm)	Grain size	Description[c]	Interpretation	Buried Soil	Samples Taken
PS-51-0223 C	5964988	493164	1.9	NE side Sandy Point	115	Fine sand	HML wavy and discontinuous in places, beds horizontal	Beach sediments	No	No
PS-51-0223 D	5964988	493164	2.3	NE side Sandy Point	109		HML continuous slightly dipping east	Beach sediments	1 thin buried soil containing wood	PS-08-W-0223
PS-51-0223 E	5964988	493164	2.1	NE side Sandy Point	160	Fine sand	HML discontinous in places and not parallel	Beach sediments	No	No
PS-51-0223 G	5964988	493164	3	NE side Sandy Point	85	Fine sand	HML continuous and parallel	Beach sediments	No	No
PS-51-0223 H	5964988	493164	2.5	NE side Sandy Point	125	Fine - medium sand	Horizontal HML, wood sampled at 47 cm depth, marine shells look modern sampled at 71 cm depth	Beach sediments	No	PS-09-S-0223 PS-10-W-0223
PS-57-0224	593958	484503	11.9	North Shore of Big Brook	70	Fine sand and silt	Layer of granules with clasts, clast content 20%, A-SR	Fluvial overlying marine	No	No
PS-72-0226	5963981	494186	7.1	Sandy Point	80	fine	Oxidized below 18 cm, compact no structure seen	Aeolian overlying marine beach sediments	Yes	PS-19-O-0226
PS-76-0229*	5974843	485401	Intertidal zone	North of Big Brook	100	fine to coarse	Fine, well-sorted sand overlying medium to coarse sand, containing upright tree stump	Beach sediments	No	PS-21-W-0229
PS-84-0231	6004876	468982	21	Upper Sandy Cove	60	fine sand	No structures	Aeolian sediments	Yes	PS-22-O-0231
PS-85-0231*	6005046	469413	5.5	Lower Sandy Cove	50	fine sand	No structures	Aeolian overlying marine beach sediments	Yes (containing rooted tree stumps)	PS-23-W-0231
PS-86-0231	6004138	470909	9.7	Tub Harbour	190	fine	No structures, two palaeosols, first at 66 cm depth, second at 173 cm depth	Aeolian above palaeosols and marine below 2nd palaeosol	Yes	PS-24-O-0231 PS-25-O-0231
PS-87-0201	5998955	475092	5.5	Seal Cove	76	gravelly sand	Bottom of blowout, contains well-rounded pebbles and cobbles	Beach sediments	No	No
PS-94-0205	5963097	495124	6.1	Sandy Point	40	Fine sand	Fine sand overlying peat horizon, identified in a blowout wall through a raised beach	Aeolian sediment overlying buried peat with marine sediment below	Yes (top and bottom sampled)	PS-36-O-0205 PS-37-O-0205
PS-101A-0208	5963490	494269	6.9	Sandy Point, side of blowout	120	fine sand	Fine sand separated by two palaeosols, sediment at 110 cm contains rounded cobbles and HML	Aeolian above palaeosols and marine below 2nd palaeosol	Yes	PS-50-O0208 PS-51-O-0208

Cont. of Table A

Site[a]	Northing	Easting	Elevation (m)[b]	Location	Depth (cm)	Grain size	Description[c]	Interpretation	Buried Soil	Samples Taken
PS-103-0208	5964000	494504	2.6	Sandy Point	60	fine	40 cm aeolian sand overlying 2 cm thick palaeosol, discoid cobbles are found *in situ* in underlying compact fine to medium sand	Aeolian overlying palaeosol, marine below	Yes	none
PS-104A-0208	5963940	494247	4.4	Sandy Point, side of blowout	126	fine sand	75 cm of aeolian sand with HML, overlying 3 cm palaeosol, fine sand identified below	Aeolian overlying palaeosol, marine below	Yes	PS-56-O-0208
PS-105-0209	5963551	493865	7*	Sandy Point	35	Fine sand	No structures	Aeolian overlying palaeosol, marine below?	Yes	PS-59-O-0209 PS-60-O-0209
PS-109-0209	5964328	494084	Unknown	Sandy Point	40	Fine sand	No structures	Aeolian overlying palaeosol, marine below?	Yes	none
PS-114-0209	5963593	493685	9.6	Sandy Point	40	Fine sand	30 cm of fine sand overlying palaeosol, fine sand below	Aeolian overlying palaeosol, marine below?	Yes	none
PS-115-0210	5962901	494574	7*	Sandy Point, beach ridges	52	Fine sand	Fine sand below modern vegetation mat, parallel HML that dip east	Marine	No	none
PS-116-0210	5962968	495075	Unknown	Sandy Point, beach ridges	65	Fine sand	Dug into beach ridge first 30 cm modern vegetation, mottled fine sand underneath	Marine	No	none
PS-119-0210	5963269	493950	Unknown	Sandy Point	41	Fine sand	Peat 33 cm (lower few cm sampled), underlain by 7 cm of fine sand and a thin palaeosol		Yes	PS-73-O-0210 PS-74-O-0210
PS-120-0211	5964241	494312	8.2	Sandy Point blowout Z at site 120	63	Fine sand	Fine sand, dipping laminations, 5 cm thick organics horizon, below are horizontal laminations in fine to medium sand	Aeolian overlying palaeosol, and marine sediments underneath	Yes	PS-80-O-0211
PS-122-0214	6005221	469451	Unknown	Sandy Cove blowout F	152	Fine sand	87 cm of fine sand, 3 cm organic layer, 5 cm fine sand, 2 cm organic layer underlain by fine to medium sand with discontinuous laminations, as well as some thin organic layers	Aeolian sand seperated by palaeosols	Yes	no
PS-122-0214	6004976	469119		Sandy Cove beach ridge	150	Fine to medium sand	Fine to medium sand with granules and pebbles throughout	Beach ridge	No	no
PS-87-0215	5998750	474700	0.5	Seal Cove western beach ridge	50	Pebbles	Angular pebbles and cobbles under a 7 cm peat horizon	Beach ridge	No	PS-103-S-0215

Cont. of Table A

Site[a]	Northing	Easting	Elevation (m)[b]	Location	Depth (cm)	Grain size	Description[c]	Interpretation	Buried Soil	Samples Taken
PS-145-0221	5968083	487480	12.2	South of Big Brook	100	Fine sand	Fine horizontal bedded sand overlying palaeosol. Fine sand underneath contains HML, dipping beds ripples, and dewatering structures	Aeolian sediments, palaeosol, marine sediments	Yes	PS-136-O-0221
PS-131-0219 B	5964158	493775	Unknown	Sandy Point Site 131 100 x100 m grid	182	Fine sand	Fine sand overlying organics, compact fine sand with HML, pebbles and horizontal beds	Aeolian sediments, palaeosol, marine sediments	Yes	none
PS-131-0219 F	5964108	493727	8.2	Sandy Point Site 131 100 x100 m grid	70	Fine sand	Fine sand overlying peat horizon samples taken from the top and bottom, fine sand below peat horizon	Aeolian sand, peat horiozon, marine sediments	Yes	PS-115-O-0219T PS-116-O-0219B
PS-131-0219 N	5964187	493781	Unknown	Sandy Point Site 131 100 x100 m grid	95	Fine sand	75 cm of sand overlying 7 cm of organic material. 10 cm of fine sand, second organic layer 1 cm thick. Compact fine sand underneath containing discoid clasts, layers of granules and dipping laminations	Aeolian sand, palaeosol, aeolian sand, palaeosol, marine sediments	Yes	PS-109-O-0219 PS-111-O-0219

[a] asterisk mark sites in which test pits were sketched, see attached

[b] Elevations marked with an asterisk were measured with the GPS altimeter, remaining elevations were measured with the digital Sokkia altimeter

[c] HML - heavy mineral laminations; clast roundness: A - angular, SA - subangular, SR - subrounded

APPENDIX 2:

DESCRIPTIONS OF BLOWOUTS

Table B includes location, size, shape and stability of blowouts.

Table C lists the presence of buried organic horizons, dunes and surface debris within blowouts.

Table B: Size, shape and stability of blowouts mapped along Porcupine Strand.

