Geomorphological evidence for an ongoing transgression on northwestern Svalbard

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Cover Picture: Hjellen and Kiärfjellet, facing south. Modified after http://toposvalbard.npolar.no/ © A. Skoglund / Norsk Polarinstitutt.

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KRISTIAN WESTLUND

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Abstract: Rise and fall of the global sea level during Pleistocene and Holocene are mainly caused by glacio-isostatic and glacio-eustatic factors directly linked to the cyclic increase and decrease of the Earth's ice sheets. Apart from the dominating glacio-isostatic and glacio-eustatic factors, several other components have influenced the global sea level, which complicates the regional sea level curves of the world. One place with such a complicated *relative* sea level curve is northwestern Svalbard, which was covered by ice sheets during the Weichselian glaciations and started to emerge when it was deglaciated around 13 ^{14}C ka BP. Since the 1950s numerous authors have argued that there is an ongoing transgression taking place at northwestern Svalbard based upon sedimentary and geomorphological ground and the dating of whale bones.

The development of geomorphological features such as lagoons, estuaries and deltas forming in protected areas, are all linked to fluctuations in sea level and can be used to determine whether or not a sea level rise is taking place. A combined map, satellite image and aerial photo analysis has been done to determine whether or not there is an ongoing transgression taking place at northwestern Svalbard and if the coastline can be considered a representative transgressive coast. The study supports the hypothesis of a slow, ongoing transgression but does not offer conclusive evidence for the same. Hence the coastline cannot be considered a typical example of a transgressive coast.

Keywords: sea level, Svalbard, geomorphology, lagoons, estuaries, deltas

Supervisor(s): Helena Alexanderson

Subject: Quaternary Geology

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Geomorfologiska bevis för en pågående transgression på nordvästra Svalbard.

KRISTIAN WESTLUND

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Sammanfattning: Höjningar och sänkningar av den globala havsnivån under pleistocen och holocen har framför allt styrts av glacio-isostatiska och glacio-eustatiska faktorer, direkt kopplade till de cykliska ökningarna respektive minskningarna av Jordens istäcken. Förutom de dominerande glacio-isostatiska och glacio-eustatiska faktorerna har flera andra komponenter påverkat havsnivån, vilket komplicerar de regionala havsnivåkurvorna på olika platser i världen. Ett sådant område med en komplicerad *relativ* havsnivåkurva är nordvästra Svalbard. Där inleddes en landhöjning efter att regionens istäcken började smälta under slutet av weichselglaciationen, ca 13 ^{14}C ka BP. Sedan 1950-talet har flera forskare argumenterat för att det pågår en transgression på nordvästra Svalbard, baserat på sedimentära och geomorfologiska tecken samt datering av valben.

Utvecklingen av geomorfologiska fenomen, såsom laguner, estuarier och deltan som bildas i skyddade områden, är nära kopplad till förändringar i havsnivå och kan användas för att fastställa huruvida en havsnivåhöjning pågår. En kombinerad kart-, satellit- och flygbildsanalys har gjorts för att undersöka om det pågår en transgression på nordvästra Svalbard samt om kustlinjen kan anses vara en representativ transgressiv kustlinje. Studien stödjer hypotesen om en långsam, pågående transgression, men helt entydiga resultat har inte kunnat uppnås. Därför kan inte heller kustlinjen anses vara ett typiskt exempel på en transgressiv kust.

Nyckelord: havsnivå, Svalbard, geomorfologi, laguner, estuarier, delta

Handledare: Helena Alexanderson

Ämnesinriktning: Kvartärgeologi

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1 Introduction

It is a globally widespread realization today that we can expect great human induced climate changes in the coming decades and century but the full spectrum of consequences of the expected climate changes are impossible to predict with certainty. One of the foreseen effects of a warmer climate is a rising sea level, something that already today pose a real threat for millions of people living in coastal communities (Jackson *et al,* 2013; Hapke *et al*, 2013). In the latest report from the United Nations' climate panel (IPCC) it is stated that between 1901 and 2010, the global mean sea level rise has been between 1.5 and 1.9 mm/year and that it is *very likely* that we can expect an increase to between 4.5 and 16 mm/year in the coming century, depending on how big our future greenhouse gas emissions will be (Church *et al*, 2013).

Rise and fall of the global sea level during Pleistocene and Holocene are mainly caused by glacio-isostatic and glacio-eustatic factors directly linked to the cyclic increase and decrease of the Earth's ice sheets (Bednarski, 1988; Bird, 2000; Lambeck & Chappell, 2001; Miller *et al*, 2005; Davidson-Arnott, 2009; Huggett, 2011). The glacio-isostatic adjustment occurs as the weight of the ice sheets cause the continents to sink (as the ice load increases) or rebound (as the load of the ice decreases) and leads to a rise in sea level as the land sink or a fall in sea level as the land is rebound (Bird, 2000; Lambeck & Chappell, 2001; Davidson-Arnott, 2009; Huggett, 2011). The glacio-eustatic changes in sea level are generated by the adding and subtraction of water to the oceans as the icesheets respectively melt and build up (Bird, 2000; Miller *et al*, 2005; Davidson-Arnott, 2009; Huggett, 2011). Therefore the climate on Earth plays a significant role for the global sea level as the mean temperature controls the increase and decrease of the Earth's icesheets. Apart from the dominating glacio-isostatic and glacio-eustatic factors, several other components have influenced the global sea level, which complicates the regional sea level curves of the world (Mörner, 1976; Mörner, 2005; Woodroffe & Murray-Wallace, 2012).

These complicating factors has led to the notion of an *absolute* sea level, which is the absolute elevation of the ocean surface, and a *relative* sea level, which is the elevation of the sea compared to the land in a specific region (Pethick, 1984). This means that even though the annual global sea level rise is accounted for, in some regions, the *relative* sea level can actually be falling, if for instance the land is under the effect of tectonic or glacio-isostatic adjustment and therefore rising. One such place is Svalbard, which was covered in ice sheets during the Weichselian glaciation (Landvik *et al*, 1998).

As the western and northwestern regions of Svalbard was deglaciated around 13 ^{14}C ka BP, the coastline started to emerge (Forman *et* al, 1987; Forman, 1990; Andersson, 2000; Forman *et al*, 2004; Salvigsen & Høgvard, 2005). On Bröggerhalvöya a typical beach morphology, dated to 13-11^{14}C ka BP, is found at and below 45 m above high tide (aht) (Lehman&Forman, 1992; Forman *et al*, 2004). The boundary at 45 m aht is interpreted as the Late Weichselian marine limit (i.e. the max altitude of littoral processes during the last deglacial cycle) for Bröggerhalvöya (Forman *et* al, 1987; Forman *et al*, 2004). Between 45 and 20 m aht three distinct, large barrier beach ridges are found, with 100-200 m wide crests and a relief of up to 5 m while below 20 m aht, several smaller (5-10 m wide with a relief of up to 2 m) barrier beach ridges can be seen (Forman *et al*, 2004). This typical beach succession can be seen in several places at Spitsbergen, but the elevation varies with the Late Weichselian marine limit which is different for different localities (Forman *et al*, 2004).

This morphology indicates that the emergence and relative sea level fall following the deglaciation of northwestern Svalbard first was slow with three standstills or even transgressions taking place (the formation of the three large barrier beach ridges between 45 and 20 m aht) and then grew more rapid after the formation of the lowest large barrier beach ridge, only forming numerous small-scale beach ridges down to the present sea level where a large, coarse, clastic barrier beach ridge forming (Forman *et* al, 1987; Landvik *et al*, 1987; Forman, 1990; Lehman & Forman, 1992; Forman *et al*, 2004).

Numerous authors have argued that there is an ongoing transgression taking place at northwestern Svalbard, with *sedimentary* arguments founded upon the facts that marine and coastal sedimentary deposits can be found covering terrestrial deposits and peat, *radiocarbon dating* of whalebones and *geomorphological arguments*, such as the marine erosion of anthropogenic remnants along the coasts, the current forming of a large barrier beach ridge on several beaches along Spitsbergen and truncated alluvial fans and talus cones, mainly along the northernmost coasts of Svalbard (Feyling-Hanssen, 1955; Rudberg, 1986; Forman *et al*, 1987; Forman, 1990; Andersson, 2000; Brückner & Schellmann, 2003; Forman *et al*, 2004; Salvigsen & Høgvard, 2005). Forman (1990) is even more specific and states that it is a slow transgression that likely was initiated around 2 to 1 ka BP. Whalebone dating also indicates that sea level has at least not fallen during the last century (Forman, 1990).

On eastern Svalbard, the morphology comprises a single generation of raised beaches with an elevation of between 50 and 130 m aht, indicating an almost exponential emergence (Forman *et al*, 2004). The dating of the deglaciation of eastern Svalbard is also different, with a later start, at about 10.5-10 ^{14}C ka BP (Forman *et al*, 2004). Evidence show that western Svalbard was located at or just adjacent to the margin of the Late Weichselian ice sheet while eastern Svalbard was located at or close to the zone of highest ice sheet loading (Landvik *et al*, 1998). The different emergence curves of Svalbard can be seen in Fig. 1.

