A Reconstruction of Summer Sea Ice Conditions in the Labrador Sea Using Hudson's Bay Company Ships' Log-Books, 1751 to 1870

by

John Vincent Teillet

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF ARTS

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ABSTRACT

The sailing ships' log-books contained in the Hudson's Bay Company Archives were used to reconstruct summer sea ice conditions in the Labrador Sea from 1751 to 1870. This reconstruction involved the development of an ice severity index, derived from a content analysis of the word roots and phrases in the ice descriptions, and the comparison of historic encounters with the presence of ice in the same sector in 1965.

The ice severity index obtained for the Labrador Sea did not demonstrate a significant relationship with other ice severity indices derived for Hudson Strait and Hudson Bay. The ice severity index displayed some similarities to ice severity derived for other regions of the Labrador Sea.

A highly significant volcanic signal was found in the ice severity index indicating a relationship between volcanic dust and the atmospheric circulation responsible for late ice retreat in the Labrador Sea.

The number of icebergs sighted each year was also estimated for the period 1751 to 1870.

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Chapter 1: Introduction, Previous Research and Plan of Thesis

It is not easy for the average Canadian to acquire a balanced appreciation of the immensity and significance of the tangle of islands, peninsulas, straits and inland seas that comprise our arctic and subarctic territory. From our perspective Canada is an elongated country spanning five time zones, connecting two oceans, and its cities and agricultural land are flung in a narrow belt along the United States border. Our customary view of the country fails to grasp the fact that the linear distance from Lake Erie to the northernmost point of Ellesmere Island at Alert is approximately the same as that from Vancouver to Halifax, or that the coast of Baffin Island is encountered at roughly the midpoint between Lake Erie and Alert. Off the southeast coast of Baffin Island lies the Labrador Sea, an area that even today is considered remote.

The remoteness of the north is also reflected in the relative paucity of scientific knowledge of the region. One manifestation of this, that is relevant to the subject of this thesis, concerns our knowledge of sea ice conditions in Hudson Bay and its approaches through Hudson Strait and the Labrador Sea. The Labrador Sea has had centuries of fishing, whaling and

exploration, and together with Hudson Strait and Hudson Bay these waters have a long commercial history as a sailing route for vessels engaged in trade between Europe and harbours on Hudson Bay. Ships have plied this route since the founding of the Hudson's Bay Company in 1668 and the modern shipping era dates for the establishment of the port of Churchill in 1929. Despite this long history, knowledge of ice conditions in Hudson Bay was so deficient in the mid twentieth century that Burbidge (1951) stated:

> Until 1948 little was known about the area of ice in the central waters of Hudson Bay in winter. Ice was known to form around the edges but reports by local residents and explorers all expressed the opinion that the central parts of Hudson Bay remained as open water throughout the winter. This was also the opinion of many circles in the United States ; the authoritative *Ice Atlas of the Northern Hemisphere* (1946) shows only a narrow coastal fringe of ice.

It is surprising that only four decades have elapsed since it first became known that this great inland sea freezes over in winter. Equally surprising is that the evidence provided by Burbidge consisted not of direct observations made during scientific aircraft surveillance but rather of indirect climatological evidence. Prior to the January freeze-up, polar continental air is significantly warmed during its passage across Hudson Bay, presumably due to contact with open water. From January through March the absence of this warming indicates contact with a virtually unbroken ice cover.

Burbidge's (1951) findings were, however, published immediately before the commencement, in the early 1950s, of systematic aerial ice reconnaissance in the Canadian arctic and subarctic. By the late 1960s satellite observations became available for the whole polar basin. These technological innovations provided the means for the scientific study of sea ice while recent economic and political forces provided impetus to these studies. Among the most important of these were the energy crisis of the 1970s which pushed the search for energy resources to the high arctic and the realization by Canadians of the arctic archipelago's strategic importance. In the postwar decades the arctic occupied a position of great strategic importance with regard to the military interests of the great powers. Late in this period an awakening of Canadian concern with its sovereignty in the arctic further stimulated scientific research in general and ice surveillance in particular. This has culminated in current plans by the Canadian government to strengthen its navy and increase naval patrols as a means of asserting sovereignty in the arctic archipelago.