Site	Northing	Easting	Shape	Length	Bearing	Width	Bearing	Degree of Stability
PS-15-0215	5963980	494084	Elongate	209	30	34	150	Marram grass
PS-21-0217	5963538	493639	Elongate	32	Unknown	8	Unknown	Unknown
PS-71-0226	5963241	494480	Oval	20	45	10	135	No vegetation in bottom, some myram grass on top of dune
PS-72-0226	5963981	494186	Round	24	350	15	80	Little vegetation in bottom, some sides slumped
PS-74-0226	5963934	494625	Elongate	170	80	113	350	Little vegetation in bottom, some sides slumped and covered with aeolian sand
PS-85-0231*	6005046	469413	Elongate	155	90	100	0	Some vegetation on bottom, some slump, aeolian sediment on slopes
PS-86-0231	6004138	470909	Elongate	50	130	10	40	Vegetation in bottom and on some slopes, west end partly revegetated
PS-92-0204	5963255	494380	Elongate	250	45	32	135	Some grasses in bottom of blowout, aeolian sand on slopes
PS-92A-0204	5963268	494429	Elongate	88	45	55	135	Some grasses in bottom of blowout, aeolian sand on slopes
PS-93-0204	5963783	494578	Square	162	0	150	90	Lichen and moss in bottom, some slopes revegetated
PS-94-0205	5963097	495124	Elongate	28	0	8.7	90	Not noted
PS-96-0206	5963211	494481	Elongate	100	65	37.5	155	Not noted
PS-97-0206	5963375	494560	Elongate	111	25	12.5	115	Small amount of grasses in bottom of blowout, little slumping of sides
PS-98-0206	5963539	494524	Elongate	90	26	26	116	Minor vegetation in bottom, slopes partly revegetated
PS-99-0208	5963360	494230	Elongate	212	40	70	130	Grass in bottom of blowout, revegetated slopes
PS-100-0208	5963623	494464	Round	104	45	103	135	Vegetation on slopes, some slumping of slopes
PS-101-0208	5963741	494372	Round	70	10	72	120	Little grass in bottom of blowout, aeolian sand on slopes
PS-101A-0208	5963490	494269	Elongate	206	26	84	110	Little grass in bottom of blowout, some slumping of slopes
PS-102-0208	5963860	494421	Elongate	10	30	43	120	No slumping, very little grass on blowout floor

Cont. of Table B

Site	Northing	Easting	Shape	Length	Bearing	Width	Bearing	Degree of Stability
PS-102A-0208	Site 102 and 102 a separted by dune, no UTM		Elongate	69	10	33	100	No slumping, very little grass on blowout floor
PS-102B-0208	5963887	494426	Oval	30	10	15	100	Vegetated floor of blowout, slumped and revegetated sides
PS-103-0208	5964000	494504	Elongate	177	10	12.5	100	Eastern slopes exposed, western slopes revegetated, little vegetation in bottom of blowout
PS-104-0208	5964113	494317	Elongate	54	4	18	105	Little grass in bottom of blowout, some slumping of slopes
PS-104A-0208	5963940	494247	Elongate	150	20	12	110	Grass in bottom, west side slumped and revegetated, east side exposed
PS-105-0209	5963551	493865	Elongate	150	34	13	120	Well vegetated
PS-106-0209	5963613	493885	Round	43	79	27	340	Vegetation in bottom, slumped in east end
PS-107-0209	5963679	493850	Elongate	166	48	12	140	Grass in bottom, west side slumped, east side exposed
PS-108-0209	5963776	493727	Elongate	132	20	96	134	Vegetation (grass) on slopes and in bottom of blowout
PS-111-0209	5964154	493898	Round	28	100	10	10	Grass in west end, other sides of blowout exposed
PS-112-0209	5964041	493680	Elongate	124	54	12	144	No vegetion in bottom, some slumping of sides, reminder of sides remain exposed
PS-113-0209	5963628	493611	Elongate	63	20	9	110	modern vegetation at edges of blowout buried by 12 cm aeolian sand
PS-114-0209	5963593	493685	Elongate	128	40	5	130	some vegetation,little slumping of sides
PS-118-0210			Elongate	26	109	16	184	A little grass in bottom of blowout, little slumping around sides
PS-119-0210	5963269	493950	Elongate	13	20	5	110	Slumping of northern side, along animal tracks
PS-120-0211	5964303	494346	description: 100 x 100 m grid surveyed, measurements of blowouts and palaeosols noted, UTM co-ordinants not noted for every blowout.					
PS-120 A			Elongate	5	30	2	120	Not noted
PS-120 B			Round	8	30	8	120	Edges of blowouts all sand blown, some vegetation growth
PS-120 C			Oval	15	30	14	120	Not noted
PS-120 D			Elongate	28	30	12	120	Not noted

Cont. of Table B

Site	Northing	Easting	Shape	Length	Bearing	Width	Bearing	Degree of Stability
PS-120 E			Round	8	30	6	120	No vegetation in bottom, slopes contain wind blown sand and grasses
PS-120 F	5964280	494323	Elongate	34	30	10	120	not noted
PS-120 G			Elongate	5	30	2	120	Mosses growing in bottom, grasses along slopes, some slumping of sides
PS-120 H	5964276	494431	Kidney bean	10	45	4	135	Slopes becoming vegetated
PS-120 I			Round	8	120	7	45	No vegetation
PS-120 J			Elongate	15	60	4	150	Some grasses in blowout, slumping along sides
PS-120 K			Elongate	12	30	5	120	Not noted
PS-120 L			Elongate	15	165	6	75	Shallow blowout, slumping along edges of blowout
PS-120 M			Elongate	10	165	6	76	Deeper blowout, edges of blowout covered with sand, grass in bottom of blowout
PS-120 N			Round	5	120	4	30	Not noted
PS-120 O	5964325	494346	Round	12	30	11	120	Some slumping of sides, no vegetation in bottom
PS-120 P			Elongate	15	165	8	75	Vegetation and aeolain sand along slope
PS-120 Q			Round	6	30	6	120	Shallow blowout, vegetation growing in bottom of blowout, aeolian sand along slopes
PS-120 R				18	120	8	30	Slopes covered with aeolian sand
PS-120 S			Y shaped	15	30	7	120	Very shallow, little grass
PS-120 T	5964225	494367	L shaped	25	30	16	120	Slumping along sides, grass in bottom
PS-120 V			Round	8	120	6	30	Not noted
PS-120 W			Elongate	10	30	4	120	Slumping along SE side, vegetation in bottom, slopes covered in aeolian sand
PS-120 Y			Round	8	120	5	30	Not noted
PS-120 Z	5964241	494312	Kidney bean	30	165	20	75	No vegetation in bottom, some grasses on slopes, not much slumping
PS-122-0213	6005221	469451	Sandy Cove, large site, blowouts mapped on a grid and not all have UTM coordinates					
PS-122 B			Round	8	90	6	0	Vegetation growing on slopes, bedrock in bottom

Cont. of Table B

Site	Northing	Easting	Shape	Length	Bearing	Width	Bearing	Degree of Stability
PS-122 E			Round	20	90	10	0	North side exposed, south side slumped, vegetation in middle
PS-122 F			Elongate	100	90	15	0	Some grass in bottom, south side vegetated, north side exposed with some slump
PS-122 C			Elongate	32	90	10	0	South side slumped, almost completely revegetated, north side exposed, vegetation in bottom
PS-122 D			Oval	175	90	85	0	South and west sides slumped and revegetated, north side some slump and some exposure, east side dune
PS-122 H	6004965	469187	Elongate	50	90	20	0	Some vegetation in bottom, south side slumped, north side exposed
PS-122 I			Elongate	55	90	20	0	West side compeltely revegetated, south wall some exposure between slump, lots of vegetation in bottom
PS-122 J			L shaped	62	90	25	0	Completely revegetated
PS-122 K			Elongate	25	90	10	0	Vegetation in bottom, some exposure along sides, a lot of slumping
PS-122 L			Square	12	0	10	90	Vegetation in bottom, some slumping
PS-122 M			Square	12	0	10	90	South and west sides vegetated, north side exposed
PS-145-0221	5968083	487480	Elongate	161	0	15	90	Little vegetation in bottom, little slumping
PS-147a-0222	5967016	486940	Description:blowout is a massive area the size of a football field. (Plate 3-3).					
PS-131-0219	5964158	493775	Description: center of a 100x100 m grid, measuring blowout orientation, size and number of palaeosols.					
PS-131 A			Elongate	62	0	14	90	Little slumping, vegeation at bottom
PS-131 B			Round	8	0	6	90	Very little vegetation in bottom, very little slumping
PS-131 C			Elongate	26	0	12	90	Some slumping, vegetation on slopes and in bottom of blowout
PS-131 D			Elongate	6	0	3	90	Slumping around edges, vegetation on slope and very little on blowout floor
PS-131 E			Elongate	11	0	5	90	Slumping around edges, vegetation on blowout floor