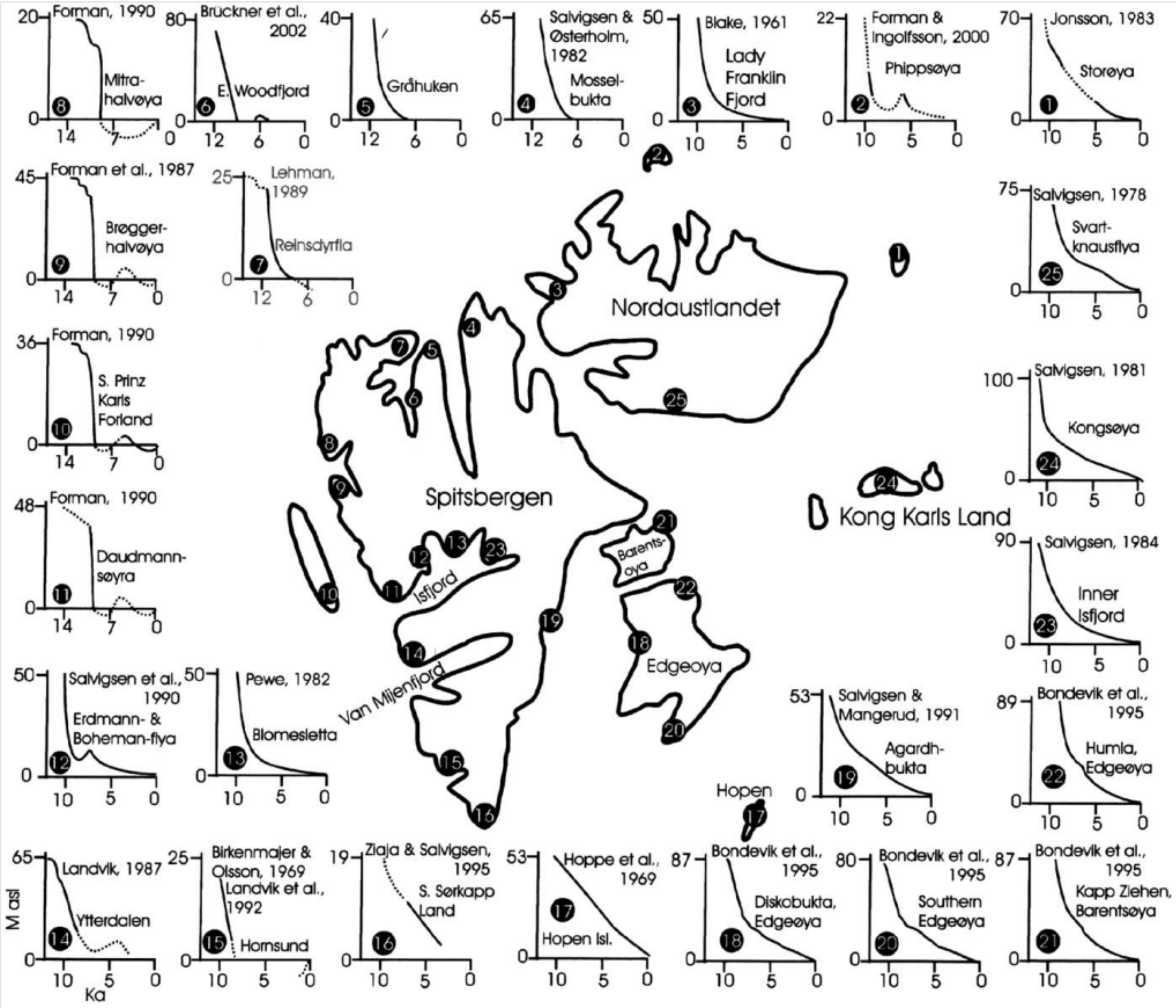

Fig. 1. Showing main part of glacial emergence curves for Svalbard, composed by the results of studies of forelands on Svalbard. (After Forman *et al*, 2004).

2 Aim

Today, there is an increasing interest, both in the scientific debate and among the public, for the effects of a changing climate on the sea level. An ongoing long term study is using GPS and satellite data to determine global, regional and local sea level changes, but there is still considerable time left for the study to show scientifically verified decadal or longer trends (Woodroffe & Murray-Wallace, 2012).

Meanwhile, there are other tools that can be used to determine whether or not a relative sea level change is taking place in different regions. One such tool is geomorphology, as the geomorphologial features of a region can indicate what is happening to the *relative* sea level in that locality (Dominguez *et al*, 1992; Martin & Dominguez, 1994; Bird, 2000; Davidson-Arnott, 2009; Huggett, 2011). The region of northwestern Svalbard (see Fig. 2) is interesting for such a study for two reasons;

- The region has been emerging for several thousands of years with only minor transgressions taking place.
- An ongoing transgression has been suggested in the region by several scientists.

This study aims to further investigate the geomorphology of northwestern Svalbard with emphasis on signs of an ongoing transgression and will try to answer the questions;

- Does the geomorphology of northwestern Svalbard support the hypothesis of an ongoing, slow transgression taking place in the region?
- Does the coastline of northwestern Svalbard represent a typical transgressive coast?

3 Geomorphology and sea level

The development of a coastal landscape and its geomorphology is strongly influenced by sea level, therefore the geomorphological features of a region can indicate what is happening to the relative sea level in that locality. For instance, studies show that during a sea level standstill or a transgression, the dominant geomorphological features found on coastlines are barrier beaches and barrier island-lagoons (Möller, 1984; Dominguez *et al*, 1992; Martin & Dominguez, 1994; Forman *et al*, 2004). Existing rivers do not empty their sediment supply onto the shelf, instead river deltas form in the protected surroundings of bays, estuaries and lagoons (Dominguez *et al*, 1992; Martin & Dominguez, 1994). As the nearshore waters deepen, increased erosion often takes place due to higher wave energy and a retrograding coast is seen (Bird, 2000; Huggett, 2011; Woodroffe & Murray-Wallace, 2012). As the sea level rises, the lagoons and estuaries will deepen and grow larger, new inlets may open and eventually the lagoons may open up to become marine bays (Bird, 2000; Huggett, 2011). In some rare cases, a sea level rise can actually lead to a aggrading or prograding beach, if for example the rising water table reaches rivers with a larger discharge or other greater sediment suppliers or the increased erosion leads to an increase in sediment supply, which can counteract the drowning of the coastline (Bird, 2000).

During a sea level fall, the most common geomorphological feature seen, is prograding wide beach ridge plains, whereas lagoons and barrier beaches will not be formed but instead be replaced by the wide beach ridge plains while river empty their discharge

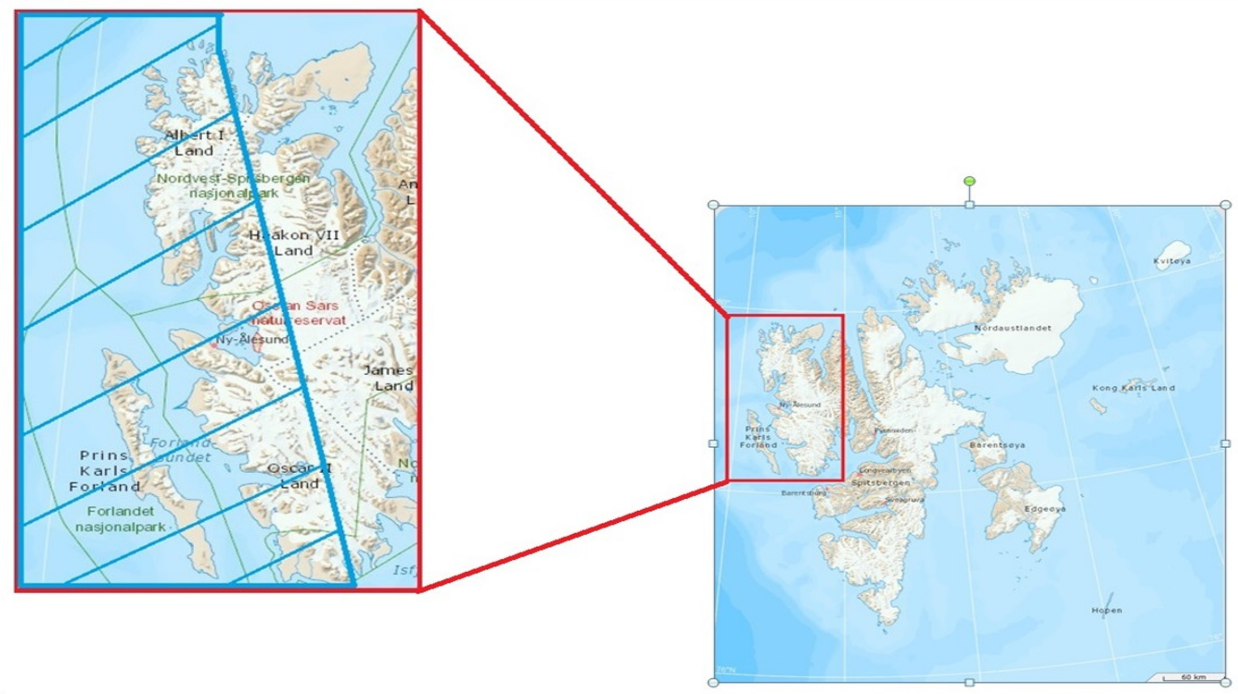

Fig. 2.Right part of the figure showing an overview map of Svalbard. In the red marked area is NW Svalbard, being shown magnified in the left side of the figure. Striped blue area is the coastal area being investigated in this study. (Modified after http://toposvalbard.npolar.no/).

directly on to the shelf (Dominguez *et al*, 1992; Martin & Dominguez, 1994; Bird, 2000; Fraser *et al,* 2005; Huggett, 2011). Described below are several such geomorphological features applicable to Svalbard and their respective correlation to sea level changes.

3.1 Lagoons and sea level

Coastal lagoons are for this study defined as bodies of comparatively shallow water with limited or no connection to the sea due to sealing barriers or spits, usually of sand or shingle (Pethick, 1984; Dominguez *et al*, 1992; Martin & Dominguez, 1994; Bird, 2000; Davidson-Arnott, 2009; Huggett, 2011)

The reason lagoons are formed mainly during periods of transgressions is explained with the help of Bruun's rule. Bruun's rule states that if a coast is in equilibrium, i.e. neither gaining nor losing sediment over a specified time period, a rise in sea level would result in a land- and upward movement of the beach-profile (Bruun, 1962). This means the beach will grow upward in balance with the rising sea level, but the swale behind the beach will stay at the same low level and will with the rising sea level, eventually develop into a lagoon (Martin & Dominguez, 1994; Bird, 2000). This type of process is known as "mainland beach detachment" and is the dominant lagoon-creating on process on low relief coastlines with loose sediments (Martin & Dominguez, 1994; Bird, 2000). Lagoons developed this way commonly have their long axis parallel to the shoreline with straight or nearly straight barrier islands; see Fig. 3 (Martin & Dominguez, 1994).