Despite these developments the period of the sea ice record remains brief. The primary sources of sea ice information in Hudson Bay, Hudson Strait and the Labrador Sea are weekly maps of ice margins in *Ice Summary and Analysis: Hudson Bay and Approaches* published annually from 1964 through 1973 by Ice

Forecasting Central of Environment Canada. The same information is available for the period since 1973 in unpublished maps prepared by Ice Forecasting Central. Two major secondary sources present the ice information observed since 1964: *Ice Atlas: Canadian Arctic Waterways* (Markham, 1981) and *Ice Atlas: Hudson Bay and Approaches* (Markham, 1988). These sources are a basis for studying spatial patterns of ice information and dispersal, seasonal ice regimes and year to year fluctuations during the last two decades. However, the modern ice record provides no information that can be used in the study of sea ice variations during recent decades and centuries. The only recourse available for the study of long term variations in sea ice is to use the indirect evidence which is primarily contained in written historical sources.

The primary objective of this study is to use the sea ice descriptions contained in the log-books of the Hudson's Bay Company (HBC), to reconstruct summer sea ice conditions in the western portion of the Labrador Sea for the period 1751 to 1870. This research is similar in several respects to that done by Catchpole and Halpin (1987). The objectives and sources of the two studies are the same and the method used to derive the indices also has some affinities with that applied by Catchpole and Halpin (1987). The ice index is compared with other historic sea ice indices, and tested for the presence of a volcanic signal.

1.1 Previous Research

Although the most direct source of historical climatic information is instrumental records, these records do not exist for many areas and where they are available they are often restricted to the recent past. To obtain information before the period of instrumental measurements and scientific surveillance, proxy records of climate must be used. Proxy records are derived from analyses of climatic dependent variables. In his study of the proxy evidence of climatic change in the Quaternary, Bradley (1985) identified historical evidence as one of the four major categories which include also ice core, geological and biological evidence. The fundamental limitation of the historical evidence is the brevity of the period of time in which it is available. However, the strengths of historical evidence lie in the accuracy with which it can be dated and the high resolution of the information it yields. Only ice core and tree ring data compare in quality with the historical evidence in terms of accuracy of dating and resolution (Bradley, 1985, p.3-9).

A general review of paleoclimatic research based on historic evidence is far beyond the scope of this thesis. This review will focus upon three aspects of the use of written historical evidence for climatic reconstruction:

1) studies based on sailing ships' log-books;
2) studies based on both the post journals and sailing ships' log-books in the Hudson's Bay Company Archives (HBCA) in the Provincial Archives of Manitoba (PAM);
3) studies of sea ice conditions in the Labrador Sea.

As early as 1855 the value of ships' log-books in scientific studies was realized: "Every ship that navigates the high seas with these ... logs on board may henceforth be regarded as a floating observatory" (Maury, 1855). Until recently, however, these sources were poorly exploited. Oliver and Kington (1970) used ships' log-books with land station data to produce synoptic weather charts of Western Europe for a number of years in the 1780s. Landsberg (1980) observed that: "a particularly useful source, often meticulously kept, is the log-book of a vessel". These are valuable historic sources because these officers, whether naval or merchant, were instructed to record all manner of details concerning their ships in the log-books. The following is an example of the official directives given to naval officers early in the eighteenth century:

> He [the Captain or Commander] is, from the Time of his going on board, to keep a Journal, according to the Form set down ... and to be careful to note therein all Occurrences, viz. Place where the Ship is at Noon; Changes of Wind and Weather; Salutes, with the Reasons thereof; Remarks on unknown Places; and in general, every Circumstance that concerns the Ship, her Stores and Provisions.
> (Oliver and Kington, 1970)

A reason why log-books have seldom been used as historical climatic sources is that: "much of the detail in ships' log-books is difficult to utilize when it comes to monthly, or longer, periods of climatic reconstruction, for the obvious reason that the period covered at any one locality is a brief one even if the vessel is at port" (Oliver and Kington, 1970). However, a collection of log-books is a potentially valuable source of information about *climatic change* if the ships followed roughly the same route and traveled at roughly the same time of year, for a considerable number of years. The collection of log-books in the HBCA meets these criteria since they were written on ships that followed a prescribed route in mid to late summer for a period of 120 years. In the studies conducted here and by Faurer (1981), Catchpole and Faurer (1983), and Catchpole and Halpin (1987), the ships' log-books in the HBCA were available for Hudson Bay and its approaches through Hudson Strait and the Labrador Sea and provided an indication of the prevailing ice clearing conditions for the 120 year period from 1751 to 1870.

