A GLOBAL CHARACTERISATION OF COASTAL REGIONS TO GUIDE NATURE-BASED SOLUTIONS TO SEA TURTLE NESTING BEACHES

Jakob Christiaanse, Delft University of Technology, j.c.christiaanse@tudelft.nl
José A. A. Antolínez, Delft University of Technology, j.a.a.antolinez@tudelft.nl
Stefan Aarninkhof, Delft University of Technology, s.g.j.aarninkhof@tudelft.nl
Arjen Luijendijk, Deltares & Delft University of Technology, arjen.luijendijk@deltares.nl
Carlos Duarte, King Abdullah University of Science and Technology, carlos.duarte@kaust.edu.sa

INTRODUCTION

Sea turtles are an important part of marine and coastal ecosystems around the world. Yet, six of seven sea turtle species are endangered (IUCN, 2021). While they spend most of their lives at sea, female turtles use sandy beaches as nesting habitat, where they dig their nests in the sand to incubate for up to two months. A major challenge to sea turtles is the degradation of their nesting beaches due to anthropogenic climate-change effects, such as accelerated sea level rise (SLR) and anomalous storm activity. While it is still uncertain how sandy beaches will respond to SLR, beaches backed by hard structures cannot migrate landward, leading to 'coastal squeeze'–the erosion and consequential narrowing of beaches. Increased storm activity may lead to persistently high water levels at nesting beaches, resulting in the flooding or even erosion of incubating nests (Fig. 1). Moreover, beach erosion during storms can bury nests under excessive sand and limit beach access through the formation of scarps.

Nature-based solutions–for example in the form of turtle-friendly design of beaches along new land reclamations or by adding coastal vegetation or reefs to limit runup and reduce erosion on existing beaches–may offer promising opportunities to preserve and even expand global habitats for turtle nesting.

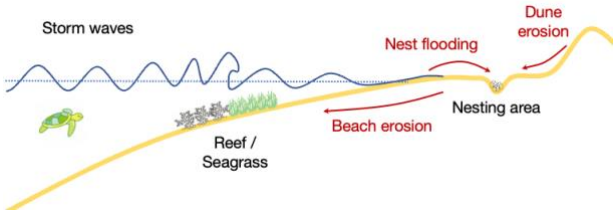

Figure 1 - Nesting beach cross-section, showing potential threats (red) and nature-based designs (reef, seagrass).

METHOD

As a first step towards nature-based designs that enable sea turtle nesting beaches, a better understanding of preferential nesting conditions and the environmental characteristics of nesting beaches is essential. In this study, we use machine learning algorithms to perform a clustering analysis of the World's coastline between 47.5° and -37.5° latitude (determined by adding a buffer to the latitudes of the furthest known nesting sites). The clustering uses global data on nesting activity, wind, wave & water level climate, beach morphology, temperature, humidity, proximity of coral reefs and seagrasses, human development, ocean currents, and tropical cyclone activity. These data are aggregated onto a ≈135km-resolution hexagonal coastline grid, based on the open-source H3 geospatial indexing system (Fig. 2, Uber Technologies, 2022), and represented through descriptive and extreme value statistics at each 'coastgon'. The resulting clusters are used to (i) examine the influence of environmental characteristics on nesting suitability; (ii) identify regions with similar and preferential characteristics across the globe; and (iii) get a first indication of the potential threats and opportunities to sea turtle nesting in each region. To verify that global results are actionable on local scales, detailed statistical and numerical modelling analyses are carried out for several study regions in the next step of this PhD project.

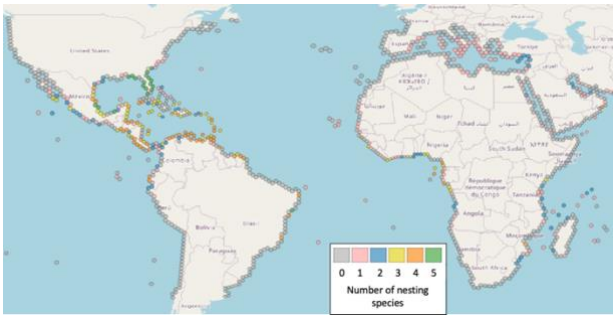

Figure 2 - 'Coastgon' grid used in the clustering (shown for Europe, Africa, and the Americas). Colors indicate the known number of nesting turtle species (Halpin, 2009; Kot, 2021).

RESULTS

The result of this study is a global environmental and morphological characterisation of coastal regions and their potential suitability for sea turtle nesting. This will (i) contribute to the identification and quantification of preferential nesting conditions and main hazards at each (potential) nesting region; (ii) drive specific research on the coastal processes driving these hazards to better shape nature-based solutions; (iii) allow the identification of preferential regions that are suitable for the implementation of full-scale measures to improve turtle nesting habitats and may serve as study cases for this project. In doing so, this study adds a unique dimension to the concept of Building with Nature as commonly applied today in engineering practice.

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