On coastlines with a higher relief, the rising sea level creates a coastline of alternating headlands and bays (Martin & Dominguez, 1994; Bird, 2000). The coastline will try to maintain its lateral continuous profile by the erosion of the headlands, the longshore dispersion of the eroded material and the final enclosing of the restricted bays through the building of spits (Penland *et al*, 1988; Martin & Dominguez, 1994). During storms, the spits can break up into segments, creating more characteristic barrier islands (Martin & Dominguez, 1994). This lagoon-creating process is called "coastwise spit progradation" and commonly creates deeper lagoons with their long axis perpendicular to the coastline; see Fig. 4 (Martin & Dominguez, 1994).

In some rare cases lagoons can form during a fall of sea level, through the process of "coastwise extension of sand spits", on the downdrift side of river mouths or when the shape of the coastline changes, as if for example the coastline has a continuous lateral profile, but during the sea level fall, an earlier coastline that was submerged, with high relief (as the one shown in Fig. 4) once again is emerged (Martin & Dominguez, 1994). This type of lagoon generally form during conditions of stable or very slowly changing sea levels, they only exist temporally because of their tendency to form in zones with high sediment supply

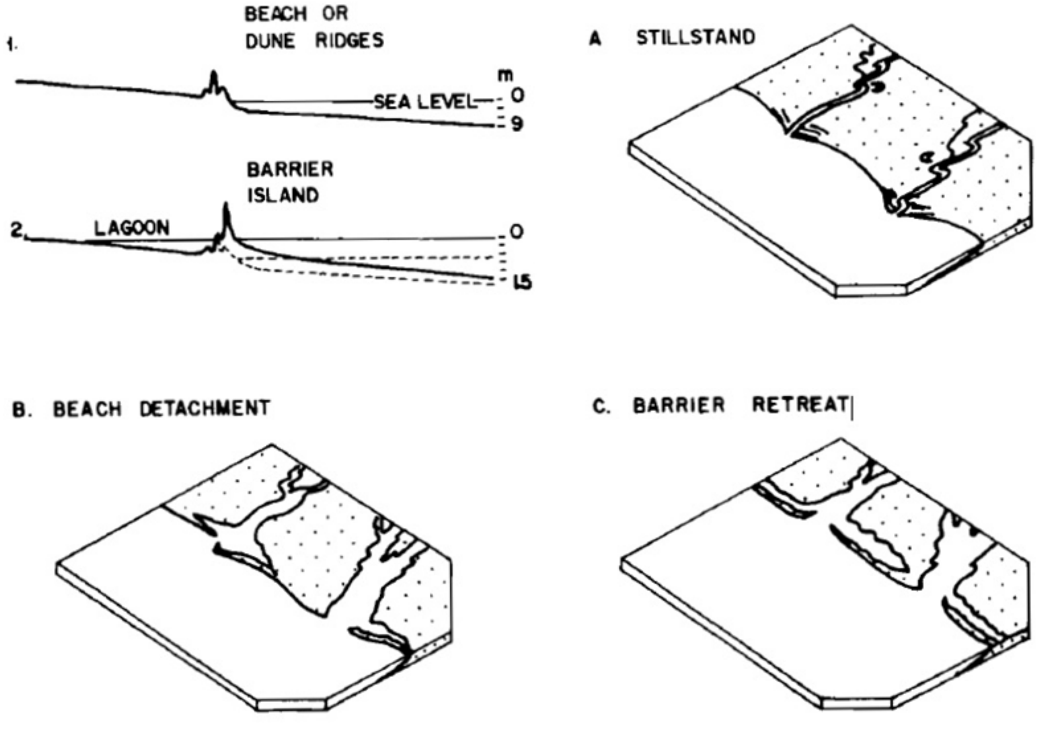

Fig. 3. The process of "mainland beach detachment" for lagoons forming on a low relief coastline, as a rise in sea level takes place. (After Martin & Dominguez, 1994).

and they are very rare (Martin & Dominguez, 1994).

Lagoons and barrier island systems are formed exclusively on meso- and microtidal coastlines, i.e. where the tidal range is less than 4 m, which makes it possible for lagoons to form on Svalbard, where the tidal range is microtidal, 1-2 m (Forman, 1990; Martin & Dominguez, 1994).

The exchange of fresh water and oceanic water in lagoons is often made through incised channels, tidal inlets, but can also be made through seepage in barriers consisting of coarse material, or through spillover; see Fig. 5 for an example of a lagoon without tidal inlets.

3.1.1 Lagoonsystems

As a result of wave- erosion and deposition, spits and barriers can form inside a lagoon, effectively segmenting the lagoon into a lagoonsystem, i.e. several smaller, interconnected lagoons (Bird, 2000; Davidson-Arnott, 2009; Huggett, 2011). The shape of the lagoonsystem is closely connected to the local wind regime (Bird, 2000).

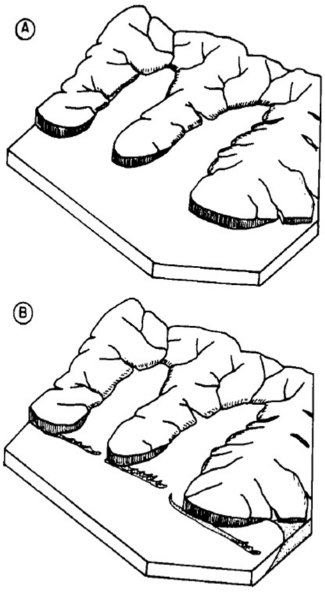

Fig. 4. The process of ”coastwise spit progradation” for lagoons forming on a medium to high relief coastline, as a rise in sea level takes place. (Modified after Martin & Dominguez, 1994).

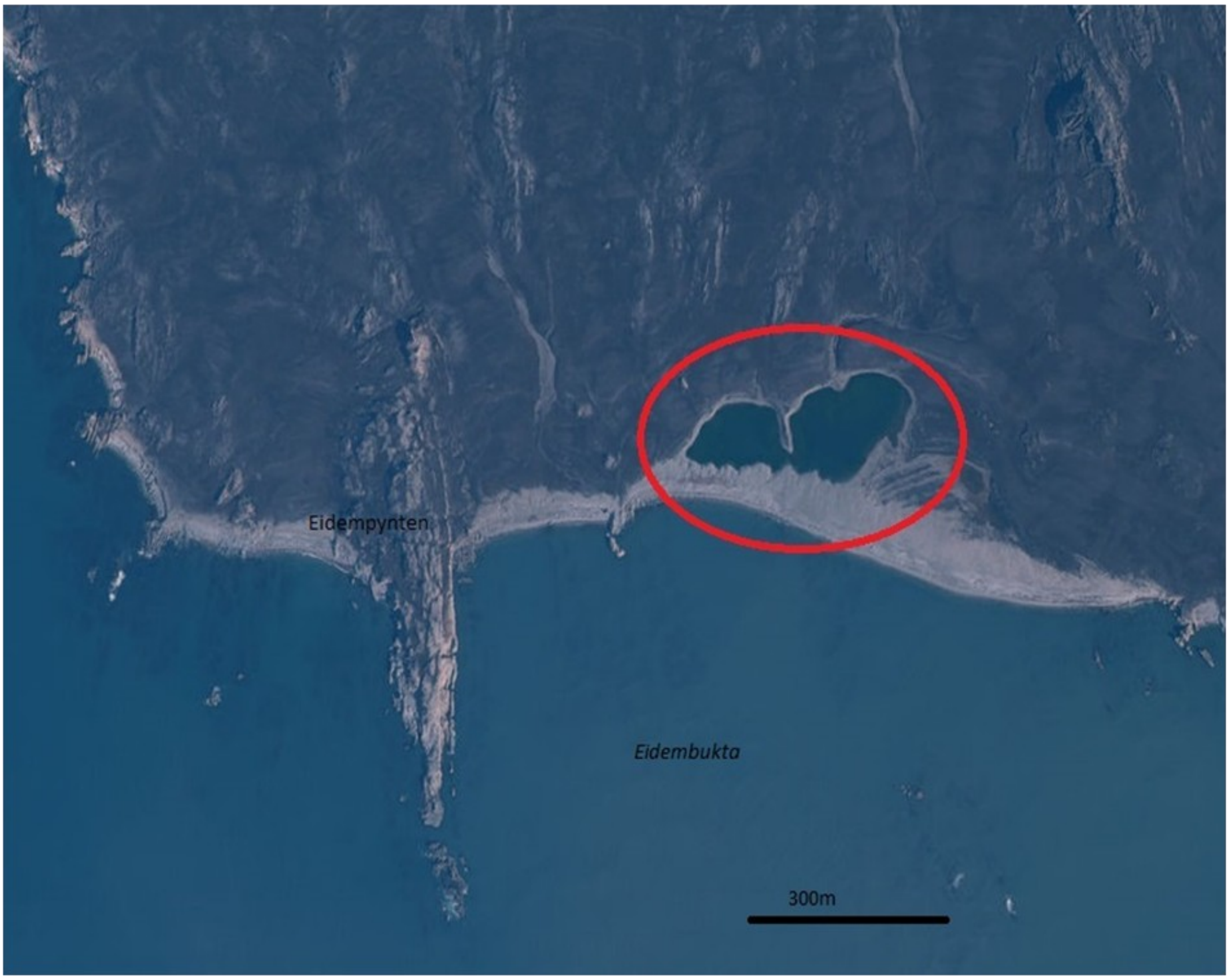

Fig. 5. Aerial photo of feature No. 21, a lagoon with no visible tidal inlets, on the coastline of northwestern Svalbard. For information about a single specific feature, see Appendix I and II. (Modified after http://toposvalbard.npolar.no/).

3.2 Estuaries

Estuaries are for this study defined as river channels shaped by unidirectional flow that widen downstream to a partially enclosed transition zone between rivers and the open sea, subject to tidal fluctuations, where fresh water mixes with salt oceanic water and sediment is supplied both from the river's catchment area and from marine sources (Pethick, 1984; Bird, 2000; Davidson-Arnott, 2009; Huggett, 2011).

