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EXPLORERS' LOGS FROM THE 19TH CENTURY PROVIDE A SOURCE FOR VERIFYING PROXY RECORDS

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ABSTRACT

The failure of 19th century expeditions to find and transit the Northwest Passage in the Canadian Arctic is often attributed to extraordinary cold climatic conditions associated with the "Little Ice Age" evident in proxy records. However, an examination of a combination of historical temperature measurements and physical observations from explorers' logs reveals that observations of climate indicators, such as the distribution and thickness of annual sea ice, monthly surface air temperature, and the onset of melt and freeze, were within the present range of variability for this region.

1. INTRODUCTION

The failure of 19th century discovery expeditions to find the Northwest Passage has been frequently attributed to extraordinary cold climatic conditions associated with the Little Ice Age within the Canadian archipelago. However, the usefulness of the term "Little Ice Age," defined as a synchronous world-wide and prolonged cold epoch, has been questioned (Bradley and Jones 1995; Ogilvie 2001). According to Jones and Briffa (2001) the Little Ice Age period was not ubiquitously colder than today on large scales. At the same time there is compelling evidence in the widespread glacial retreat that began in the latter part of the 19th century, which has apparently been accompanied by environmental changes such as thinning polar sea ice cover and perturbations in the ecosystems of high latitude ponds. Many proxy records, particularly those derived from ice cores, appear to be consistent with this basic chronology (Overpeck 1998). However, Jones (1998) found less similarity between different proxy series on 30–50 year timescales, even those located near one another.

Due to the paucity of sources of information in the Canadian archipelago, understanding of the climate in this region comes predominantly from glacial and ice core proxy records. Based on the Devon Island ice core proxy record (Fig. 1), the existence of a significantly colder surface climate in the 19th century has been hypothesized. Overpeck (1998) notes, for example: "[Our proxy] records confirm the hypothesis, originally based on a single high-Arctic ice core record of summer temperature variations, that the repeated failure of Europeans to find the Northwest Passage during the 19th century was likely a result of exceptionally severe summertime air temperatures and sea ice extent."

Given the debate on the appropriateness of the Little Ice Age concept to describe climate change, a number of questions may be raised. For example, what changes in the surface environment would be consistent with a climate of one or two standard deviations colder than present, as suggested by the proxy record? One would expect that observable phenomena would frequently reflect the impact of a markedly cooler climate. Using data from historical sources we assess whether the environmental conditions observed in the Canadian archipelago during the 19th century were consistent with the hypothesized conditions of the Little Ice Age.

2. DATA SOURCES AND METHODS

While there is an extensive literature on the history of 19th century Arctic exploration, surprisingly little use has been made of the detailed scientific and meteorological observations compiled during the expeditions. There were more than 60 expeditions or scientific enterprises dispatched to different parts of the region in the period after 1818. We investigate detailed environmental observations from 37 of these expeditions. Historical data include navigational information and observations such as hourly surface air temperature, wind and weather, sea ice conditions, and seasonal transition. We compare four categories of particular interest: sea ice extent, sea ice thickness, monthly mean temperature, and melt season phenology.

In common with most forms of visual and instrumental data, there are inherent questions of accuracy and reliability. The reliability of instrumental surface air temperature data in particular is reduced for a

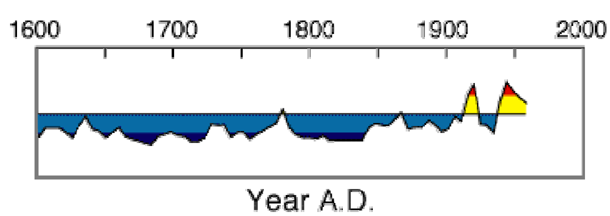

Figure 1. Temperature record derived from the Devon Island Ice Core (Koerner and Fisher 1990; Overpeck 1998). Red indicates temperatures greater than one standard deviation warmer than average for the reference period (1901–1960), whereas dark blue indicates at least one standard deviation colder than this average.

