PALAEOESKIMO SEALSKIN PROCESSING IN PORT AU CHOIX, NORTHWESTERN NEWFOUNDLAND: A PALEOENVIRONMENTAL ANALYSIS

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Palaeoeskimo Sealskin Processing in Port au Choix, Northwestern Newfoundland: A Paleoenvironmental Analysis

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ABSTRACT

Recent palaeolimnological investigations of Bass Pond, Port au Choix, have revealed a disturbance history concurrent with the Groswater and Dorset Palaeoeskimo occupations of the nearby Phillip's Garden, Phillip's Garden East, and Phillip's Garden West sites. Additionally, sealskin processing tools have been identified from the Dorset assemblage recovered from Phillip's Garden, leading to the hypothesis that Bass Pond was used in the sealskin processing procedure.

Results of a second palaeolimnological investigation of Bass Pond, presented in this thesis, indicate that the disturbance observed in Bass Pond may be more associated with the Groswater occupation of the area, and not the Dorset as previously hypothesized. The addition of geochemical investigations of $\delta^{15}N$, used elsewhere to show marine mammal influence on fresh water ponds, indicates a marine mammal presence within the pond during the same disturbance period, possibly as a result of sealskin processing activities. This, however, is not corroborated by the archaeological record.

This investigation provides some of the earliest evidence of hunter-gatherer environmental impact in Canada.

CANDIDATE'S CONTRIBUTION TO THESIS

For this thesis, J. Bambrick assisted in core retrieval and sampling of all material used in this investigation, including samples used in radiocarbon dating. Samples were dated by Beta Analytic Inc. J. Bambrick undertook all aspects of the pollen analysis, including laboratory and microscope work, as well as data entry and concentration calculation. The isotope analyses were prepared and interpreted by J. Bambrick, while Alison Pye of the Stable Isotope Laboratory, Department of Earth Sciences (Memorial University), performed the analysis.

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Although my originally planned diatom research did not come to fruition, I would still like to thank those at the University of Alberta who provided support and training in diatom processing and identification techniques. First, to Dr. Alex Wolfe and Dr. Marianne Douglas, who opened their lab to me, and made my time in Edmonton a rewarding experience. Thanks also go out to Collin Quarrie, Nathan Ballard, Selma Losic, and Dr. Will Hobbs from the Paleoenvironmental Reconstruction Laboratory at the University of Alberta for their assistance and support.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

Introduction

1.1 Introduction and Research Objectives

In 2005, Bell *et al.* (2005) published the results of a palaeolimnological investigation of Bass Pond, a small pond located in proximity to the significant Dorset Palaeoeskimo site of Phillip's Garden in Port au Choix, Newfoundland (Figure 1.1). In this publication, Bell *et al.* reported a series of marked changes in vegetation and limnology of the pond dating to 2200-1800 cal BP[1]. This disturbance was characterized by increased levels of aquatic herb and algal species, interpreted to represent nutrient enrichment (eutrophication) within the pond, and increased sedimentation rates, which may be indicative of anthropogenic activity around the pond perimeter. Bell *et al.* (2005) argued that this disturbance, which was absent from the record of a nearby pond isolated from any archaeological sites, could be attributed to the Dorset Palaeoeskimo occupation of the nearby Phillip's Garden site. They noted the presence of an earlier site near Bass Pond belonging to the Groswater Palaeoeskimo period, Phillip's Garden East, but argued on the basis of their chronology that the main disturbance event was not attributed to the Groswater occupation. Further, they hypothesized that the observed eutrophication,

[1] Dates are expressed throughout the text as radiocarbon years before present (BP) or in calibrated calendar years before present (cal BP) as either a one-sigma probability age range or a median probability single age.

coupled with slate tool artefacts from Phillip's Garden, which have been interpreted as skin processing tools, indicated that sealskin processing activities were carried out in and around Bass Pond.

The overall goal of this thesis is to test and refine the hypothesis presented by Bell *et al.* (2005) regarding the impact of Dorset Palaeoeskimo cultural activities on the ecology of Bass Pond. In doing so, the observed disturbance may be substantiated, and possibly attributed to particular cultural activities. This goal is achieved by addressing several objectives, the first of which is refining the Bass Pond sediment core chronology. Bell *et al.* established six dates for their investigation, three of which fall within the Dorset Palaeoeskimo occupation of Phillip's Garden. The addition of dates to this chronology is necessary to correlate new sediment cores to those previously obtained while also refining the previous chronology, particularly during the Palaeoeskimo occupation.

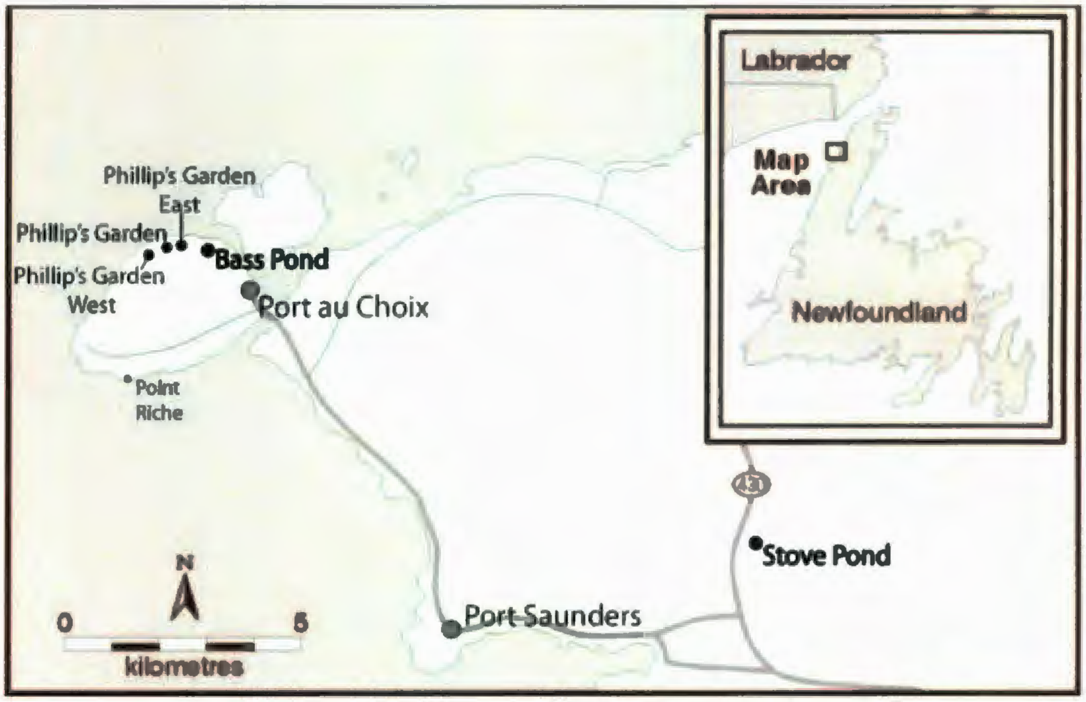

Figure 1.1: Location of Port au Choix showing the archaeological Dorset site of Phillip's Garden, and the Groswater sites of Phillip's Garden East, and Phillip's Garden West. Also identified are Bass and Stove ponds (Based on Bell *et al.* 2005).

The second objective is to increase the resolution of the palynological data, which can be achieved by increasing the sediment sampling interval. Bell *et al.* (2005) sampled the sediment core every 2.5 to 5 cm, resulting in a resolution of one to four centuries. By increasing this interval to 1 cm, the temporal resolution increases to 20-100 years. In doing so, the overall vegetation trends previously observed can be more narrowly defined, while specific pollen disturbances can be better linked to the archaeological record with higher precision.

The third and final objective of the present study is to introduce an independent variable that specifically indicates sealskin processing occurred in Bass Pond. Douglas *et* *al.* (2004) have shown that stable nitrogen isotopes ($\delta^{15}N$) can indicate a marine mammal (bowhead whale) presence in the vicinity of Arctic ponds. Therefore, the addition of isotope analysis to this investigation should provide evidence that the Palaeoeskimo used Bass Pond for marine mammal processing, in particular the act of sealskin depilation.

This thesis will begin with a general introduction to the project, providing background information for the major topics and themes to follow. This overview includes the archaeological context for the study area and cultures of interest, explanation of the cultural activities at the focus of this investigation, a brief survey of literature relating to hunter-gatherer impacts on the environment, the theory and environmental proxies with which this project is concerned, and finally an outline of this investigation and its implications. Chapter 2, appearing in manuscript format, contains a detailed description of the project, as well as the results of the investigations, and discussion of these results. Chapter 3 is a summary of the thesis, highlighting the major points of interest, implications of the results, and recommendations for future investigations. The data and procedures of the palynological and isotope investigations, as well as the radiocarbon dating results, are contained in the Appendices.

1.2 Palaeoeskimo Cultures in Newfoundland

The Newfoundland Palaeoeskimo populations are the descendants of Siberian hunting populations who migrated to North America via the Bering Strait as early as 5000 years ago (McGhee 1996; Renouf 1999). In Newfoundland, this population can be divided into two distinct cultures, Groswater and Dorset. Although the cultural connection between the two populations is somewhat ambiguous, it has been proposed that they represent two distinct cultures (Tuck and Fitzhugh 1986; Kennett 1990); while in Labrador it has been shown that the two maintained cultural boundaries while contemporaneously occupying the same area (Anton 2004). Newfoundland is the southernmost extent for Canadian Palaeoeskimo populations while St. Pierre is the southernmost extent for North American population (Leblanc 2000a).

Perhaps some of the more well known and extensive Palaeoeskimo sites in Newfoundland are located in Port au Choix on the Northern Peninsula (Figure 1.2). Two sites, Phillip's Garden East and Phillip's Garden West, were occupied by the Groswater Palaeoeskimo from 2880 to 1910 cal BP, while a third site, Phillip's Garden, was occupied by the Dorset Palaeoeskimo from 1990 to 1180 cal BP (Figure 1.3) (Renouf 2005, 2006).

Figure 1.2: Oblique aerial photograph looking southeast on the Phillip's Garden group of sites (Port au Choix Archaeological Project)

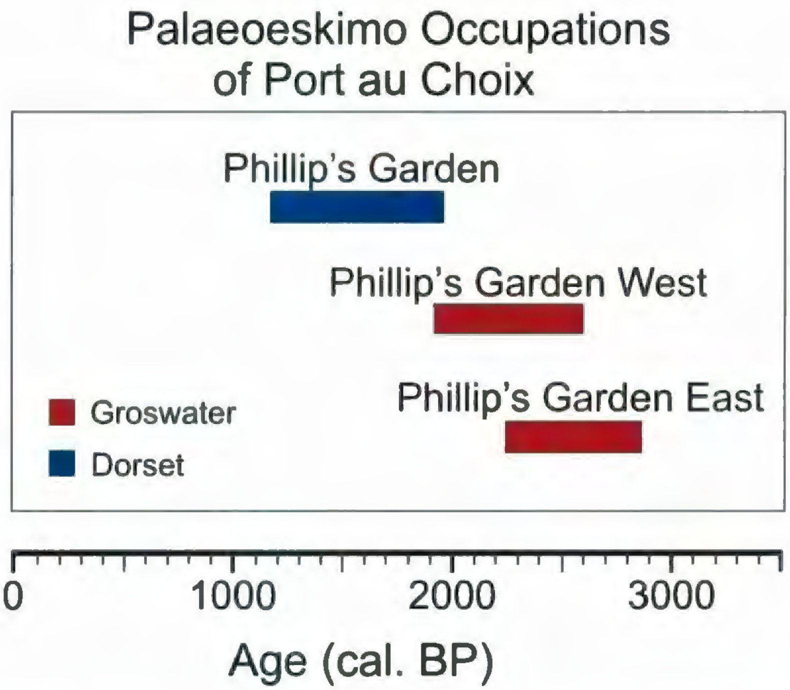

Figure 1.3: Duration of Palaeoeskimo occupation at the Phillip's Garden group of sites.

1.3 Groswater Palaeoeskimo

The Groswater Palaeoeskimo were first defined by Fitzhugh (1972) while investigating the central Labrador coast, and since have been identified extensively throughout the coast of Labrador (Tuck 1975; Cox 1977; Fitzhugh 1980; Loring and Cox 1986; Pintal 1994; Anton 2004), Newfoundland (Linnamae 1975; 1978; Carignan 1975; Pastore 1982; Robbins 1985; Renouf 1994; Melnik 2007), and the Quebec Lower North Shore (Leblanc 1996; Pintal 1994). They have been dated to 2800 to 2200 BP[i] in Labrador (Cox 1978), and from 2800 to 1900 cal. BP in Newfoundland (Renouf 2005).

The Groswater toolkit is characterized by box-based, side-notched endblades, circular and ovate sideblades, microblades, burin-like tools, flared-end endscrapers, and a variety of bifaces; most typically composed of colourful fine-grained chert (Fitzhugh

1972; Auger 1984; Renouf 2005). Few features have been found; however it appears that dwellings are defined by stone slab paved floors containing mid-passage structures and box hearths (Loring and Cox 1986), and are possibly circular or bi-lobate in nature (Renouf 1994, 2003). Dwellings were distributed both in outer coastal (Pastore 1986) and inner bay areas (Loring and Cox 1986; Anton 2004). Many Groswater sites are fairly small in size with few artifacts, which led Fitzhugh (1972) to suggest that the population was small and dispersed.

Faunal collections from several Newfoundland sites show that subsistence patterns were focused on marine mammals (Maxwell 1985; Renouf 1993), waterfowl, small game, and caribou (Auger 1984, Renouf 1991, 1993), indicating that the Groswater exploited a wide range of resources. Foraging strategies largely appear to be based on location and, in some cases, the predictability of seasonal resources (Leblanc 1996, 2000a). This, in conjunction with the varied site locations, indicates that Groswater populations seasonally relied on both inland and marine resources (Tuck and Fitzhugh 1986; Renouf 1993), and remained highly mobile in order to maximise resource procurement year round (Renouf 1993; Leblanc 1996, 2000a).

1.4 Phillip's Garden West

Phillip's Garden West, the Phillip's Garden site located furthest from Bass Pond, is situated on a terrace 13 m above sea level (Figure 1.2). The small site, of just 500 m^2, has been fully excavated, yielding radiocarbon dates that range from 2600 to 1910 cal BP

(Renouf 2005). Atop the terrace is evidence of an ephemeral dwelling, a tent lacking fire cracked rock, indicating this was a short-term seasonal occupation site (Renouf 1993, 1994). The artefacts recovered from this site, however, are not typical of the usual Groswater assemblage; many are delicately made, with a ground facet on one face and a finely serrated edge (Renouf 1991, 1993, 2005). The varied faunal remains recovered at the site are dominated by seal (Renouf 1993; Wells 2002).

1.5 Phillips Garden East

Phillip's Garden East is located approximately 1 km from Phillip's Garden West, and is the closest site to Bass Pond (Figure 1.2). The site is fairly small, approximately 1300 m^2, and is situated on a terrace 12 m above sea level (Renouf 1993). Excavations at the site have yielded radiocarbon dates from 2880 to 2230 cal BP, making it the oldest Palaeoeskimo site in Port au Choix (Renouf 2005). Two atypical Groswater structures have been excavated on the site. The first consisted of a small circular depression devoid of debris and surrounded by charcoal and fire cracked rock, and has been interpreted as a tent or a large pit; however, Renouf (2005) suggests it may be attributed to Dorset rather than Groswater. The second structure was larger, contained a sleeping platform and storage pit, and was filled with debris, indicating it is likely a dwelling structure (Kennett 1990; Renouf 1991, 1993). The faunal remains associated with this dwelling were composed of both terrestrial and marine resources, but were dominated by juvenile harp seal, indicating that the dwelling was occupied in the late winter to early spring (Hodgetts *et al.* 2003; Hodgetts 2005). A high proportion of hunting tools recovered from the site indicate this was predominantly a hunting and processing encampment with a reliance on harp seals (Kennett 1990; Renouf 1991, 1993; Leblanc 1996, 2000b).

1.6 Dorset Palaeoeskimo

The Dorset Palaeoeskimo were first documented in Newfoundland in two publications by Wintemberg (1939, 1940) where the author noted deviations from the usual tool forms found in Dorset sites elsewhere in the Arctic. Dorset populations inhabited the Canadian Arctic for roughly 2000 years, and are divided into three distinct periods based on the location of Dorset occupations and patterns in tool types. The early period is dated from approximately 2500 to 2000 BP, the middle period from approximately 2000 to 1000 BP, and the late period from approximately 1000 to 600 BP (Maxwell 1985; Tuck and Fitzhugh 1986). Of these three, only the middle period Dorset inhabited Newfoundland. The Dorset within Newfoundland also show regional variations in lithic technology, as west coast, northeast coast, and south coast variants have been identified (Robbins 1986; Leblanc 2000a; Erwin 2001).