The post journals in the HBCA contain both direct instrumental weather observations and also proxy evidence of climatic conditions. The instrumental observations are primarily of air temperature and, less frequently, surface pressure. The distributions of these observations, instruments and observing routines have been examined by Ball (1983b) and by Wilson (1983,

1985a and 1985b). These researchers developed procedures for correcting the primary observations for inconsistencies in instrumental design and exposure. The proxy evidence in these sources has been used for two general types of climatic reconstruction. The phenological studies have examined seasonal changes by studying dates of first occurrences of river break-up and freeze-up (Moodie and Catchpole, 1975), rainfall and thunder in spring, and snowfall and frost in fall (Ball, 1982). The second approach to the use of proxy evidence has enumerated the frequencies of occurrence of rainfall, snowfall, thunder, specific wind directions etc. (Ball, 1982) to provide indications of the frequencies of occurrence of specific phenomena within the seasons.

A more immediate background to this research was provided by the analyses of historical sea ice conditions conducted by Faurer (1981), Catchpole and Faurer (1983), Catchpole and Halpin (1987), and Catchpole and Hanuta (unpublished manuscript). These studies were also based on the HBC supply ships' log-books. Faurer's (1981) and Catchpole and Faurer's (1983) analysis derived indices of annual summer sea ice severity in Hudson Strait. This analysis was based on the relationship between the duration of the passage through Hudson Strait and ice severity, but did not analyze the descriptions of ice given in the log-books in detail. Catchpole and Halpin's (1987) study of sea ice conditions in eastern Hudson Bay proved to be a useful source

because its methodology was applicable, with some modifications, to the ice descriptions in the Labrador Sea.

Few studies have concentrated on sea ice conditions in the Labrador Sea, either historically or at the present day. These include studies by Crane (1978), Sowden and Geddes (1980), Markham (1981 and 1988), and Newell (1983). Each of these relied on a common primary source of information on recent sea ice conditions. Ice Forecasting Central of the Atmospheric Environment Service published weekly, or biweekly, maps showing the spatial distribution of ice conditions classified according to age and concentration, from 1964 to 1973. This information is still available, although unpublished, for the period since 1973. Sowden and Geddes (1980) used these sources to construct a series of weekly maps showing the maximum and minimum ice limits for the period 1964 to 1979 and the median ice limit for the period 1964 to 1973. The ice limits were based on only ten or 15 years of data, but because of the lack of ice information in Hudson Bay and its approaches these limits have been used to represent present day normal and present day extremes. Crane (1978) used the information compiled by Ice Forecasting Central in his analysis of summer ice dispersal, winter ice formation, and the relevant synoptic atmospheric patterns in the Labrador Sea. Crane identified two distinct patterns of ice retreat, termed early and late, and these are discussed in more detail in Chapter 2 and Chapter 7.

Newell's (1979, 1983) research was of particular relevance to this thesis. Newell concentrated on the eastern Canadian arctic, and he reconstructed both modern and historical ice conditions. Newell (1983) used historical evidence from the Moravian missions in Labrador to establish ice conditions in the nineteenth century in the Labrador Sea. In the western part of the Labrador Sea, his sources mainly provided information between 55°N and 59°N. His ice information for north of 59° was from West Greenland sources compiled by Speerschneider (1931). Thus the research in this thesis was adjacent geographically and had very little overlap. There was, however, a large overlap in time period. Although the first mission was established at Nain in 1770, with Okak established in 1776, and Hopedale in 1786, most of Newell's data were from 1800 to 1900. There was a temporal overlap with this research from 1800 to 1870, a total of 50 years. The information derived from the HBCA put together with the information Newell obtained from the Moravian missions gave each set of data a measure of validity. From this a measure of the ice conditions in the western end of the Labrador Sea in the nineteenth century was established.