Cont. of Table B

Site	Northing	Easting	Shape	Length	Bearing	Width	Bearing	Degree of Stability
PS-131 F	5964108	493727	Elongate	44	0	12	90	Sides of blowout exposed very little vegetation
PS-131 G			Kidney bean	8	0	6	90	Vegetation in bottom some slumping with revegetated slopes
PS-131 H			Elongate	10	90	4	0	Some slumping, little grass in bottom
PS-131 I			Elongate	6	100	3	10	Some slumping, vegetation starting to grow on slopes
PS-131 J			Elongate	20	0	8	90	Slumping and vegetation in west end, while exposure of sides are seen in the south and north end
PS-131 K			Elongate	20	0	6	90	No vegetation in bottom, little slumping
PS-131 L			Elongate	26	135	8	45	Edges exposed, little slumping, no vegetation in bottom
PS-131 M			Round	8	0	8	90	No slumping, no vegetation in bottom
PS-131 N	5964187	493781	Elongate	74	0	30	90	Little slumping, no vegetation in bottom
PS-131 O			Round	8	0	6	90	Little slumping and little vegetation on slope and in bottom of blowout
PS-131 P			Elongate	8	90	5	0	Not noted
PS-131 Q				6	135	4	45	Not noted
PS-131R			U shaped	10	0	10	90	Some vegetation in bottom, little slumping of sides
PS-131S			Elongate	12	0	6	90	Some vegetation in bottom, little slumping of sides
PS-131 T			Elongate	34	0	10	90	Some slumping, no vegetation
PS-132-0219	5963660	494000	Description: center of a 100x100 m grid, measuring blowout orientation, size and number of palaeosols.					
PS-132 A			Elongate	30	90	18	0	Vegetation in bottom, with slumping around edges
PS-132 B			Elongate	82	45	15	135	Sides slumped and vegetation in bottom
PS-132 D			Oval	10	0	6	90	Sides slumped and vegetation in bottom
PS-132 E			Round	16	45	8	135	Some slumped edges and vegetated slopes
PS-132 F			Elongate	65	45	24	135	Slopes vegetated, little exposure
PS-132 G			Elongate	10	45	4	135	Most sides slumped, vegetation in bottom

Cont. of Table B

Site	Northing	Easting	Shape	Length	Bearing	Width	Bearing	Degree of Stability
PS-132 H			L shaped	20	0	10	90	East side exposed, remainder of blowout vegetated
PS-132 I			Kidney bean	6	90	4	0	Shallow blowout, no vegetation
PS-132 J			Kidney bean	7	90	8	0	Sides slumped, some vegetation
PS-132 K			Elongate	50	0	26	90	Slopes covered with aeolian, west end some vegetation
PS-132 L			U shaped	26	45	8	135	Vegetation at bottom, sides slumped with some vegetation
PS-132 M			Elongate	8	45	4	135	Almost completely vegetated
PS-132 N			Elongate	12	45	4	135	Slumped edges, vegetation starting to grow

Table C: Description of blowouts, including the presence of buried organic material.

Site	Northing	Easting	Buried organic horizon present	Depth to buried soil horizon (cm)	Elevation of blowout floor (m)	Sample	Dune present	Direction of sand movement	Debris on surface	Section or test pit
PS-15-0215	5963980	494084	Yes	209	3.8	No	Small 1 m high	Northeast	Granules and pebbles	Section test pit
PS-21-0217	5963538	493639	No	Unknown	Unknown	No	No	Unknown	Not noted	None
PS-71-0226	5963241	494480	Yes	110	3	PS-16-W/O-0226 PS-17-W/O-0226	Yes 1.1 m high	Southeast	Granules, few pebbles, flakes	Section
PS-72-0226	5963981	494186	Yes	11-49	5.2	PS-19-W/O-0226	No	East	Granules, pebbles, discoid shaped cobbles, flakes and artifacts	Test pit
PS-74-0226	5963934	494625	Yes	88-450	4.26	PS-20-O-0226	yes 4.5 m high	East	High concentration of pebbles and cobbles, shells, flakes and artifacts	Section
PS-85-0231*	6005046	469413	Yes	86-810	7	PS-23-W-0231 PS-89-O-0214	Yes 8.1 m high	East	Granules to pebbles, archaeological debris	Test pit
PS-86-0231	6004138	470909	Yes	34-66	8.4	PS-24-O-0231 PS-25-O-0231	No	East	Granules to cobbles, clasts 10%, SA-R	Test pit
PS-92-0204	5963255	494380	Yes	2.5	3.1	No	No	Not noted	Granules to cobbles	None
PS-92A-0204	5963268	494429	Yes	150	3.8	PS-40-W-0206 PS-42-O-0206	Yes	Not noted	Granules to cobbles	Section
PS-93-0204	5963783	494578	Yes	150	3.2	whalebone from bottom of blowout PS-35-Wb-0204	Yes	East	Lots of discoid shaped cobbles	None
PS-94-0205	5963097	495124	Yes	20	5.5	PS-36-O-0205 PS-37-O-0205	No	East	Granules	Test pit
PS-97-0206	5963375	494560	Yes	84	2.1	No	Yes	East	Granules to cobbles, 25%, clasts discoid shaped SR-SA	None
PS-98-0206	5963539	494524	Yes	75	3.6	No	Yes	East	Pebbles and cobbles discoid shaped	None
PS-96-0206	5963211	494481	Yes	Not measured	3.1	No	Yes	East	Granules to pebbles, clasts discoid shaped SR-SA	None

Cont. Table C

Site	Northing	Easting	Buried organic horizon present	Depth to organic horizon (cm)	Elevation of blowout floor (m)	Sample	Dune present	Direction of sand movement	Debris on surface	Section or test pit
PS-99-0208	5963360	494230	Yes	600	3.4	PS-46-O-0208	Yes	East	Contrations of pebble to cobble discoid shaped clasts on floor	Section
PS-100-0208	5963623	494464	Yes	250	2.7	No	No	Not noted	Pebbles	None
PS-101-0208	5963741	494372	Yes	83	3.7	No	Yes	East	Pebbles	None
PS-101A-0208	5963490	494269	Yes	70	3.3	PS-50-O0208 PS-51-O-0208	Yes	East	High concentration of discoid pebbles to cobbles	Test pit
PS-102-0208	5963860	494421	Yes	100	4.6	No	Yes	Not noted	Low concentrations of pebbles	None
PS-102A-0208	Site 102 and 102 a		Yes	88	4.9	No	Yes	Not noted	Low concentrations of	None
PS-102B-0208	5963887	494426	Yes	40	5.6	PS-52-Wb-0208	No	Not noted	One piece of whale bone	None
PS-103-0208	5964000	494504	Yes	40	2.6	No	No	Not noted	High concentration of discoid pebbles to cobbles, archaeology site	Test pit
PS-104-0208	5964113	494317	Yes	90	3.4	PS-53-O-0208 PS-54-O-0208	No	Not noted	Some clasts	Test pit
PS-104A-0208	5963940	494247	Yes	75	3	PS-56-O-0208	Yes	East	Granules to pebbles	Test pit
PS-105-0209	5963551	493865	Yes	40	Unknown	No	Yes	Not noted	Few clasts	Test pit
PS-106-0209	5963613	493885	Yes	110	4.6	No	No	Not noted	Discoid shaped clasts on surface	None
PS-107-0209	5963679	493850	Yes (2)	120, 53	6.6	PS-61-O-0209 PS-62-O-0209	No	Not noted	Few clasts on surface	Section
PS-108-0209	5963776	493727	Yes	200	Unknown	No	Yes	East	Granules to pebbles	None
PS-111-0209	5964154	493898	Yes	12	8.5	No	No	Not noted	Not noted	None
PS-112-0209	5964041	493680	Yes	30	4.3	No	No	Not noted	Some clasts on surface	None
PS-113-0209	5963628	493611	No	12	not known	No	No	Not noted	Not noted	None
PS-114-0209	5963593	493685	Yes	30	8	PS-72-O-0209	No	Not noted	Not noted	Test pit
PS-118-0210			Yes	20	3.2	No	No	Not noted	Few clasts SA-SR	None
PS-119-0210	5963269	493950	Yes	34	Unknown	PS-73-O-0210 PS-74-O-0210	No	Not noted	Few clasts	Test pit