The Newfoundland Dorset toolkit is characterized by triangular concave based endblades, ground burin-like tools, microblades, and a variety of scrapers (Harp 1964; Renouf 1993; Wright 1995). They also made extensive uses of soapstone lamps for heating their dwellings with seal oil (McGhee 1996), while tools are often geared towards marine hunting (Maxwell 1985; Robbins 1986; Renouf 1993; Leblanc 2000a). Dorset dwellings are often semi-subterranean structures with stone slab paved floors and sleeping platforms, and contain axial hearth features (Renouf 2003, 2006). Dorset occupations were located primarily in coastal areas (Pastore 1986), while subsistence strategies were focused almost primarily on marine mammals, with less attention paid to terrestrial resources (Pastore 1986; Renouf 1993; Wells 2005).

1.7 Phillip's Garden

The Phillip's Garden site is a large meadow measuring approximately two hectares (Figure 1.2). It is composed of three raised terraces, two of which were extensively occupied, containing over sixty Dorset dwellings, making this one of the largest and richest Dorset sites in Canada (Figure 1.4) (Renouf 2006; Renouf and Bell 2008). The site has been extensively excavated by Harp (1964, 1976) and Renouf (1993, 1999, 2006, 2009). Based on the size, number, and age of the dwellings excavated, the site has been divided into three phases of Dorset occupation, 1990 – 1550 cal BP, 1550 – 1350 cal BP, and 1350 – 1180 cal BP. Dwellings tended to be larger and more numerous during the middle phase, suggesting that the Dorset population reached its maximum during this time (Figure 1.5) (Erwin 1995; Renouf 2006).

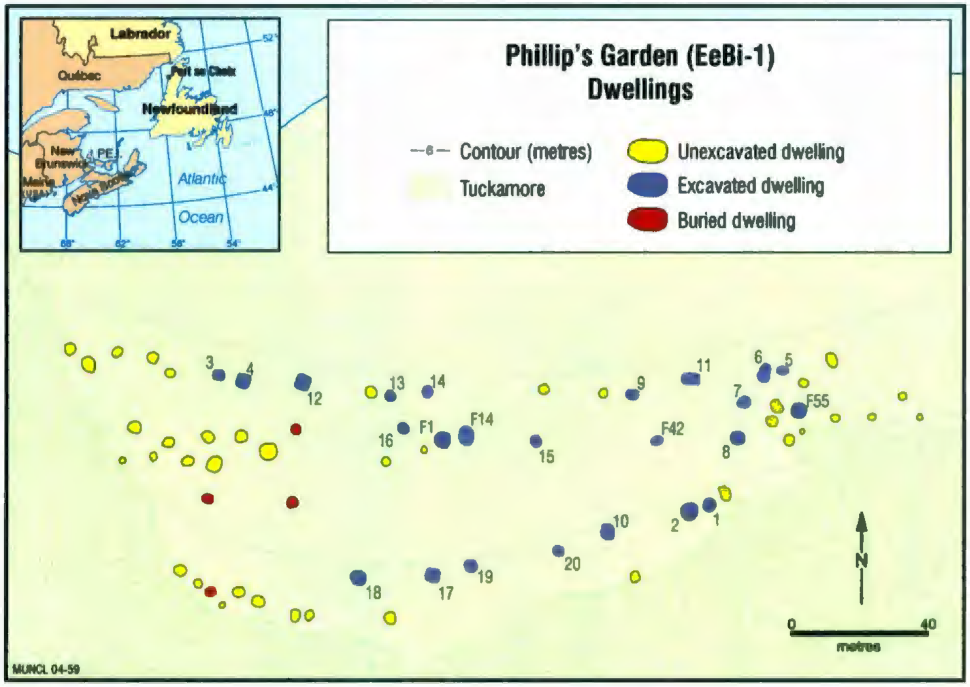

Figure 1.4: Map of Phillip's Garden showing identified dwelling depressions (Port au Choix Archaeological Project)

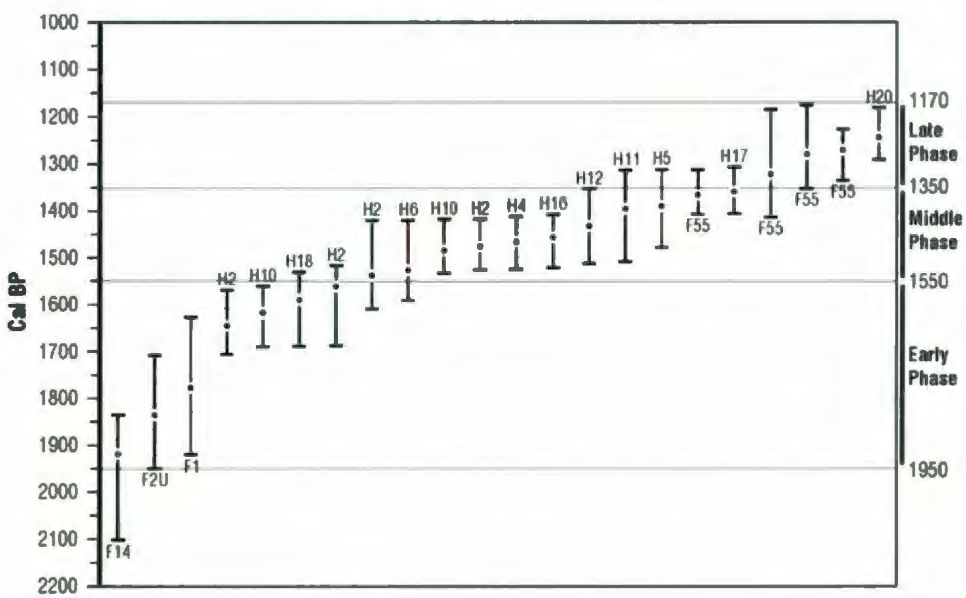

Figure 1.5: Dated dwellings at Phillip's Garden. H# refers to a dwelling excavated by Harp (1976) and F# refers to a dwelling excavated by Renouf (2002). (Port au Choix Archaeology Project)

The majority of houses located in Phillip's Garden seem to have been occupied seasonally, while a few substantial dwellings may have been permanently occupied on a seasonal basis (Renouf 2003, 2006, 2009). Structures were very large in size and semi-subterranean, with low stone walls and sleeping platforms, and contained a central cooking area (Renouf 2006). It has been proposed that the house frames were likely composed of wood and bone, and covered by several seal skins (Harp 1976; Renouf 1999, 2003, 2006), while Renouf (2009) suggests that whale ribs were used to frame all Phillip's Garden dwellings (Renouf 1999, 2006; Cogswell 2006). This elaborate structure reflects the time and effort invested into building such a dwelling, indicating that these dwellings were designed for regular and extended use, particularly throughout the winter and spring, and may have been reused on a semi-annually basis (Renouf 2003, 2006, 2009). Overall, these features suggest that Dorset dwellings were much larger and more substantial that those of the Groswater (Renouf 2003).

The main subsistence endeavour for the site, illustrated by the contents of midden deposits, was harp seal. Over 90% of the faunal remains recovered from the Phillip's Garden site are harp seal (Murray 1992; Renouf and Murray 1999; Hodgetts *et al.* 2003; Hodgetts 2005). The majority of seal remains at the site are shown to be from the spring seal migration, based on season of death studies and the presence of young seal remains within the collection (Renouf 1993; Hodgetts 2005). The large proportion of harp seal material found at the site indicates that the Dorset relied heavily on this seasonal resource which would have provided the population with meat for food, oil and blubber for fuel, and raw materials such as sealskin for the manufacture of such items as clothing, boots, and dwelling covers. In addition to the abundant faunal remains at the site, a series of tabular slate tools have been recovered from Dorset context. Use wear analysis and classification of these tools show that they are in fact a specialised tool set for processing sealskins, an activity that was not previously considered to be central to the site (Knapp 2008). This indicates that Phillip's Garden was a multi-functional site geared towards sealskin processing in addition to harp seal hunting.

The climatic history of the Phillip's Garden region has been inferred by previous analysis of pollen and chironomid assemblages from Bass Pond. Overall, it appears that summer temperatures have fluctuated, and seem to correspond with changes in settlement patterns in the Port au Choix region (Bell *et al.* 1997; Bell *et al.* 2004; Rosenberg *et al.* 2005). This is especially demonstrated by the chironomid inferred maximum summer surface temperatures established for Bass Pond. In general, the temperature record indicates that the Groswater occupied Phillip's Garden East and West during a prolonged cooler period, while the Dorset occupied Phillip's Garden during a warming period (Rosenberg *et al.* 2005). The implications of this temperature fluctuation on subsistence patterns may be significant, especially in relation to marine species. Harp seal migration patterns are largely determined by sea ice quantity and movement (Sergeant 1991); as a result, the reliability of this resource may have been different for the Groswater and Dorset (Renouf 1993).

1.8 Harp Seals in Port au Choix

Archaeological evidence shows that the Palaeoeskimo population of the Phillip's Garden group of sites, particularly the Dorset, relied heavily on harp seal for subsistence (Murray 1992; Hodgetts *et al.* 2003, Hodgetts 2005). Harp seals would not only provide sustenance to these populations, but would also provide several valuable raw materials such as oil, bone, and skin. Previous investigations have focused on the hunting aspect of the site; however, as mentioned earlier, recent use wear analysis of slate tools from Phillip's Garden has shifted this focus to seal processing (Knapp 2008). This indicates that the site was specifically geared towards exploiting all resources related to the harp seal (Renouf and Bell 2005; Knapp 2008).

Seals provided a wealth of resources for the Palaeoeskimo population, including meat, oil, bone, and skins, and were the main resource exploited at the Phillip's Garden sites. The abundance of this predictable seasonal resource at Port au Choix can be attributed to the migration patterns of the Atlantic harp seal populations. Each fall, the seals move south along the Labrador coast from their summer feeding grounds in the Canadian Arctic. By mid-December, they reach the Strait of Belle Isle and divide into two breeding populations known as the Front and Gulf herds. The Front herd remains in place off the coast of Newfoundland and Labrador while the Gulf herd descends southward towards the breeding grounds of the Gulf of St. Lawrence, passing through the Strait of Belle Isle. At the conclusion of the breeding and moulting season in May, the herd then begins migrating north, passing relatively close to the Port au Choix coast (Figure 1.6) (Sergeant 1991: 33-56; Leblanc 1996: 24-28). Although seals could be exploited during both the south and north migrations, hunting was likely more practical when the herd could be found closer to the shore and was better accessed by sea ice (Leblanc 1996). This is illustrated by the abundance of remains from Phillip's Garden indicating a spring seal harvest (Hodgetts 2005).

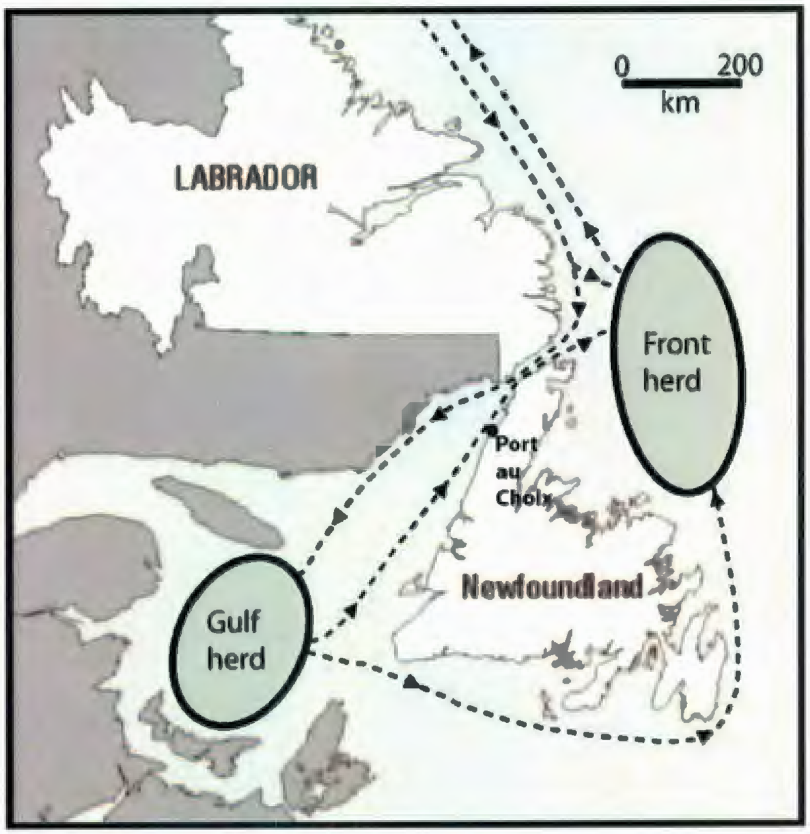

Figure 1.6: Migration routes and breeding areas of the northwest Atlantic harp seal population (based on Hodgetts 2005).

1.9 Sealskin Processing

Arctic and Subarctic environments are often characterized by extremely cold temperatures and stormy weather events. For this reason, clothing that keeps the wearer warm and dry is essential, and was especially necessary for the survival of prehistoric hunter-gatherer populations in the Canadian Arctic. Animal hides were readily available to these populations and were the best materials for clothing manufacture; particularly the skin of caribou and seals. The open cellular structure of caribou skin traps heat around the body, but is not waterproof, making it best suited for cold and dry environments. The closed cellular structure of sealskin, although not as warm, repels water better, making it best suited for warm and wet environments (Bogoras 1909; Oakes 1987; Oakes and Riewe 1998; Meeks and Cartwright 2005). For other items requiring a tough material, such as boots and tent covers, the thicker and more durable sealskin was used (Oakes 1987; Issenman 1997). The large amount of harp seal faunal remains recovered from the Phillip's Garden group of sites strongly suggests that sealskin was readily available for Dorset and Groswater Palaeoeskimo clothing manufacture in Newfoundland. Additionally, the many Dorset sewing and skin processing tools recovered from Phillip's Garden may indicate that sealskin processing was a common activity at the site (Knapp 2008).

To make sealskin suitable for the manufacture of items such as clothing, boots, and kayak covers, it must be transformed into a pliable material. Ethnographically, several methods of sealskin processing, particularly the act of leather making, have been observed in Arctic and Subarctic populations. Across Arctic and Subarctic cultures, similar methods are used to flense the seal, scrape the skin to remove fat and oil, and lash the skin to a frame. In contrast, there appears to be a wide variety of procedures used for hair removal, or depilation. Many such methods have been observed, including shaving the hair with an ulu (Turner 1894; Issenman 1997), or rolling the skin in a putrefying substance and leaving it overnight to loosen the hair before scraping (Turner 1894; Nelson 1899). In some cases, the skins would be soaked in hot water (Nelson 1899; Oakes 1987; Issenman 1997), cold water (Bogoras 1909; Oakes and Riewe 1998), a small river (Boas 1888), or in a small lake (Hall *et al.* 1994) to loosen the hair before the final scraping takes place. The final tanning process most often uses a steeped bark mixture, which tints the color of the skin, most often producing red, yellow, orange, brown, and black colors depending on the barks used (Jochelson 1908; Bogoras 1909; Oakes and Riewe 1998).

Of particular interest to this investigation is the method used for the past century on the Northern Peninsula of Newfoundland (Figure 1.7), which Firestone (1992, 1994) argues is likely borrowed from the Labrador Inuit. According to Firestone (1992, 1994), Bock (1991), and the Great Northern Peninsula Craft Producers (Multimedia Creations Inc. 2002), after the seal has been killed (typically in the spring) it is flensed, and the fat is removed from the pelt with a sharp blade (Figure 1.7a). The skin is then covered in salt and tightly rolled to be preserved for the next steps later in the season (Figure 1.7b). As the temperature rises in the early summer months, the skin is unrolled and rinsed. It is then lashed to a wooden frame, which tightly stretches the skin (Figure 1.7c). Sawdust is rubbed on the inside of the pelt to absorb oil prior to scraping. All of the fat and oil must be removed from the pelt to ensure consistent coloring later during the tanning process, so the skin is thoroughly scraped with a blunt iron scraper (Figure 1.7d). The frame is placed to dry in the sun for several weeks while scraping continues twice daily. The frame is then immersed into a shallow, freshwater pond, and rocks are placed on top to ensure the entire frame has been submersed (Figure 1.7e). At this point in the season, the pond has warmed enough to promote the growth of bacteria which naturally aids in the loosening of hair from the pelt over duration of three to four weeks. When the frame is removed from the pond, the hair has been loosened, and is easily removed by scraping the outside of the pelt again with an iron scraper (Figure 1.7f). At which time, the skins are removed from the frame, scraped a final time, and set aside for the tanning process (Bock 1991, Multimedia Creations Inc. 2002).