1.2 Plan of Thesis

Chapter 2 describes the routes and sailing routine of the HBC supply ships and it also defines the study area used in this thesis. The chapter also examines the modern ice conditions observed in the Labrador Sea at the time of the year when the sailing ships made their crossing. The objective of this is to provide background information on the ice conditions that the sailing ships would encounter if they sailed today.

Chapter 3 discusses the HBCA as a data source. The log-books are analyzed in terms of their period of record, numbers, format and contents of the individual log-page, and how information was retrieved from them.

Chapter 4 concentrates on the ability of the HBC officers to locate their ships while at sea. Navigational accuracy is tested and a method of correcting obvious errors is introduced to establish a network of marine sectors in which to locate the ships.

Chapter 5 is an analysis of the word roots and phrases contained in the ice descriptions. These word roots and phrases are coded, using content analysis, to obtain an index of summer sea ice severity in the Labrador Sea.

In Chapter 6 the interpretation of the results involves a comparison of the index obtained in Chapter 5 with other historic sea ice indices from Hudson Bay, Hudson Strait, and the Labrador Sea.

Chapter 7 examines the relationship between volcanic dust and sea ice severity. A significant volcanic signal is observed in the index of summer sea ice severity obtained for the Labrador Sea.

Chapter 8 contains a discussion of icebergs, including the notation used by the HBC, and an attempt is made to provide an annual estimate of icebergs from 1751 to 1870.

Chapter 9 summarizes the results of the study and contains some concluding remarks.

Chapter 2: The HBC Supply Ships

2.1 Sailing Route & Study Area

One of the reasons the data from the ships' logs are very useful is that in each of the 117 years the ships followed the same general route across the Atlantic Ocean. Figure 2.1 shows the usual route of the ships across the Labrador Sea, while Figure 2.2 has the routes of two specific examples, 1835 and 1836. In both figures it is obvious that the HBC crews gave Cape Farewell, Greenland a wide berth. They did this for two reasons. Firstly to avoid ice and secondly because they were unsure of the exact location of Cape Farewell. Chappell mentions this in his narrative. "According to some charts, we considered ourselves this day to be in the longitude of Cape Farewell in Greenland. Nothing can exceed the uncertainty that prevails in almost every chart and book of navigation, respecting the longitude of the Cape in question" (Chappell, 1817, p.34). Once past Cape Farewell the ships headed northwest until they were at about the same latitude as Resolution Island. When they were within sight of Resolution Island the ships entered Hudson Strait by passing close to the south of Cape Resolution. The reasons for this route will become apparent when ice conditions and ocean currents are examined.