Cont. Table C

Site	Northing	Easting	Buried organic horizon present	Depth to organic horizon (cm)	Elevation of blowout floor (m)	Sample	Dune present	Direction of sand movement	Debris on surface	Section or test pit
PS-120-0211	5964303	494346								
PS-120 A			Not noted	Not noted	Not noted	Not noted	Not noted	Not noted	Not noted	None
PS-120 B			No		5.9	No	Not noted	Not noted	Not noted	None
PS-120 C			Yes	60	Not noted	No	Yes	East	Granules and pebbles	None
PS-120 D			Not noted	Not noted	Not noted	No	Not noted	Not noted	Not noted	None
PS-120 E			Yes	28	Not noted	No	Not noted	Not noted	Granules and pebbles	None
PS-120 F	5964280	494323	Yes	20	4.1	No	Yes	Northeast	Granules to cobbles	None
PS-120 G			no		Not noted	No	No	Not noted	Few pebbles	None
PS-120 H	5964276	494431	Yes	34	Not noted	No	No	Not noted	Few discoid clasts	None
PS-120 I			Yes	45	Not noted	No	No	Not noted	No clasts	None
PS-120 J			Yes	67	4.6	No	Yes	East	Granules to pebbles, some discoid shaped	None
PS-120 K			Not noted	Not noted	Not noted	No	Not noted	Not noted	Not noted	None
PS-120 L			Yes	10	5	No	Yes	East	Few clasts pebbles	None
PS-120 M			no		Not noted	No	No	Not noted	Casts	None
PS-120 N			Not noted	Not noted	Not noted	No	Not noted	Not noted	Not noted	None
PS-120 O	5964325	494346	Not noted	Not noted	4.7	No	No	Not noted	Granules to pebbles,discoid to round	None
PS-120 P			Yes	20	Not noted	No	No	Not noted	Not noted	None
PS-120 Q			Yes	Not noted	Not noted	No	No	Not noted	No clasts	None
PS-120 R			Yes	23	4.5	No	No	Not noted	Clasts pebbles	None
PS-120 S			Yes	10	Not noted	No	No	Not noted	No clasts	None
PS-120 T	5964225	494367	Yes (2)	28, 22	4.9	PS-76-O-0211T PS-77-O-0211B PS-78-W-0211	Yes	East	Few clasts	None
PS-120 V			Not noted	Not noted	Not noted	No	Not noted	Not noted	Not noted	None
PS-120 W			yes	10	Not noted	No	Not noted	Not noted	Not noted	None
PS-120 Y			Not noted	Not noted	Not noted	No	Not noted	Not noted	Not noted	None
PS-120 Z	5964241	494312	Yes	63	5.3	PS-80-O-0211	Yes	East	A lot of clasts, pebbles	Test pit

Cont. Table C

Site	Northing	Easting	Buried organic horizon present	Depth to organic horizon (cm)	Elevation of blowout floor (m)	Sample	Dune present	Direction of sand movement	Debris on surface	Section or test pit
PS-122-0213	6005221	469451								
PS-122 B			No		not noted	No	No	Not noted	Not noted	None
PS-122 E			Yes	32	8.3	No	No	Not noted	Not noted	None
PS-122 F			Yes	113	7.8	No	No	East	Granules and cobbles SA-SR	Test pit
PS-122 C			Yes	44	9.5	No	No	Not noted	Archeological site	None
PS-122 D			Yes	100	5	PS-94-O-0214 PS-95-O-0214 PS-96-O-0214 PS-97-O-0214	Yes	East	Clasts range from granules to boulders, archeological site in bottom, MAI longhouse	Section
PS-122 H	6004965	469187	Yes	58	8.7	PS-101-W-0214	No	Not noted	A few small clasts, mainly granules	None
PS-122 I			Yes	100	8.2	No	No	Not noted	Not noted	None
PS-122 J			Yes	34	8.4	No	No	Not noted	Vegetation	None
PS-122 K			Yes	82	12.3	No	No	Not noted	Not noted	None
PS-122 M			Yes	34	not noted	No	No	Not noted	Not noted	None
PS-145-0221	5968083	487480	Yes	250	not noted	PS-136-O-0221	Yes	Northeast	No clasts in bottom	Test pit
PS-147a-0222	5967016	486940	Yes	85	not noted	PS-140-O-0222 PS-142-O-0222	Yes	East	Granules to boulders (few SA), mostly cobbles SR	Section
PS-131-0219	5964158	493775								
PS-131 A			Yes	85	7.1	No	Yes	East	Discoid-shaped cobbles, SR-R	None
PS-122 L			Yes	63	10.9	No	No	Not noted	Not noted	None
PS-131 B			Yes	59	7.6	No	No	Not noted	Pebbles	Test pit
PS-131 C			Yes	23	Not noted	No	No	East	Few clasts	None
PS-131 D			Yes	15	Not noted	No	No	Not noted	No clasts	None
PS-131 E			Not noted	Not noted	Not noted	No	No	Not noted	Not noted	None
PS-131 F	5964108	493727	Yes	37	6.6	PS-115-O-0219 PS-116-O-0219	No	Not noted	Clasts	Test pit
PS-131 G			Yes	15	Not noted	No	No	Not noted	Not noted	None

Cont. Table C

Site	Northing	Easting	Buried organic horizon present	Depth to organic horizon (cm)	Elevation of blowout floor (m)	Sample	Dune present	Direction of sand movement	Debris on surface	Section or test pit
PS-131 H			Yes	36	Not noted	No	No	Not noted	Few clasts	None
PS-131 I			Yes	15	Not noted	No	No	Not noted	No clasts	None
PS-131 J			Yes	15	Not noted	No	No	Not noted	Granules to cobbles	None
PS-131 K			Yes	10	7.8	No	No	Not noted	Not noted	None
PS-131 L			Yes	8	Not noted	No	No	Not noted	Not noted	None
PS-131 M			Yes	45	Not noted	No	No	Not noted	Very few clasts	None
PS-131 N	5964187	493781	Yes (2)	75	6	PS-109-O-0219 PS-111-O-0219	No	East	Discoid-shaped cobbles, SR-R	Test pit
PS-131 O			Yes	48	Not noted	No	No	Not noted	Not noted	None
PS-131 P			Not noted	Not noted	Not noted	no	No	Not noted	Not noted	None
PS-131 Q			Not noted	Not noted	Not noted	No	No	Not noted	Not noted	None
PS-131R			Yes	35	Not noted	No	No	Not noted	Few clasts	None
PS-131S			Yes	45	Not noted	No	No	Not noted	Few cobbles	None
PS-131 T			No		Not noted	No	No	Not noted	Not noted	None
PS-132-0219	5963660	494000				No				
PS-132 A			Yes	60	5.2	No	No	Not noted	Few discoid cobbles	None
PS-132 B			Yes	100	4.8	No	No	Not noted	Pebbles discoid	None
PS-132 D			Yes	20	4.8	No	No	Not noted	Not noted	None
PS-132 E			Yes	64	6.8	No	No	Not noted	Granules to pebbles less than 1%	None
PS-132 F			No		4.5	No	No	Not noted	Granules to cobbles, less than 5%, SA-SR	None
PS-132 G			Yes	40	7.2	No	No	Not noted	Not noted	None
PS-132 H			Yes	90	8.3	No	No	Not noted	Not noted	None
PS-132 I			No		Not noted	No	No	Not noted	Not noted	None
PS-132 J			No		Not noted	No	No	North	Not noted	None
PS-132 K			No		7.9	No	No	Not noted	Less 5% clasts: SA-SR, granules to cobbles discoid	None
PS-132 L			Yes	60	5.7	No	No	Not noted	Less 1% clasts	None
PS-132 M			Yes	30	Not noted	No	No	Not noted	Not noted	None
PS-132 N			No		Not noted	No	No	Not noted	Not noted	None

APPENDIX 3:

RESULTS OF GRAIN SIZE ANALYSIS

Table D lists the results of grain size analysis.

Table D: Results from grain size analysis. Asterisk indicates duplicate sample.

