European trading, whaling and climate history of West Greenland documented by historical records, drones and marine sediments

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The European trading and whaling activities of the 17th–19th centuries provide records of climate and sea- ice conditions off West Greenland in the form of ships' logs and other official documents in many archives around Europe. These documents, combined with evidence from marine sediments, help describe climate changes in general, and sea-ice volume changes in particular, in connection with human activity in the region. The Greenland National Museum & Archives in Nuuk (NKA) hosts a unique collection of original documents presenting detailed insight into weather and ice conditions as well as the daily life of the colonial centres and outposts recorded by the documents of the Danish administration. These documents also reveal many aspects of the interaction between the Inuit and Europeans from 1779 onwards. Information retrieved from the archives in Nuuk has been combined with results from palaeo-environmental investigations of marine sediment cores to unravel climate variability and changes in sea ice. This information has been supplemented with data from an extensive field programme using drones to document onshore remains from the whaling period in the Disko Bugt region (Fig. 1).

History of European whaling off West Greenland

European Arctic whaling around Svalbard and Jan Mayen declined in the early 18th century, and it has been debated whether over-exploitation (e.g. Nansen 1924) or climate change (e.g. Vibe 1967) was responsible for the decline. European summer temperature records (Luterbacher *et al.* 2016) indicate that the decline coincided with a marked climate cooling in Europe. High hunting pressure on the whales and thick sea-ice cover in Svalbard waters early in the 18th century apparently forced the whale population to seek away from inshore areas into the ice-loaded waters farther offshore. As a consequence, European whaling companies began to look for other areas, which led them to explore the whale resources of the Davis Strait. Taking a general 'seesaw' winter-climate pattern between (West) Greenland and Europe into consideration (Seidenkrantz *et al.* 2008), in contrast to the cold conditions around Svalbard (Luterbacher *et al.* 2016), the sea-ice and whaling conditions in Disko Bugt around 1700 were likely more favourable. A large part of the European whaling fleet therefore moved their activities to the Davis Strait off West Greenland where the Disko Bugt region became the focal point of whaling activities. In the region, the European whalers' contact with the local Inuit population significantly impacted their culture and living conditions through the exchange of goods and social interaction.

In 1719, an increased number of Dutch whaling vessels started to operate in the Davis Strait (Leinenga 1995; Hacquebord 2006) with the Greenland (bowhead – *Balaena mysticetus*) whale as the main target. Whaling activities in the

Fig 1. Disko Bugt was the focus of whaling activities in past centuries. Areas investigated in 2016 and 2017 were Rodebay embayment, Hunde Ejland and Pullat. A sediment core POR16_RB#1 was retrieved just outside the Rodebay embayment.

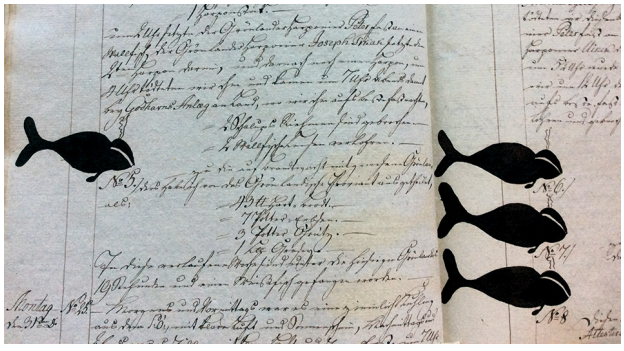

Fig 2. Whales caught by Danish shore-based whaling stations were numbered and often drawn as cartoons in Danish reports. This document clearly illustrates that whaling had been successful for the period reported (source NKA Archives, Nuuk).