Most estuaries are formed when a carved out river valley is drowned by a rising sea level, and the former incised river channel is widened and deepened, forming the partially enclosed transition zone that is the estuary, see Fig. 6 (Pethick, 1984; Bird, 2000; Davidson-Arnott, 2009; Huggett, 2011).

During a rise of sea level, estuaries will generally widen and deepen while they move landwards (Bird, 2000; Huggett, 2011). The sediment discharge of the rivers will be thwarted and a larger part of the fluvial sediment supply will stay in the estuary instead of flowing out onto the sea floor or surrounding coast (Bird, 2000).

3.2.1 Fiords and sea level

Fiords are a kind of estuary that formed when formerly glaciated valleys and troughs were submerged and drowned by the rising sea when the late Weichselian ice sheets melted (Pethick, 1984; Bednarski, 1988; Bird, 2000). They are often deep (300-400 m is common, but depths of more than 1300 m exist) and have a submerged sill at their mouths, limiting the flow of tidal water (Pethick, 1984; Bird, 2000). The fiords have steep sides, are often comparatively straight, hanging tributary valleys with waterfalls are common and the shores within the fiord are often rocky, with talus cones, see Fig. 7 (Bird, 2000).

During a sea level rise, the fiords can widen and deepen, just as other estuaries and if there are talus cones on the shores, they will get truncated (Bird, 2000; Rudberg, 1986).

3.3 Wide beach ridge plains

Wide beach ridge plains are for this study defined as successions of (relict) ridges secluded from the present shoreline, each ridge representing a former position of a (prograding) shoreline (Bird, 2000; Davidson-Arnott, 2009; Huggett, 2011). They form as the result of a *relative* sea level fall, as the shoreline gradually progrades (Bird, 2000; Davidson-Arnott, 2009; Huggett, 2011).

Fig. 6. Aerial photo showing feature No. 90, an estuary on the coastline of northwestern Svalbard. For information about a single specific feature, see Appendix I and II. (Modified after http://toposvalbard.npolar.no/).

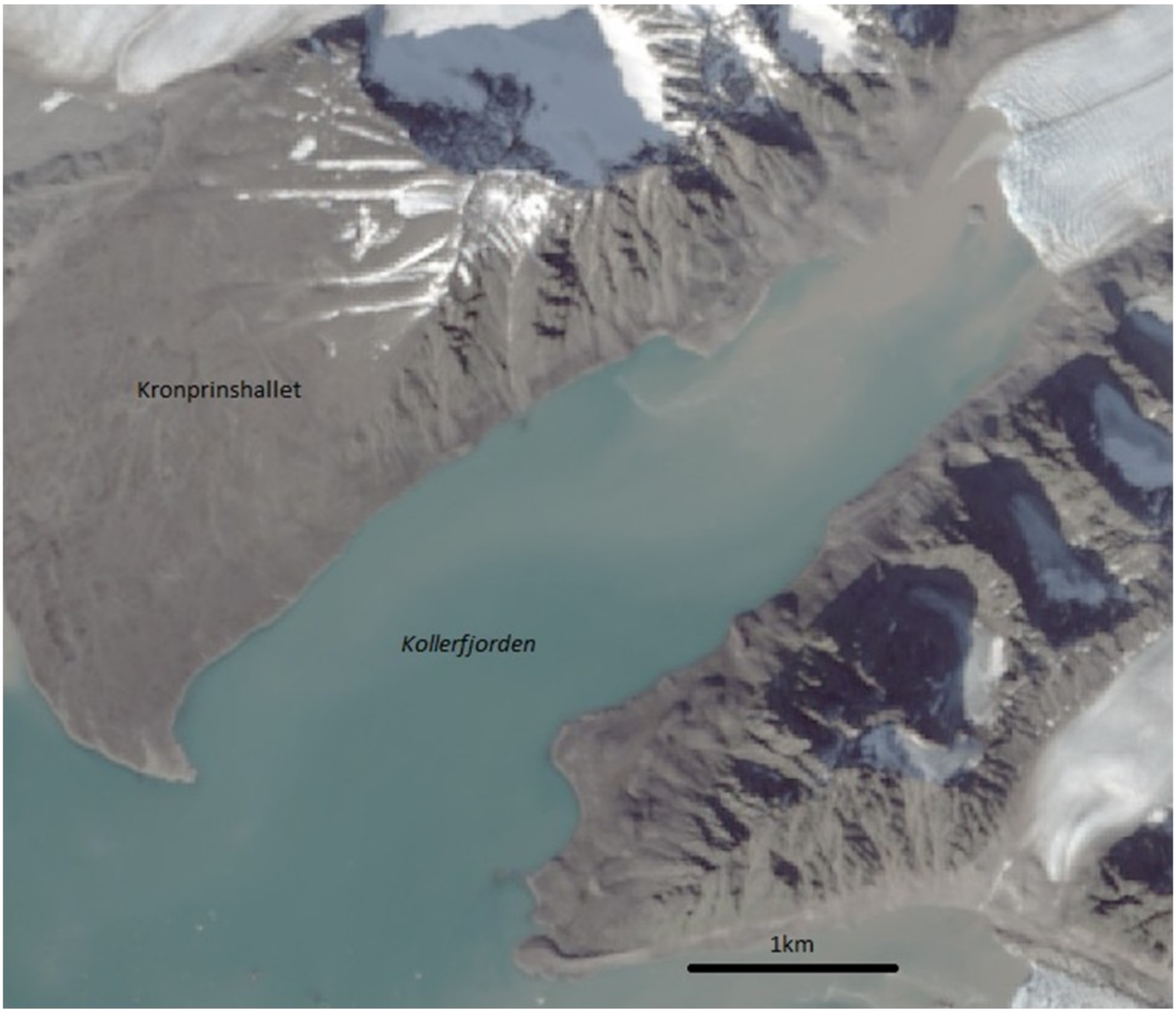

Fig. 7. Satellite image showing Kollerfjorden at Spitsbergen. (Modified after http://toposvalbard.npolar.no/).

3.4 Barrier beach ridges and sea level

Barrier beach ridges consist of beach material that during storm events are being uplifted, eventually above the normal wave zone, to form barrier ridges (Forman *et al*, 1987; Høgvard, 1992). They can form as the result of emergence of land, as storm beach ridges are being gradually uplifted, but the kind of massive, coarse clastic barrier beach ridge that is higher than the older ones, which today is being built up at several places at Spitsbergen, is generally considered a result of a slow transgression, forming as earlier deposited beach sediments are being eroded, reworked and redeposited landwards, over existing beaches (Möller, 1984; Forman *et al*, 1987).

On the other hand, the barrier beach ridge currently forming does not necessarily indicate a rising sea level, as similar geomorphological forms could result from an increase in storm surge levels (Bird, 2000).

3.5 Rivers, deltas and sea level

With an increasing sea level, river channels will likely get drowned and estuaries will form as described above. This means that rivers' discharge will not empty directly on to the shelf nor will the deltas created by rivers be formed directly on the shelf, but in the calm, protected environments of estuaries, lagoons and fiords (Dominguez *et al*, 1992; Martin & Dominguez, 1994; Bird, 2000; Huggett, 2011). The progradation of deltas forming today directly on the shelfs, will be halted as increased submergence and erosion sets in (Bird, 2000). On Svalbard the river discharge is lighter than the oceanic water, due to the river discharge being brackish and warmer, making the river sediments able to travel far out into the ocean (Høgvard, 1992).

In the case of a falling sea level a progradation of wide beach ridge plains will ensue and river channels will incise in to these plains, while the rivers empty their discharge directly on to the shelf where deltas will form (Dominguez *et al*, 1992; Martin & Dominguez, 1994; Bird, 2000; Fraser *et al,* 2005; Huggett, 2011).

3.6 Truncated talus cones and alluvial fans

Rudberg (1986) explains how talus cones and alluvial fans formed on coastlines can be used as a geomorphological sign for an increase in sea level. As the alluvial fans and talus cones both are developed during long time spans and need undisturbed environments to reach comparable size, signs of strong marine erosion at their base level heavily suggest a rising sea level; see Fig. 8. (Rudberg, 1986).

4 Methods

This study was carried out in two steps, first as a literature review of the link between geomorphology and sea level, and secondly as a combined map, satellite image and aerial photography analysis, using the material provided by Norwegian Polar Institute in their topographical Svalbard map portal, at http://toposvalbard.npolar.no/.

Two things governed what geomorphological features were focused on in the map, satellite image and aerial photography analysis;

- All the studied material were maps or vertical images taken at a considerable altitude, which made detecting geomorphological features such as barrier beach ridges, truncated alluvial fans and talus cones hard.
- Several previous geomorphological studies, investigating a possible ongoing transgression on Svalbard, have focused on barrier beach ridges, the erosion of rocks and truncated alluvial fans and talus cones (Rudberg, 1986; Forman *et al,* 1987; Forman, 1990; Forman *et al*, 2004).

Therefor this study was focusing mainly on detecting lagoons and estuaries, while also looking at the size, location and shapes of rivers and deltas. As wide beach ridge plains with or without incised river valleys indicate a falling sea level, such features were also looked for.

5 Results

The results of the combined map, satellite image and aerial photography analysis can be seen in Table 1. As seen, the numbers between the studied geomorphological features vary, but they are all considerably high, except for wide beach ridge plains.

Table 1. Showing the number of found features for each type.

Feature	**Number**
Lagoons	136
Estuaries	14
Deltas in protected areas	22
Wide beach ridge plains	6

For a complete list of each individual feature found and their location, see Table 2, Appendix I. In the digital version of this study, an attached HTML-

Fig. 8. Photography showing truncated talus cones, Svalbard. (Modified after Rudberg, 1986).

document can be found, containing four maps of the studied area, complete with all the found features marked. These four maps can also be reached through direct links found in Appendix II. For general information about and a legend for the HTML-document, see Appendix II.

