APPENDIX B

PHYSICAL BASELINE STUDY:
NORTHEAST BAFFIN BAY

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1 PHYSICAL ENVIRONMENT

1.1 Weather

Baffin Bay is surrounded by steep coasts with heights exceeding one kilometre (Fig. 1) that have a significant impact on the local weather. Air flows along the steep coasts instead of across them, and the strongest winds blow primarily from the northwest or southeast (see further below).

Our knowledge of the marine weather conditions is primarily derived from two coastal weather stations located on the west coast of Greenland near the study area: Upernavik in the south, with data from 1873 to the present, and Pituffik in the north, with data from 1948 to the present (Cappelen 2008). Conventional ship-based weather data are very sparse by comparison, and therefore not fully representative of the weather conditions. Because of the scarcity of empirical weather data, numerical models such as the European Centre of Medium Weather Forecasts (ECMWF) have also been used for studies of the weather climatology and trends.

1.1.1 Air Temperature

Baffin Bay belongs is located in an arctic region, with mean air temperatures below 10°C all year round. Summer (July–September) temperatures over the ocean are usually close to the surface water temperatures, which range from -1.8°C to 5°C (Fig. 2), although air temperatures as low as -5°C can occur for short periods. In coastal areas, air temperatures can be as high as +15°C, or even higher, under foehn conditions (Hansen et al. 2004), which can also persist into the winter months. Monthly air temperatures for the coastal stations of Pituffik and Upernavik are given in Figure 3).

Air temperatures, winds, and other meteorological variables undergo a great deal of year-to-year variability in Baffin Bay. The long-term measurements of the yearly mean air temperatures at weather stations along the west coast of Greenland reveal large variations over time scales ranging from a few years to 10 years or longer (Fig. 4). Some of the interannual variability in annual air temperatures can be associated with the North Atlantic Oscillation (NAO) index, computed as the normalized difference in sea level pressure between southwest Iceland and Gibraltar (see Figure 5).
Above (below) normal air temperatures off West Greenland are associated with below (above) normal values of the NAO index. During positive NAO events, storm tracks are more likely to track south of Greenland and a colder arctic airmass becomes more prevalent over Baffin Bay resulting in a negative air temperature anomaly of approximately -3 °C, and more sea ice (Pedersen et al. 2011). A persistent and strong negative North Atlantic Oscillation (NAO) index was responsible for southerly air flow along the west coast of Greenland that caused anomalously warm weather in winter 2010-2011 and summer 2011 (Box et al. 2011).

FIGURE 5. Time series of the winter (December–March) index of the NAO from 1865–1866 to 2010–2011. The heavy solid line represents the NAO index smoothed with a 3-year running mean filter to remove fluctuations with periods <3 years. Source: Osborne (2011).

1.1.2 Winds

Southeasterly and easterly winds prevail along the northern coast of Greenland, and northwesterly winds dominate over the open ocean (Fig. 6). The mean wind velocity for the entire area is ~4m/s. The winds are the strongest and most persistent near the coast. In summer, the winds are generally from the southeast at all locations, with lower wind speeds than those near the coast (Valeur et al. 1996). In winter, the strongest winds blow from the northwest, especially in western and central Baffin Bay.

The occurrence of stronger wind speeds over a few days at a time, especially in summer and early autumn, are associated with low-pressure systems moving northeastward in Baffin Bay and Davis Strait (Fig. 7).

At the windiest locations, Stations 5 and 7 (Figs. 6 and 8), 0.9% of winds over the year are gale force. In summer (June–September), the frequencies of occurrence of gale force winds are reduced to 0.5% at Station 5 and 0.3% at Station 7 (Hansen et al. 2004).

1.1.3 Other Weather Variables

Precipitation

As determined from the coastal weather stations, total precipitation levels are ~200 mm/year, which are small by comparison with southern Greenland. The largest monthly values of precipitation occur in late summer and fall (Fig. 3) with very low levels during the winter and early spring. Most of the precipitation occurs in the form of snow except in summer, when rainfall does occur (Fig. 9).