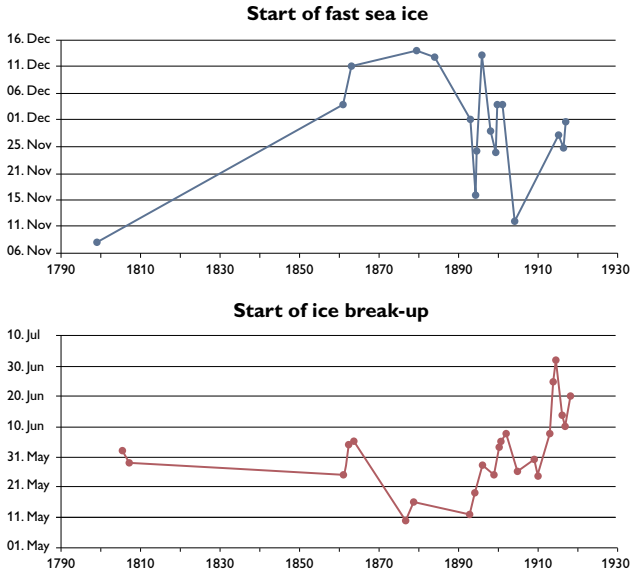

Fig. 3. Dates of freezing and ice breakup in the Upernavik district plotted from archival data. The time of sea-ice breakup shows a clear shift, with the sea-ice duration increasing by *c.* 40 days over a period of *c.* 30 years (*c.* 1890–1920; A. Kuijpers, unpublished data 2014).

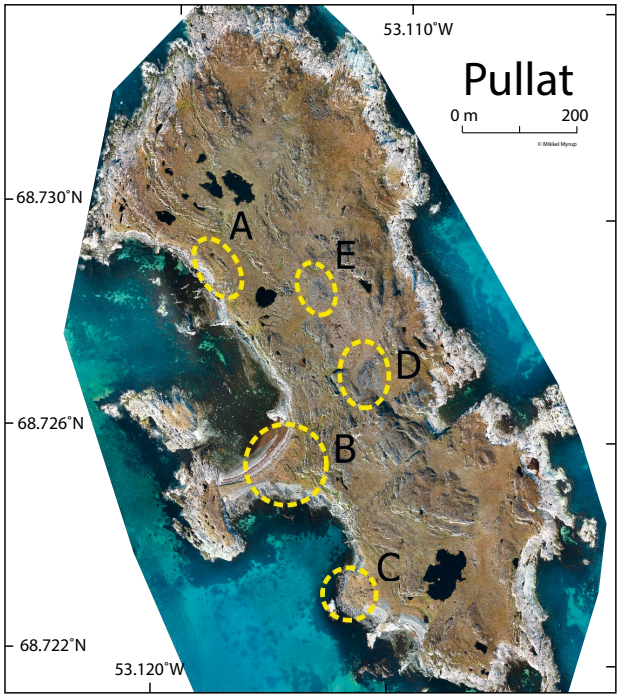

Fig. 4. Remains from the coastal whaling period on the island of Pullat are documented on the orthophotomosaic based on drone flights. **A**: winter house. **B**: the main structures from the whaling station period 1823–1825. **C**: winter houses. **D**, **E**: grave fields. Photo: M. Myrup 2017.

Davis Strait were concentrated around Disko Bugt. In 1721, Denmark affirmed sovereignty over Greenland and in 1776 established the state-owned Royal Greenland Trade Department (KGH) with whales and seals as the primary commodities. This Danish initiative had difficulty competing with other highly efficient whaling fleets and after disappointing catches, further attempts with Danish sea-going whaling ceased after 1780. Instead Danish activities primarily used shore-based stations for sealing and whaling and this hunting turned out to be economically successful in the following decades.

After the Napoleonic wars, European demand for whale products increased, and new Danish coastal whaling projects were started in the Davis Strait area (e.g. the island of Pullat off the coast at Aasiaat – Egedesminde). However, due to increasing industrial use of coal and other types of oil in Europe and as a consequence of a series of severe ship losses early in the 19th century, the Davis Strait whaling lost its importance.