	Sieve								
Wentworth Class*	Peb.	Gran.	V.c.sa	C.sa	M.sa	F.sa	V.f.sa	C.si	
mm	4	2.83	1.41	0.5	0.35	0.21	0.88	0.044	<0.044
Phi (Φ)	-2	-1.5	-0.5	1	1.5	2.32	3.64	4.5	>4.5
Sample #	Weight retained in sieve (%)								
PS-41-Sda-0206	0.00	0.00	0.00	2.77	15.11	60.50	21.35	0.21	0.00
PS-43-Sdg-0220	0.00	0.00	0.00	0.20	2.64	50.31	46.51	0.54	0.27
PS-43-Sdb-0206	0.00	0.07	0.07	0.35	4.24	66.67	29.37	0.14	0.00
PS-45-Sd-0208	0.00	0.07	0.00	1.35	15.80	65.56	17.58	0.00	0.00
PS-47-Sdg-0208	0.00	0.00	0.00	0.79	12.71	67.52	17.92	0.64	0.64
PS-48-Sd-0208	0.00	0.14	0.00	1.43	19.00	66.45	13.26	0.07	0.07
PS-49-Sd-0208	0.00	0.07	0.07	0.35	4.16	66.62	29.29	0.00	0.00
PS-55-Sda-0208	0.00	0.00	0.00	0.56	6.20	62.30	31.15	0.28	0.00
PS-58-Sdb-0208	0.00	0.00	0.00	1.19	12.98	67.58	18.60	0.21	0.00
PS-65-Sd-0809	0.00	0.00	0.07	0.21	5.77	66.79	26.94	0.36	0.07
PS-66-Sdb-0209	0.07	0.07	0.00	0.63	7.99	64.14	27.73	0.28	0.07
PS-66-Sdb$_2$-0209	0.00	0.00	0.00	0.93	9.35	65.24	24.27	0.21	0.14
PS-67-Sda-0209	0.07	0.07	0.00	0.69	10.01	63.31	26.27	0.27	0.00
PS-67-Sda-0209*	0.00	0.07	0.00	1.00	11.39	63.49	24.27	0.07	0.00
PS-68-Sd-0209	0.00	0.00	0.00	0.07	2.58	69.20	26.99	0.50	0.43
PS-68-Sdg-0209	0.00	0.00	0.00	0.15	3.32	70.24	25.18	0.37	0.30
PS-68-Sdg-0209*	0.00	0.00	0.00	0.07	2.46	67.17	29.35	0.65	0.43
PS-69-Sdb-0209	0.00	0.00	0.00	0.07	1.73	49.53	48.67	0.07	0.00
PS-70-Sd-0209	0.00	0.08	-0.08	0.00	0.83	15.98	82.97	0.08	0.00
PS-79-Sd-0211	0.00	0.14	0.07	0.57	5.67	50.21	42.92	0.28	0.07
PS-81-Sd-0211	0.00	0.00	0.00	0.43	4.04	44.93	51.03	0.43	0.07
PS-82-Sdb-0211	0.00	0.07	0.00	4.93	24.49	56.69	13.53	0.15	0.07

* Wentworth class: Peb.= pebble, Gran.= granule, V.c.sa= very coarse sand, C.sa= coarse sand, M.sa= medium sand, V.f.sa = very fine sand, C.si= clay and silt

Cont. Table D

Wentworth Class*	Peb.	Gran.	V.c.sa	C.sa	M.sa	F.sa	V.f.sa	C.si	
	Sieve								
mm	4	2.83	1.41	0.5	0.35	0.21	0.88	0.044	<0.044
Phi (Φ)	-2	-1.5	-0.5	1	1.5	2.32	3.64	4.5	>4.5
Sample #	Weight retained in sieve (%)								
PS-88-Sda-0214	0.00	0.07	0.00	4.48	24.98	61.44	8.66	0.22	0.14
PS-90-Sdg-0214	0.00	0.22	0.22	11.31	31.11	51.99	5.58	0.07	0.00
PS-91-Sdb-0214	0.21	0.49	0.35	27.42	28.55	37.60	3.53	0.07	0.00
PS-92-Sdg-0214	0.00	0.07	0.00	5.04	22.85	61.89	10.08	0.07	0.07
PS-93-Sdb-0214	0.00	0.00	0.00	10.10	38.54	48.78	3.28	0.00	0.00
PS-98-Sdg-0214	0.00	0.00	0.00	2.76	27.85	63.58	6.15	0.14	0.00
PS-99-Sda-0214	0.00	0.14	0.07	6.14	30.20	57.08	6.58	0.22	0.00
PS-105-Sda-0216	0.07	0.07	-0.07	0.14	3.79	74.03	21.46	0.43	0.36
PS-107-Sdb-0216	0.07	0.07	0.07	0.42	6.30	82.02	10.47	0.21	0.85
PS-108-Sda-0219	0.00	0.00	0.00	0.88	7.71	62.04	28.78	0.44	0.22
PS-112-Sdg-0219	0.00	0.00	0.00	0.50	6.46	68.20	24.41	0.36	0.22
PS-113-Sdb-0219	0.00	0.00	0.00	0.46	5.87	67.68	25.92	0.26	0.07
PS-114-Sdb-0219	0.00	0.00	0.00	3.20	9.03	61.69	26.23	0.14	0.00
PS-118-Sda-0220	0.14	0.28	0.36	2.56	4.98	25.11	62.59	3.84	0.36
PS-120-Sdb-0220	0.00	0.00	0.00	4.79	9.80	33.69	49.28	2.36	0.07
PS-123-Sdb-0220	0.00	0.07	0.00	5.35	27.63	59.60	6.42	0.20	0.00
PS-124-Sd-0220	0.00	0.07	0.07	8.55	14.46	34.12	41.03	1.64	0.21
PS-124-Sd-0220*	0.00	0.00	0.15	8.93	14.73	34.62	39.77	1.60	0.15
PS-129-Sd-0221	0.00	0.00	0.00	1.64	5.77	31.67	57.58	3.49	0.14
PS-130-Sdb-0221	0.07	0.00	0.07	10.83	18.12	36.90	31.19	2.31	0.43
PS-131-Sda-0221	0.07	0.21	0.14	4.00	10.64	37.26	43.97	3.64	1.07
PS-134-Sda-0221	0.00	0.21	0.14	4.78	13.40	40.84	39.27	2.71	0.36
PS-135-Sda-0221	0.00	0.07	0.00	2.00	11.55	51.14	34.02	1.28	0.07
PS-137-Sd-0221	0.00	0.14	0.00	1.50	8.58	51.18	38.03	1.29	0.29

Cont. Table D

Wentworth Class*	Sieve								
Wentworth Class*	Peb.	Gran.	V.c.sa	C.sa	M.sa	F.sa	V.f.sa	C.si	
mm	4	2.83	1.41	0.5	0.35	0.21	0.88	0.044	<0.044
Phi (Φ)	-2	-1.5	-0.5	1	1.5	2.32	3.64	4.5	>4.5
Sample #	Weight retained in sieve (%)								
PS-138-Sdb-0221	0.00	0.00	0.00	21.81	33.93	34.35	10.33	0.14	0.00
PS-139-Sda-0222	0.07	0.14	0.07	3.02	10.04	54.56	31.04	0.98	0.14
PS-141-Sdg-0222	0.00	0.07	0.00	2.94	12.39	47.99	34.81	1.72	0.36
PS-143-Sdb-0222	0.00	0.00	0.00	2.94	13.85	54.13	28.79	0.50	0.22
PS-144-Sdlb-0222	0.00	0.00	0.00	7.93	18.23	53.97	19.73	0.36	0.00
PS-146-Sdb-0222	0.00	0.00	0.07	13.09	27.32	42.20	16.67	0.72	0.14
PS-147-Sd-0222	0.00	0.07	0.00	4.09	18.71	54.05	22.58	0.43	0.14
PS-147-Sd-0222*	0.00	0.00	0.00	4.58	20.89	53.36	21.17	0.50	0.14
PS-148-Sdg-0222	0.00	0.00	0.00	1.77	9.54	49.26	37.53	1.41	0.42
PS-150-Sdb0221	0.00	0.00	0.07	12.11	18.64	35.48	31.47	2.22	0.29
PS-151-Sda-0222	0.00	0.07	0.07	4.44	16.90	50.70	26.55	1.20	0.21
PS-158-Sda-0223	0.00	0.15	0.22	3.68	11.92	42.02	40.84	1.91	0.22
PS-159-Sdg-0223	0.00	0.07	0.07	4.86	12.63	37.81	40.04	3.51	1.01
PS-160-Sdb-0223	0.00	0.00	0.00	3.92	17.21	43.92	33.21	1.13	0.38
PS-161-Sd-0224	0.81	0.67	0.54	9.76	13.80	40.04	34.05	0.13	0.00