![Figure 8](image1.png)

**Figure 8.** Occurrence of wind speeds >13 m/s derived from ECMWF data (1980–1993), case interval 6 h. The frame indicates area of interest for hydrocarbon exploration. Source: Valeur et al (1996).

![Figure 9](image2.png)

**Figure 9.** Frequency of precipitation at Upernavik. Source: Valeur et al. (1996).
Visibility

Visibility restrictions attributable to fog occur most frequently in summer in association with ice clearing accompanied by remnants of sea ice and cold surface water temperatures. Fog conditions primarily occur because of the advection of warm, moist air passing over a cold sea surface caused by melting sea ice (Pedersen et al. 2011). The estimated frequency of occurrence of fog in the open waters of July is approximately 30% in offshore areas and decreasing nearer the coastline (Fig. 10). The occurrence of fog decreases later in the summer and in autumn with the decreased presence of sea ice.

1.2 Oceanography

Baffin Bay measures about 1400 km by 550 km with a large abyssal plain in the central region with depths >2300 m. The continental shelf off Greenland is relatively wide compared to the Canadian side, with large canyons traversing the shelf. The outer shelf extends to water depths of ~400–600 m. Baffin Bay is connected to the Labrador Sea by its biggest and deepest channel, Davis Strait, which has a sill depth of ~650 m and a width of ~170 km at the 500-m contour (Fig. 11). It is also connected to the Arctic Ocean through narrower channels: Smith Sound, Jones Sound, and Lancaster Sound, located to the northwest with sill depths of 250 m, 120 m, and 125 m, respectively (Tang et al. 2004).

Oceanographic data, primarily temperature and salinity in northeastern Baffin Bay, have been collected since the late 1920s (Kiilerich 1939). The measurements have been limited to summer and early autumn, and have been sporadic compared to the marine areas off southwest Greenland.

1.2.1 Water Masses

Baffin Bay has three major water masses (Tang et al. 2004):

- The Arctic or Polar Water, forming the upper water column of Baffin Bay, is cold and has low salinity. This water mass is formed by mixing between the upper layer of water entering Baffin Bay on the eastern side of Davis Strait, which is cooled in winter as it circulates in the Bay, and the inflow of upper water from the Arctic Ocean via Lancaster, Jones, and Smith sounds, which has been cooled in the Arctic Ocean in previous winters. Salinities are 32–34 psu (practical salinity units), with a prominent temperature minimum as low as -1.7°C at a salinity of 33.7 psu. The Arctic Water extends to water depths of ~100 m in eastern Baffin Bay, and up to 300 m in western Baffin Bay.

The West Greenland Intermediate Water warm layer is found below the Arctic Water to depths of up to 800 m in most of Baffin Bay. It has temperatures >0°C and salinities >34 psu. This water mass is advected into Baffin Bay by the West Greenland Current and is of Atlantic Ocean origin in the areas southeast of Greenland in the Irminger Basin and the southeast Greenland shelf (under the influence of the East Greenland Current), with modifications in Davis Strait off southwestern Greenland.

The Baffin Bay Deep Water (to 1800 m deep) and Baffin Bay Bottom Water (>1800 m deep), which are present below the West Greenland Intermediate Water. These water masses occur well below the Davis Strait sill depth and have no direct access the Atlantic and Arctic Ocean water masses. Here, the salinity changes little and the temperature decreases consistently to the bottom. The salinity in these two water masses is only slightly less than 34.5 with a minimum at 1800 m. The temperature at the bottom is approximately -0.5°C.

The temperature, salinity, and density across northern Baffin Bay are plotted in Figure 12. The temperature minimum in the Arctic Water is clearly present in western to central Baffin Bay as seen by the cold temperatures of less than -1°C. In eastern Baffin Bay, the temperature minimum is at higher temperatures exceeding -1°C. The temperature maximum exceeding +1°C is also evident in the West Greenland Intermediate Water mass at water depths >500 m in western Baffin Bay and a few hundred metres in eastern Baffin Bay.