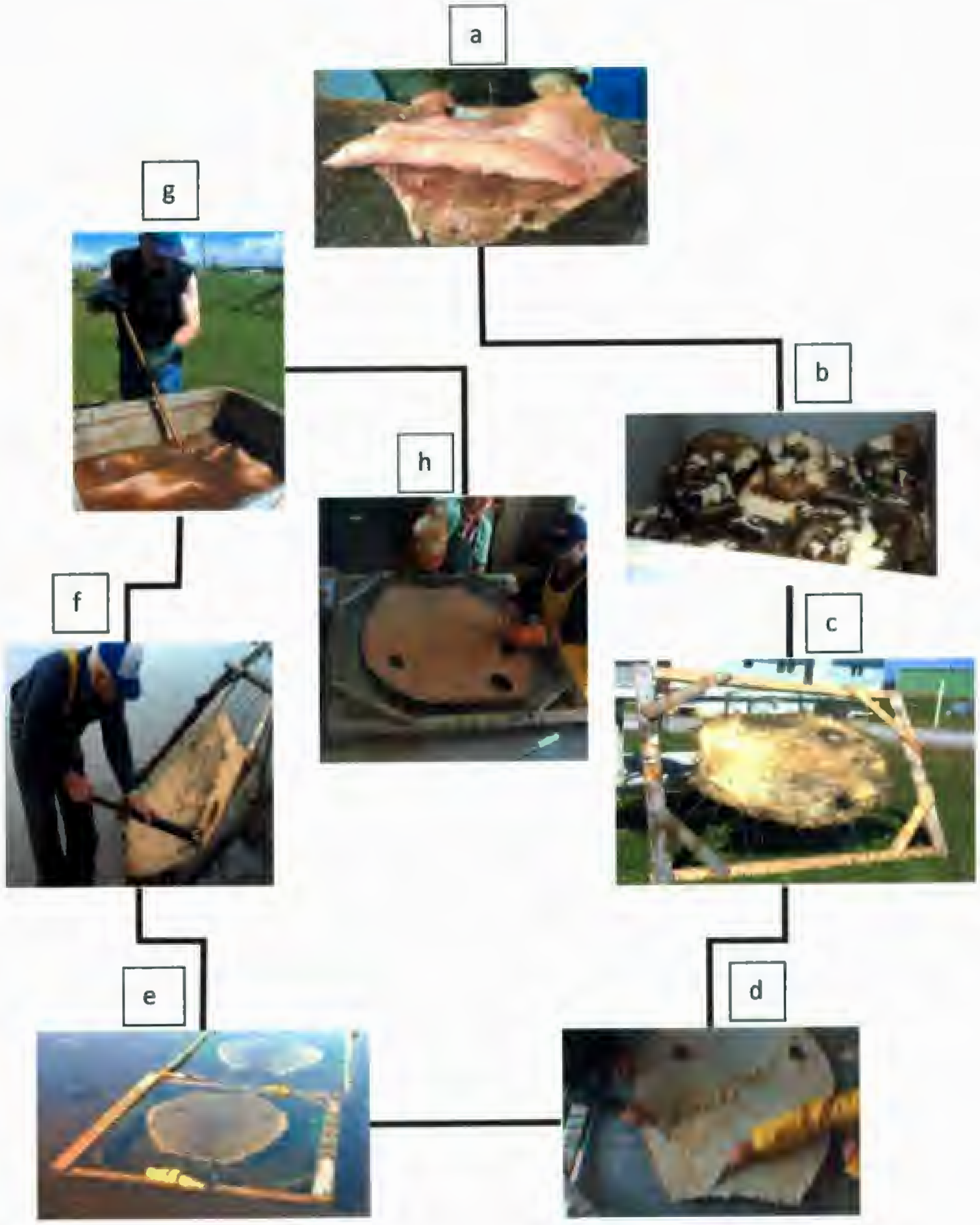

Figure 1.7: Sealskin processing method used by Great Northern Peninsula Crafts (Modified from Multimedia Creations Inc, 2002).

Tanning helps to preserve and waterproof the skins for use as clothing, such as boots, or other functions, such as kayak covers, as well as tint the skin a specific color. In addition, leather articles such as boots were preferable to fur-covered articles, as less snow clung to them (Firestone 1992: 117). The tanning solution, a steeped solution of salt water and bark, is used to color the skin. On the Northern Peninsula, the most common bark used is that of birch (for a red color) or fir (for yellow), and is often a combination of the two to produce the desired color. The bark is steeped for several weeks and removed prior to immersing the skins, which are soaked for over a week (Figure 1.7g). After the skin has been tanned, it is removed from the solution, laced back onto the frame (Figure 1.7h), and allowed to dry before being worked into clothing, most often, boots (Bock 1991; Multimedia Creations Inc 2002).

This procedure for processing sealskin, particularly the depilation and tanning process, relies heavily on ideal conditions within a small pond. If this was the method used by Palaeoeskimo populations at the Phillip's Garden group of sites, one might anticipate that evidence of this procedure would be preserved in the limnological record of the pond sediments. Further, if Bass Pond was the pond of choice for this process, the increased activity around the pond perimeter and submersion of marine mammal material within the pond would likely alter the local ecology and environment of Bass Pond.

1.10 Hunter-Gatherer Environment Interactions

Limnology has often been used to show that hunter-gatherer groups have altered their environment through a variety of ways. A popular and long standing assumption is that hunter-gatherers had very little impact on their environment; however this view is quickly changing as recent investigations indicate that the activities of prehistoric populations were, in fact, altering their environment (Innes and Blackford 2003). Investigations of lake bottom sediments throughout the northern hemisphere have yielded a wealth of paleoenvironmental data; in many cases, investigations of diatoms, pollen, fungal spores, and charcoal concentrations have shown that prehistoric populations have heavily altered vegetation regimes surrounding archaeological sites. This area of research has largely been focused in Europe (e.g. Kolstrup 1988; Bennett *et al.* 1990; Hicks 1993; Bos and Janssen 1996; Simmon and Innes 1996a; Simmon and Innes 1996b; Macklin *et al.* 2000; Moore 2000; Innes and Blackford 2003; Hornberg *et al.* 2005; Kunes *et al.* 2008); however, Canadian researchers are starting to focus on this research area as well.

Several paleolimnological investigations in Canada have indicated that prehistoric populations impacted their environment much more than previously considered. In Ontario, for instance, diatom studies carried out on Crawford Lake have shown that Iroquoian horticultural activities, dating to roughly 670 cal BP, caused eutrophication of the lake (Ekdahl *et al.* 2004, 2007). More often, however, Canadian investigations are focused on Arctic and Subarctic locations. For instance, Lacourse *et al.* (2007) have shown that the Haida population of Anthony Island in the Queen Charlotte Islands significantly altered the surrounding forest by relying almost exclusively on a specific species of tree for creating houses, dugout canoes, and other objects. Palynological investigation of SGang Gwaay Pond showed a marked decrease in *Cupressaceae* (cedar) pollen, coinciding with the Haida occupation at roughly 1000 cal BP. In Nunavut, significant research has been carried out on Thule Inuit sites dating roughly to 700 cal BP. Investigations of diatoms and $\delta^{15}N$ on Somerset Island (Douglas *et al.* 2004), Bathurst Island (Hadley 2007a), and Ellesmere Island (Hadley 2007b) have shown that Thule bowhead whaling practices resulted in the input of marine-derived nutrients in nearby lakes, thereby causing eutrophication. These studies have not only shown that hunter-gatherer populations carried out cultural activities that altered their surrounding environment, but also demonstrated that the evidence of these activities can be identified through paleolimnological investigations.

1.11 Environmental Indicators in Paleolimnology

Reconstructions of past environmental conditions through paleolimnology employ a variety of physical, chemical, and biological indicators preserved in lake sediment records. These include, but are not limited to, diatoms, pollen, charcoal, stable isotopes, micro and macro fossils, and sediment accumulation itself. As discussed earlier, these indicators, which are typically used in concert with each other, can aid in describing the environmental history of archaeological sites.

Diatoms, classified as algae, are unicellular, eukaryotic organisms with a siliceous cell wall. They are sensitive to a variety of factors, including changes in temperature, light availability, ice cover, pH, salinity, mixing within the water column, and nutrient changes (Stoermer and Smol 1999; Battarbee *et al.* 2005). Diatoms are found worldwide, in both freshwater and marine environments, while many are indicative of specific environmental parameters and have tolerances for a range of variables (Birks 1998). Of particular interest here is their ability to indicate eutrophication, particularly relating to nitrogen and phosphorus, which are nutrients commonly associated with human influence (e.g. Bradbury 1975).

With this in mind, the original research plan of the current Bass Pond investigation was centred on diatom analysis. Although diatoms would have been the best indicator for eutrophication within Bass Pond, initial analysis of the sediments showed that diatoms are not readily preserved during the period of interest. This is a result of silica dissolution, which is known to affect diatom preservation, and can be caused by a number of factors, including pH, temperature, and salinity (e.g. Mikkelson 1977; Barker *et al.* 1994; Bidle *et al.* 2002), bacterial dissolution (e.g. Bidle and Azam 1999; Bidle *et al.* 2003), bioturbation (e. g. Gibson *et al.* 2000) and differential dissolution of more delicate species (e. g. Ryves *et al.* 2001; Battarbee *et al.* 2005).

Although the cause of diatom dissolution within Bass Pond sediments is not clear, it is obvious that this environmental proxy could not be used in the current investigation. For this reason, other proxy indicators were focused on as a basis upon which to infer changes in past limnology of the pond. Elsewhere, particularly in northern Europe, pollen assemblages have been used to identify small scale prehistoric impact on surrounding forests (Hicks 1993; Aronsson 1994).The previous investigation carried out by Bell *et al.*

(2005) relied heavily on the pollen, algal, and charcoal record contained within the pond sediments. Although all pollen and algal taxa preserved within the pond sediment were counted, several species stood out as possible indicators of eutrophication. Most notable were the aquatic species *Pediastrum* and *Myriophyllum*.

Pediastrum, an aquatic alga, has been used to show eutrophication in lakes, most notably in Europe (e.g. Bradshaw *et al.* 2005a; Bradshaw *et al.* 2005b; Milecka and Szeroczynska 2005; Lawson *et al.* 2007). Further, Myriophyllum, an aquatic herb, has been linked to eutrophic lakes elsewhere in Newfoundland (Bouchard *et al.* 1978). Both species are preserved within Bass Pond; therefore any changes observed would directly reflect the changing limnology in the pond itself. For this reason, it was advantageous to resurvey Bass Pond, supplementing the data of Bell *et al.* (2005).

In addition to micropaleontological indicators, geochemical indicators can also be utilized to identify environmental disturbance. Marine biomass, enriched in $\delta^{15}N$ (Wolfe *et al.* 1999; Hirons *et al.* 2001), has recently been used to identify marine nutrient input into freshwater systems from bowhead whales (Douglas *et al.* 2004; Hadley 2007a, 2007b), sockeye salmon (Finney *et al.* 2002; Gregory-Eaves *et al.* 2003), and birds (Blais *et al.* 2005). This indicates that any marine faunal input into a freshwater body (i.e. seals or sealskins) should be evident in the paleolimnological signature of the associated sediment (i.e. Bass Pond).

Perhaps the most important aspect of any palaeolimnological investigation is the chronology. Most prehistoric archaeological chronologies are determined through radiocarbon dating, which measures the amount of carbon-14 remaining in a given sample. Radiocarbon is naturally formed in the Earth's stratosphere through the interaction of atmospheric ^{14}N and neutrons produced by cosmic rays, and naturally becomes incorporated in living matter (Libby *et al.* 1949). The rate of radiocarbon production, however, is not constant, and therefore must be corrected for when interpreting radiocarbon dates (Stuiver and Quay 1981). For this reason, radiocarbon dates are typically calibrated to obtain ages on a calendar time scale (Stuiver and Seuss 1966). This calibration is based on sets of tree ring chronologies, providing the standard on which all radiocarbon dates are compared, and resulting in an age range rather than an individual radiocarbon date (Stuiver *et al.* 1998; Guilderson *et al.* 2005).

Although radiocarbon dating is a necessity for creating a chronology of disturbance, it is an imperfect and imprecise method. On occasion, radiocarbon analysis produces anomalous dates, or outliers, that appear much older or younger than the rest of the data set (Lowe and Walker 2000). This can be attributed to natural phenomena, such as marine and lake reservoir offsets or reworking of macrofossils within sediments, or human error, such as mislabelling or through contamination in retrieval or laboratory testing (Shore *et al.* 1995; Wohlfarth *et al.* 1998). For this reason, it is advantageous to obtain several samples for radiocarbon dating, thus minimizing the reliance on potential outliers. Although several radiocarbon dates have been obtained for Bass Pond, the addition of more dates should further refine the chronology and more precisely indicate the specific timing of the disturbance event within the pond.

1.12 The Current Study

It has been argued that sealskin processing activities were carried out at Phillip's Garden by the Dorset Palaoeskimo population (Bell *et al.* 2005; Knapp 2008; Renouf and Bell 2008). Further, preliminary palynological investigations have shown that the pollen signature of the Phillip's Garden area shows marked disturbances that are contemporaneous with the Dorset occupation of the site (Bell *et al.* 2005). The present investigation will build upon the previous research relating to sealskin processing activities within Bass Pond. In doing so, the hypotheses presented by Bell *et al.* (2005) will be tested.

Several new sediment cores were obtained from Bass Pond to carry out this investigation. Macrofossil samples were taken for radiocarbon analysis to be added to the previously established chronology and to correlate sediment cores. Also, this will aid in confirming the increased sedimentation rate observed by Bell *et al.* (2005) at 2200 cal BP. The new cores were sampled at a greater resolution than those recorded by Bell *et al.* (2005), providing a more precise pollen record of species thought to be indicative of eutrophication, specifically the aquatic species Pediastrum and Myriophyllum. In addition, pond-side species potentially affected by trampling, such as sphagnum moss, were included in the analysis. Sedimentation rates were also calculated and used to infer activity around the pond perimeter. The analysis of $\delta^{15}N$ was added to the palynological data to infer the presence of marine mammal matter within the pond (i.e. sealskins). If the Palaeoeskimo populations were soaking sealskins in Bass Pond as Bell *et al.* (2005)

suggested, evidence of this action should be preserved in the palynological and geochemical record of the pond.

1.13 Implications

The results of this research have implications not only for the study of Palaeoeskimo groups at Phillip's Garden, but also for hunter-gatherer populations as a whole. On a broader scale, this study adds to the growing literature regarding hunter-gatherer impact on the environment, showing that these smaller, nomadic populations do indeed leave an environmental footprint. On a narrower scale, this investigation provides insight into the cultural activities of the Palaeoeskimo populations of the Phillip's Garden group of sites and, in conjunction with other studies (Knapp 2008; Renouf and Bell 2008), will aid in further interpretation of site function.

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CHAPTER 2

Establishing Anthropogenic Disturbance through High Resolution Vegetation and Isotope Data Analysis in Bass Pond, Port au Choix, Newfoundland

2.1 Introduction

The overall goal of this chapter is to test and refine the disturbance history of Bass Pond, Port au Choix, as indicated by Bell *et al.* (2005). In their investigation, Bell *et al.* suggested that the disturbance observed within the pond sediments can be ascribed to the nearby Groswater and Dorset Palaeoeskimo occupations of Phillip's Garden, Phillip's Garden East, and Phillip's Garden West. In this study, the authors concluded that activities such as tree cutting, wood burning and working, pond-side trampling, and sealskin processing may have been common in the surrounding area from 2200 to 1000 cal BP. Their investigation has suggested that prehistoric hunter-gatherer populations in Newfoundland have more impact on the environment than previously assumed. Their study is also, to this author's knowledge, the oldest recorded evidence of environmental change caused by prehistoric hunter-gatherers in a circumpolar context. In addition, it has provided insight to Palaeoeskimo cultural activities at the Phillip's Garden site.

Bell *et al.* (2005) proposed that marked changes observed in vegetation and limnology of Bass Pond during the Palaeoeskimo period (specifically 2200-2000 cal BP), including increased levels of aquatic algal and herb species interpreted to represent nutrient enrichment within the pond, were indicative of sealskin processing activities. This relates primarily to the depilation process, which involves soaking the sealskin in a small pond to loosen and remove the hair from the pelt prior to the final tanning stage; this method remains in use locally in the Port au Choix region and is thought to be derived from the Labrador Inuit (Bock 1991; Firestone 1992, 1994; Multimedia Creations Inc. 2002). These changes were less pronounced in the record prior to the Palaeoeskimo presence at Phillip's Garden group of sites, and were absent from the record of the nearby Stove Pond which is isolated from any archaeological sites. This indicated that the disturbance was localized immediately surrounding Bass Pond and may be attributed to anthropogenic factors (Bell *et al.* 2005).