APPENDIX 4:

AERIAL PHOTOGRAPHIC INTERPRETATIONS OF SURFICIAL GEOLOGY UNITS

Glaciofluvial

Unit colour: Yellow
Percent coverage: 35% (See Figures 2-4 and 2-5 for distribution)
General location: Large outwash plains on the lowlands in the northern portion of the field area, as well as valley outwash plains in the uplands.
Observed in the field: No
Elevation range: 6 to 262 m asl
Surficial morphologies: Glaciofluvial blanket (Gb), eroded (Ge), hummock (Gh), kettle (Gk), plain (Gp), ridge (Gr), terrace (Gt), veneer (Gv) and undivided G

Glaciofluvial blanket (Gb):

Percent coverage within unit: 10%
General location: Most occurrences south of North River
Observed in the field: No
Elevation range: 18 to 262 m asl
Tone: Moderate to dark
Texture: Relatively smooth textures where vegetation is moderate, stippled textures where vegetation is not plentiful
Vegetation Cover: Moderate
Comprised of: Unknown
Found adjacent to: Bedrock concealed, bedrock, glaciomarine,bog, till and colluvium
Overlying contacts: Bog, colluvium
Underlying contacts: N/A

Glaciofluvial eroded (Ge):

Percent coverage within unit: 20%
General location: Generally confined to river valleys with in the Uplands
Observed in the field: No
Elevation range: 18 to 122 m asl
Tone: Moderate to dark
Texture: Smooth to slightly stippled
Vegetation Cover: Moderate
Comprised of: Unknown
Found adjacent to: Till, bog, marine, bedrock, fluvial, and colluvium
Overlying contacts: Fluvial
Underlying contacts: Glaciomarine

Glaciofluvial plain (Gp):

Percent coverage within unit: 40%
General location: Lower valleys in the Uplands
Observed in the field: No
Elevation range: 80 to 122 m asl
Tone: Light grey
Texture: Rough, stippled
Vegetation Cover: Sparse
Comprised of: Unknown
Found adjacent to: Bog, fluvial, colluvium and bedrock
Overlying contacts: Bog, and fluvial
Underlying contacts: Marine

Glaciofluvial kettled (Gk):

Percent coverage within unit: 7%
General location: Lower valleys in the Uplands
Observed in the field: No
Elevation range: 91 - 116 m asl
Tone: Light grey when empty; dark grey when water filled
Texture: Surrounding area stippled
Vegetation Cover: Sparse
Comprised of: Unknown
Found adjacent to: Rock concealed
Overlying contacts: Fluvial
Underlying contacts: Glaciofluvial

Glaciofluvial veneer (Gv):

Percent coverage within unit: 15%
General location: Where glaciofluvial material fades out, i.e. slopes of hill in the Uplands
Observed in the field: No
Elevation range: 79-348 m asl
Tone: Light grey tones
Texture: stippling
Vegetation Cover: Sparse
Comprised of: Unknown
Found adjacent to: Till, colluvium,bogs and bedrock
Overlying contacts: Bog
Underlying contacts: Glaciomarine

Glaciofluvial terrace (Gt):

Percent coverage within unit: 1%
General location: Along the sides of the larger river systems
Observed in the field: No
Elevation range: 18- 79 m asl
Tone: Moderate dark tones
Texture: Slightly stippled
Vegetation Cover: Low to moderate
Comprised of: Unknown
Found adjacent to: Rock concealed, fluvial and bog
Overlying contacts: Fluvial
Underlying contacts: Unknown

Glaciofluvial hummock (Gh):

Percent coverage within unit: 5%
General location: Southwest portion of the study area
Observed in the field: No
Elevation range: 146 to 170 m asl
Tone: Moderate dark tones
Texture: Slightly stippled
Vegetation Cover: Moderate
Comprised of: Unknown
Found adjacent to: Bog, rock concealed, and fluvial
Overlying contacts: Bog
Underlying contacts: Unknown

Glaciofluvial ridge (Gr):

Percent coverage within unit: 1%
General location: Southwest portion of the study area and south side of Porcupine Hills
Observed in the field: No
Elevation range: 91 to 152 m asl
Tone: Light to moderate dark tones
Texture: Slightly stippled
Vegetation Cover: Moderate
Comprised of: Unknown
Found adjacent to: Bog, and rock concealed
Overlying contacts: Bog
Underlying contacts: Unknown

Glaciomarine/Marine

Unit colour: Blue
Percent coverage: 25% (See Figures 2-4 and 2-5 for distribution)
General location: Coastal lowlands
Observed in the field: Yes
Elevation range: 0 to 120 m asl
Surficial morphologies: Marine plain (Mp), blanket (Mb), eroded (Me), terrace (Mt), veneer (Mv) and ridge(Mr)

Marine plain (Mp):
Percent coverage within unit: 70%
General location: Coastal lowlands
Observed in the field: Yes
Elevation range: 6 to 91 m asl
Tone: Light to moderately dark
Texture: coarse to smooth (where there is moderate vegetation)
Vegetation Cover: Sparse to moderate
Comprised of: Fine sand overlying clay
Found adjacent to: Bedrock concealed, bedrock, glaciofluvial, and aeolian deposits
Overlying contacts: Bog and aeolian
Underlying contacts: Till (only seen West Bay)

Marine blanket (Mb):
Percent coverage within unit: 8%
General location: Coastal lowlands
Observed in the field: Yes
Elevation range: 12 to 110 m asl
Tone: Dark
Texture: Relatively smooth
Vegetation Cover: Moderate to dense
Comprised of: Well sorted sand and clay
Found adjacent to: Glaciofluvial, bog, fluvial, and bedrock
Overlying contacts: Bog, and fluvial
Underlying contacts: N/A

Marine eroded (Me):
Percent coverage within unit: 2%
General location: Coastal lowlands
Observed in the field: Yes
Elevation range: 0 to 37 m asl
Tone: Dark to light,
Texture: Smooth but dissected by gullies
Vegetation Cover: Moderate, in areas between gullies sparse vegetation
Comprised of: Well sorted fine sand and clay
Found adjacent to: Till, glaciofluvial,bog, bedrock, and aeolian
Overlying contacts: Fluvial, bog
Underlying contacts: N/A

Marine terrace (Mt):
Percent coverage within unit: 4%
General location: Coastal lowlands
Observed in the field: No
Elevation range: 24 to 91 m asl
Tone: Light - dark
Texture: slightly stippled /or rough to smooth
Vegetation Cover: Sparse to moderate
Comprised of: Unknown
Found adjacent to: Glaciomarine,bog, aeolian, fluvial
Overlying contacts: Aeolian and bog
Underlying contacts: N/A

Marine veneer (Mv):

Percent coverage within unit: 1%
General location: Coastal lowlands
Observed in the field: Yes
Elevation range: 6 to 120 m asl
Tone: Moderate to dark
Texture: Smooth
Vegetation Cover: Sparse to moderate
Comprised of: Unknown
Found adjacent to: Bog and bedrock
Overlying contacts: Bog
Underlying contacts: N/A

Marine ridges (Mr):

Percent coverage within unit: 15%
General location: Coastal lowlands
Observed in the field: Yes
Elevation range: 0.5 to 91 m asl
Tone: Light to dark (generally at crests)
Texture: Generally smooth where tones are darker, but slightly course with minor stippling in areas of lighter tones
Vegetation: Sparse to moderate (at crests)
Comprised of: Fine sand and cobbles
Found adjacent to: Glaciofluvial, bog, and aeolian
Overlying contacts: Aeolian and bog
Underlying contacts: Glaciomarine

Organic Material (bog)

Unit colour: Grey
Percent coverage: 12.5% (See Figures 2-4 and 2-5 for distribution)
General location: Generally confined to the lowlands, but are also identified in valleys of the uplands
Observed in the field: Yes
Elevation range: 6 to 341 m asl
Surficial morphologies: Organic (O), blanket (Ob), lineated (Ol), plain (Op) ridge (Or)