Evidence from historical archive data

Data from several whaling settlements are available in the archives in Nuuk and provide a wealth of detailed information after 1779 on weather, sea ice occurrence, number of whales caught (Fig. 2) as well as results from hunting, fishing, travelling, social life, health conditions, religious celebrations and occasional visits by European whalers (NKA archives). Successful coastal whaling was only possible with participation of the local Inuit population, in many cases also involving women. The European whaling activities thus had significant impact on the previously prosperous Inuit hunting and their traditional way of life. The Inuit women's national costume rich in bead decoration, and various forms of folk dance music are examples of social interaction between the two groups. Although Dutch whaling activities along the West Greenland coast had virtually ceased by 1800, a series of geographical Dutch names are a reminder of this period, such as: Vaigat (Dutch for windy passage), Rodebay, Fortunebay, Grønne Ejland, and Hunde Ejlande.

In the early 20th century, Scottish whalers, the only group still active in the area, moved their centre of activity northwards and made port calls at Upernavik instead of Disko Bugt. As can be seen in the historical records from Upernavik (Fig. 3), this period is clearly characterised by longer sea-ice seasons than in the later part of the 19th century suggesting that better whaling conditions in the early 20th century had shifted northwards into more ice-affected areas along the west coast of Greenland.

Tracing past whaling activities onshore

The coastal areas of the Disko Bugt region display a rich variety of physical remains from the whaling period. To locate and investigate former whaling sites, Mikkel Myrup from

Fig. 5. Among the graves in the 'Old Whalers Graveyard' on Kitsissuarsuit (Hunde Ejlande), two graves are marked with plain squared timbers. This type of grave marking has only been found in the old whalers' graveyard on Svalbard established in the 17th century. Modern graves with the traditional white painted wooden crosses are seen in the background.

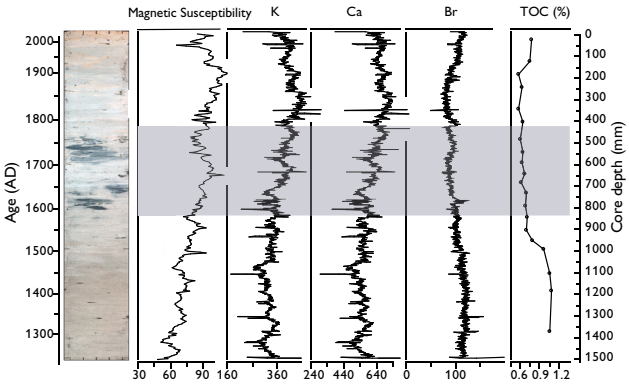

Fig. 6. Sediment core POR16_RB#1 was retrieved just outside the Rodebay embayment. The geochronology of this 158 cm core was based on ^{210}Pb and ^{137}Cs analyses of the upper 15 cm, and 3 AMS ^{14}C dates on marine bivalves. The prominent dark colouring of the interval corresponding to the period *c.* AD 1600–1750 of the Little Ice Age reveals the presence of non-oxic conditions most likely due to persistent sea-ice cover. Sediments deposited after AD 1600 display regular oscillations in K and Ca with a duration of close to 80 years.

NKA in 2017 undertook a number of drone operations in three areas in the Disko Bugt region: Oqaatsut (Rodebay), Kitsissuarsuit (Hunde Ejlande) and Pullat (Fig. 1).

The small Greenlandic settlement Oqaatsut (Rodebay) is located in a protected embayment just north of Ilulissat. In the 1600s, this area was called 'Roo Baj – Red Bay' by the Dutch. Whales caught locally by traditional whaling techniques were pulled ashore on the flat rocks where blood from the butchered animals coloured the small embayment red. Today remains from the whaling activities are visible in the form of natural butchering places created by rock depressions with winches still present.

Amongst other structures still visible are the remains of a whaling station established by Danish authorities on the island of Pullat in 1823 (Fig. 4). It was a sudden and intense effort by KGH to boost the coastal-based whaling activity in the area and also to counteract the strong presence of European whalers interacting with the Inuit farther north. The whaling station at Pullat, however, was closed after only two years due to unsuccessful whale hunting. Towards the middle of the 19th century, KGH eventually gave up the whaling outposts in the Disko Bugt region and focused its efforts on seal hunting and procuring other Greenlandic products.

