Potential Mechanisms for the salt marsh recession on Sturgeon Bank

Richard Marijnissen[a], Bas Borsje[b], Stefan Aarninkhof[a], Marcel Stive[a], Bram van Prooijen[a], Daan Rijks[c], Gord Ruffo[d], Sean Boyd[e], Brent Gurd[f], Brad Mason[g]

a) Delft university of Technology, b) Unversity of Twente, c) Boskalis, d) Vancouver Fraser Port Authority, e) Environment & Climate Change Canada, f) Ministry of Forests, Lands and Natural Resource Operations, g) Community Mapping Network

South of Vancouver, Canada, at the western front of the Fraser Delta lies Sturgeon Bank. Here the marsh, an important ecosystem for the estuary, has severely receded up to 0.5 km along the 5 km stretch. The research explored the morphological processes that could have led to the recession.

Introduction

Near Vancouver (Canada) at the mouth of the Fraser River a large amount of inter-tidal marshland has been lost at an alarming rate. In the area called Sturgeon Bank the marsh has receded 0.5 km in the space of just 22 years or less. The marsh is an important part of the Fraser Delta as it supports migratory birds on the Pacific Flyway, it is used for recreation and is part of the coastal protection of the city of Richmond.

Causes for the marsh recession have been extensively investigated, but not conclusively found. This research explored the recession from a new hydro-morphological angle. It was carried out as an MSc project from March 2016 to January 2017 and supported by a joint team from Canada and the Netherlands.

Research methods

Water level records:
At Point Atkinson between 1984-2016
Wind speed records:
At YVR airport between 1985-2012
Air photo analysis:
Photos from 1930, 1954, 1979, 1986, 2001, 2002, 2003, 2005 and 2015
Satellite image analysis:
Landsat images made available by the USGS between 1985-2015
Fieldwork:
In-field GPS elevation measurements and observations
Sediment sample analysis:
Grain size analysis of the top soil in and near the marsh
Model study:
Delft-3D flow model and a basic model for wave breaking
Expert opinion on ecology:
Literature and meetings in Canada and the Netherlands

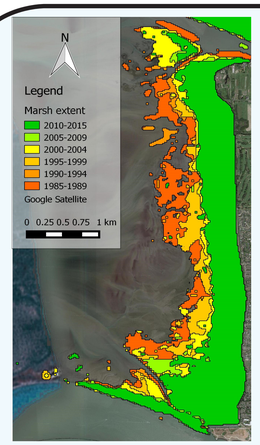


Figure 1: The salt marsh extent as derived from Landsat satellite imagery between 1985 and 2015 by mapping the green regions on the images

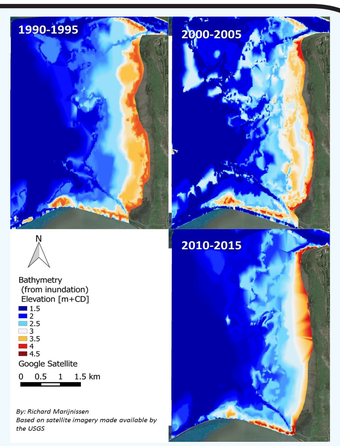


Figure 2: Elevations between 1990 and 2015 .The water lines on the satellite images were extracted and assigned the same elevation as the tide. By combining many images over a 5-year period a bathymetry was reconstructed.

Hypothesized mechanisms

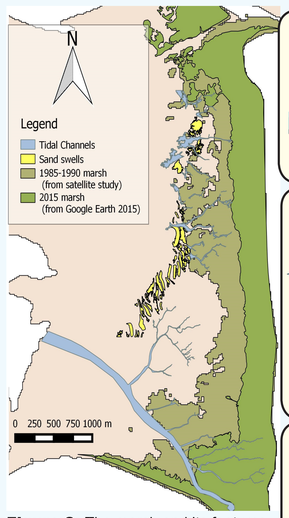
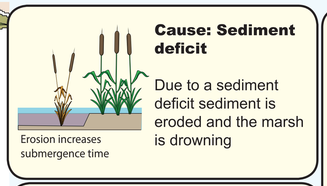
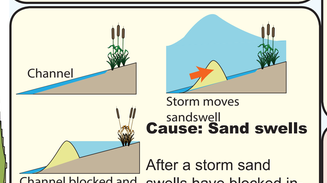


Figure 3: The marsh and its features in 1985 and 2015.