In addition, Bell *et al.* (2005) have also shown that changes in the sedimentation rate within Bass Pond coincided with changing pollen concentrations. Of particular interest is the increased sedimentation occurring between 2200 and 1000 cal BP, and notably between 2200 and 2000 cal BP. This, in conjunction with decreasing pond-shore plant species, may indicate increased human activity and trampling around the pond (Bell *et al.* 2005).

In their investigation of the remains of chironomid assemblages, Rosenberg *et al.* (2005) indicated that a salinity peak appears in Bass Pond sediments at 2000 BP, which coincides with changes in vegetation and high sedimentation rates found by Bell *et al.* (2005). Rosenberg *et al.* (2005) attributed this salinity increase to a marine incursion or the reworking of marine sediments within the pond; however Bell *et al.* (2005) argued that the salinity change may be related to soaking sealskins or to the tanning solution itself.

The model of disturbance proposed by Bell *et al.* (2005), although compelling, fails to unequivocally prove that the changes observed within the Bass Pond catchment area are the result of anthropogenic activities. The variables investigated, most notably the palynological data, could also be heavily influenced by environmental phenomena unrelated to Palaeoeskimo cultural activities such as forest fires, large storms, and climatic fluctuations. Their model can be tested and clarified through 1) refining the current chronology of palaeoenvironmental change, 2) increasing the resolution of vegetation data, and 3) testing an independent variable that indicates presence of marine mammal matter within the pond. In doing so, the disturbance event can be identified in greater detail, assigned to a specific time period, and confirmed by an independent line of evidence.

The current chronology of Bass Pond established by Bell *et al.* (2005) is based on six dates, and of those, only three coincide with the Dorset Palaeoeskimo occupation of Phillip's Garden. These dates have also been used to calculate sedimentation rates. Although the existing chronology is useful and can be correlated to new sediment cores, the addition of new dates verifies and refines the previous chronology. Further to this addition, it is also advantageous to obtain radiocarbon samples from key sections within the core that have been visually identified as points of interest (based on color changes) during the sampling process. The addition of these data points not only refines the current chronology and sedimentation rates, but also potentially brackets specific time periods when human activity around the pond was at a maximum, as mirrored in the archaeological record of the nearby Phillip's Garden group of sites.

Decreasing the sampling interval also augments the existing data resolution. Bell *et al.* (2005) sampled the sediment core every 2.5 to 5 cm, which is a fairly coarse sampling interval relative to human activities at the site, providing a chronological resolution of one to four centuries. By decreasing this interval to 1 cm, the chronological resolution of the data is increased to 20 years to a century. This increased chronological resolution allows specific pollen disturbances to be assigned to a precise time period and correlated with site occupation.

The pollen disturbance can be identified in Bass Pond sediments by examining specific taxa that Bell *et al.* (2005) have linked to possible human disturbance. These key species include spruce (*Picea*), fir (*Abies*), and birch (*Betula*) trees, which have decreased in frequency, possibly as a result of fire, tree cutting, or wood-working activities carried out by the Palaeoeskimo populations of the Phillip's Garden group of sites (Bell *et al.* 2005; Renouf 2005). Decreasing levels of *Sphagnum* moss, which is found bordering the pond edge, may indicate increased human activity and trampling around the pond (Bell *et al.* 2005). In addition, the aquatic species *Myriophyllum* has been shown to indicate eutrophication in area lakes (Bouchard *et al.* 1978), as has the aquatic algae *Pediastrum* elsewhere (Bell *et al.* 2005, Burden *et al.* 1986). Charcoal concentrations are also useful in identifying fire events, whether natural or anthropogenic in nature. By carrying out a higher resolution pollen investigation focused on these selected taxa, the palynological disturbance can be better assigned to a specific time period and compared to the Palaeoeskimo occupation of the Phillip's Garden group of sites.

Although high resolution pollen data from Bass Pond sediments can indicate anthropogenic disturbance surrounding the pond, it is necessary to identify another independent proxy that can specifically point to sealskin processing within the pond itself. Elsewhere nitrogen isotope levels (specifically $\delta^{15}N$) in pond sediments have been used to show limnological disturbance as a result of whale butchering near freshwater ponds (Douglas *et al.* 2004; Hadley 2007a, 2007b). It is known that marine mammals have elevated levels of $\delta^{15}N$; therefore, if isotope levels were elevated or fluctuated over a period of time, the cause could be related to the presence of marine mammal remains in the pond. Elevated $\delta^{15}N$ levels in Bass Pond sediments, in conjunction with evidence for nutrient enrichment, pond-side disturbance, and archaeological evidence for sealskin processing activities at the archaeological site, may strongly suggest that skins were indeed being soaked in Bass Pond in a manner similar to that currently practiced on the Northern Peninsula of Newfoundland (Multimedia Creations Inc. 2002; Knapp 2008; Renouf and Bell 2008).

By verifying the chronology, producing a higher resolution pollen record, and surveying nitrogen isotope levels, a better sense of limnological disturbance, particularly anthropogenic disturbance, can be discerned from Bass Pond sediments. If the same conclusions can be reached through a second independent study, the hypothesis of Palaeoeskimo sealskin processing at Phillip's Garden group of sites becomes more convincing.

2.2 Archaeological and Ethnographic Context

The Northern Peninsula of Newfoundland, in particular Port au Choix, has a rich history of human occupation. Of particular interest is the Phillip's Garden site, which contains over 60 Dorset Palaeoeskimo dwellings that, for nearly 800 years, were occupied regularly on a seasonal basis, from approximately 1990 to 1180 cal BP (Renouf 2006). Bordering Phillip's Garden on either side are two Groswater Palaeoeskimo sites, Phillip's Garden East and West, which were occupied on a smaller scale for a similar duration, from 2880 to 1910 cal BP (Renouf 2005).

The Phillip's Garden houses were semi-subterranean, containing low stone walls and sleeping platforms, and a central cooking area (Renouf 2006, 2009). On the basis of archaeological features, it is proposed that house structures were composed of a whalebone frame, and covered by several seal skins (Harp 1976, Renouf 1999, 2003, 2006, 2009). The dwellings were large, indicating that they likely housed several families, while the expansive size of the site suggests that it was heavily populated and may have been a meeting ground for several families of Dorset Palaeoeskimo. The larger houses and site size indicates that the Dorset occupation of Phillip's Garden was much more intensive than the Groswater occupation of Phillip's Garden East and West (Renouf 1993, 1994, 1999). Renouf (1999, 2006) suggests that this congregation of people would solidify their collective cultural identity, and also create relationships between several individuals while partaking in the annual seal hunt.

Port au Choix has a rich base of resources that were undoubtedly utilized on a regular basis by all prehistoric groups during their occupations of the area. Faunal remains recovered from Phillip's Garden indicate that the Dorset Palaeoeskimo occupants made extensive use of the harp seal population (Murray 1992; Renouf and Murray 1999; Hodgetts *et al.* 2003; Hodgetts 2005a, 2005b). The harp seal migration from Greenland to the breeding grounds in the Gulf of St. Lawrence in December, and back again in March, passes close to the Port au Choix Peninsula each year, making this herd a predictable and accessible resource (Sergeant 1991). Recent analysis of slate tools recovered from the site has shifted the focus of Phillip's Garden from seal hunting alone to seal hunting and sealskin processing (Knapp 2008; Renouf and Bell 2008). Large numbers of seals were hunted, yielding a wealth of resources, including meat for eating, fat for burning, bones for tool making, and skins for clothing manufacture (Renouf 1999).

Of particular relevance to this project is the process of leather making, which requires the removal of fat, oil, and hair from the pelt once it is removed from the animal. This mode of skin processing continues to be practiced today by those living on the Northern Peninsula (Bock 1991; Multimedia Creations Inc. 2002), and is thought to be derived from the Labrador Inuit (Firestone 1992, 1994). After the seal is killed in the spring, the skin is removed from the animal and, in most cases, rolled in salt for preservation until early summer. At this time, the inside surface of skin is scraped repeatedly with stone tools to remove fat and oil, and stretched over a wooden frame to be dried in the sun. As the pelt is drying, it is scraped several more times to ensure the complete removal of oil, which, if left in the skin, will cause uneven coloring during the tanning process. When the water temperature has increased to an appropriate level (in mid to late summer), the pelt, still stretched over the frame, is placed into a pond. Bacteria in the pond naturally loosen the hair from the pelt within a few weeks, which can then be easily removed by scraping. The now hairless skin is cleaned and placed in a solution composed of saltwater and tree bark, which will tan and color the skin. The skin is soaked for several days until it has reached the desired coloration, is then laced back onto the wooden frame, and dried again to become leather. At this point, the skin is worked to create an article of clothing, most often boots (Bock 1991). Although skin clothing is not preserved in Phillip's Garden, the wealth of seal bones (Murray 1992; Renouf and Murray 1999; Hodgetts *et al.* 2003; Hodgetts 2005a, 2005b) and specialized slate scraping tools (Knapp 2008; Renouf and Bell 2008) recovered from the site indicate skin working was likely a significant activity.

Most pertinent to this investigation is the act of soaking sealskins in the pond. This activity would likely leave a signature within the pond itself, as the organic matter from the skin would be released through soaking and bacterial action. In addition, it would be expected that the activity of preparing and soaking the skins within Bass Pond would disturb the shoreline vegetation and increase erosion into the pond.

2.3 Site Description

Bass Pond is a small, shallow lake (roughly 1 m deep) located about 550 m east of Phillip's Garden, and about 500 m east of the Groswater Palaeoeskimo site of Phillip's Garden East (Figure 2.1 & 2.2). The pond is situated at an elevation of 8 m and is within

100 m of the Port au Choix Cove shoreline (Renouf 1993; Bell *et al.* 2005). The 5-hectare lake, and 30-hectare catchment area, are underlain by the dolomitic Port au Choix formation (Bostock *et al.* 1983) and surrounded by open woodland consisting mainly of fir (*Abies*), spruce (*Picea*), and birch (*Betula*). Small streams pass through a fen before draining into the pond (Bell *et al.* 2005). The small size, shallow depth, and low throughflow of Bass Pond make it ideal for skin processing, as the pond water warms to an ample temperature during the summer months (Rosenberg *et al.* 2005), aiding the depilation process (Hall *et al.* 1994). The proximity of the pond to the Phillip's Garden group of sites makes it likely that any sealskin leather processing occurring at the sites would have involved this pond. This is particularly the case for the act of soaking the skin.

Figure 2.1: Location of Bass Pond and the Phillip's Garden group of sites at Port au Choix (modified from Renouf and Bell 2008).

Figure 2.2: Oblique Aerial view of Phillip's Garden and associated sites looking southeast (modified from Port au Choix Archaeological Project).

2.4 Methods

In February 2007, four sediment cores were recovered from Bass Pond using the Glew and percussion coring methods (Glew 1988; Cawley *et al.* 2001; Glew *et al.* 2001). All cores were obtained from a water depth of 1 m within roughly a 3 m radius from the center of the pond. Glew cores were sub-sampled at an interval of 5 mm using the Glew extrusion method (Glew 1988), while percussion cores were split, described, and selectively sampled.

During the sub-sampling process, plant macrofossils were removed from the core and separated from associated sediments. Several of these macrofossils were chosen for radiocarbon analysis based on their orientation and location within the core. When possible, samples associated with visual changes within the core were selected, while emphasis was placed on bracketing the Palaeoeskimo period, which had been identified through correlation with previously obtained cores. Samples were identified (when possible) by Dr. Peter Scott of the Memorial University Biology Department and then analyzed by Beta Analytic Inc. in Miami, Florida. Radiocarbon dates were calibrated using the Calib online calibration program version 5.0.2.

In order to perform geochemical analysis on the sedimentary material recovered in 2007, sub-samples from the Glew core BP-02 and the percussion core BP-04 (the longest of those obtained) were weighed and freeze dried. A portion of the freeze dried material was crushed, and the nitrogen stable isotope ratio was analyzed with either the ThermoElectron Delta V plus or the Finnigan MAT252 isotope ratio mass spectrometer coupled with a Carlo Erba NA1500 Series II elemental analyser using both International Atomic Energy Agency N1and N2, and USGS 25 and 26 reference standards (Pye pers. com. 2007).

Freeze dried material was measured and processed according to standard pollen processing procedures (Appendix 1) (Faegri and Iverson 1989). A known quantity of *Eucalyptus* pollen was added during processing to permit the calculation of concentration values during counting. Only those key species thought to be best indicative of anthropogenic influence or for correlation to previous cores were identified and counted. These species included spruce, fir, and birch trees and shrubs, *Sphagnum* moss, and the aquatic species *Myriophyllum* and *Pediastrum,* and were identified using several taxonomic keys (Kapp 1969; Lewis 1983; Faegri and Iverson 1989). Both birch tree and shrub pollen was included in the analysis as the pollen grains of a birch tree species found only in Newfoundland (*Betula cordifolia* Regel) are smaller than those elsewhere (Bell *et al.* 1997: 50). For this reason, all birch pollen measuring less than 25 μm in diameter was classified as shrub, while larger grains may be shrubs or trees. The slides were examined at 400x magnification on a transmitted light microscope using a horizontal transect pattern. On average 366 individual grains of these taxa were counted per slide, ranging from 230 to 561 grains per slide. Charcoal fragments, counted in addition to the selected taxa, were originally divided into two records (less or greater than 8μm), but were grouped for the final analysis.

2.5 Results

Four closely spaced cores were recovered from Bass Pond in February 2007 (Figure 2.3). The pond bottom was covered with a thick fibrous mat of mossy vegetation growing on the surface of the pond substrate. Of the four cores retrieved, only three were used for analysis. The fourth was sampled and archived. All three cores were composed primarily of marl ranging in color from grey to brown (Figure 2.4).

Core lengths ranged from 34.5 to 45 cm for Glew cores, and 44.5 to 63 cm for percussion cores. The uppermost sediment in two of the cores (BP-02 and BP-03) was composed of a greenish, fibrous gyttja which showed signs of disturbance from the coring process and ranged in thickness from 2 to 4.5 cm. Gyttja was absent in the longest percussion core likely as a result of disturbance during core retrieval. The texture of the marl was generally silty-clay, becoming increasingly more clayey with depth. Occasional diffuse sandy layers could be observed, although they were not substantial. A discrete brownish marl between 15 and 20 cm thick occurred in all three cores at a depth of 15 to 24 cm, and may be indicative of a higher organic content within these sediments (Figure 2.5). All cores contained wood fragments and shell (mainly gastropod) concentrations. Five wood macrofossils, primarily black spruce fragments (P.J. Scott, pers. comm. 2007), from BP-02 were submitted for AMS dating to establish a chronology, while one sample from BP-03 and two samples from BP-04 were dated for correlative purposes (Table 2.1).

Figure 2.3: Dr. Trevor Bell and Bryan Martin retrieving a percussion core from Bass Pond. (Photo: J. Bambrick)

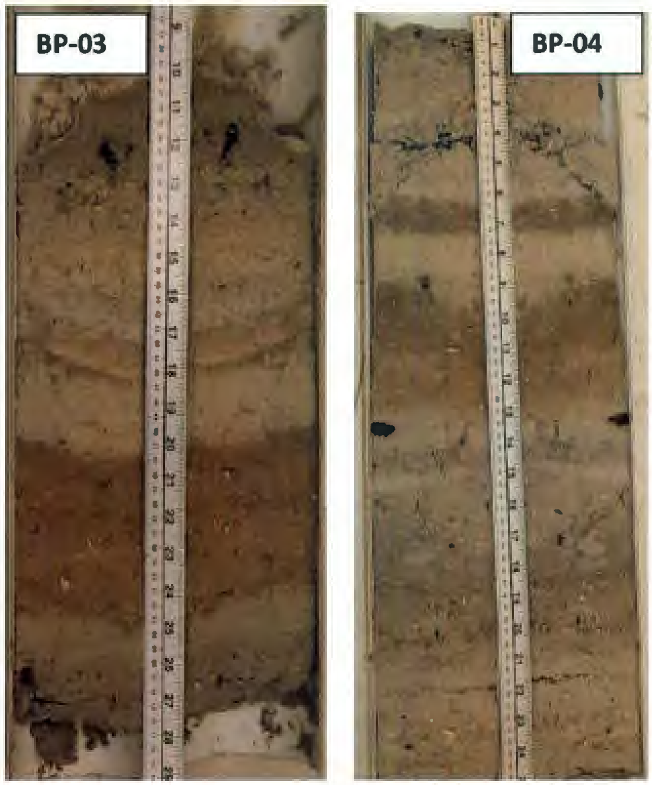

Figure 2.4: Split core images of percussion cores BP-03 and BP-04 illustrating the layering of grey and brown marl. (Photo: J. Bambrick)

The correlation of these three cores is based mainly on changes in color, as all three showed an obvious brown section of similar thickness. The depth of this section varied over the cores as a result of compaction; the large percussion core barrels were pushed down into the substrate, compacting the sediment as more force was applied. The smaller Glew cores relied mainly on gravity to penetrate the pond sediment; therefore compaction is likely less of an issue. If the percussion cores were stretched to match the visual record of the Glew core, it would reveal that the brown marl section can be traced at roughly the same thickness through all three cores. Shell concentrations also correlate between cores once this shift has been made. Textural changes throughout the cores were slight and difficult to discern, and were therefore not useful for correlation purposes. The radiocarbon chronology established for these cores (Table 2.1) confirms this visual correlation as dates are sequential when shifted to match the Glew core (Figure 2.5).