5.1 Lagoons

The lagoons found are of different size and shape, from a few meters wide up to 1 km wide. A common feature among them, is the lack of visible tidal inlets, see Fig. 9. Both "mainland beach detachment"- and "coastwise extension of sand spits"-lagoons were found, the former being the more common type and the later only found on coastlines with a high relief, such as in fiords.

5.2 Estuaries

The estuaries are like the lagoons of different shape and size. Many have deltas developing inside; examples can be seen in Fig. 10.

5.3 Deltas in protected areas

Rivers on northwestern Svalbard empty their discharge almost exclusively in protected environments such as fiords, estuaries or lagoons, see Fig. 10.

5.4 Wide beach ridge plains

Wide beach ridge plains on northwestern Svalbard are virtually absent (only 6 are found in the study) but the found features are large, often stretching over several kilometers of the coastline; see Fig. 11.

6 Discussion

As Table 1 and Table 2 show, there is an abundance of lagoons and estuaries on northwestern Svalbard. Further, deltas almost exclusively form in protected areas such as estuaries, fiords and lagoons while there is a virtual absence of wide beach ridge plains. As these are all geomorphological features that form preferentially during a sea level rise (described above), this all speaks for the hypothesis that there is an ongoing slow transgression taking place on northwestern Svalbard (Pethick, 1984; Dominguez *et*

Fig. 9. Compilation of aerial photos showing, from the top left, features No. 21, 59, 57 and 96, lagoons without tidal inlets, on the coastline of NW Svalbard. For information about a single specific feature, see Appendix I and II. (Modified after http://toposvalbard.npolar.no/).

Fig. 10. Compilation of aerial photos showing, from the top left, features No. 93, 90, 8 and 6, estuaries on the coastline of NW Svalbard. In the lower left picture, a delta can be seen forming in the estuary. For information about a single specific feature, see Appendix I and II. (Modified after http://toposvalbard.npolar.no/).

al, 1992; Martin & Dominguez, 1994; Bird, 2000; Huggett, 2011). The few wide beach ridge plains found, are most likely geomorphological features formed during the post-glacial emergence that has characterized northwestern Svalbard for thousands of years (Forman *et* al, 1987; Landvik *et al*, 1987; Forman, 1990; Lehman&Forman, 1992; Forman *et al*, 2004).

Many of the lagoons have few or completely lack tidal inlets, something which could indicate a falling sea level, as the barriers would be emerging as the sea level falls, and the tidal inlets would disappear as the lagoon is sealed off from the ocean (Dominguez *et al*, 1992; Martin & Dominguez, 1994; Bird, 2000; Huggett, 2011). However, what we do know from earlier studies is that most of the barriers sealing off the lagoons on Svalbard consist of coarse material, which can explain why the lagoons have few if any visible tidal inlets, as the exchange of fresh and oceanic water occur via seepage through the barrier (Carter & Orford, 1984; Høgvard, 1992).

Another complicating factor to consider when interpreting present day coastal geomorphology is the theory of re-occupied coastlines (Pethick, 1984; Bird, 2000). The theory states that since the amount of available water on Earth remains approximately the same, it is not a farfetched thought that the fluctuating global sea level would reach the same level several times throughout the Earth's history (Pethick, 1984; Bird, 2000; Huggett, 2011). This means that if the same processes act upon the coast, at the same sea level as it has before, several times, geomorphological features that we see today could in reality be ancient, fossile features (Pethick, 1984). However, other studies claim that the observed rate of ongoing coastal processes is enough to explain their total evolution during the last 6000 years (Trenhaile, 1980).

Other factors to reflect upon, beside sea level, that can affect the type of coastal geomorphology which has been studied and is hard to account for, when just doing a map, satellite image and aerial photography analysis, is river discharge (especially important in the close vicinity of glaciers that can produce large amounts of sediments), temperature, the formation of sea ice, salinity and changes in tidal range, something to have in mind when interpreting the acquired results (Pethick, 1984).

One last complicating component to observe is the fact that the analysis is based upon photos and images that are snapshots in time. On http://toposvalbard.npolar.no/ there is no possibility of comparing images from different times, which could have proved very useful, as changes in the morphology of the coastline could have been more obvious and easier to interpret. The features studied could possibly all have been formed during an earlier transgression and be on the verge of being changed into a prograding coastline. However, the Norwegian Polar Institute mentions on its website (http://www.npolar.no/en/themes/mapping/svalbard.html) that there are aerial photographs taken with a tilted camera during the 1930s. Due to the limited time available for this bachelor's thesis, these photographs were not used for this study, but they could prove useful for future studies in which comparisons could be made between contemporary photographs and these older ones. Additionally, the few wide beach ridge plains, incising river channels and the absence of deltas prograding directly onto the shelf plus the many large lagoons that does not seem to be filling up with sediments, speak against the fact that the geomorphological features studied were formed during a previous transgression (Pethick, 1984; Dominguez *et al*, 1992; Martin & Dominguez, 1994; Bird, 2000; Huggett, 2011).

Considering all these factors, it is clear that the geomorphological features studied here, do support the hypothesis of an ongoing transgression but as there are several complicating factors as both to *how* these features are formed and also *when* these features were formed, the coastline of northwestern Svalbard cannot be considered a representative transgressive coastline, as such a coastline would ideally not offer any doubt as to whether or not a transgression is ongoing.

Concerning the reasons for this probable ongoing transgression, there are a number of possibilities, none of which this study have had the possibility to investigate. It could be local tectonic downdrift of the land, an increasing ice load causing the continent to sink or a similar reason but a very likely theory considering what is known about the increased global mean sea level rise, is that the increased rate of sea level rise has caught up on the post-glacial emergence rate that characterized northwestern Svalbard for several thousands of years (Forman *et al*, 2004; Church *et al*, 2013). If this is the case, the knowledge that this is already happening on some coastlines, could prove an important part in future studies that aim to predict consequences of the expected climate change in the coming century as many post-glacial emerging coastlines have been considered out of reach or at least safe for decades for future sea level rise (Bird, 2000; Huggett, 2011; Church *et al*, 2013).

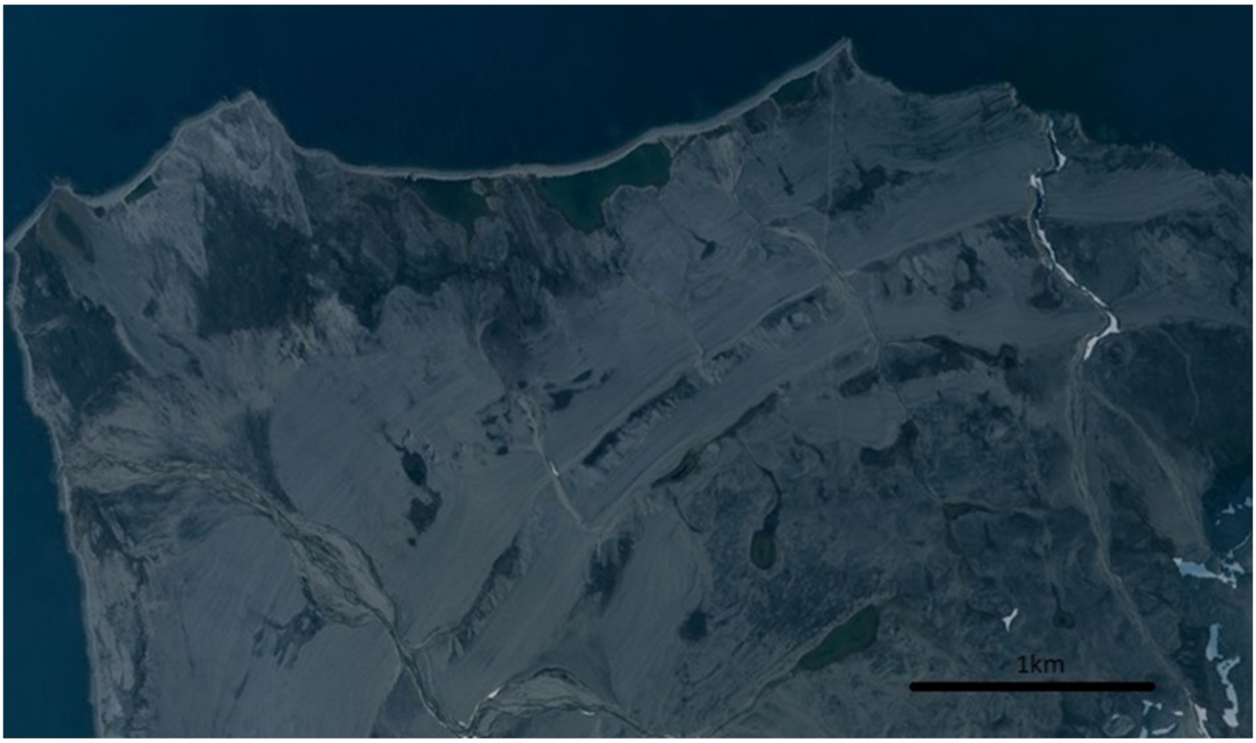

Fig. 11. Aerial photo showing feature No. 175, a wide beach ridge plain at Bröggerhalvöya, northwestern Svalbard. For information about a single specific feature, see Appendix I and II. (Modified after http://toposvalbard.npolar.no/).

7 Conclusions

Based upon the results and interpretations made in this study, the following conclusion can be drawn:

- The geomorphology of northwestern Svalbard support the hypothesis of an ongoing slow transgression but the evidence are not conclusive, as there are several complicating factors to be considered, see above.
- As the evidence for a transgression taking place on northwestern Svalbard is not conclusive, the coastline cannot be considered a representative transgressive coastline.
- For a more definite answer as to whether or not a transgression is taking place, more factors have to be studied; river discharge, temperature, the formation of sea ice, salinity and changes in tidal range.
- Studies that include images from a longer time span should be made for more conclusive evidence.
- The ongoing global GPS/satellite study can help to finally prove whether or not the hypothesis is right, as can the .