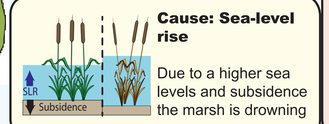
Cause: Sediment deficit

Due to a sediment deficit sediment is eroded and the marsh is drowning



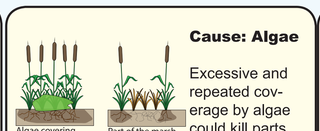
Cause: Sand swells

After a storm sand swells have blocked inter tidal channels leading to drowning of marsh



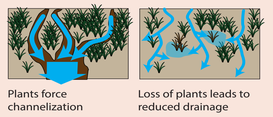
Cause: Sea-level rise

Due to a higher sea levels and subsidence the marsh is drowning



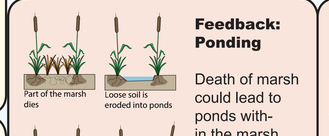
Cause: Algae

Excessive and repeated coverage by algae could kill parts of the marsh, resulting in the formation of ponds



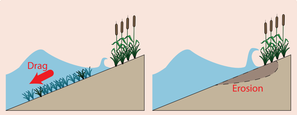
Feedback: Loss of channels

Plants force channelization within the marsh. Without them the drainage decreases and ponds would form.



Feedback: Ponding

Death of marsh could lead to ponds within the marsh. Ponds can grow within the marsh, furthering the recession.



Feedback: Larger waves

Plants attenuate wave energy. As a consequence of marsh loss, bigger, more erosive waves will reach the marsh.

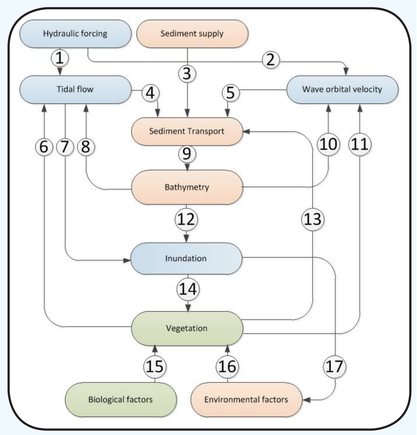


Figure 4: The complex interactions considered governing the tidal marsh.

Results

Most of the marsh receded between 1985 and 2000 after being stable and/or growing for over 50 years. During the marsh recession the northern tidal channels disappeared and sand swells (sandy bed forms 70-100 m long and 0.2-0.5 m high) migrated shoreward.

Erosion of a terrace at the historic marsh was detected after 3 major storms between 2000-2003. Elevation measurements since 2013 suggest the bank is currently stable with negligible erosion/deposition. The marsh itself has seen little recession since 2000-2005.

More important factors were noted. Sand content within the top soil has increased up to 30% between 2011-2016. Also algae coverage of the marsh and water logging was observed.

Processes

Mechanisms were proposed to explain the cause of the marsh recession (see block above). These were evaluated with the results from this research.

Sediment deficit: Although the sediment supply has likely been affected by dredging and the Steveston Jetty, results show no structural loss of sediment from the marsh since dredging commenced as would be expected.

Sea-level rise: Even assuming no deposition the rate of sea-level rise alone was found insufficient to cause a retreat of 22 m/year as observed.

Sand swells: Movement of sand swells is only possibly under strong wave action. Recession had already started before the storms hit after 2000. It is thus unlikely they started the recession.

Algae: Though algae cover can cause local die-off of marsh, experts in both literature and met during the research agree that marshes can recover from such events and would not cause permanent loss on their own.

Feedback mechanisms: These mechanisms do not explain what has caused the recession but could have promoted further recession. As the marsh retreated stronger waves would be able to reach the marsh during storms causing erosion as observed in 2000-2005. Furthermore the loss of channels is observed on aerial photos after the marsh had receded. Finally in front of the current marsh ponds with standing water and clumps of dead roots are still found. This would be expected from the ponding mechanism. Increased erosion and inundation from the feedbacks would have accelerated the recession.

Conclusions

None of the hypotheses of causes presented above could singularly support the severity and timespan of the recession. Feedback mechanisms were qualitatively supported but were not quantified. An integral approach is required combining the initial causes with the feedback mechanisms to quantify their cumulative effects on the marsh.

Recommendations

More research is required to quantify the tolerance of the marsh plants to the proposed stresses as to better predict the tipping point towards marsh recession. Also the changes in environment (e.g. channels and bed forms) that affect these stresses should be studied further. A pilot study is proposed to study the response of the marsh to a higher elevation, better drainage and protection from waves.

TU Delft Boskalis

Full report available at:
repository.tudelft.nl

Corresponding author:
richard.marijnissen@hotmail.com