A previous percussion core obtained from Bass Pond in 1993 and used by Bell *et al.* (2005) could also be visually correlated to the three study cores. The core was 170 cm in length; however only the upper 84 cm are relevant to this investigation (Figure 2.5). The sediment was generally grey marl with abundant shells, and contained a brown section from 24.5 to 42 cm. This core also contained concentrations of wood fragments, which were dated (Table 2.2; Bell *et al.* 2005).

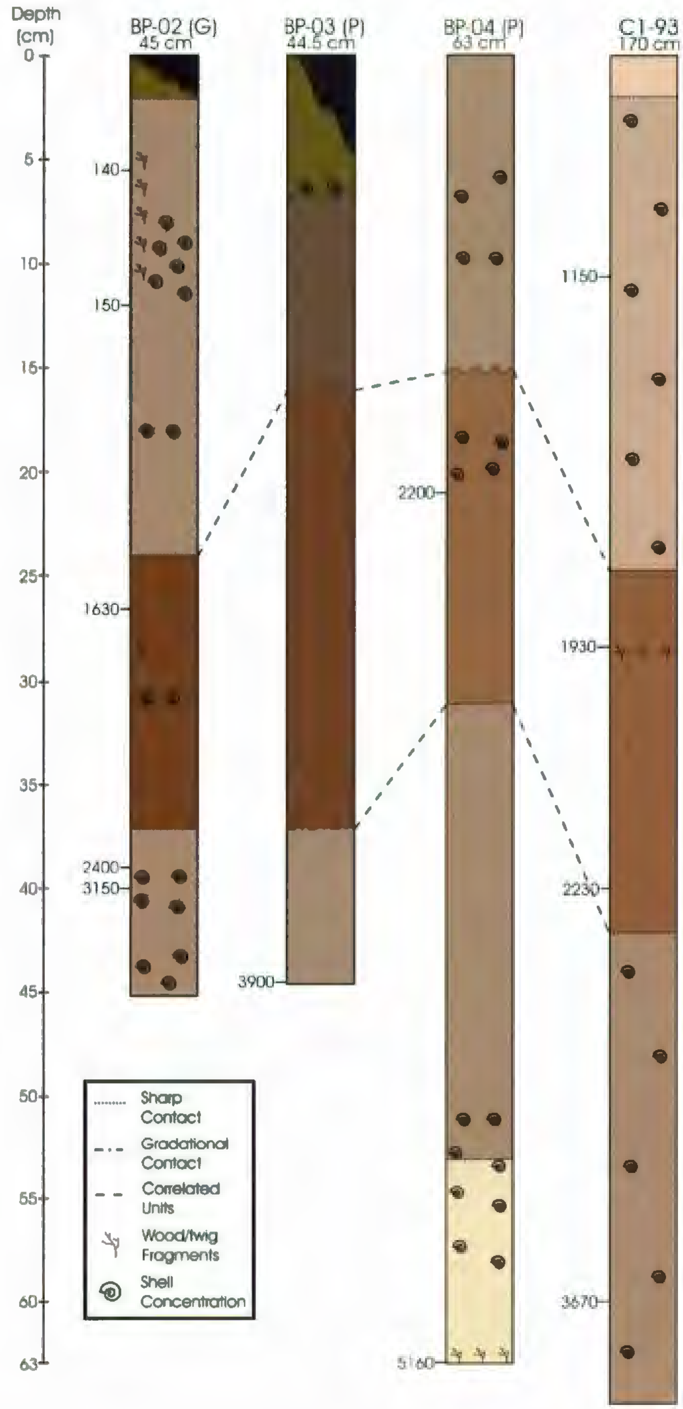

Figure 2.5: Sediment core logs from Bass Pond (BP=2007, C1=1993). Median probability calibrated single ages are shown to the left of each core. ('G' denotes Glew, 'P' denotes percussion for 2007 cores). Coloring reflects sediment color, which clearly illustrates a distinct brown marl section throughout all cores and has been used for correlation purposes.

Table 2.1: Radiocarbon dates and calibrated calendar ages (1σ) for samples collected from Bass Pond, 2007. Radiocarbon dates were calibrated using Calib 5.0.2 (Stuiver and Reimer 2005). Conventional ages are calculated based on a constant C-14 value through time, whereas calibrated ages account for natural atmospheric variations in C-14.

Lab ID	Core	Depth (cm)	Corr. Depth (cm)	Radiocarbon Age	Conv. Age	Cal. Age range	Med. Prob.
Beta-238618	BP-02	5.5	5.5	190 ± 40	140 ± 40	0-270	140
Beta-240786	BP-02	12	12	140 ± 40	150 ± 40	0-280	150
Beta-238620	BP-02	26.5	26.5	1730 ± 40	1720 ± 40	1570-1690	1630
Beta-249549	BP-04	21	31.5	2180 ± 40	2180 ± 40	2130-2300	2220
Beta-240787	BP-02	39	39	2390 ± 40	2360 ± 40	2340-2460	2400
Beta-238621	BP-02	40	40	3000 ± 40	2970 ± 40	3080-3210	3150
Beta-249548	BP-03	44.5	52	3660 ± 40	3590 ± 40	3840-3960	3900
Beta-249550	BP-04	63	73	4580 ± 40	4520 ± 40	5060-5300	5160

Table 2.2: Radiocarbon dates and calibrated calendar ages (1σ) for samples collected from Bass Pond in 1993 (Bell *et al.* 2005). Radiocarbon dates were calibrated using Calib 4.4 (Stuiver and Reimer 1993)

Lab ID	Depth (cm)	Radiocarbon date	Calibrated age range	Median Probability Age
Beta-115780	10.5	1230 ± 60	1070-1260	1150
TO-8744	27-29	1980 ± 50	1880-1990	1930
TO-9162	40	2230 ± 60	2100-2330	2230
TO-9163	60	3420 ± 60	3579-3820	3670
Beta-115782	82	5100 ± 50	5753-5910	5820

Although eight dates were obtained for the 2007 cores, not all have been included in the chronology. Two dates, 140 cal BP (Beta-238618) at 5.5 cm and 150 cal BP (Beta-240786) at 12 cm, are found at the top of the core where material has a high water content and is less consolidated, likely resulting in disturbance. This disturbance could have been exacerbated by the coring process and transport of the core prior to sampling. As a result, these dates may be unreliable and are excluded from the analysis. Further, the uppermost portion of the core does not correspond to occupations of interest at the Phillip's Garden group of sites, therefore it is not pertinent to the following analysis. A third date, 3150 cal BP (Beta-238621) at 40 cm appears 700 years older than the previous date only a centimetre away. This date is thought to be unreliable based on this discrepancy with surrounding dates. This may be a consequence of disturbance within the section where macrofossils have shifted, thereby providing incorrect reference points for dating. This chronology can be compared with that of Bell *et al.* (2005), which provides a slightly different chronology (Table 2.2).

Although the chronologies for each set of cores differ slightly, the sedimentation rates are quite similar (Figure 2.6). Prior to roughly 2500 cal BP the two records are nearly identical; 1.1 cm/century accumulation in the 1993 core compared to 1.2 cm/century in the 2007 cores. At this point, slight differences can be observed between the records. In the 1993 core, sediment accumulated most rapidly between 2200 and 1000 cal BP (2.7 cm/century), particularly from 2200 to 2000 cal BP (4.3 cm/century). Similarly in the 2007 cores, sediment accumulated most rapidly from 2400 to 2200 cal BP (3.7 cm/century). The rates differ, however, immediately after this period. In the 2007 record, sedimentation slows drastically (9mm/century) from 2200 to 1630 cal BP (Figure 2.6), showing another divergence in the chronologies.

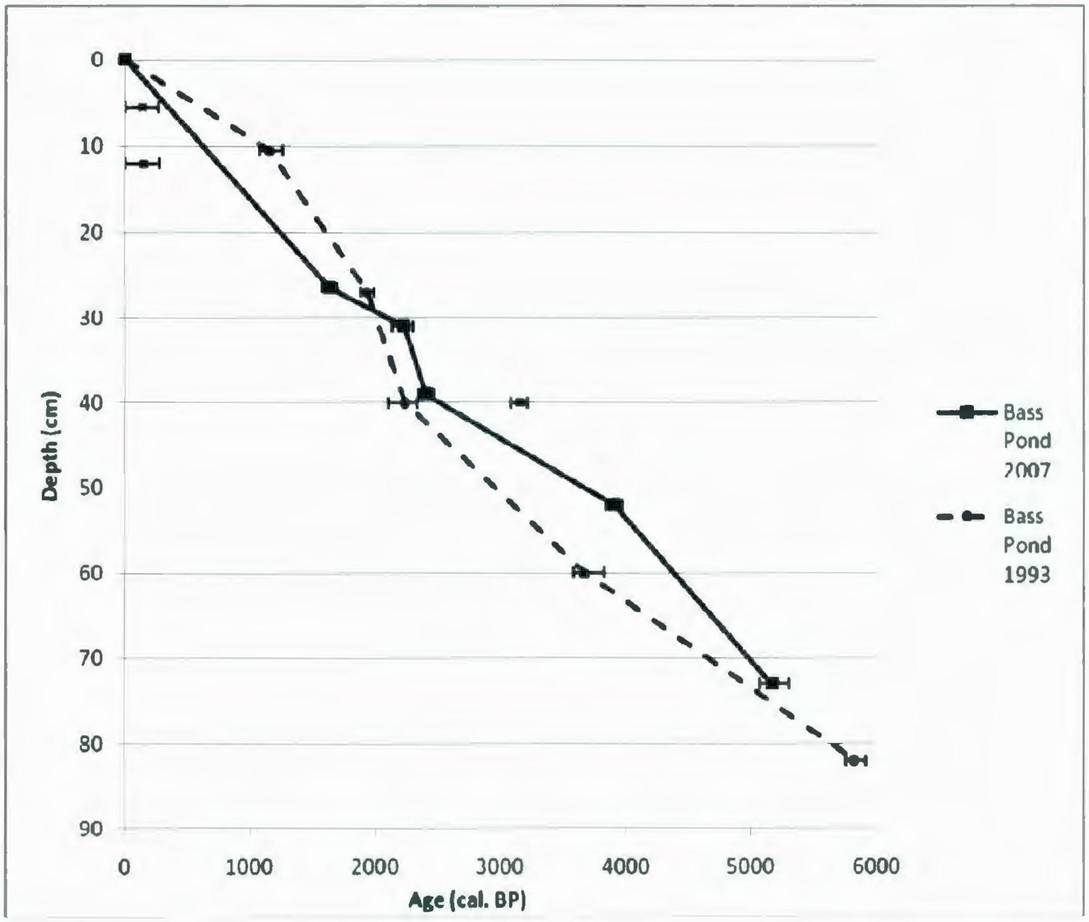

Figure 2.6: Age depth curves for both Bass Pond cores displaying 1σ calibrated age ranges (refer to discussion for Bass Pond 1993). Dates appearing outside of the age depth curve for Bass Pond 2007 were not included in sedimentation rate calculations.

The pollen record also shows some interesting patterns (Figure 2.7; Appendix 2). Samples at the base of the record were taken 10 cm apart, resulting in very low resolution. The sampling interval was decreased to 1 cm from 45 cm onwards, revealing a much more detailed record of disturbance. The selected tree species appear relatively stable from roughly 45 to 40 cm. At 40 cm *Picea* and *Abies* begin to decrease slightly until 30 cm, at which point a major decrease is observed. *Betula* trees seem to decrease steadily until 16 cm. As tree species are decreasing, *Betula* shrubs vary widely, peaking several times before suddenly decreasing at 31 cm. *Sphagnum* moss varies with several sharp peaks from 44.5 until a slight decrease from 37 to 34 cm, followed by a major decrease from 23.5 to 16 cm. *Pediastrum* levels increase from 38.5 to 31 cm, peaking greatly at 33 cm. Levels then slightly lower from 31 to 28 cm, and then decrease again from 24.5 to 16 cm before returning to a moderate level. The largest increase is observed in *Myriophyllum*, which peaks sharply at 35 cm before returning to relatively low levels at 28 cm until present. Charcoal levels vary over the record, with noticeable peaks at 44, 37, 32, and 25 cm. Overall, it appears that the greatest changes in the observed pollen and algal concentration occurred from 39 to 31 cm (roughly 2400 to 2200 cal BP).

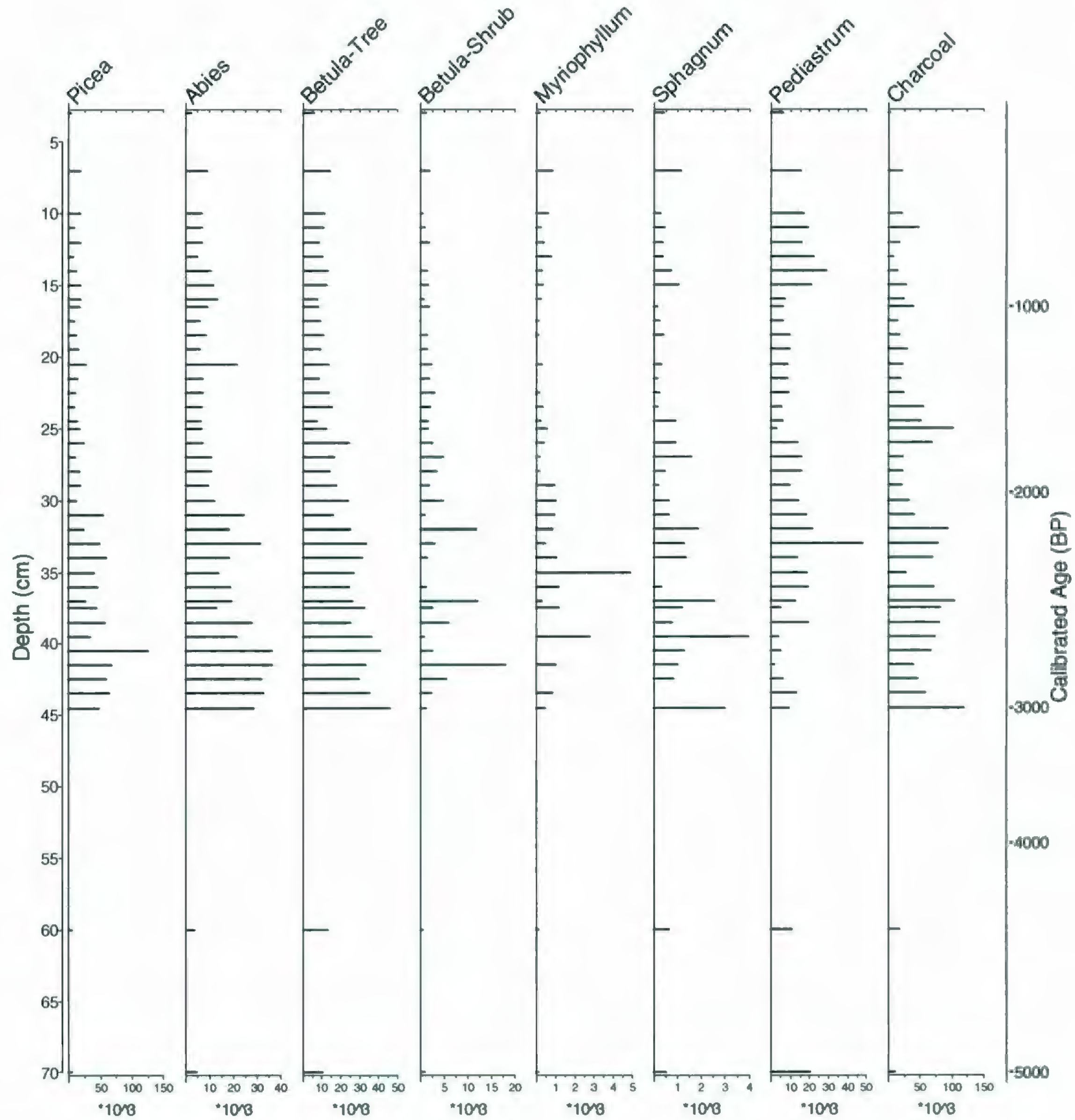

Figure 2.7: Pollen concentrations from cores BP-02 (0 cm- 45 cm) and BP-04 (60 cm- 70 cm) related to both depth and age.

