Spatial and temporal growth of coastal dune - field observation of the German Wadden Sea Coast

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1. INTRODUCTION

Natural vegetated coastal dunes are an essential component on many sandy, low-sloped coastlines around the world. In addition to their unique ecosystem services, they often provide a first natural barrier of protection against storm surges and protect the adjacent hinterland from flooding. However, sea level rise, changing and widely intensifying coastal wave climates and storm surges are expected to have an impact on dune development and their protection function in the future.

Here, we investigate the development of an incipient elongated coastal dune system on the wide beach of St. Peter-Ording, located at the German North Sea, over a 20-year period. The study is based on digital terrain data with a resolution of 10 m x 10 m for the period from 1996 to 2016, obtained from the EasyGSH-DB portal www.easygsh-db.org (www.doi.org/10.18451/k2_easygsh_1). The goal is to analyze the spatial and temporal variance of the dune in order to understand its evolution velocity, quantify dune dimensions and possibly identify a potentially added natural contribution to coastal protection.

2. METHODS

The changes of relevant dune parameters were evaluated along 144 transects and over a time span of 20 years. In order to reliably record the location of the dune, it is crucial to identify the dune extent. In the past, the location of a dune toe was usually defined by a threshold vertical elevation (e.g. by Hofstede (1997) at St. Peter-Ording, Germany, with +2 m elevation above sea level). However, since this definition does not take into account the individual profile of a dune, it is difficult to draw conclusions about long-term shifting of the dune toe (Diamantidou *et al.* 2020). Therefore, an alternative procedure was developed, that detects the dune toes based on the calculated minimum slopes (Fig. 1). Subsequently, the dune volume results from a numerical integration of the dune cross- section between the two toes.

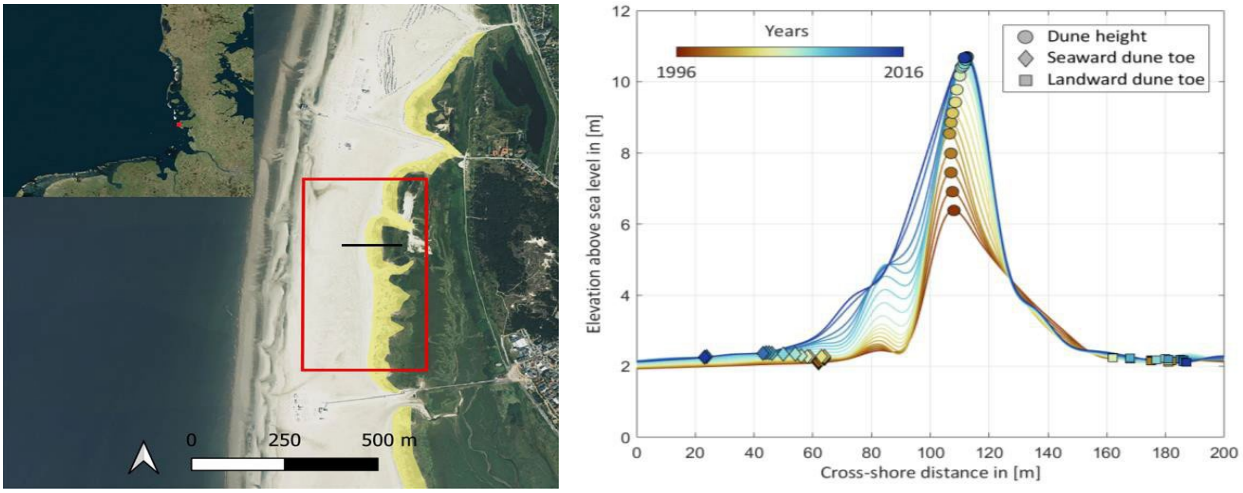

Figure 1: Study area in St. Peter-Ording at the German Bight (©Bing VirtualEarth) and development of the dune along an exemplary transect.