Organic (O):
Percent coverage within unit: 40%
General location: throughout field area
Observed in the field: Yes
Elevation range: 6-298 m asl
Tone: Light to moderate grey
Texture: Smooth broken by ponds
Vegetation Cover: Low to moderate shrubs
Comprised of: Fine to coarse organic material
Found adjacent to: Bedrock concealed, bedrock, glaciomarine, glaciofluvial, till, colluvium, aeolian deposits
Overlying contacts: N/A
Underlying contacts: Bedrock concealed, bedrock, glaciomarine, glaciofluvial, till, colluvium, aeolian deposits

Organic ridges (Or):
Percent coverage within unit: 30%
General location: Coastal lowlands
Observed in the field: Yes
Elevation range: 18 to 109 m asl
Tone: Moderate grey
Texture: Irregular raised ridges associated with ponds
Vegetation Cover: Low shrubs
Comprised of: Fine to coarse organic material
Found adjacent to: Glaciofluvial, glaciomarine, aeolian
Overlying contacts: N/A
Underlying contacts: Glaciofluvial, glaciomarine, and aeolian

Organic lineated (Ol):
Percent coverage within unit: 1%
General location: Coastal lowlands
Observedin the field: No
Elevation range: 30 to 79 m asl
Tone: Moderate grey, white around some edges
Texture: Smooth interrupted by small ponds
Vegetation Cover: Low shrubs
Comprised of: Fine to coarse organic material
Found adjacent to: Glaciomarine
Overlying contacts: N/A
Underlying contacts: Glaciomarine

Organic blanket (Ob):
Percent coverage within unit: 10%
General location: North side of Porcupine Hills
Observed in the field: No
Elevation range: 98-128 m asl
Tone: Light to moderate grey
Texture: Smooth
Vegetation Cover: Low shrubs
Comprised of: Fine to coarse organic material
Found adjacent to: Glaciomarine, glaciofluvial, colluvium
Overlying contacts: N/A
Underlying contacts: Glaciomarine

Organic plain (Op):

Percent coverage within unit: 19%
General location: Coastal lowlands
Seen in the field: No
Elevation range: 24 to 49 m asl
Tone: Moderate grey, white along edges
Texture: Appears raised above surroundings, smooth/ flat
Vegetation Cover: Low shrubs
Comprised of: Fine to coarse organic material
Found adjacent to: Glaciomarine, bedrock
Overlying contacts: N/A
Underlying contacts: Glaciomarine, bedrock

Bedrock

Unit colour: Brown
Percent coverage: 15% (See Figures 2-4 and 2-5 for distribution)
General location: Generally confined to the uplands, however, outcrops occur at Cape Porcupine, offshore islands, and north of *West Bay*
Observed in the field: Yes
Elevation range: 0 to 493 m asl
Surficial morphologies: Bedrock exposed (R) and concealed (Rc)

Bedrock exposed (R):

Percent coverage within unit: 5%
General location: Hill tops and exposures along the coast
Observed in the field: Yes
Elevation range: 0 to 493 m asl
Tone: Light to medium grey
Texture: Rough
Vegetation Cover: Very little to none
Comprised of: Bedrock
Found adjacent to: Bedrock concealed, and aeolian deposits
Overlying contacts: N/A
Underlying contacts: N/A

Bedrock concealed (Rc):

Percent coverage within unit: 15%
General location: Uplands, north of West Bay, along the coastline
Observed in the field: Yes
Elevation range: 6 to 481 m asl
Tone: Medium to dark grey
Texture: Relatively smooth
Vegetation Cover: Moderate to completely forested
Comprised of: Bedrock
Found adjacent to: Bedrock exposed, till, glaciofluvial, glaciomarine, marine,colluvium, bog, aeolian
Overlying contacts: Marine, till, glaciofluvial
Underlying contacts: N/A

Till

Unit colour: Green
Percent coverage: 7% (See Figures 2-4 and 2-5 for distribution)
General location: On the Porcupine Hills and uplands northeast of the 'Local Mealy Mountains'
Observed in the field: No (one occurrence seen in field, the thickness of which could not be determined)
Elevation range: 79 to 426 m asl
Surface Morphology: Till veneer (Tv) and Till blanket (Tb)

Till Veneer:

Percent coverage within unit: 95%
General location: Uplands
Observed in the field: No
Elevation range: 79 to 426 m asl
Tone: Medium to dark grey tones
Texture: Smooth
Found adjacent to: Bedrock, bog, glaciofluvial, glaciomarine, colluvium
Overlying contacts: Bog, glaciomarine
Underlying contacts: Bedrock

Till Blanket:

Percent coverage within unit: 5%
General location: Valleys in uplands
Observed in the field: No
Elevation range: 103 to 304 m asl
Tone: Medium to dark grey tones
Texture: Smooth
Found adjacent to: Bedrock, bog, glaciofluvial
Overlying contacts: None
Underlying contacts: Bedrock

Aeolian

Unit colour: Bight yellow
Percent coverage: 4% (See Figures 2-4 and 2-5 for distribution)
General location: Generally found on the coastal lowlands, but also found in isolated back bays north of *West Bay*
Observed in the field: Yes
Elevation range: 0 to 493 m asl
Surficial morphologies: Aeolian veneer (Ev) and ridge (Er)

Aeolian veneer (Ev):

Percent coverage within unit: 45%
General location: Coastal lowlands
Observed in the field: Yes
Elevation range: 0 to 37 m asl
Tone: Very light grey to white
Texture: Smooth but interrupted by ridges in some places
Vegetation Cover: Very little to none
Comprised of: Very fine to fine sand
Found adjacent to: Bedrock concealed, marine plains, and organic (bog) deposits
Overlying contacts: Bog
Underlying contacts: Bedrock, bog, marine

Aeolian ridge (Er):

Percent coverage within unit: 55%
General location: Coastal lowlands, back bays north of *West Bay*
Observed in the field: Yes
Elevation range: 6-37 m asl
Tone: Very light to dark depending on vegetation cover
Texture: Smooth to rough, in places slightly stippled
Vegetation Cover: no vegetation, sparse grasses to low shrubs
Comprised of: Bedrock
Found adjacent to: Bedrock exposed, marine plains, and organic (bog) deposits
Overlying contacts: Bog
Underlying contacts: Bedrock, bog, marine

Fluvial

Unit colour: Peach
Percent coverage: 1% (See Figures 2-4 and 2-5 for distribution)
General location: Confined to the rivers and large brook systems, i.e North River, Porcupine River, South Feeder Brook, Woolfrey's Brook, Fancies Brook, and Big Brook
Observed in the field: Yes
Elevation range: 0 to 140 m asl
Surficial morphologies: Fluvial undivided (F), plain (Fp), and terrace (Ft)

Fluvial undivided (F):

Percent coverage within unit: 75%
General location: Valleys with larger brooks and rivers
Observed in the field: Yes
Elevation range: 0 to 140 m asl
Tone: Light to dark grey
Texture: Smooth to slightly rough
Vegetation Cover: None to grasses and trees
Comprised of: Reworked glaciofluvial and glacial marine
Found adjacent to: Bedrock concealed, till, glaciomarine, glaciofluvial
Overlying contacts: N/A
Underlying contacts: Glaciofluvial and glaciomarine

Fluvial undivided (Fp):

Percent coverage within unit: 20%
General location: North River and Herder River
Observed in the field: Yes
Elevation range: 0 to 91 m asl
Tone: Light
Texture: Smooth
Vegetation Cover: None to forested on larger islands
Comprised of: Reworked glaciofluvial and glaciomarine which form bars
Found adjacent to: Bedrock concealed, bog, glaciomarine, glaciofluvial
Overlying contacts: N/A
Underlying contacts: Glaciofluvial and glaciomarine

Fluvial undivided (Ft):

Percent coverage within unit: 5%
General location: North River
Observed in the field: Yes
Elevation range: 0 to 18 m asl
Tone: Light to dark grey
Texture: Smooth to slightly rough
Vegetation Cover: None to forested
Comprised of: Eroded glaciofluvial and glaciomarine
Found adjacent to: Bedrock concealed, bog, glaciomarine, glaciofluvial
Overlying contacts: N/A
Underlying contacts: Glaciofluvial and glaciomarine

Field Description:

North River and Big Brook were the only fluvial systems that were traversed.
The first 10 km of North River were traversed by canoe. North River's bedload is primarily sand. However, at one time this river carried pebbles to boulders. Some boulders are exposed during low tide at the river mouth. Subangular to subround pebbles and boulders are most common within river channels and on bar banks approximately 8 km upstream. Fluvial bars are also common in this area. Bars range in length from 0.1 to 1.9 km and have a width of 30 to 200 m. Some of these bars can be classified as having a lateral or longitudinal form. The river banks in this area are steep and composed of fine sand and marine mud. Marine mud also underlies much of the river channel. Tides affect the river level approximately 10 km inland.