Figure 2.1: Typical Route Through the Labrador Sea

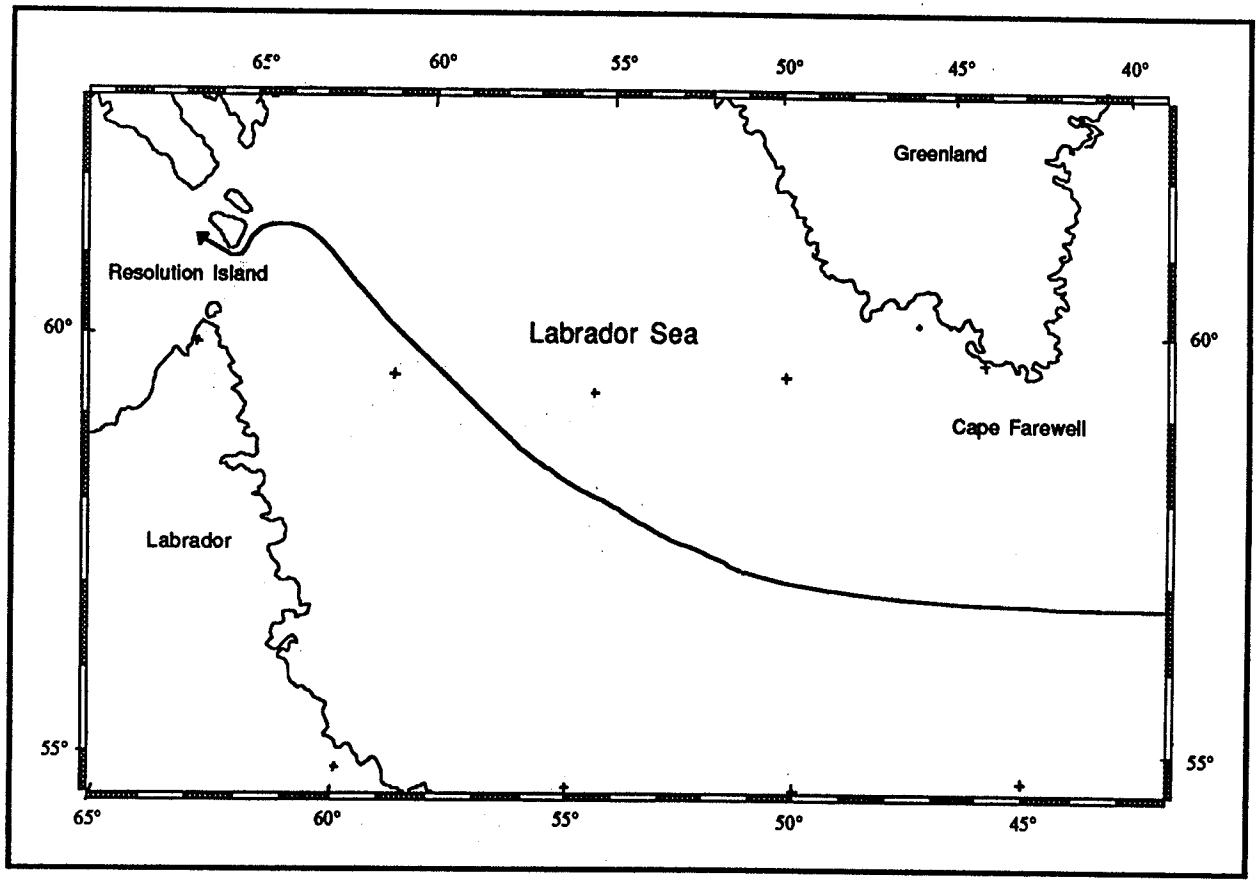


Figure 2.2: Routes Sailed