3. RESULTS

Between 1996 and 2016, the lateral position of the seaward dune toe has shifted towards the sea by an average of 2.06 m/year, whereas the landward toe shows no clear direction of movement. Similar to the findings by van IJzendoorn *et al.* (2021) on the Dutch coast, it is also evident that the seaward toe has grown several centimeters in height over the period investigated, accruing faster than the local sea level rise. As shown in Fig. 2, the mean dune height has almost doubled over the years and reached 7.9 m in 2016, with a maximum dune height slightly below 11 m (Fig. 1). The average growth rate was calculated to be approximately 0.2 m/year. Due to the increased dune height as well as the dune width, the mean dune volume has also increased significantly, from 128 m³/m in 1996 to 345 m³/m in 2016. Fig. 2 also shows the storm surge classes defined at the German North Sea coast as a function of the local mean high water of 1.65 m above sea level. This shows that the mean dune height is now greater than the level of potential storm surges or storm surges that occurred during this period. However, it should be noted that along the dune system there are several blowouts through which water can flow behind the dune and submerge the adjacent dune troughs.

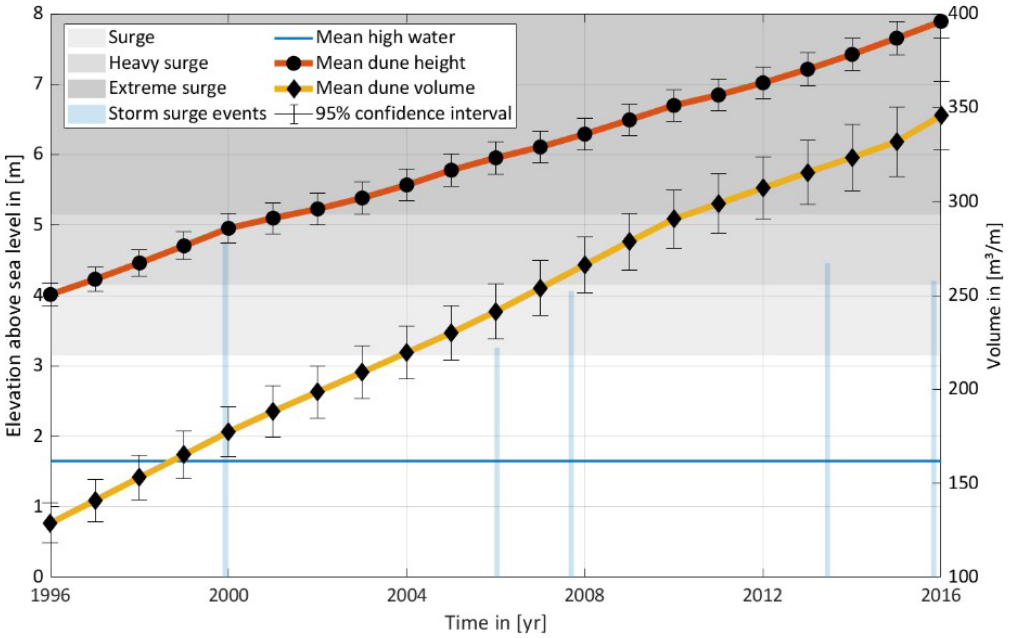

Figure 2: Development of the mean dune height and volume compared to typical storm surge classes and past events

4. DISCUSSION

The results show that an incipient coastal dune system has developed on the beach of St. Peter- Ording over the past decades. The evaluation indicates that this process is not yet complete and that the dune will continue to grow in the near future. For this reason, additional terrain data from the years after 2016 will soon be obtained and processed in order to be able to infer the current development and possible forecasts for the future. In addition, other data sets from before 1996 are currently being analyzed to investigate at what time the initial dune formation process began. This will help to infer possible causes and correlations to sea level, changing wave and wind conditions, certain storm surge events, and other influences. Furthermore, the level of protection provided by the dune will be analyzed in a timely manner to assess its potential contribution as a natural protective barrier.

5. REFERENCES

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