The nitrogen isotope level within Bass Pond sediments varies over time (Figure 2.8; Appendix 3). It is rather low in general, initially at 1.45‰ at 70 cm (5000 cal BP) and increasing to a peak of 4.28‰ at 37.5 cm (2370 cal BP). The signature then decreases to a low of 0.9‰ at 23.5 cm (1450 cal BP) and fluctuates back up to a modern value of 2.15‰.

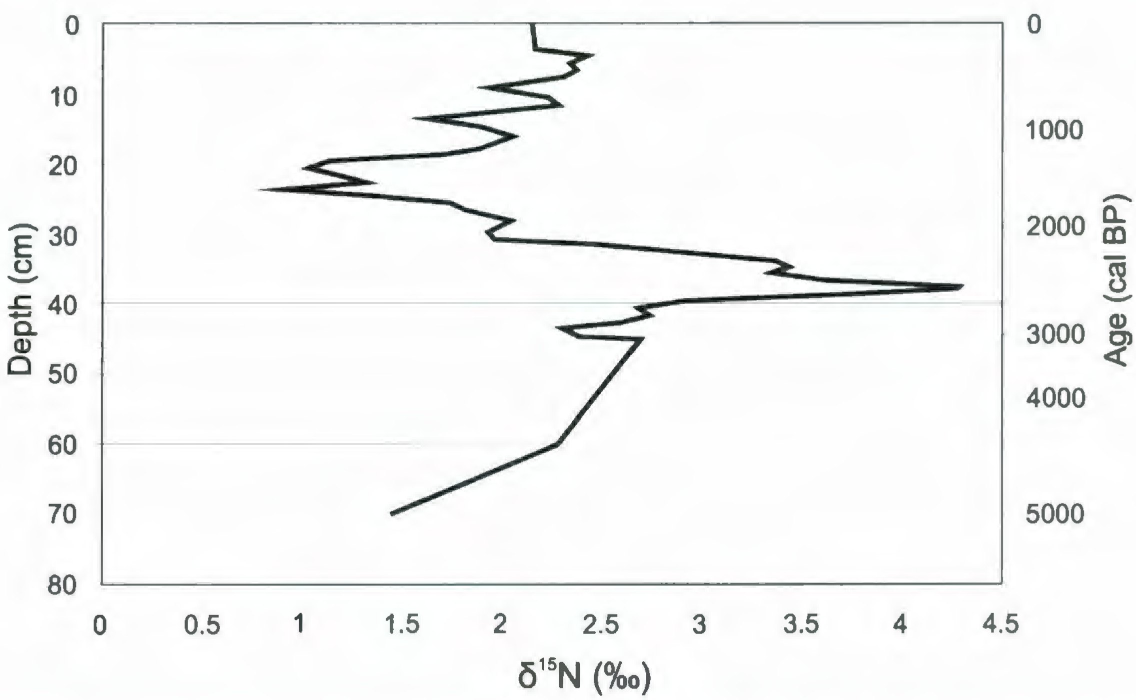

Figure 2.8: Change in $\delta^{15}N$ from cores BP-02 (0 cm- 45 cm) and BP-04 (60 cm- 70 cm) related to depth and age.

Although the two sets of cores (from 1993 and 2007) visually correlate quite well (Figure 2.5), the chronologies established from the radiocarbon dating do not match (Tables 2.1 and 2.2). While this is somewhat problematic, it is not unexpected as Bass Pond sediments exhibit evidence of several disturbance events. One chronology is not necessarily superior to the other; in fact, it is likely that the true chronology falls somewhere in between the two. The implications of this are discussed below.

2.6 Discussion

Throughout this investigation, several interesting patterns have arisen in the environmental history of Bass Pond. The presence of elevated δ^{15} N levels comparable to those recorded in the Arctic strongly suggests a marine mammal influence within Bass Pond, particularly around 2400 cal BP (Figure 2.9). The δ^{15} N values in Bass Pond sediments increase from 2.3‰ to 4.3‰ (a change of 2‰), which is only slightly less than those observed in sediments of an Arctic lake associated with whale butchering by Douglas *et al.* (2004), which increased from 2.5‰ to 5.4‰ (a change of 2.9‰).

At the base of the core, from 70 to 39.5 cm (4980 to 2460 cal BP), the rate of increase appears gradual and constant. However, this is likely a function of the sampling interval, which is much coarser (10 cm) than that of the core above 45 cm (approximately 1 cm). If this section were sampled at a higher resolution, the record may mimic the irregular increase observed from 23.5 cm (1450 cal BP) to present. With this in mind, it is interesting to see that these two sections of the record exhibit similar rates of increase, with the signature at the bottom of the core rising 1.47‰ in 2520 years, and the recent increase of 1.25‰ in 1450 years.

At 39.5 cm the increase in the δ^{15}N record occurred much faster, rising 1.36‰ in only 90 years, and corresponds to significant vegetation changes within the pond, namely the peak in *Myriophyllum*. This sudden increase, a marked change from the preceding section of small incremental increases, indicates that something major is happening at this point within the pond to elevate the isotopic record significantly. Equally notable is the similar rate of steady decrease in the $\delta^{15}N$ signature that occurs from 37.5 cm (2370 cal BP). This indicates that the cause of such a strong increase was short lived, lasting from roughly 2920 until 2370 cal BP, and ceased abruptly. This may suggest that human activity, specifically sealskin processing, was most intensive leading up to this point, and significantly decreased thereafter.

The $\delta^{15}N$ decrease that begins at 37.5 cm continues until reaching a low of 0.9‰ at 23.5 cm (1450 cal BP), at which time the record begins to increase yet again. The steady decrease of 1.4‰ from 33.5 to 30.5 cm (2280 to 2150 cal BP) may indicate that activity around the pond decreased significantly, while the further decline until 23.5 cm could indicate abandonment. This low roughly corresponds to a decrease in tree and shrub species as well as *Pediastrum*, *Sphagnum*, and *Myriophyllum.* It also occurs slightly after a period of elevated charcoal levels, and is less pronounced than the one occurring previously, under more ambiguous circumstance (no change in sedimentation despite a decrease in pond-side vegetation, and a decrease of nutrients within the pond).

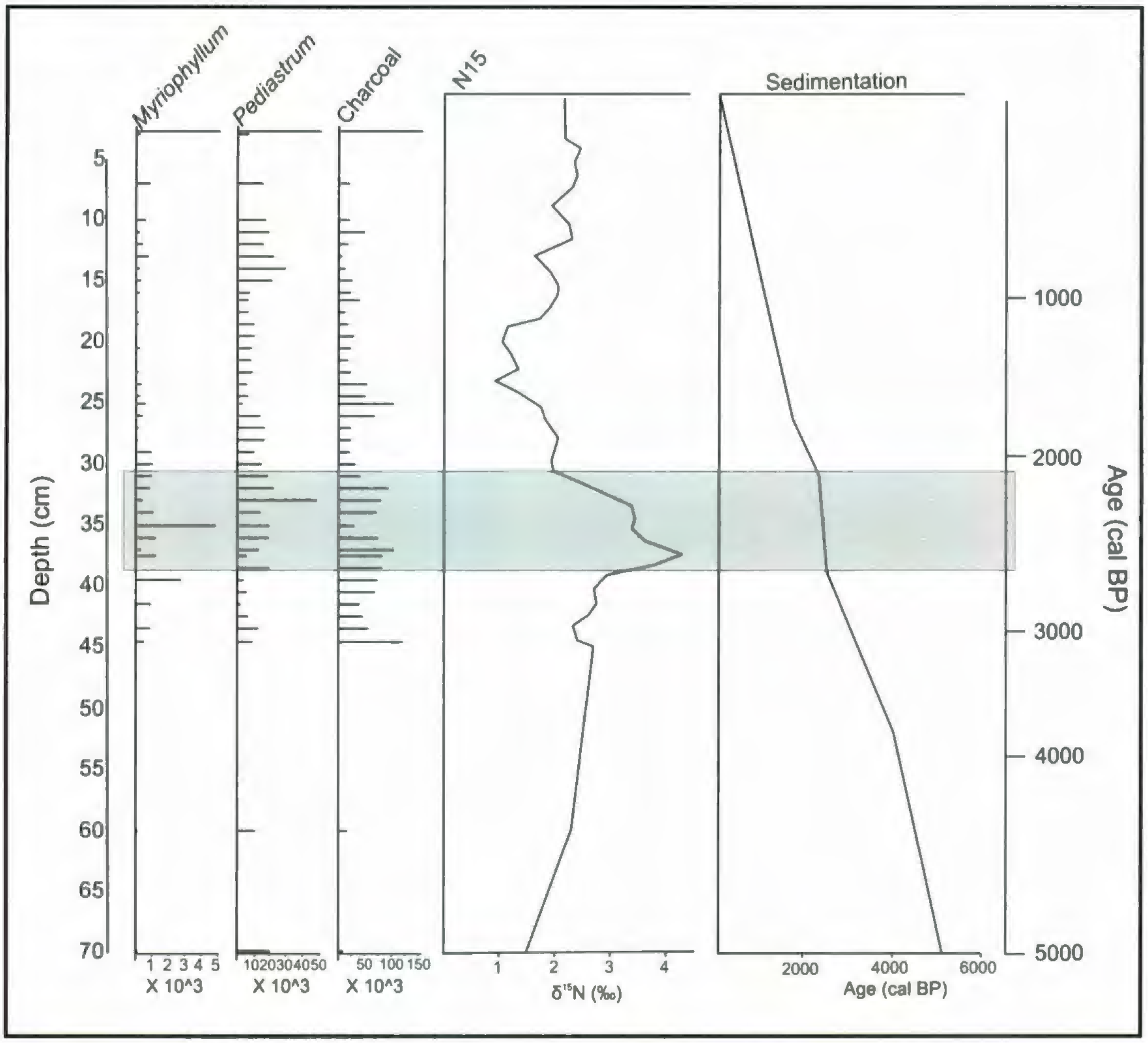

Figure 2.9: Summary diagram of Bass Pond disturbance showing pollen and $\delta^{15}N$ data, and sedimentation rate from cores BP-02 (0 cm- 45 cm) and BP-04 (60 cm- 70 cm). The shaded area indicates the area of disturbance potentially related to the Phillip's Garden group of sites.

The $\delta^{15}N$ record appears to show a repeating pattern of rising and falling values. Most recently, however, it appears that the signature may be stabilizing, with essentially the same value recorded for the last 200 years. It would be interesting to obtain values from deeper in the pond sediment record to see if this is, indeed, a recurring pattern, or if it is isolated to the Palaeoeskimo period of the Phillip's Garden sites. Further, obtaining more $\delta^{15}N$ values from earlier in the sediment record would establish the natural baseline signature, and could be useful in quantifying the elevated levels of the Palaeoeskimo period. Without these older values, however, it appears that this independent variable is perhaps the best evidence supporting Bell *et al.*'s (2005) hypothesis that sealskin soaking occurred within the pond. In addition, when coupled with sedimentation and pollen data (discussed below), it seems quite obvious that a major disturbance is associated with the pond at that time, corresponding well with the Palaeoeskimo occupation of the Phillip's Garden group of sites, particularly that of the Groswater.

The 2007 pollen record of Bass Pond sediments indicates that a major disturbance event occurred between roughly 2400 to 2200 cal BP (Figure 2.9). Within this time period, tree species decrease slightly, *Betula* shrubs and *Sphagnum* moss vary widely, while peaks are observed in the aquatic herb and algal species *Myriophyllum* (2310 cal BP) and *Pediastrum* (2265 cal BP) before reducing suddenly at 2090 cal BP. The decrease in tree species is likely related to the increased charcoal levels at this time, indicating a fire event within the catchment area. This fire event appears to be local, as the vegetation decrease and higher charcoal levels are absent from Stove Pond sediments, indicating it was not a regional disturbance.

Tree species decrease again at 2090 cal BP, and stay at moderately low levels for the rest of the record. This decrease is also preceded by an increase in charcoal levels, indicating that the cause is likely another burning event. Although charcoal levels fluctuate later in record, the effects are not nearly as pronounced as those mentioned above. Tree species appear to decrease after roughly 2000 cal BP, while charcoal concentrations are quite variable throughout the more recent samples. Although this appears to indicate a major disturbance within the surrounding forest, it may simply be a function of the focus on select species rather than the entire pollen assemblage. Overall, fewer grains of the selected taxa were counted relative to the *Eucalyptus* control sample, which may be related to an increase in those taxa not surveyed. *Pediastrum* concentrations unexpectedly rise again to comparable levels at roughly 1000 cal BP; however there appears to be no discernable reason for such an increase.

Pond-side vegetation, represented by *Sphagnum* moss, shows a disturbance at 37 cm (2360 cal BP) when it suddenly decreases, and continues to decrease for 3 cm (to 2290 cal BP). The sudden and obvious decline in this species suggests that a disturbance occurred immediately around the pond edge at this time. The decrease in this pollen record concurs with fluctuating charcoal levels; however the changes in frequency of *Sphagnum* do not coincide with rapid changes in charcoal concentrations. A lack of correlation between these two records indicates that burning events do not necessarily have a significant impact on this species, and the disturbance is likely independent of the fire. This suggests that a decrease in pond-side vegetation is a result of increased activity around the pond edge, particularly between 2360 and 2290 cal BP.

The increase in aquatic taxa around 2300 cal BP, particularly that of *Myriophyllum* which has been observed in eutrophic ponds elsewhere in the region (Bouchard *et al.* 1978), suggests that nutrient availability within Bass Pond increased during the Groswater period. This increase is concurrent with elevated charcoal levels, indicating that the increased nutrient input into the pond may be related to a fire event. Although this is a possible explanation for the observed rise in these species, it is interesting to note that despite recurrent increases in charcoal levels in the record since 1000 cal BP, no peaks of similar magnitude occur. It seems therefore that another variable beyond burning is responsible for these increases, or is causing an additive effect in conjunction with the burning events around 2300 cal BP. The timing of this increased nutrient input coincides fairly well with the increased $\delta^{15}N$ values, suggesting that sealskin soaking may be the factor responsible for these changes within the pond.

Bell *et al.* (2005) argue that the higher sedimentation rate observed from 2200 to 2000 cal BP may be a result of increased human activity around the pond, based on the concurrent decrease in *Sphagnum* moss in the pollen record from 2200 to 1800 cal BP. Although there is a marked increase of charcoal at 2200 cal BP indicating a fire event, they argue that the prolonged nature of the disturbance may be caused by trampling around the pond edge, eroding sediment into the basin. The 2007 model shows a much more active fire record, with higher charcoal levels occurring during the period of increased sedimentation (2400 to 2200 cal BP). This increased rate may be a result of a forest fire, as soil in the catchment area would be disturbed after such an event. It is interesting to note, however, that despite recurrent peaks of charcoal, the sedimentation rate does not increase more recently in the record. With this in mind, the increased sedimentation within the pond coupled with increased nutrient levels and decreased pond-side vegetation seems to indicate that the disturbance from 2400 to 2200 cal BP is unique to this time period.

Although the increased sedimentation rates and decreased pond-side vegetation suggest activity around Bass Pond, they do not necessarily indicate that the disturbance is anthropogenic in nature. Wildlife living in proximity to the Phillip's Garden group of sites, such as moose and caribou, may also cause similar disturbances through trampling in and around the pond. It is interesting to note, however, that the disturbance appears to coincide with the Palaeoeskimo habitation of the Phillip's Garden group of sites. With this in mind, it seems logical to suggest that the disturbance observed in Bass Pond sediments is external to that caused by the usual wildlife interactions that would have occurred prior to and following the Palaeoeskimo period. It therefore seems reasonable to conclude that these factors could indicate increased human activity around Bass Pond during the Palaeoeskimo occupation of the Phillip's Garden group of sites, and specifically during the Groswater occupation of Phillip's Garden East and West.

The increased sedimentation rate may, however, be misleading. The estimated rate of sedimentation is based on the radiocarbon chronology established from the cores, which has proven to be problematic. If one (or both) of the dates associated with the increase is incorrect, this rate may be exaggerated, or conversely, underestimated. The fact that both the 1993 and 2007 chronologies present similar estimated sedimentation rates suggests that this potential source of error is not a serious issue.

Even though similar patterns are observed between this investigation and that of Bell *et al.* (2005), the chronology is slightly different. The sedimentation rates (Figure 2.6), despite differing in actual position, seem to mimic each other closely. This is especially the case between 30 and 40 cm, where both rates are approximately 0.4 mm/yr.