by the HBC Ships in 1835 and 1836

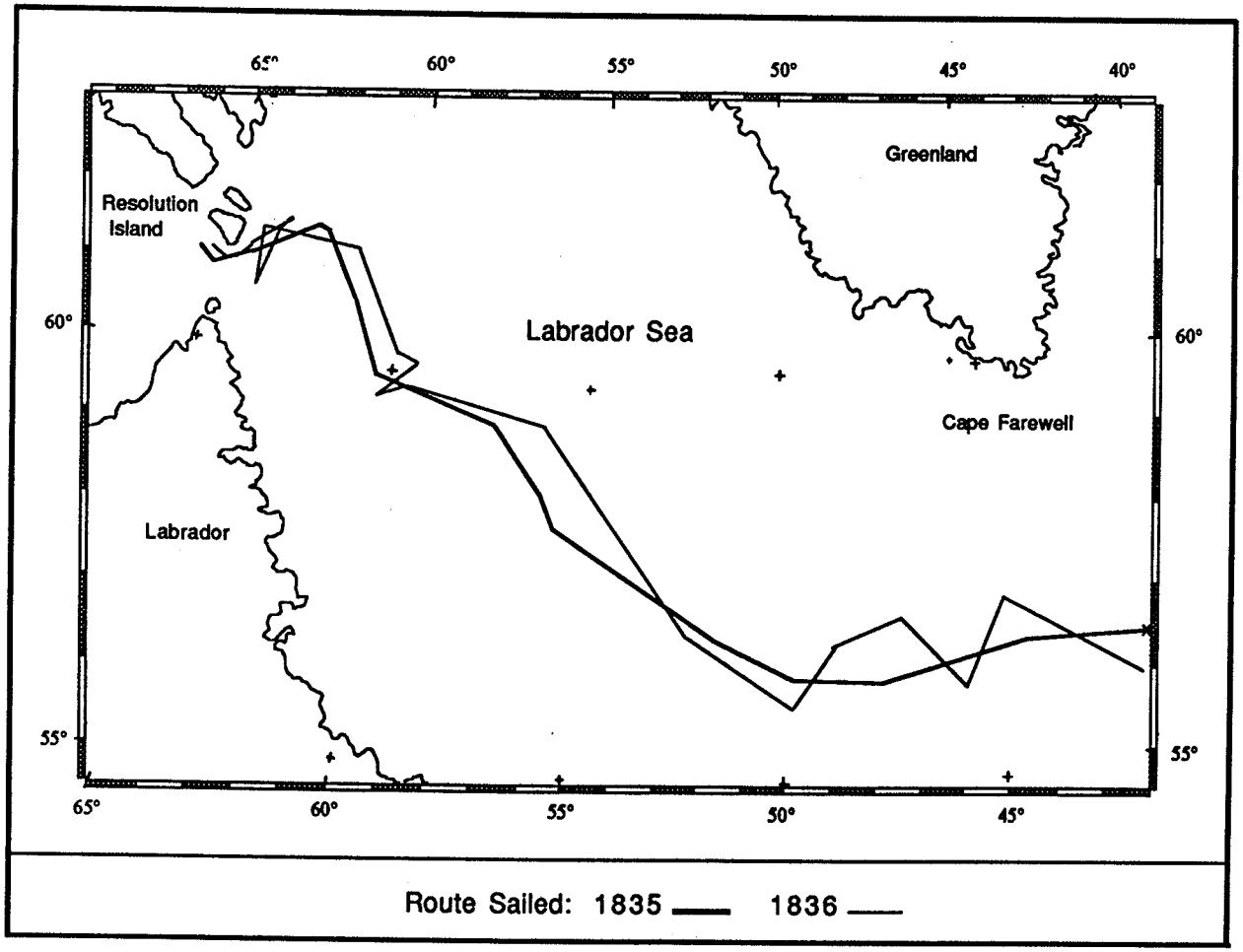
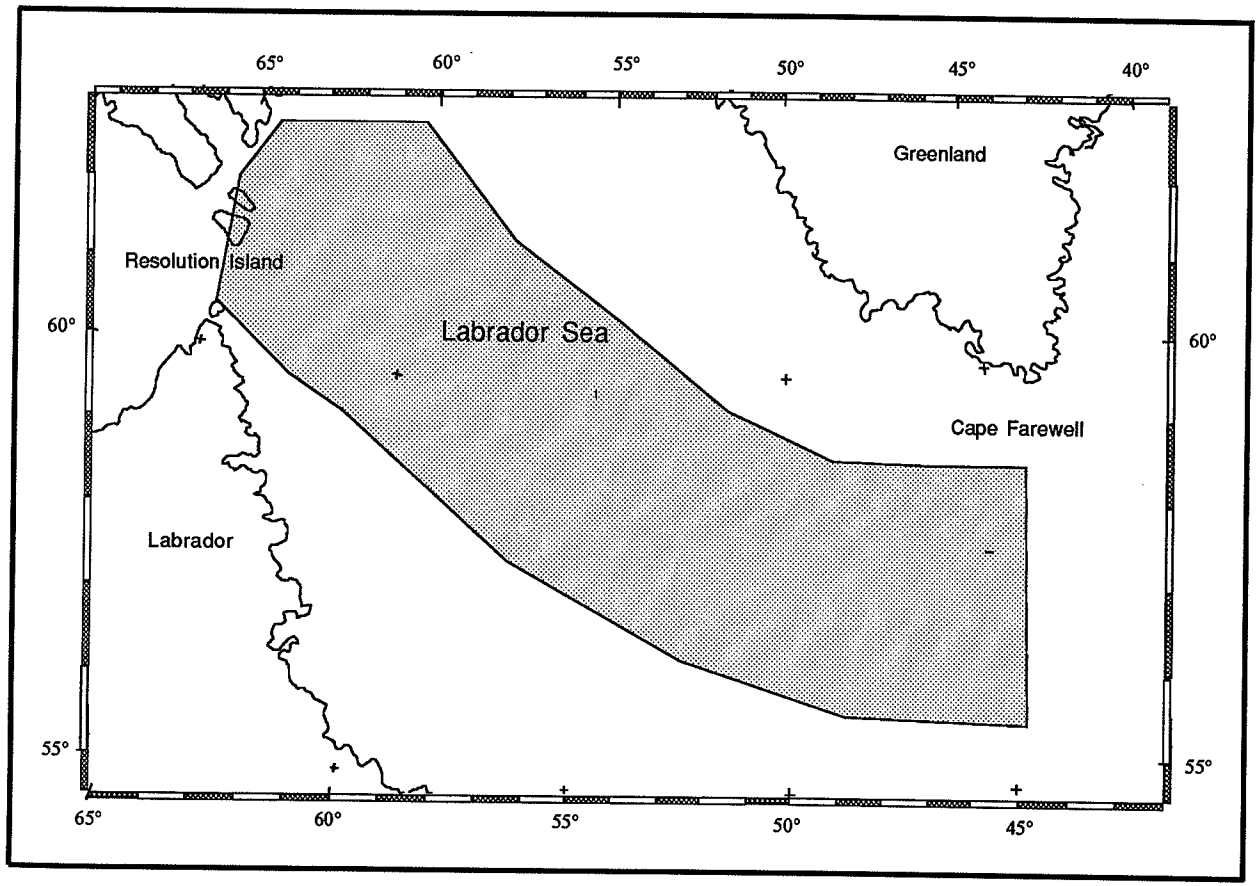