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Appendix I

Table 2. Complete results of combined map, satellite image and aerial photography analysis, showing each feature, in what area it was found and its exact latitude and longitude. Additional comments added for selected features.

No.	Feature	Place/area	Latitude	Longitude	Comment
1	Lagoon	Daudmannsöyra	78.2019°N	13.5843°E	Visible tidal inlet
2	Lagoon	Daudmannsöyra	78.2076°N	13.4914°E	Small, visible inlet
3	Estuary	Daudmannsöyra	78.2083°N	13.4682°E	
4	Estuary	Daudmannsöyra	78.2104°N	13.4413°E	
5	Estuary	Daudmannsöyra	78.2110°N	13.4048°E	
6	Estuary	Daudmannsöyra	78.2167°N	13.2902°E	
7	Estuary	Daudmannsöyra	78.2194°N	13.2434°E	
8	Estuary	Daudmannsöyra	78.2326°N	13.1280°E	
9	Lagoon	Daudmannsöyra	78.2125°N	13.0313°E	Large, no visible inlet
10	Lagoon	Daudmannsöyra	78.2118°N	13.0116°E	Large, visible inlet
11	Lagoon	Daudmannsöyra	78.2054°N	12.9939°E	Small, no visible inlet
12	Lagoon	Daudmannsöyra	78.2310°N	12.9481°E	Large, visible inlet
13	Lagoon	Daudmannsöyra	78.2680°N	12.9170°E	No visible inlet
14	Estuary	Daudmannsöyra	78.2987°N	12.9336°E	
15	Estuary	Daudmannsöyra	78.3103°N	12.9152°E	
16	Lagoon	Daudmannsöyra	78.3153°N	12.8949°E	Small, no visible inlet
17	Lagoon	Daudmannsöyra	78.3193°N	12.8817°E	Large, large visible inlet
18	Lagoon	Daudmannsöyra	78.3066°N	12.9137°E	No visible inlet
19	Estuary	Eidembukta	78.3464°N	12.8766°E	
20	Lagoonsystem	Eidembukta	78.3727°N	12.8484°E	Large system of lagoons, in front of a glacier
21	Lagoon	Eidempynten	78.3696°N	12.7117°E	No visible inlet
22	Lagoon	Below Jörgenfjellet	78.3885°N	12.6061°E	Small, visible inlet
23	Lagoon	Below Jörgenfjellet	78.3919°N	12.5915°E	Small, visible inlet
24	Lagoon	Below Jörgenfjellet	78.3955°N	12.5833°E	Large, visible inlet
25	Lagoon	Müllerneset	78.4882°N	12.3578°E	No visible inlet
26	Delta in fiord	St. Jonsfiorden	78.5024°N	12.5123°E	

Table 2. Continued.

27	Lagoon	St. Jonsfiorden	78.4981°N	12.8665°E	Visible inlet
28	Lagoon	St. Jonsfiorden	78.5050°N	12.9388°E	No visible inlet
29	Delta in fiord	St. Jonsfiorden	78.5054°N	12.9634°E	
30	Delta in fiord	St. Jonsfiorden	78.5519°N	13.2599°E	
31	Delta in fiord	St. Jonsfiorden	78.5470°N	13.0562°E	
32	Delta in fiord	St. Jonsfiorden	78.5409°N	12.9216°E	
33	Delta in fiord	St. Jonsfiorden	78.5326°N	12.7385°E	
34	Lagoon	Dahlbrebukta	78.5596°N	12.3627°E	Opened, due to transgression?
35	Lagoon	Dahlbrebukta	78.5630°N	12.4060°E	
36	Lagoon	Dahlbrebukta	78.5645°N	12.4434°E	Several small lagoons
37	Lagoon	Dahlbrebukta	78.5924°N	12.2310°E	No visible inlet
38	Estuary	Kaffiöyra	78.5947°N	12.1716°E	
39	Lagoon	Kaffiöyra	78.6090°N	12.0191°	Visible inlet
40	Lagoon	Kaffiöyra	78.6223°N	11.9726°E	Visible inlet
41	Estuary	Kaffiöyra	78.6282°N	11.9532°E	
42	Lagoon	Kaffiöyra	78.6387°N	11.8917°E	No visible inlet
43	Lagoon	Kaffiöyra	78.6483°N	11.8860°E	
44	Delta in a lagoon	Kaffiöyra	78.6467°N	11.8872°E	
45	Lagoon	Kaffiöyra	78.6628°N	11.8387°E	
46	Delta in a lagoon	Kaffiöyra	78.6712°N	11.8266°E	
47	Lagoonsystem	Hornbäkbukta	78.6780°N	11.8391°E	Several inlets
48	Lagoonsystem	Hornbäkbukta	78.7077°N	11.7655°E	Large inlet
49	Delta in lagoon	Hornbäkbukta	78.7147°N	11.7094°E	
50	Lagoon	Sarsöyra	78.7376°N	11.6002°E	Clearly visible tidal inlet
51	Delta in lagoon	Sarsöyra	78.7723°N	11.6554°E	Visible inlet in the lagoon
52	Delta in fiord	Engelskbukta	78.8394°N	11.8820°E	

Table 2. Continued.

53	Delta in fiord	Engelskbukta	78.8491°N	11.8067°E	
54	Lagoon	Leinstranda	78.8610°N	11.6566°E	No visible inlet
55	Delta behind barrier beach	Leinstranda	78.8632°N	11.6479°E	
56	Lagoon	Leinstranda	78.8690°N	11.6019°E	Visible inlet
57	Lagoon	Bröggerhalvöya	78.9667°N	11.3440°E	
58	Lagoon	Bröggerhalvöya	78.9665°N	11.4067°E	No visible inlet
59	Lagoon	Bröggerhalvöya	78.9670°N	11.4279°E	No visible inlet
60	Lagoon	Bröggerhalvöya	78.9714°N	11.4689°E	No visible inlet
61	Lagoon	Kongsfjorden	78.9450°N	11.8667°E	No visible inlet
62	Delta in fiord	Kongsfjorden	78.9359°N	11.8643°E	
63	Lagoon	Kongsfjorden	78.9140°N	12.0617°E	No visible inlet
64	Delta in fiord	Kongsfjorden	78.9106°N	12.0996°E	
65	Delta in fiord	Kongsfjorden	78.9012°N	12.1851°E	
66	Delta in fiord	Kongsfjorden	78.8950°N	12.2182°E	
67	Lagoon	Kongsfjorden	78.8907°N	12.3312°E	Visible inlet
68	Lagoon	Kongsfjorden	78.8887°N	12.3486°E	No visible inlet
69	Delta in fiord	Kongsfjorden	78.9928°N	12.4088°E	
70	Delta in fiord	Kongsfjorden	79.0038°N	12.2729°E	
71	Lagoon	Bratliekollen	78.9861°N	11.9741°E	Uncertainty
72	Lagoon	Kongsfjorden	79.0143°N	11.9585°E	
73	Lagoonsystem	Kapp Guissez	79.0665°N	11.6689°E	Visible inlet
74	Delta in fiord	Krossfjorden	79.1956°N	11.9146°E	
75	Lagoon	Ministerodden	79.2665°N	12.0436°E	No visible inlets
76	Lagoon	Kongshamaren	79.2176°N	11.8468°E	Uncertainty
77	Lagoon	Langskipet	79.2388°N	11.7528°E	No visible inlets, uncertainty
78	Delta in fiord	Signehamna	79.2685°N	11.4870°E	

Table 2. Continued.

79	Lagoon	Ebeltofthamna	79.1618°N	11.5632°E	Semi open, large inlet
80	Lagoon	Collinsodden	79.1107°N	11.3544°E	No visible inlet
81	Lagoon	Collinsodden	79.1085°N	11.3064°E	No visible inlet
82	Lagoon	Mitrahalvöya	79.1077°N	11.2619°E	No visible inlet
83	Lagoon	Mitrahalvöya	79.1080°N	11.2577°E	No visible inlet
84	Lagoon	Mitrahalvöya	79.1089°N	11.2427°E	No visible inlet
85	Lagoon	Kapp Mitra	79.1155°N	11.1835°E	No visible inlet
86	Lagoon	Mitrahalvöya	79.1365°N	11.1934°E	No visible inlet
87	Lagoon	Mitrahalvöya	79.1379°N	11.1904°E	No visible inlet
88	Lagoon	Mitrahalvöya	79.1422°N	11.1821°E	No visible inlet
89	Lagoon	Mitrahalvöya	79.1580°N	11.1704°E	No visible inlet
90	Estuary	Mitrahalvöya	79.1879°N	11.1743°E	
91	Lagoon	Mitrahalvöya	79.1877°N	11.1612°E	No visible inlet
92	Lagoon	Mitrahalvöya	79.1901°N	11.1576°E	No visible inlet
93	Estuary	Mitrahalvöya	79.1920°N	11.1584°E	
94	Lagoon	Mitrahalvöya	79.1995°N	11.1456°E	No visible inlet
95	Estuary	Mitrahalvöya	79.2037°N	11.1523°E	
96	Lagoon	Mitrahalvöya	79.2236°N	11.1475°E	Very large, visible inlet
97	Lagoonsystem	Mitrahalvöya	79.2584°N	11.0533°E	Visible inlet
98	Lagoon	Mitrahalvöya	79.3080°N	10.9948°E	Large, semi open lagoon in front of a glacier
99	Lagoonsystem	Mitrahalvöya	79.3409°N	10.8590°E	Visible inlets
100	Lagoonsystem	Krossfjellet	79.3924°N	10.8732°E	Connected to periglacial lakes
101	Lagoon	Kvedfjordbukta	79.4184°N	10.9151°E	Visible inlet
102	Lagoon	Munthefjella	79.4759°N	10.9016°E	No visible inlet
103	Lagoon	Sjubrebukta	79.4952°N	10.8316°E	Visible large inlet
104	Lagoon	Rekvedbukta	79.5062°N	10.7944°E	Visible inlet

Table 2. Continued.