The duration of this increased sedimentation rate is shorter in the 2007 investigation, however, lasting 200 years as opposed to 300 in that of 1993.

Although the sampling interval of the 2007 pollen investigation improved the temporal resolution, increasing it from roughly 200 years to as little as 20 years in the Palaeoeskimo period, it did not necessarily reveal any major deviations from that of Bell *et al.* (2005). It did, however, verify that the patterns they observed were valid. Both pollen sequences show decreases in all tree species and *Sphagnum* moss for approximately the same amount of time, while *Pediastrum* and *Myriophyllum* levels increase concurrently. Of particular interest is the sharp peak of *Myriophyllum*, which is thought to be the strongest evidence for eutrophication within Bass Pond. As with the sedimentation rates, the timing of the pollen record is also slightly out of sync with Bell *et al.* (2005); they report this peak at 32.5 cm (2030 cal BP), while it occurs at 35 cm (2310 cal BP) in the current investigation. Both peaks appear to fall at the midpoint of increased sedimentation for each chronology.

Upon initial investigation, the sedimentation and pollen records of the 1993 and 2007 studies show similar patterns of disturbance; the 2007 chronology, however, appears to place this disturbance a few hundred years earlier than that reported by Bell *et al.* (2005). This apparent shift, however, is not constant throughout the entire chronology. Shortly after the sedimentation rate of the recent investigation increases (Figure 2.6), the rates of the two sediment cores cross; therefore, events occurring prior to approximately 2000 cal BP appear older in the recent chronology than they do in that of Bell *et al.* (2005). After 2000 cal BP, however, events occurring in the newer record appear younger. This crossover in the chronologies indicates that the lag time of the record is not constant. The true chronology likely falls in between the two existing ones; however there must be an explanation as to why the chronologies of the independent investigations do not agree.

The non synchronous chronologies may be related to radiocarbon plateaus which have occurred several times throughout pre-history. These plateaus are a result of atmospheric variations of the $^{14}C/^{12}C$ ratio which cause ambiguity in radiocarbon ages of a certain period. During these periods, calibration curves yield much wider calendar age ranges for a single radiocarbon date, thus resulting in a less precise calibrated age (Guilderson *et al.* 2005). The cause of such phenomena is not fully understood; however, atmospheric carbon-14 levels are known to fluctuate with sunspot activity, and may be related to ambiguous radiocarbon dating (i.e. Bray 1967). One of these plateaus occurs from 2700 to 2400 cal BP (Guilderson *et al.* 2005: 363) which corresponds to the Groswater Palaeoeskimo occupation of Phillip's Garden East. Although the dates obtained in this analysis fall slightly short of the established plateau, the presence of such a methodological problem so close to the observed disturbance may account for some of the dating discrepancies faced in this analysis. Similar dating issues have also been observed elsewhere in the Arctic (McGhee 2000; Sutherland 2000), illustrating that this time period is highly problematic when establishing chronologies for this region.

Further to this inherent methodological issue, it is not surprising that the dates may be unreliable when dealing with a disturbance event such as this. It would be expected that if activity within the pond were disturbing the substrate, older material would be brought back into suspension, mixing with and settling out on top of younger material, especially during times of increased activity. Although these issues call into question the validity of the established chronology for the Bass Pond disturbance, it may account for the dating problems encountered throughout this analysis, as well as the lack of continuity with the previous investigation

Despite the discrepancies between the two chronologies, both indicate that the disturbance is caused during the Groswater period of Phillip's Garden. On strictly archaeological grounds it seems much more plausible, however, that sealskin processing, in particular leather making, would have been carried out by the Dorset. The Dorset occupation of Phillip's Garden was on a much larger scale than that of the Groswater occupation of Phillip's Garden East, resulting in a more intensive seal hunt, as shown in the volume of seal remains recovered from Phillip's Garden (Renouf 1993, 1994, 1999).

Recent usewear investigations of Dorset tool assemblages have shown that sealskin processing was likely a common activity at the site (Knapp 2008). This leads to several questions relating to the sealskin processing activities of the two Palaeoeskimo groups; mainly the lack of archaeological evidence for large scale Groswater skin processing activities despite strong indications of this from the limnological investigation, contrasted with the opposite scenario for the Dorset. Perhaps the Dorset were not soaking skins in Bass Pond, but rather another pond on the peninsula. Bass Pond, however, is not only the closest water body, but also the best suited pond for this task because of its small size, shallow depth, and lack of through flow which allows the water to warm to an ample temperature during the summer months; it seems unlikely that another source would be used. Perhaps the Dorset did not soak sealskins to remove the hair, but used another method altogether. Ethnographically, other methods have been used to depilate the skin for leather; this includes soaking in cold or hot water (Nelson 1899; Oakes 1987; Issenman 1997; Oakes and Riewe 1998), shaving with an ulu (Turner 1894; Issenman 1997), or scraping after treatment in a putrefying substance (Turner 1894; Nelson 1899). Although plausible, these other methods seem unlikely, especially if other Palaeoeskimo groups in the same location with the same resource were using Bass Pond.

Alternatively, it is possible that seasonality may have determined another method of Dorset sealskin processing. Although a large proportion of faunal remains from Phillip's Garden indicate a spring hunting season, there is evidence of an early-winter harp seal hunt as well (Hodgetts 2005b). This may indicate that sealskin processing could have been carried out during the winter when Bass Pond was likely ice covered and therefore not accessible by the Dorset population. Further, the temperature of the pond at that time would have been insufficient to promote the bacterial growth that is central to the soaking method of depilation, requiring that an alternative method be used. If the Dorset population employed an alternate processing method without the use of the pond during the winter, such as those discussed previously, it is likely the spring and summer population did as well. This alternate option could account for the skin processing tools prevalent in Dorset assemblages, and also justify the lack of disturbance recorded in Bass Pond sediments during the Dorset occupation of Phillip's Garden.

Although Phillip's Garden East contains a high proportion of harp seal remains within the faunal assemblage, the smaller volume of seal does not compare to the large collection of Phillip's Garden. Also, no Groswater tools recovered from the site have been specifically identified as skin processing tools. This suggests that sealskin processing, if it did occur, was not as intensive at Phillip's Garden East as it was at Phillip's Garden.

Based on existing archaeological and chronological data two scenarios are possible to justify the discrepancy between limnological and archaeological evidence: a) despite less convincing archaeological evidence of intensive sealskin processing at the Phillip's Garden East site, the dates of the 2007 investigation are correct and the Groswater were responsible for the disturbance within Bass Pond sediments, or b) despite the earlier dates, the overwhelming archaeological evidence of sealskin processing at Phillip's Garden indicates the Dorset were responsible for the disturbance, and the dates are incorrect. In both scenarios, the dates prove to be problematic in relating the environmental signature to the archaeology. Although neither scenario can be confirmed at this time, further studies relating to other paleolimnological indicators within Bass Pond sediments, or further Groswater tool classification and analysis, such as that carried out at Phillip's Garden (Knapp 2008), are needed to fill in the gaps.

Alternatively, a third potential scenario would be an older, undocumented Dorset presence at Phillip's Garden. This option is unlikely considering the date range of the Phillip's Garden site fits in the context of Dorset elsewhere in Newfoundland, which are dated from roughly 1920 to 1140 cal BP island wide. Conversely, there is also the chance that the disturbance is not related to anthropogenic factors. With this in mind, other avenues of disturbance, such as those suggested by Rosenberg *et al.* (2005), must be explored.

In their investigation of chironimids and salinity levels within Bass Pond sediments, Rosenberg *et al.* (2005) suggested that the disturbance may be related to a marine incursion (tsunami) or reworking of marine sediments just after 2000 cal BP (using the Bell *et al.* (2005) chronology). If this were the case, however, other physical lines of evidence would be expected. A force such as a tsunami would surely disrupt Phillip's Garden and the surrounding area. It seems reasonable to expect that dwelling footprints and artefact distributions would be impacted, especially at Phillip's Garden East which is the closest site to Bass Pond. It would also be expected that the vegetation surrounding Bass Pond would have been impacted immediately as well. Although a decrease in all tree species is observed in the pollen record, the 2007 model shows this at 2220 cal BP (before the salinity peak), and the 1993 model does not register the change until 1890 cal BP (well after the salinity peak). In addition, there is no evidence of significant textural changes within the sediment profile. If a large amount of marine material were introduced into the pond, sediment and textural changes would be evident within the core. Beyond this, no major disturbances have been observed in the Bass Pond catchment area, indicating that a catastrophic environmental factor is not likely the cause. The possibility of a non- catastrophic event is also unlikely considering the elevation of Bass Pond in relation to sea level. The other explanation of reworked sediments proposed by Rosenberg *et al.* (2005) would result from a disturbance within the pond (such as sealskin processing activities); however this does not account for the vegetation changes observed at the same time, indicating that other factors are at work.

With no obvious physical cause, perhaps the disturbance is related to another environmental factor. Rosenberg *et al.* (2005) also used chironimids to show that the summer surface water temperature of Bass Pond was at its coolest around 2000 cal BP. Is it possible that this change in climate is also responsible for the changes within the pond? If this is the case, similar changes in pollen would have been expected in Stove Pond as well, the control used by Bell *et al.* (2005), but none are present. Furthermore, it seems unlikely that all of the disturbance indicators (salinity, eutrophication, sedimentation rates, and isotope levels) could be caused by a single environmental factor. It seems much more likely that the Palaeoeskimo occupation of the nearby Phillip's Garden sites would be responsible for disturbance within the pond, despite issues in the dates.

Although the $\delta^{15}N$, pollen, and sedimentation data indicate that a major disturbance is occurring in Bass Pond, the timing of this event is somewhat unclear. In this case, an attempt to refine the established chronology of Bell *et al.* (2005) by adding more dates from a separate set of cores further confused the exact timing of certain disturbances. To clarify this issue, it would be advantageous to perform additional dating of the cores, particularly outside the main period of disturbance. Dating material from either side of the disturbance event rather than dating potentially disturbed material from within the sediments associated with the event should help establish an undisturbed chronology for Bass Pond, allowing the disturbance event to be closely bracketed, and therefore assigned to a specific time period.

Despite issues with the chronologies, two independent investigations have proven that there is a significant disturbance event occurring in and around Bass Pond during the Palaeoeskimo occupation of the nearby Phillip's Garden group of sites. It seems plausible, and even likely, that these two factors are related, indicating that the disturbance is anthropogenic in nature. To rule out a natural environmental source of this disturbance, however, it would be beneficial to find if the $\delta^{15}N$ signature peaks at any point prior to 5000 cal BP, as this variable provides the strongest evidence of sealskin soaking within the pond. If levels remain low beyond this point, it seems reasonable to conclude that Bass Pond was the site of Palaeoeskimo sealskin processing activities.

2.7 Conclusion

The purpose of this investigation was to refine and expand upon the model of disturbance in Bass Pond ecology proposed by Bell *et al.* (2005). In the 2007 sediment cores the environmental signature of this disturbance, exhibited by the increased sedimentation rate, increases in aquatic species *Myriophyllum* and *Pediastrum*, and a large increase in $\delta^{15}N$, occurs between 2400 and 2220 (Figure 2.9), which is during the Groswater occupation of Phillip's Garden East and Phillip's Garden West. This chronology is slightly older than that presented by Bell *et al.* (2005), indicating that ecological changes observed in Bass Pond sediments can not be attributed to the Dorset occupation of Phillip's Garden; however, recent studies of Dorset tool assemblages have shown that sealskin processing was a common activity at Phillip's Garden (Knapp 2008).

Overall, if the 2007 chronology is correct, these findings suggest that the cultural activities of the Groswater Palaeoeskimo population at Phillip's Garden may be more extensive than previously thought. If so, this means that Groswater as well as Dorset populations at the Phillip's Garden group of sites processed sealskins as part of their harp seal exploitation.

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CHAPTER 3

Summary and Conclusions

3.1 Summary

The primary objective of this thesis was to test and refine the disturbance history of Bass Pond reported by Bell *et al.* (2005). Paleolimnological investigation showed that a significant disturbance occurred between 2400 and 2200 cal BP. This suggests that the Groswater occupation of Phillip's Garden East may be responsible for the sedimentological disturbance of Bass Pond. However, archaeological evidence supports the hypothesis that Dorset sealskin processing activities are the source of the disturbance.

This thesis began with an overall introduction to the Palaeoeskimo cultures of Newfoundland and the sites of Phillip's Garden, Phillip's Garden West, and Phillip's Garden East. This was followed by a review of the harp seal migration relating to Port au Choix and an ethnographic description of sealskin processing procedures. Literature relating to the environmental impact of hunter-gatherer societies was reviewed, with particular focus on Canadian examples. Then, a brief introduction to environmental proxies used in palaeolimnological investigations was provided. The chapter concluded with an explanation of the current study, and possible implications of the results.

The results of this investigation were presented in Chapter 2 as an academic paper in manuscript form. This began with an explanation of the project, followed by a summary of the archaeological context of the study area and a site description. This was followed by the methods and procedures used in this study. The results are then described in detail, including a table of radiocarbon dates, and figures illustrating sediment core logs, sedimentation rates, pollen concentrations, and $\delta^{15}N$ levels. A detailed discussion section provides extensive interpretation of the data. The chapter ends with a summary and conclusion section, including a summary diagram of results from the investigation.

Chapter 3, the final chapter, includes a detailed comparison of the recent investigation and that of Bell *et al.* (2005). This is followed by a discussion of the implications of this study in the broader scope of hunter-gatherer research, and finally a summary of the thesis.

3.2 Study Comparison

During their palynological investigation of Bass Pond Bell *et al.* (2005) concluded that the vegetation disturbance observed within the pond sediments occurred from 2200 to 1800 cal BP. This disturbance was identified by increased sedimentation rates, particularly from 2200 to 2000 cal BP, a peak in aquatic species *Pediastrum* and *Myriophyllum* at 2000 cal BP, and decreases in pond-side vegetation, particularly Sphagnum moss, from 2200 to 1800 cal BP. They indicated that the disturbance appears concurrent with both Groswater and Dorset Palaeoeskimo occupations near the pond; however, they suggest that the observed eutrophication of Bass Pond may have been caused mainly by Dorset sealskin processing activities.

Building upon the previous investigation of Bell *et al.* (2005), this project set out to conduct a higher resolution study of the disturbance history of Bass Pond sediments using palynology, sedimentation rates, and geochemistry. Although disturbance patterns appear to be similar in the current investigation, newly obtained radiocarbon dates from the 2007 Bass Pond sediment core show that this disturbance may have occurred slightly earlier than those reported by Bell *et al.* (2005). This is demonstrated by increased sedimentation rates from 2400 to 2220 cal BP, peaks of *Myriophyllum* at 2310 cal BP and *Pediastrum* at 2270 cal BP, and a decrease of *Sphagnum* moss from 2360 to 2290 cal BP. Although these disturbance events appear earlier than those reported by Bell *et al.* (2005) when considering calibrated median probability ages, the points actually refer more to age ranges. For this reason the two chronologies may actually be more similar than different, showing similar trends within an overlapping time range. Regardless, the dated disturbance in both this investigation (2400-2200 cal BP) and that of Bell *et al.* (2005) (2200-1800 cal BP) suggest that the vegetation disturbance began prior to the arrival of the Dorset at Phillip's Garden (1990 cal BP).

The addition of an independent variable further indicates the magnitude of the disturbance history of Bass Pond. Analysis of the $\delta^{15}N$ signature, used elsewhere to indicate marine mammal influence in freshwater bodies (Douglas *et al.* 2004; Hadley 2007a, 2007b), shows that the isotope was present in high amounts, peaking at 2370 cal BP. This supports the hypothesis that sealskin processing activities were carried out in Bass Pond. Although this peak in $\delta^{15}N$ falls within the Groswater occupation, predating the Dorset arrival to Phillip's Garden, the signature actually begins the steady and rapid rise to this peak at 2570 cal BP. According to these dates, the cause of such an extreme increase is related to Groswater activities involving the pond.

The comparison of these two investigations reveals a significant chronological discrepancy; while Bell *et al.* (2005) attributed the disturbance to both Groswater and Dorset Palaeoeskimo based on their radiocarbon dates, the radiocarbon dates from the current study shows that it appears to be solely caused by the Groswater. Although this presents a considerable issue in interpreting the data, the concern may be exacerbated by methodological issues relating to radiocarbon dating. Radiocarbon plateaus, which are created by atmospheric variations of $^{14}C/^{12}C$ ratio, cause ambiguity in radiocarbon ages where the plateaus occur (Guilderson *et al.* 2005). Although the dates in question are slightly younger than an established plateau period, which occurred from 2700 to 2400 cal BP, the presence of such a methodological issue in proximity to this time period may explain the discrepancy. Despite the challenges associated with the two chronologies, it is likely that neither is necessarily correct. The true chronology may fall somewhere in between the two, or perhaps overlaps both. Initially, this indicates that the chronology of vegetation disturbance in Bass Pond sediments may be attributed to either the end of the Groswater occupation of Phillip's Garden East or the start of the Dorset occupation of Phillip's Garden. The broader $\delta^{15}N$ investigation, however, shows that the isotope levels began rising as early as 2900 cal BP, and most notably from 2570 cal BP, indicating that the possible marine mammal presence in Bass Pond sediments should be attributed solely to the Groswater.