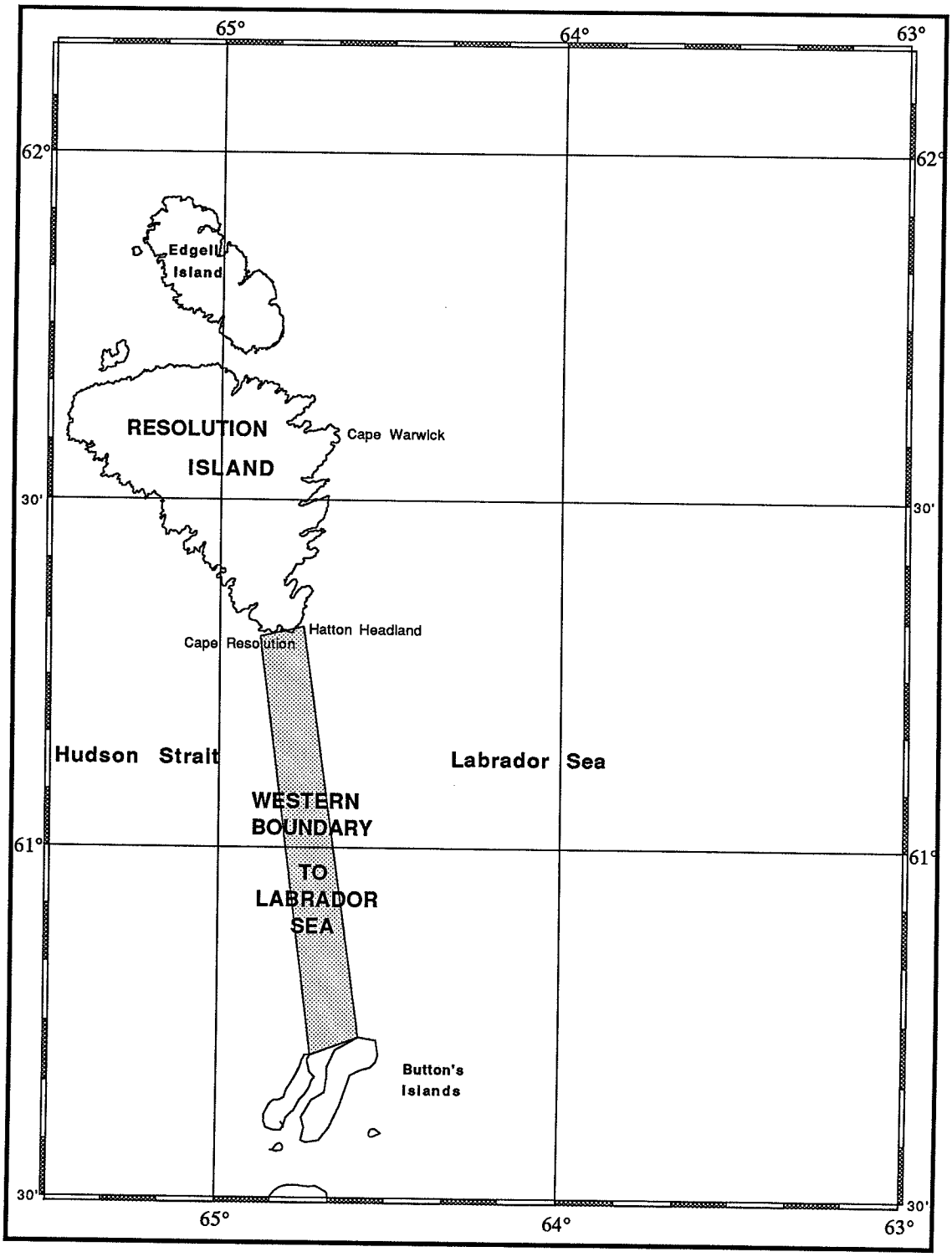
Figure 2.3: Study Area: The Labrador Sea