105	Delta in lagoon	Rekvedbukta	79.5084°N	10.8149°E	
106	Lagoon	Hamburgbukta	79.5295°N	10.6952°E	Opened, due to transgression?
107	Lagoon	Hamburgbukta	79.5390°N	10.6651°E	Visible inlet
108	Lagoon	Magdalenefjorden	79.5594°N	10.8130°E	No visible inlet
109	Lagoon	Magdalenefjorden	79.5583°N	10.9173°E	No visible inlet
110	Barrier islands	Magdalenefjorden	79.5634°N	11.1650°E	Possible forming of barrier islands
111	Lagoon	Magdalenefjorden	79.5737°N	11.0466°E	No visible inlet
112	Lagoon	Magdalenefjorden	79.5790°N	11.0002°E	Visible inlet
113	Lagoonsystem	Scheibukta	79.6315°N	11.1250°E	Visible inlets
114	Lagoon	Björnfjorden	79.6257°N	11.3864°E	No visible inlet
115	Spitbarrier	Blessingberget	79.7225°N	11.1855°E	Possible forming of a barrier through spit
116	Lagoon	Kennedybukta	79.7646°N	11.2037°E	No visible inlet
117	Lagoon	Fuglegattet	79.7809°N	11.3436°E	No visible inlet
118	Lagoon	Vasahalvöya	79.8283°N	11.6494°E	Large visible inlet
119	Lagoon	Vasahalvöya	79.8363°N	11.7483°E	No visible inlet
120	Lagoon	Amsterdamöya	79.7732°N	10.7416°E	No visible inlet
121	Lagoon	Amsterdamöya	79.7679°N	10.8631°E	No visible inlet
122	Lagoon	Amsterdamöya	79.7448°N	10.9492°E	No visible inlet
123	Lagoon	Amsterdamöya	79.7387°N	10.9964°E	No visible inlet
124	Lagoon	Amsterdamöya	79.7363°N	10.9861°E	No visible inlet
125	Lagoon	Amsterdamöya	79.7334°N	10.9958°E	No visible inlet
126	Lagoon	Dansköya	79.7198°N	10.8280°E	No visible inlet
127	Lagoon	Dansköya	79.7013°N	10.7960°E	No visible inlet
128	Lagoonsystem	Dansköya	79.6956°N	11.0055°E	Visible large inlet
129	Lagoon	Dansköya	79.6669°N	11.0345°E	No visible inlet
130	Lagoon	Dansköya	79.6660°N	11.0611°E	No visible inlet

Table 2. Continued.

131	Lagoon	Dansköya	79.6807°N	10.7696°E	No visible inlet
132	Lagoon	Dansköya	79.6612°N	10.7462°E	No visible inlet
133	Lagoon	Prins Karls Forland	78.2093°N	12.1346°E	No visible inlet
134	Lagoonsystem	Prins Karls Forland	78.2302°N	11.8774°E	Visible inlets
135	Lagoon	Prins Karls Forland	78.2561°N	11.8287°E	Visible inlet
136	Lagoon	Prins Karls Forland	78.2666°N	11.7813°E	No visible inlet
137	Lagoon	Prins Karls Forland	78.2908°N	11.8234°E	No visible inlet
138	Lagoon	Prins Karls Forland	78.3069°N	11.8017°E	No visible inlet
139	Lagoonsystem	Prins Karls Forland	78.3235°N	11.7381°E	Visible inlets
140	Lagoonsystem	Prins Karls Forland	78.3371°N	11.6733°E	Visible inlets
141	Lagoon	Prins Karls Forland	78.4113°N	11.4903°E	Visible inlets
142	Lagoon	Prins Karls Forland	78.4556°N	11.2003°E	No visible inlet
143	Several small lagoons	Prins Karls Forland	78.4433°N	11.1336°E	No visible inlets
144	Lagoon	Prins Karls Forland	78.5613°N	10.9673°E	No visible inlet
145	Lagoonsystem	Prins Karls Forland	78.6235°N	10.8388°E	Visible inlets
146	Lagoonsystem	Prins Karls Forland	78.6613°N	10.7734°E	Visible inlets
147	Lagoonsystem	Prins Karls Forland	78.6775°N	10.7391°E	Visible inlets
148	Lagoonsystem	Prins Karls Forland	78.6886°N	10.7248°E	Visible inlets
149	Lagoon	Prins Karls Forland	78.7207°N	10.6637°E	Visible inlets
150	Lagoon	Prins Karls Forland	78.7315°N	10.6274°E	Visible inlets
151	Lagoonsystem	Prins Karls Forland	78.7629°N	10.5563°E	Visible inlets
152	Lagoon	Prins Karls Forland	78.7993°N	10.5022°E	Visible inlets
153	Lagoonsystem	Prins Karls Forland	78.8024°N	10.5185°E	Visible inlets
154	Lagoon	Prins Karls Forland	78.8093°N	10.5293°E	Visible inlets
155	Lagoon	Prins Karls Forland	78.8414°N	10.5315°E	No visible inlets
156	Lagoon	Prins Karls Forland	78.8482°N	10.5365°E	No visible inlets

Table 2. Continued.

157	Lagoon	Prins Karls Forland	78.8973°N	10.4979°E	No visible inlets
158	Lagoonsystem	Prins Karls Forland	78.8858°N	10.6387°E	Visible inlets
159	Lagoonsystem	Prins Karls Forland	78.8724°N	10.7493°E	Visible inlets
160	Lagoon	Prins Karls Forland	78.8645°N	10.8418°E	Visible inlets
161	Lagoon	Prins Karls Forland	78.8483°N	10.8817°E	No visible inlets
162	Lagoon	Prins Karls Forland	78.8407°N	10.9321°E	No visible inlets
163	Lagoon	Prins Karls Forland	78.7931°N	10.9351°E	Very large, visible inlets
164	Lagoonsystem	Prins Karls Forland	78.7372°N	11.1557°E	Visible inlets
165	Lagoon	Prins Karls Forland	78.7184°N	11.0766°E	Large open, visible inlets
166	Lagoonsystem	Prins Karls Forland	78.6096°N	11.2147°E	Visible inlets
167	Lagoonsystem	Prins Karls Forland	78.5819°N	11.2213°E	Visible inlets
168	Lagoonsystem	Prins Karls Forland	78.5053°N	11.4535°E	Visible inlets
169	Lagoon	Prins Karls Forland	78.4430°N	11.8701°E	No visible inlets
170	Lagoon	Prins Karls Forland	78.3862°N	11.8743°E	No visible inlets
171	Lagoon	Prins Karls Forland	78.3585°N	11.9174°E	No visible inlets
172	Lagoon	Prins Karls Forland	78.3396°N	11.9374°E	No visible inlets
173	Lagoon	Prins Karls Forland	78.3318°N	11.9436°E	No visible inlets
174	Lagoon	Prins Karls Forland	78.2803°N	12.0765°E	Visible inlets
175	Wide beach ridge plain	Bröggerhalvöya	78.9531°N	11.4582°E	
176	Wide beach ridge plain	Kaffiöyra	78.6335°N	11.9902°E	
177	Wide beach ridge plain	Prins Karls Forland	78.8524°N	10.8059°E	
178	Wide beach ridge plain	Prins Karls Forland	78.3656°N	11.8496°E	
179	Wide beach ridge plain	Sarsöyra	78.7381°N	11.7108°E	
180	Wide beach ridge plain	Daudmannsöyra	78.2584°N	12.9515°Eå	

Appendix II

The attached HTML-document will take you to a web-portal where you can choose to look closer at 4 maps, each showing a different part of the coastline, with the studied features marked for that particular stretch of coast. The reason the map is presented in four parts, are purely technical; most internet browsers have a limit of 2000 characters for a single URL, which means that the map would not load properly in most browsers, if presented as a single map.

To look closer at a specific map in the webportal, press the symbol that looks like this:

This will open a new tab in your browser, with a larger version of the chosen map.

The maps in the attached HTML-document show, from the left to the right, features on Oscar II land - Haakon VII Land - Albert I Land – and the last one show Prins Karls Forland. The last map also includes all found wide beach ridge plains plus feature No. 57, found on Haakon VII Land, due to technical reasons.

Legend for the dots appearing on the maps:

🔵	Deltas forming in protected areas
🔴	Lagoons
🟢	Estuaries
🟡	Wide beach ridge plains

Direct links to the four maps (they need to be manually copied and pasted into the adress-field, as the length of the URL prevents the making of hyperlinks):

Oscar II Land:

http://toposvalbard.npolar.no/index.html?lat=78.4981,long=12.8665,zoom=3;poi=78.2019,13.5842,r,%27%27,%27%27;poi=78.2076,13.4921,r,%27%27,%27%27;poi=78.2083,13.4686,g,%27%27,%27%27;poi=78.2102,13.4414,g,%27%27,%27%27;poi=78.2108,13.4049,g,%27%27,%27%27;poi=78.2164,13.2887,g,%27%27,%27%27;poi=78.2195,13.2416,g,%27%27,%27%27;poi=78.2327,13.1283,g,%27%27,%27%27;poi=78.2129,13.0311,r,%27%27,%27%27;poi=78.2122,13.0103,r,%27%27,%27%27;poi=78.2051,12.9917,r,%27%27,%27%27;poi=78.2319,12.9468,r,%27%27,%27%27;poi=78.2678,12.9114,r,%27%27,%27%27;poi=78.2984,12.9327,g,%27%27,%27%27;poi=78.3103,12.9133,g,%27%27,%27%27;poi=78.3158,12.8950,r,%27%27,%27%27;poi=78.3195,12.8824,r,%27%27,%27%27;poi=78.3063,12.9164,r,%27%27,%27%27;poi=78.3468,12.8782,g,%27%27,%27%27;poi=78.3724,12.8597,r,%27%27,%27%27;poi=78.3698,12.7160,r,%27%27,%27%27;poi=78.3890,12.6052,r,%27%27,%27%27;poi=78.3924,12.5901,r,%27%27,%27%27;poi=78.3955,12.5777,r,%27%27,%27%27;poi=78.4884,12.3590,r,%27%27,%27%27;poi=78.5024,12.5110,b,%27%27,%27%27;poi=78.4979,12.8628,r,%27%27,%27%27;poi=78.5049,12.9394,r,%27%27,%27%27;poi=78.5052,12.9634,b,%27%27,%27%27;poi=78.5517,13.2606,b,%27%27,%27%27;poi=78.5468,13.0578,b,%27%27,%27%27;poi=78.5401,12.9160,b,%27%27,%27%27;poi=78.5328,12.7407,b,%27%27,%27%27;poi=78.5593,12.3641,r,%27%27,%27%27;poi=78.5630,12.4089,r,%27%27,%27%27;poi=78.5653,12.4466,r,%27%27,%27%27;poi=78.5924,12.2305,r,%27%27,%27%27;poi=78.5940,12.1730,g,%27%27,%27%27;poi=78.6093,12.0128,r,%27%27,%27%27;poi=78.6230,11.9701,r,%27%27,%27%27;poi=78.6284,11.9530,g,%27%27,%27%27;poi=78.6393,11.8908,r,%27%27,%27%27;poi=78.6482,11.8865,r,%27%27,%27%27;poi=78.6464,11.8870,b,%27%27,%27%27;poi=78.6629,11.8388,r,%27%27,%27%27;poi=78.6712,11.8278,b,%27%27,%27%27;poi=78.6781,11.8419,r,%27%27,%27%27;poi=78.7067,11.7642,r,%27%27,%27%27;poi=78.7146,11.7107,b,%27%27,%27%27;poi=78.7380,11.5914,r,%27%27,%27%27;poi=78.7722,11.6551,b,%27%27,%27%27;poi=78.8385,11.8782,b,%27%27,%27%27;poi=78.8491,11.8080,b,%27%27,%27%27;

Haakon VII Land:

http://toposvalbard.npolar.no/index.html?lat=79.0143,long=11.9585,zoom=3;poi=78.8608,11.6614,r,%27%27,%27%27;poi=78.8632,11.6472,b,%27%27,%27%27;poi=78.8692,11.6022,r,%27%27,%27%27;poi=78.9663,11.4066,r,%27%27,%27%27;poi=78.9672,11.4267,r,%27%27,%27%27;poi=78.9715,11.4692,r,%27%27,%27%27;poi=78.9450,11.8671,r,%27%27,%27%27;poi=78.9360,11.8656,b,%27%27,%27%27;poi=78.9142,12.0625,r,%27%27,%27%27;poi=78.9106,12.0980,b,%27%27,%27%27;poi=78.9015,12.1869,b,%27%27,%27%27;poi=78.8951,12.2186,b,%27%27,%27%27;poi=78.8908,12.3304,r,%27%27,%27%27;poi=78.8888,12.3484,r,%27%27,%27%27;poi=78.9927,12.4091,b,%27%27,%27%27;poi=79.0031,12.2766,b,%27%27,%27%27;poi=78.9860,11.9737,r,%27%27,%27%27;poi=79.0145,11.9583,r,%27%27,%27%27;poi=79.0665,11.6689,r,%27%27,%27%27;poi=79.1961,11.9135,b,%27%27,%27%27;poi=79.2665,12.0434,r,%27%27,%27%27;poi=79.2176,11.8470,r,%27%27,%27%27;poi=79.2386,11.7527,r,%27%27,%27%27;poi=79.2684,11.4898,b,%27%27,%27%27;poi=79.1616,11.5637,r,%27%27,%27%27;

Albert I Land:

http://toposvalbard.npolar.no/index.html?lat=79.4184,long=10.9151,zoom=3;poi=79.1106,11.3539,r,%27%27,%27%27;poi=79.1085,11.3061,r,%27%27,%27%27;poi=79.1077,11.2614,r,%27%27,%27%27;poi=79.1078,11.2570,r,%27%27,%27%27;poi=79.1087,11.2432,r,%27%27,%27%27;poi=79.1154,11.1850,r,%27%27,%27%27;poi=79.1363,11.1942,r,%27%27,%27%27;poi=79.1382,11.1897,r,%27%27,%27%27;poi=79.1422,11.1823,r,%27%27,%27%27;poi=79.1579,11.1700,r,%27%27,%27%27;poi=79.1877,11.1725,g,%27%27,%27%27;poi=79.1877,11.1618,r,%27%27,%27%27;poi=79.1900,11.1582,r,%27%27,%27%27;poi=79.1920,11.1583,g,%27%27,%27%27;poi=79.1995,11.1455,r,%27%27,%27%27;poi=79.2037,11.1514,g,%27%27,%27%27;poi=79.2244,11.1502,r,%27%27,%27%27;poi=79.2583,11.0523,r,%27%27,%27%27;poi=79.3080,10.9929,r,%27%27,%27%27;poi=79.3410,10.8591,r,%27%27,%27%27;poi=79.3927,10.8737,r,%27%27,%27%27;poi=79.4183,10.9153,r,%27%27,%27%27;poi=79.4760,10.9007,r,%27%27,%27%27;poi=79.4953,10.8330,r,%27%27,%27%27;poi=79.5072,10.7882,r,%27%27,%27%27;poi=79.5084,10.8112,b,%27%27,%27%27;poi=79.5300,10.6956,r,%27%27,%27%27;poi=79.5391,10.6642,r,%27%27,%27%27;poi=79.5599,10.8127,r,%27%27,%27%27;poi=79.5585,10.9176,r,%27%27,%27%27;poi=79.5632,11.1639,r,%27%27,%27%27;poi=79.5737,11.0464,r,%27%27,%27%27;poi=79.5789,11.0003,r,%27%27,%27%27;poi=79.6322,11.1318,r,%27%27,%27%27;poi=79.6260,11.3838,r,%27%27,%27%27;poi=79.7226,11.1825,r,%27%27,%27%27;poi=79.7646,11.2038,r,%27%27,%27%27;poi=79.7810,11.3440,r,%27%27,%27%27;poi=79.8282,11.6495,r,%27%27,%27%27;poi=79.8363,11.7486,r,%27%27,%27%27;poi=79.7740,10.7413,r,%27%27,%27%27;poi=79.7678,10.8671,r,%27%27,%27%27;poi=79.7446,10.9536,r,%27%27,%27%27;poi=79.7389,10.9969,r,%27%27,%27%27;poi=79.7365,10.9869,r,%27%27,%27%27;poi=79.7336,10.9960,r,%27%27,%27%27;poi=79.7204,10.8258,r,%27%27,%27%27;poi=79.7016,10.7935,r,%27%27,%27%27;poi=79.6953,11.0065,r,%27%27,%27%27;poi=79.6668,11.0346,r,%27%27,%27%27;poi=79.6657,11.0623,r,%27%27,%27%27;poi=79.6805,10.7703,r,%27%27,%27%27;poi=79.6613,10.7471,r,%27%27,%27%27;

Prins Karls Forland, including wide beach ridges plus feature No. 57.:

http://toposvalbard.npolar.no/index.html?lat=78.6335,long=11.9902,zoom=3;poi=78.2091,12.1353,r,%27%27,%27%27;poi=78.2301,11.8766,r,%27%27,%27%27;poi=78.2565,11.8284,r,%27%27,%27%27;poi=78.2667,11.7799,r,%27%27,%27%27;poi=78.2907,11.8237,r,%27%27,%27%27;poi=78.3069,11.8009,r,%27%27,%27%27;poi=78.3234,11.7387,r,%27%27,%27%27;poi=78.3362,11.6741,r,%27%27,%27%27;poi=78.4110,11.4913,r,%27%27,%27%27;poi=78.4561,11.2015,r,%27%27,%27%27;poi=78.4435,11.1231,r,%27%27,%27%27;poi=78.5615,10.9664,r,%27%27,%27%27;poi=78.6237,10.8374,r,%27%27,%27%27;poi=78.6616,10.7727,r,%27%27,%27%27;poi=78.6771,10.7394,r,%27%27,%27%27;poi=78.6873,10.7278,r,%27%27,%27%27;poi=78.7207,10.6660,r,%27%27,%27%27;poi=78.7320,10.6267,r,%27%27,%27%27;poi=78.7630,10.5560,r,%27%27,%27%27;poi=78.7993,10.5021,r,%27%27,%27%27;poi=78.8024,10.5197,r,%27%27,%27%27;poi=78.8095,10.5301,r,%27%27,%27%27;poi=78.8414,10.5313,r,%27%27,%27%27;poi=78.8480,10.5387,r,%27%27,%27%27;poi=78.8973,10.4996,r,%27%27,%27%27;poi=78.8861,10.6380,r,%27%27,%27%27;poi=78.8727,10.7503,r,%27%27,%27%27;poi=78.8647,10.8417,r,%27%27,%27%27;poi=78.8491,10.8830,r,%27%27,%27%27;poi=78.8409,10.9309,r,%27%27,%27%27;poi=78.7928,10.9343,r,%27%27,%27%27;poi=78.7384,11.1547,r,%27%27,%27%27;poi=78.7192,11.0771,r,%27%27,%27%27;poi=78.6107,11.2194,r,%27%27,%27%27;poi=78.5824,11.2207,r,%27%27,%27%27;poi=78.5051,11.4660,r,%27%27,%27%27;poi=78.4432,11.8681,r,%27%27,%27%27;poi=78.3867,11.8735,r,%27%27,%27%27;poi=78.3588,11.9204,r,%27%27,%27%27;poi=78.3397,11.9369,r,%27%27,%27%27;poi=78.3321,11.9422,r,%27%27,%27%27;poi=78.2808,12.0748,r,%27%27,%27%27;poi=78.9667,11.3437,r,%27%27,%27%27;poi=78.9560,11.4538,y,%27%27,%27%27;poi=78.6333,11.9898,y,%27%27,%27%27;poi=78.8523,10.8034,y,%27%27,%27%27;poi=78.3658,11.8548,y,%27%27,%27%27;poi=78.7372,11.7096,y,%27%27,%27%27;poi=78.2579,12.9502,y,%27%27,%27%27;

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