3.3 Implications

This investigation has shown that a palaeoenvironmental signature of ecological disturbance can be identified in Bass Pond. Although this contributes information regarding the activities of the Palaeoeskimo groups at the Phillip's Garden group of sites, the timing of such an event is somewhat problematic. The date of this disturbance, from 2400 to 2200 cal BP, indicates that it can be attributed to the Groswater population; however, the archaeological evidence at the Phillip's Garden group of sites does not necessarily support this.

The Groswater sites Phillip's Garden East and West are both relatively small in size, containing two dwelling structures (Renouf 1993). Although faunal material recovered from the sites include a high proportion of harp seal (Renouf 1993), the faunal remains recovered from the adjoining Dorset site are much more impressive. Phillip's Garden contains over 60 dwelling structures, most of which are larger and more substantial than those found on either Groswater site (Renouf 2003). Also, a very high proportion of faunal material recovered from Phillip's Garden has been identified as harp seal (Murray 1992; Renouf & Murray 1999; Hodgetts *et al.* 2003; Hodgetts 2005). This indicates that the Dorset occupation was much more intensive than that of the Groswater, and was more reliant on higher proportions of harp seal. In addition, the archaeological record shows that slate tools from the site are specifically geared towards sealskin processing, indicating this was an activity Dorset populations engaged in at Phillip's Garden (Knapp 2008). For this reason, it would be expected that large scale sealskin processing activities would have been carried out by the Dorset, and not necessarily the

Groswater. If the archaeological evidence at Phillip's Garden is any indication, it would seem that the dates acquired in this investigation are incorrect, appearing much older than the actual age of the disturbance. This is certainly a possibility, as the sediments analyzed are inherently disturbed. It is probable that macrofossils used for radiocarbon dating have been re-distributed throughout the sediment column as the substrate has been disturbed. Although this could easily account for the later age of the vegetation disturbance, it is less likely an explanation of the elevated $\delta^{15}N$ age, as the rise in values begins as early as 2900 cal BP. It seems unlikely that subtle disturbances within Bass Pond could skew the geochemical record to such a degree.

If the dates obtained for this investigation are correct, the assumptions that have been made regarding the Groswater and Dorset occupations of Phillip's Garden must be revisited. This introduces several questions relating to these occupations. If such a significant disturbance is related to Groswater cultural activities, particularly large scale sealskin processing, why does the archaeological evidence not support this? Additionally, if the Dorset were processing sealskin, as the evidence suggests, which method did they employ? If they were using the soaking method as the ethnographic information suggests, which pond were they using to do so? Although none of these questions are easily answered, it is clear that a disturbance did occur in the vicinity of Bass Pond, while the timing of this disturbance suggests an anthropogenic influence, particularly relating to the Groswater occupation of Phillip's Garden East.

Although the Groswater tool assemblage from Phillip's Garden East does not appear to contain skin processing tools, perhaps the assemblage could be revisited much like the Dorset assemblage from Phillip's Garden has been. Dorset sealskin processing tools were only identified after the assemblage had been re-classified, and use-wear analyses had been performed. With this consideration, perhaps Groswater skin processing tools from Phillip's Garden East have been previously overlooked or misinterpreted as well. If this is the case, although unlikely, there may be more archaeological evidence supporting this scenario than previously assumed. Although further investigations are needed to confirm this, it is clear that currently held assumptions regarding Groswater cultural activities at the site should be revisited.

This investigation also leads to questions regarding the long-held notions of Groswater mobility. The currently held view is that the Groswater were highly mobile, travelling in smaller populations, and relying on a wide range of seasonal resources in a variety of locations (Renouf 1993; Leblanc 1996, 2000). The chronology of this analysis, however, suggests an extended spring and summer Groswater occupation of Phillip's Garden East, or perhaps a re-visitation of the site to process skins outside the harp seal hunting season. Both of these options seem uncharacteristic based on what is known of Groswater populations; however, the disturbance reflected in Bass Pond sediments should not be ignored. Although it seems unlikely that the conventional notion of Groswater mobility is incorrect, the results of this investigation suggest this concept be revisited. Alternatively, it may not be the idea of mobility that should be questioned, but rather the role of Phillip's Garden East. Perhaps this is a unique site within the Groswater landscape, viewed in a different way than other sites in the region. With this in mind it would be advantageous to conduct further archaeological surveys, especially in areas surrounding Bass Pond, to investigate the possibility of a more expansive Groswater site at this location.

In addition to contributing to the knowledge base of Dorset and Groswater cultural activities at the Phillip's Garden group of sites, this investigation has also provided insight into the impact of hunter-gatherer populations on their environment. Although this area of research had previously been focused on European examples, several recent Canadian investigations have shown that environmental impact is not restricted to modern populations. Elsewhere in the Canadian arctic, for example, several investigations have shown that Thule Inuit whaling practices impacted freshwater ponds as early as 700 cal BP (Douglas *et al.* 2004; Hadley 2007a, 2007b). This investigation demonstrates that hunter-gather impact can be discerned in the environmental record as far back as 2400 cal BP, making this the oldest evidence of hunter-gatherer environmental impact in Canada to date.

These palaeolimnological studies illustrate that even activities perceived as having a lower impact on the environment, such as those associated with hunter-gatherer populations, can have lasting effects. These populations used natural materials found in their surrounding environment, with no access to synthetic materials traditionally associated with modern pollution and environmental degradation. Also, hunter-gatherer populations often lived in smaller, nomadic groups as opposed to large settled communities, eliminating many of the environmental issues conventionally associated with these settings today. For these reasons, it is often assumed that hunter-gatherer populations had little impact on their surrounding environment. However, this impact appears much greater than previously understood. With this consideration, it would be advantageous for other investigations to focus on the broader landscape surrounding archaeological sites, including features such as small ponds which can provide valuable insight into cultural activities and environmental use in hunter-gatherer settings.

Even though hunter-gatherer populations lived off of the land and are viewed as having little to no impact on their surroundings, it is apparent that even smaller scale activities are capable of altering the natural environment. This investigation suggests that this is case with the Palaeoeskimo populations of the Phillip's Garden group of sites, particularly the Groswater. Although the chronology may be somewhat ambiguous, it is clear that Bass Pond ecology has been permanently altered by anthropogenic cultural activities.

3.4 Conclusions

This investigation has applied a scientific methodology to quantify the environmental impact of prehistoric hunter-gatherers on the landscape. Although some of the methodological approaches of this study have proven to be inherently problematic, the overall approach was successful and could be applied to other such limnological investigations. Future investigations must, however, keep several issues in mind. When quantifying anthropogenic disturbance, the sediments in questions are, by definition, disturbed. This may lead to uncertainty within the results; however, notable trends may still be discernable. Many environmental proxies are sensitive to surrounding conditions, and may encounter issues of preservation. Although this is challenging, it is unlikely that these issues will be a concern for all proxies. Finally, remain flexible and be prepared to adjust the project as need be. Methodological issues are often encountered in environmental research, but can be overcome, as is evidenced throughout this investigation.

Throughout this final chapter, several recommendations for future work have been presented. Many of these suggestions require a closer look at the Phillip's Garden East tool assemblage and a comprehensive archaeological survey surrounding Bass Pond. Additionally, further analyses of the previously obtained cores would be beneficial to rule out any uncertainty presented throughout this investigation. These analyses may include a comprehensive geochemical survey of the brownish marl layer to discern the origin of the color change, or further micro paleontological investigations of other potential environmental indicators (such as marine phytoplankton) to rule out a possible marine incursion. It would also be advantageous to carry out similar investigations of other ponds in proximity to the Phillip's Garden group of sites. In doing so, the true influence of Palaeoeskimo populations on Bass Pond in particular can be identified.

In conclusion, this thesis has shown that a major disturbance occurred near Bass Pond from 2400 to 2200 cal BP, which is concurrent with the Groswater occupation of Phillip's Garden East. Presumably, this disturbance is related to cultural activities carried out at the site, and may be a result of sealskin processing activities. This serves as the oldest evidence of hunter-gatherer environmental impact in Canada.

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APPENDIX 1

Pollen Processing Procedures

1. Add 0.5 ml of exotic Eucalyptus pollen to 1.0 ml of dried sediment sample in a plastic test tube
2. Add 10 ml of 10% hydrochloric acid (HCl) to sample; wait until bubbles cease. Centrifuge and decant, wash with water, centrifuge and decant again
3. a. Add 10% potassium hydroxide (KOH) solution, heating in warm water bath for 5 minutes, stirring several times. b. Strain through Gooch crucible, discarding large particles.

   c. Wash with water, centrifuge and decant
4. a. Add 10ml stock hydrofluoric acid (HF), stir with plastic rods. Leave in cold HF overnight, stirring occasionally. Centrifuge and decant. Add 10 ml warm 10% HCl, leaving in warm water bath for 20 minutes. Centrifuge and decant.

   b. wash with water, centrifuge and decant again
5. Acetolysis
   a. Wash with 5 ml glacial acetic acid. Centrifuge and decant.
   b. Add 5 ml acetic anhydride, stir; add 4 drops of concentrated sulfuric acid (H_2SO_4); stir. Heat in water bath for 5 minutes. Centrifuge and decant.
   c. Wash with 5 ml glacial acetic acid. Centrifuge and decant.
6. Wash three times with water. Centrifuge and decant each time.
7. Add 1-3 drops of safranin-O solution; stir well
8. Dehydration
   a. Wash twice with tertiary butyl alcohol (TBA). Centrifuge and decant each time
   b. Transfer to small vial with TBA. Centrifuge and decant
9. Add silicon oil and leave uncapped, but covered with a tissue, overnight to evaporate TBA
10. Put several drops of oil solution on slide. Warm slides on hotplate to ensure final evaporation of TBA before covering with cover-slip

- HCl dissolves carbonates
- KOH disaggregates and removes humic acid
- HF removes silicates
- Acetolysis removes cellulose and hemi-cellulose
- Dehydration removes water before silicon oil is added

APPENDIX 2

Pollen Concentrations (grains/ml)

*All samples were taken from the Glew core recovered from Bass Pond (BP-02) except for the lowermost samples which were taken from a percussion core as noted (BP-04)

Sample ID	Depth (cm)	*Picea*	*Abies*	*Betula* tree	*Betula* shrub	*Myriophyllum*	*Sphagnum*	*Pediastrum*	Charcoal
top	3	3602	2355	5749	1247	139	416	6303	2355
9	7	18497	8968	14293	1962	841	1121	15414	20739
15	10	18513	7002	11155	593	593	237	16733	19818
17	11	8961	6655	11002	1065	177	444	19431	47025
19	12	18519	6798	8439	1875	352	352	16057	16526
21	13	7022	5174	10348	0	739	370	22175	6468
23	14	10958	10259	13290	1399	233	699	28561	13406
25	15	18915	11263	12706	1588	289	1011	20648	28012
27	16	18896	13025	7338	734	183	0	7155	24216
29	16.5	16968	9181	7787	1976	0	116	5927	38585
31	17.5	8396	5820	9255	95	95	191	6011	13931

Sample ID	Depth (cm)	*Picea*	*Abies*	*Betula* tree	*Betula* shrub	*Myriophyllum*	*Sphagnum*	*Pediastrum*	Charcoal
33	18.5	11362	8496	10952	1331	102	409	9724	16889
35	19.5	15574	5866	9405	1416	0	0	9709	28620
37	20.5	27567	21379	13502	2250	281	281	8439	22504
39	21.5	13780	7462	8587	1840	0	102	8382	19013
41	22.5	9849	7415	13672	3128	116	231	8922	24216
43	23.5	7816	6788	15529	2057	309	103	5759	55124
45	24.5	12444	6222	7644	1600	178	889	5955	51107
47	25	16426	6712	12541	1590	530	0	2826	102091
49	26	23356	7200	24585	2459	351	878	13697	68311
51	27	9781	10213	16254	4747	144	1582	15535	21721
53	28	17292	10435	14460	3578	149	447	15652	21317
55	29	17557	9406	17557	1881	941	157	9562	20692
57	30	12224	11823	23847	4810	1002	601	13827	31862
59	31	54118	24599	15682	922	922	615	17834	40896

Sample ID	Depth (cm)	*Picea*	*Abies*	*Betula* tree	*Betula* shrub	*Myriophyllum*	*Sphagnum*	*Pediastrum*	Charcoal
61	32	23288	18260	24876	11909	794	1852	21700	93416
63	33	49660	31298	33385	2921	417	1252	47990	78037
65	34	58371	18091	31063	1365	1024	1365	13313	68952
67	35	41160	13720	26460	0	4900	0	18620	27440
69	36	45996	18455	24702	1136	1136	284	19307	71265
71	37	26258	19199	26258	12141	282	2541	12423	103337
73	37.5	43609	12585	32195	2634	1171	1171	4976	82242
75	38.5	56775	27823	25191	6016	0	752	19176	80462
77	39.5	33800	21473	36186	795	2784	3976	3976	73962
79	40.5	125094	36379	40847	2553	0	1276	5106	67015
81	41.5	68230	36356	32870	17929	996	996	1494	38847
83	42.5	58635	31875	29514	5509	0	787	6296	46042
85	43.5	63894	32550	34961	2411	804	0	12859	58670
87	44.5	47522	28428	46249	1273	424	2970	8910	118380

Sample ID	Depth (cm)	*Picea*	*Abies*	*Betula* tree	*Betula* shrub	*Myriophyllum*	*Sphagnum*	*Pediastrum*	Charcoal
04-50	60	5220	3685	13307	614	102	614	10952	16275
04-60	70	5323	4749	10482	983	82	491	20308	10891

APPENDIX 3

δN^{15} Results

Sample ID	Lab ID	Depth (cm)	Mass Analyzed (g)	Amount $\delta^{15}N$ (‰)
BP-02-Top	N-250	0	3.422	2.15
BP-02-02	N-251	3.5	4.063	2.17
BP-02-04	N-252	4.5	4.607	2.44
BP-02-06	N-181	5.5	5.070	2.34
BP-02-08	N-253	6.5	6.181	2.38
BP-02-10	N-254	7.5	7.257	2.31
BP-02-13	N-182	9	8.251	1.94
BP-02-16	N-255	10.5	8.342	2.23
BP-02-18	N-256	11.5	8.322	2.29
BP-02-20	N-257	12.5	8.319	1.9
BP-02-23	N-183	13.5	8.210	1.63
BP-02-25	N-258	14.5	8.323	1.9
BP-02-27	N-259	15.5	8.266	2.04
BP-02-29	N-260	16.5	8.232	2.04
BP-02-31	N-261	17.5	8.247	1.89
BP-02-33	N-184	18.5	9.173	1.71
BP-02-35	N-262	19.5	8.223	1.14
BP-02-37	N-263	20.5	8.233	1.03
BP-02-39	N-264	21.5	8.228	1.19
BP-02-41	N-265	22.5	8.093	1.33
BP-02-43	N-185	23.5	8.037	0.90

Sample ID	Lab ID	Depth (cm)	Mass Analyzed (g)	Amount $\delta^{15}N$ (‰)
BP-02-45	N-266	24.5	8.037	1.39
BP-02-48	N-267	25.5	8.024	1.74
BP-02-50	N-268	26.5	7.787	1.82
BP-02-53	N-186	28	7.121	2.05
BP-02-56	N-269	29.5	6.745	1.93
BP-02-58	N-270	30.5	6.541	1.97
BP-02-60	N-271	31.5	6.285	2.47
BP-02-63	N-187	33.5	5.782	3.37
BP-02-66	N-272	34.5	5.744	3.43
BP-02-68	N-273	35.5	5.797	3.36
BP-02-71	N-274	36.5	5.769	3.62
BP-02-73	N-188	37.5	5.699	4.28
BP-02-75	N-275	38.5	5.723	3.75
BP-02-77	N-276	39.5	5.762	2.92
BP-02-79	N-277	40.5	5.731	2.69
BP-02-81	N-278	41.5	5.725	2.74
BP-02-83	N-189	42.5	5.869	2.60
BP-02-85	N-279	43.5	5.763	2.31
BP-02-87	N-280	44.5	5.793	2.4
BP-02-88	N-190	45	5.817	2.69
BP-04-50	N-329	60	8.506	2.29
BP-04-60	N-330	70	9.039	1.45