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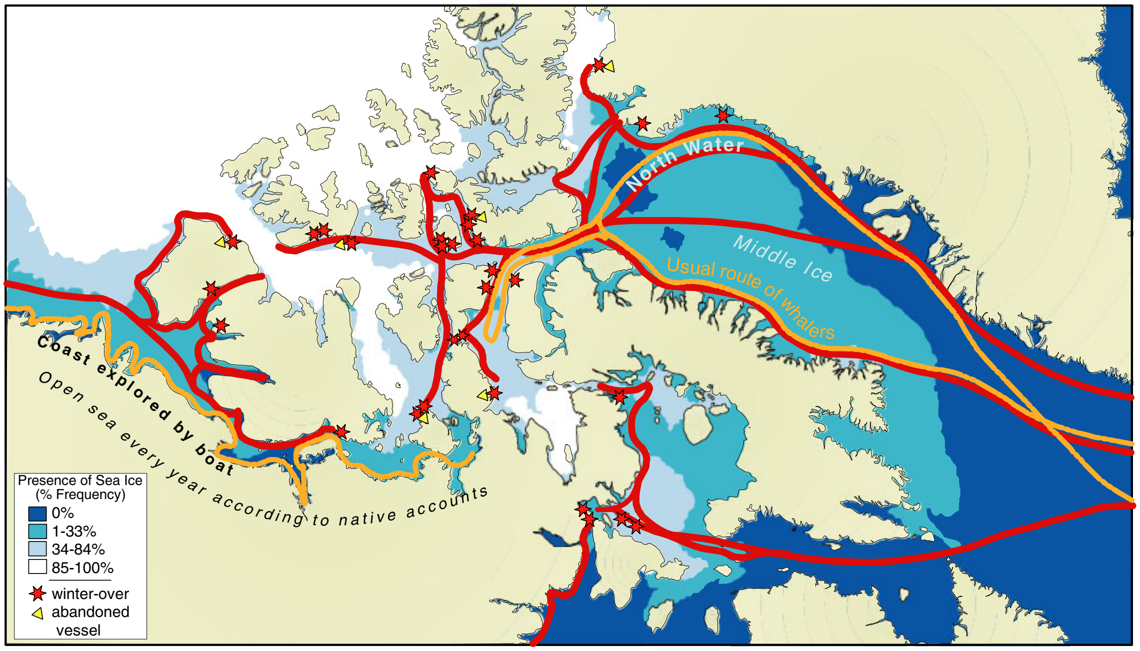

Figure 2. Area explored by principal 19th century expeditions, 1818 to 1859. Climatic sea ice distribution shown reflects percent frequency of sea ice presence on September 10 (Canadian Ice Service 2002).

number of reasons. Prior to the mid-19th century the placement and sheltering of instruments was not standardized and often calibration data were not recorded. Thermometers capable of measuring extremely cold temperatures were not fully developed. However, the metadata that does exist indicate that instruments were accurate at the 32°F (0°C) calibration point. After about 1850, most expeditions wintering over in the Arctic began to use well calibrated suites of thermometers placed in shelters away from the ships. Data from this period is therefore generally more reliable.

3. RESULTS

3.1 *Sea Ice Extent*

Specific cases of failure in the past, especially those involving the besetment or loss of ships, have been presented as examples of the impact of the Little Ice Age on the surface environment. This argument seems apt when these events are placed in contrast with the sea ice climatology of the 20th century, when such occurrences would appear to be very unlikely. However, it may be more informative to consider the explorers' combined success, rather than focus on particular failures.

In Fig. 2 the area explored by expeditions between 1818 and 1859, and the usual route of the Davis Strait whaling fleet, is shown on a chart depicting the frequency that sea ice occurs in the region in recent decades. It is notable how closely the area explored in the 19th century is delimited by this ice climatology. This comparison is particularly interesting because sailing ships and low-powered steam auxiliaries had almost no ability to move once new ice started to form, nor could they move effectively through closely packed ice. According to Parry, half an inch of ice would stop a sailing ship without a strong favorable wind. In addition, the difficult ice conditions encountered by 19th century expeditions in unfavorable seasons would not be unusual in unfavorable seasons today.

There is evidence that suggests that sea ice in Baffin Bay persisted through August and September more frequently in the 19th century. Ships sometimes encountered concentrations of sea ice at times when it would be unlikely to be found today. The besetment of the auxiliary-steamship *Fox* in Melville Bay in August 1857 has been cited as an example (Markham 1981; Dunbar 1985). From this and some similar events Dunbar concluded that "it can definitely be stated that ice conditions in [Baffin Bay] are considerably less severe at present than they were in the 19th century." However, the besetment of the *Fox* and the other ships cited by Dunbar can be explained by specific circumstances unrelated to climate, such a northward displacement of ice like that which that occurred in 1996, for example. In a recent analysis of sea-salt concentrations in a Baffin Island ice core, Grumet (2001) also found that "the last few decades of sea-ice extent lie within Little Ice Age variability and correspond to instrumental records of lower temperatures in the Eastern Canadian Arctic over the past three

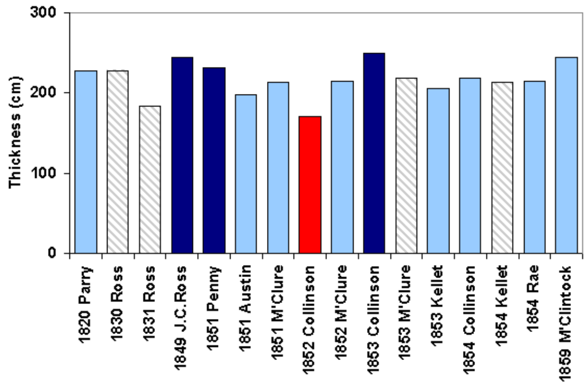

Figure 3. Maximum sea ice thickness measurements made in the years between 1820 and 1859. Red indicates thickness more than one standard deviation less than average, and dark blue indicates thickness more than one standard deviation greater than average, in comparison to ice thickness records compiled in the region between 1948 and 1986 (data provided by Environment Canada). Four measurements shown with cross-hatching were interrupted before the end of the normal ice growth period.

decades." This assessment is congruent with historical descriptions of spring break-up in Davis Strait in the 18th and early 19th centuries and the seasonal migration of whalers through the fishing grounds that correspond closely with present climatology.