The area of study for this research is the Labrador Sea, shaded in Figure 2.3. This is a broad area spanning about 180 miles (nautical miles are used throughout this historical study) in width but the ships usually followed a fairly straight route and did not range over a very large north-south area in the Labrador Sea in any one year. The eastern boundary is the west coast of Greenland and the longitude of Cape Farewell in the Atlantic Ocean. Precision in determining this boundary is not a major concern as ice was very seldom seen in this area. In fact, almost all pack ice sightings were in the western portion of the Labrador Sea. The western boundary to the study area is the entrance to Hudson Strait which is enlarged in Figure 2.4. The entrance to Hudson Strait is a natural boundary and the sailors considered that the rounding of Cape Resolution marked the end of their Atlantic crossing and the end of the first leg of their trip. The following excerpts from two different voyages demonstrate how the crew considered passing Cape Resolution as the entrance to Hudson Strait:

> 10 am Rounding Cape Resolution and at 10 AM I judge we were abreast of it.
> noon About 10 AM I think we entered Hudson's Straits.
> *(HBCA, PAM, King George II log-book, August 7, 1776, C.1/380.)*
>
> At 9 past the Cape and entered the Strait.
> *(HBCA, PAM, King George III log-book, July 20, 1787, C.1/390.)*

Figure 2.4: The Western Boundary of the Study Area



If the log-keeper did not actually specify when the ship entered Hudson Strait or passed Cape Resolution, the time of entry would be approximated from the bearings of the landmarks. For example, if Cape Resolution was recorded as having a south-east bearing with respect to the ship then the ship had passed the Cape and could be considered in Hudson Strait.

In one year, 1753, the ships did not enter Hudson Strait by passing to the south of Cape Resolution. Instead, the HBC ships became embayed in ice and were carried into Hudson Strait north of Resolution Island. The route the ships were forced to take cannot be determined since precise locational information was not given in the log-books on this occasion. The log-book entries from July 26 to July 28, 1753 are given in Figure 2.5, and these demonstrate the helplessness of the crew as the ocean current and ice forced the convoy into Hudson Strait.

It is important to note that Faurer (1981), in her analysis of ice conditions in Hudson Strait, used a different definition of the entrance to Hudson Strait. In her study, the ships were considered to have entered Hudson Strait when the crew reported that they first saw Resolution Island. This means that there is a slight overlap in the areas covered by the two studies. In most cases, this is a minor overlap spanning about one day but, in 1816 the Prince of Wales I did not enter Hudson Strait for 25 days after the crew first sighted Resolution Island.