The graveyard on Kitsissuarsuit (Hunde Ejlande) hosts modern graves with traditional white-painted wooden crosses and a central section from the European whaling period. This central section known as 'the Old Whalers Graveyard' is occupied by *c.* 100 graves covered by elongated stone piles. Unlike the modern white crosses, two of these graves are marked with plain wooden, squared posts (Fig. 5). Similar old graves are reported from the graveyard 'Liknesset' on north-western Svalbard, which was established by Dutch whalers in the 17th century.

Evidence from marine sediment records

In August 2016, A sediment coring campaign was undertaken from the Research Vessel *Porsild*. Twelve sediment cores were retrieved from the Rodebay area to obtain a record of climate and hydrographic changes and possible environmental effects of human activity in this area spanning the whaling period. Cores collected from the enclosed inner part of the Rodebay area consist of unconsolidated mud with high organic contents are underway. DNA analyses will be performed on these cores to identify which mammalian species were slaughtered at the site throughout the whaling period. To capture changes in the marine environment a core (Core POR16_RB#1) was retrieved just outside the Rodebay embayment. The geochronology of this 158 cm core was based on ^{210}Pb and ^{137}Cs analyses of the upper 15 cm, and 3 AMS ^{14}C dates on marine bivalve shells. The age-model was constructed using Bayesian analyses with the BACON package available in the R platform. The radiocarbon offset used was 140 ± 60 years, and radiocarbon dates were calibrated using the Marine13 calibration curve. The core was XRF scanned and analysed in terms of magnetic susceptibility and total organic carbon (TOC) content (Fig. 6). The prominent dark colouration of the interval corresponding to the period *c.* AD 1600–1750 reveals the presence of poorly oxygenated sediments. Locally enhanced organic matter fluxes can be expected at this site to originate from whale butchering colouring the sediments black. However, this dark interval precedes by *c.* 100 years the beginning of intensive whaling activity in the region, and the organic carbon content does

not indicate enhanced fluxes in organic matter. Instead, local hydrographic conditions with reduced bottom-water oxygenation are likely to be responsible for the dark layers. This sediment interval corresponds to one of the more severe Little Ice Age cooling episodes during which the sea-ice cover along the coast of the inner part of Disko Bugt may have persisted throughout most of the year (Ribeiro *et al.* 2011).

During cold intervals of the Little Ice Age, the mean annual temperature in the Disko Bugt region area was 2–4°C lower than present day values (Humlum 1999). Prior to this period of generally colder climate, about 1000 years ago, the regional atmospheric climate was relatively mild in West Greenland, but soon after, i.e. close to AD 1200, average temperatures started abruptly to decline by as much as 4°C over about 80 years (D'Andrea *et al.* 2011). This climate deterioration involved an increase of widespread ice formation in the inshore waters and fjords of West Greenland (Kuijpers *et al.* 2014). Regional climate since then has remained generally colder until about 150 years ago, although with large fluctuations (Ribeiro *et al.* 2011).

The XRF data of core POR16_RB#1 reveal regular oscillations in the upper part of the core that appear to occur on a multi-decadal time scale. During the past 1000 years, 60–80 years periodicity is noted in sea-surface conditions of the Disko Bugt areas (Allan *et al.* 2018) suggesting clear linkages with the 'Atlantic Multidecadal Oscillation' (AMO) in which warmer and more saline North Atlantic surface-water conditions alternate with cooler and less saline conditions around AD 1910 (Reverdin 2010).

Based on historical information from the KGH records from Upernavik (A. Kuijpers, unpublished data 2014), the temperature and salinity may also be reflected by the duration of the sea-ice season off West Greenland, which in the beginning of the 20th century extended into June (Fig. 3). Such a relationship between winter sea-ice conditions in the north-western North Atlantic and 'Atlantic Multidecadal Oscillation' has also been reported by Chan *et al.* (2017), who found that during the past four centuries an extended sea-ice cover and associated reduced ice productivity can be linked to the cool phase of the 'Atlantic Multidecadal Oscillation'.

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