3.2 *Annual Sea Ice Thickness*

Measurements of annual sea ice thickness were recorded during many 19th century expeditions. The methodology ranged from simply recording the depth of ice alongside the ship to systematic surveys. Sixteen maximum sea ice thickness measurements made in the years between 1819 and 1859 are presented in Fig. 3. The majority (12 of the 16) were taken between 1851 and 1854, when ice measurements were made by two or more ships in different locations.

Most of these measurements fall between the 20th century mean and +1 standard deviation, though in 4 of the 16 examples the measurement series were interrupted before the end of the usual ice growth season. There are two examples that exceed modern maximum thickness: a single measurement of 244 cm taken in Peel Sound during James Clark Ross' sledge journey in 1849, and a maximum measurement of 250 cm from a series taken during Collinson's winter-over at Cambridge Bay in 1853.

3.3 *Monthly Mean Temperatures*

Thirty-two year-long series of monthly mean surface air temperature, consisting of 343 discrete samples, were collected and compared to a 50-year reference period (1951–2001). Two-thirds of these (21) were taken during the height of the Franklin search between 1850 and 1854, when a large number of ships were deployed across the Arctic. Overall, 63% of the observations fall within one standard deviation of the modern mean, with 41% above the mean and 59% below. Only 19 observations are less than record minimum temperatures for the reference period, and 7 of these occurred in 1853. One observation in 1852 is above the maximum temperature recorded during the reference period.

In the summer period between 1850 and 1854, 85% of the observations were cooler than the reference average, though most (25 of 33) were between the mean and –1 standard deviation for the reference period. June 1851 and June 1853 were warmer than average. However, during the summer surface air temperature is constrained by the presence of melting ice and snow in the area, particularly during the latter part of June and July, making interpretation difficult. An operational factor also caused an additional sampling bias in the historical data: temperature measurements were generally suspended as soon as ice conditions were open enough for the ships to move, and would only continue through the navigation season in August and September if the ships were icebound. Thus, a preponderance of historical summertime data reflect an ice dominated environment, particularly in the month of August when only icebound ships continued to collect data.

3.4 *Observations of Melt and Freeze Phenology*

Because melting ice and snow tend to hold the surface air temperature near the melting point, Rigor (2000) has suggested that the onset of melt and freeze and the length of the melt season would better reflect changes in surface air temperature during the summer. Melt season transition dates are defined when the value of a 15-day running mean of daily temperatures rises above or falls below freezing. This method is relatively tolerant of error in the data, and the resulting transition dates reflect observable changes in the environment.

Fifty-two melt season transition dates were calculated from daily mean temperature data collected on seventeen expeditions between 1819 and 1906 and compared to transition data for the reference period 1979–1997 (Fig. 4). The historical transition dates are within the 20th century range of variability and do not show a marked tendency toward later melt or earlier freeze.

4. DISCUSSION

Neatby (1958) observed that the dangers of the Arctic climate were originally underestimated because people were prone to reason too much on the basis of a few fortunate results and neglect the accidental circumstances which produced them. This caution could equally apply today when conclusions are drawn about the history of

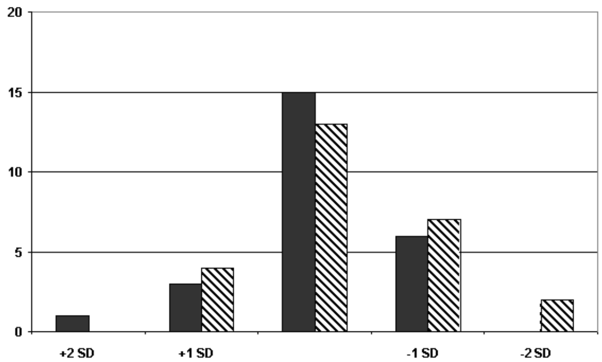

Figure 4. Incidence of 19th century melt season transition dates above and below average for the 20th century reference period 1979–1997. Melt is shown by solid bars, and freeze by cross-hatched bars. The period of summer melt is not inconsistent with modern values.

the Arctic climate on the basis of a few unfortunate results. And indeed, it is misleading to state that the Northwest Passage was not found during the Little Ice Age period when in fact it was.

While the data is limited, it is possible to assess whether the environmental conditions observed on 19th century Arctic expeditions were consistent with the hypothesized severe conditions of the Little Ice Age. The historical data we examined did not fit the Little Ice Age model. Both warm and cool episodes were experienced in comparison to 20th century norms, whereas if there had been a shift in the summertime mean temperature of the large magnitude suggested by the proxy record, evidence of cold conditions should have predominated. However, little evidence of consistently cold or severe conditions was found. The difference may lie in the fact that environmental change at the surface is influenced to a relatively greater extent by interdecadal modes of variability in atmospheric and oceanographic circulation.

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