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Raising the (Subtidal) Bar for Embryonic Dune Growth and Survival

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Introduction

Along sandy coasts, the seaward expansion of dunes starts with the development of embryonic dunes. During severe storms, embryonic dunes may be partially or even completely eroded. The tolerance to and recovery from their (partial) removal during storms is vital to the long-term (months to years) resilience of the dune building process. Areas with high embryo dune abundance have been correlated to wider beaches[1], and recent observations have shown that alongshore variations in subtidal sandbar morphology may also lead to variations in wave attenuation and foredune erosion, following a series of extreme storms[2, 3] (Figure 1).

Here, we aim to answer the following research question:
Do subtidal bar characteristics play a role in long-term (months to years) embryo dune development?

Two approaches:
➔ **Hourly video observations**
➔ **Yearly aerial photographs and bed levels**

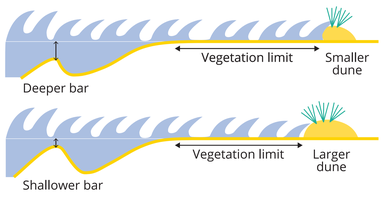


Figure 1 Hypothesis
Shallower bars dissipate more wave energy than deeper bars during storms. Over time, this allows embryonic dunes to grow in volume and further seaward.

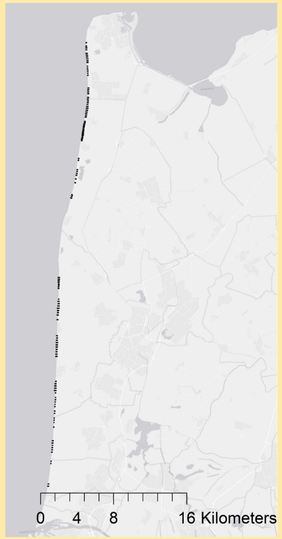


Figure 2 Study sites
Egmond aan Zee (triangle): Video observations
112 sites along the North-Holland coast (dots):
Yearly photos & bed levels. Meteorological measurements (*)

➔ Hourly video observations

Dune erosion events were visible in the video images, allowing us to observe **when** and **how much** embryonic dunes eroded.
Not all storms resulted in erosion and the degree of erosion varied alongshore.

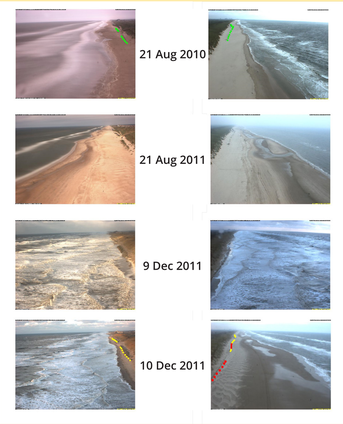
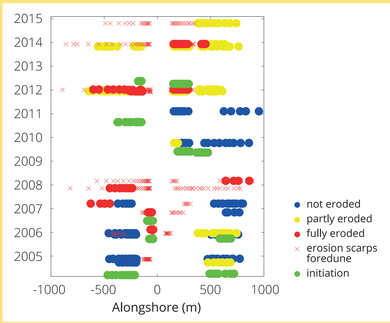


Figure 3 Example of observations of embryonic dune initiation and erosion from August 2010 – December 2011.



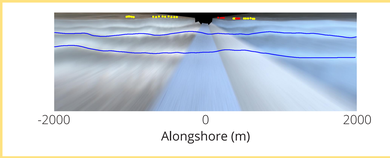


Figure 4 Video observations of embryonic dune erosion events and embryonic dune initiation. The planview below from 8 December 2011 gives an example of the alongshore variation in bar morphology and dune erosion extent.

Conclusions and outlook

➔ Embryonic dune development varies alongshore
? Alongshore variable dune **erosion** ⟷ Alongshore variable dune **growth**

➔ Subtidal bar depth correlates to embryonic dune development
? Alongshore variable **bar** morphology ⟷ Alongshore variable **dune** morphology

➔ Storms result in different erosion extents
? Pre-storm **dune** morphology ⟷ **Storm** properties ⟷ **Bar-beach** morphology

➔ Yearly aerial photos and bed levels

Aerial photographs ➔ **supervised classification** of vegetation pixels (2-6 m MSL).

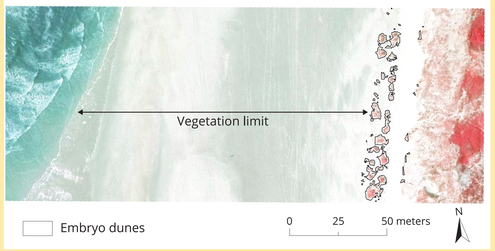


Figure 5 Example of embryo dune extraction from aerial photographs using supervised classification, for one location. The vegetation limit represents the distance between the 0m-contourline and the most seaward extent of the embryo dune vegetation.

Linear regression model, including:
- Storminess: Maximum water level, wave height, wave run-up, duration
- Weather during growing season: Precipitation and temperature
- Morphology: Beach width, beach slope, shoreface volume, **bar crest depth**

Experimental design	
112 sites 100 m alongshore	2010-2016
Response variables	
Area of embryo dunes	Aerial photograph
Vegetation limit	
Explanatory variable	
• Beach width • sandbar morphology	Cross-shore elevation profiles
• Storm intensity • Wave dissipation • Weather conditions	Meteorological measurements

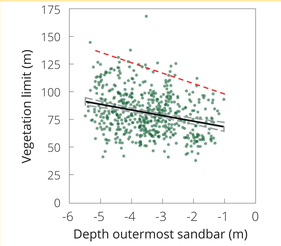


Figure 6 The linear regression model showed that cross-shore profiles with a more seaward vegetation extent significantly correlated to shallower subtidal sandbars, in particular during stormy years.

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