Colluvial Deposits

Unit Colour: Orange
Percent coverage: 0.5% (See Figures 2-4 and 2-5 for distribution)
General location: Commonly found along steep slopes of the 'Local Mealy Mountains' and in a number of places in the Porcupine Hills
Observed in the field: No
Elevation range: 30 to 457 m asl
Surficial Morphology: Colluvial apron (Ca), blanket (Cb) and veneer (Cv)

Colluvial apron (Ca):
Percent coverage within unit: 15%
General location: Steep slopes in the Porcupine Hills
Observed in the field: No
Elevation range: 97 to138m asl
Tone: Light to medium grey tones
Texture: Slightly rough
Vegetation Cover: Low to moderate - low grasses and shrubs
Comprised of: bedrock debris and reworked till
Found adjacent to: Bedrock, till, and glaciofluvial sediment
Overlying units: n/a
Underlying units: Till and glaciofluvial

Colluvial blanket (Cb):
Percent coverage within unit: 35%
General location: North side of North River
Observed in the field: No
Elevation range: 12 to 54 m asl
Tone: Moderate to dark grey tones
Texture: Slightly rough and stippled
Vegetation Cover: Moderate
Comprised of: Reworked glaciofluvial material
Found adjacent to: Glaciofluvial and bog
Overlying units: n/a
Underlying units: Glaciofluvial

Colluvial veneer (Cv):
Percent coverage within unit: 50%
General location: Bottom of steep slopes in uplands and North side of North River
Observed in the field: No
Elevation range: 18 to 457 m asl
Tone: Moderate to dark grey tones
Texture: Rough - shallow channels cut surface
Vegetation Cover: Low to moderate - low shrubs
Comprised of: bedrock debris and reworked till
Found adjacent to: Glaciofluvial and bog
Overlying units: n/a
Underlying units: Glaciofluvial

APPENDIX 5:

LIST OF COLLECTED PEAT AND PALAEOSOL SAMPLES

Table E lists the location and presence of charcoal in collected peat and palaeosol samples.

Table E: List of palaeosol and peat samples, some of which contained charcoal.

Site	Sample	Material type	Charcoal	Easting	Northing
PS-015	PS-001-O-0215	palaeosol	Yes	494083	5963979
PS-019	PS-004-O-0216	palaeosol	No	485250	5963675
PS-038	PS-005-O-0219	palaeosol	No	491626	5963753
PS-051	PS-007-O-0223	palaeosol	No	493244	5965193
PS-069	PS-014-O-0225	palaeosol	Yes	491434	5965138
PS-069	PS-015-O-0225	palaeosol	No	491434	5965138
PS-071	PS-016-O/W-0226	peat	Yes	494479	5963240
PS-071	PS-017-O/W-0226	peat	Yes	494479	5963240
PS-072	PS-018-O-0226	palaeosol	Yes	494185	5963980
PS-072	PS-019-O-0226	palaeosol	Yes	494185	5963980
PS-074	PS-020-O-0226	palaeosol	No	494625	5963934
PS-086	PS-024-O-0231	peat	No	470909	6004138
PS-086	PS-025-O-0231	palaeosol	Yes	470909	6004138
PS-087	PS-026-O-0201	palaeosol	Yes	475092	5998955
PS-089	PS-030-O/W-0203	peat	No	491598	5965100
PS-089	PS-031-O-0203	peat	Yes	491598	5965100
PS-089	PS-032-O-0203	palaeosol	Yes	491598	5965100
PS-094	PS-036-O-0205	peat	No	495124	5963097
PS-094	PS-037-O-0205	peat	No	495124	5963097
PS-092	PS-042-O-0206	palaeosol	No	494429	5963268
PS-074	PS-044-O-0206	peat	Yes	494625	5963934
PS-099	PS-046-O-0208	palaeosol	Yes	494230	5963360
PS-101	PS-050-O-0208	palaeosol	Yes	494303	5963738
PS-101	PS-051-O-0208	palaeosol	Yes	494303	5963738
PS-104	PS-053-O-0208	palaeosol	No	494229	5963952
PS-104	PS-054-O-0208	palaeosol	Yes	494229	5963952
PS-104	PS-056-O-0208	palaeosol	Yes	494229	5963952
PS-105	PS-059-O-0209	palaeosol	Yes	493865	5963551
PS-105	PS-060-O-0209	palaeosol	No	493865	5963551
PS-107	PS-061-O-0209	palaeosol	No	493850	5963679
PS-107	PS-062-O-0209	palaeosol	Yes	493850	5963679
PS-110	PS-071-O-0209	palaeosol	Yes	494009	5964266
PS-114	PS-072-O-0209	palaeosol	Yes	493688	5963593
PS-119	PS-073-O-0210	palaeosol	Yes	493950	5963269
PS-119	PS-074-O-0210	peat	Yes	493950	5963269
PS-108	PS-075-O-0211	palaeosol	Yes	493727	5963776
PS-120	PS-076-O-0211	palaeosol	Yes	494367	5964225
PS-120	PS-077-O-0211	palaeosol	Yes	494367	5964225
Ps-120	PS-080-O-0211	palaeosol	Yes	494318	5964243
PS-121	PS-083-O-0212	palaeosol	Yes	469134	6004595
PS-121	PS-084-O-0212	palaeosol	Yes	469134	6004595
PS-121	PS-085-O-0212	palaeosol	Yes	469134	6004595
PS-121	PS-086-O-0212	palaeosol	No	469134	6004595
PS-122	PS-089-O-0214	peat	Yes	469310	6005043
PS-122	PS-094-O5-0214	palaeosol	Yes	469276	6005094
PS-122	PS-095-O4-0214	palaeosol	No	469276	6005094
PS-122	PS-096-O2-0214	palaeosol	Yes	469276	6005094
PS-122	PS-097-O1-0214	palaeosol	Yes	469276	6005094

Cont. of Table E

Site	Sample	Material type	Charcoal	Easting	Northing
PS-122	PS-100-O-0214	palaeosol	Yes	469276	6005094
PS-087	PS-104-O-0216	peat	Yes	474758	5998672
PS-131	PS-109-O-0219	palaeosol	Yes	493781	5964187
PS-131	PS-111-O-0219	palaeosol	Yes	493781	5964187
PS-131	PS-115-O-0219	peat	Yes	493781	5964187
PS-131	PS-116-O-0219	peat	Yes	493781	5964187
PS-134	PS-125-O-0220	peat	Yes	484800	5972600
PS-137	PS-126-O-0220	peat	Yes	485050	5971600
PS-137	PS-127-O-0220	peat	Yes	485050	5971600
PS-141	PS-128-O-0221	palaeosol	Yes	485691	5968916
PS-141	PS-132-O-0221	peat	No	485691	5968916
PS-141	PS-133-O-0221	palaeosol	No	485691	5968916
PS-145	PS-136-O-0221	palaeosol	Yes	487480	5968083
PS-147	PS-140-O-0222	palaeosol	Yes	487480	5968083
PS-147	PS-142-O-0222	palaeosol	Yes	487480	5968083
PS-147b	PS-145-O-0222	palaeosol	Yes	487130	5967444
PS-147b	PS-149-O-0222	palaeosol	No	487130	5967444
PS-147b	PS-150-O-0222	peat	Yes	487130	5967444
PS-150	PS-153-O-0223	palaeosol	Yes	489542	5965706
PS-151	PS-154-O-0223	peat	Yes	489504	5965440
PS-151	PS-155-O-0223	peat	Yes	489504	5965440
PS-091	PS-156-O-0223	peat	Yes	489892	5964918
PS-091	PS-157-O-0223	peat	No	489892	5964918
PS-153	PS-166-O-0226	peat	No	494439	5964357
PS-148	PS-151a-O-0223	peat	Yes	489593	5965989
PS-084	PS-022a-O-0231	peat	Yes	468982	6004876
PS-084	PS-022b-O-0231	peat	Yes	468982	6004876
PS-084	PS-022c-O-0231	peat	Yes	468982	6004876
PS-105	PS-060b-0-0209	palaeosol	No	493865	5963551

A gently sloping accumulation of debris deposited by a stream issuing from