Tools and methodologies for dealing with coastal retreat due to SLR

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Summary: *Sea level rise constitutes a serious threat to countries whose coastal areas have high population densities. However, it should be noted that sea-level rise is not the only cause of increased vulnerability. Other factors, such as storms, wave climate, and the lack of sediments supply to the coast imply a current need for more appropriate strategies and major adaptation measures. This is the case of Portugal, where two-thirds of the population currently lives less than 50 km from the coastline. This work presents a discussion on the applicability of approaches based on equilibrium beach profiles for estimation of retreat, using beach profile measurements at two different locations of the Portuguese coast. A sound methodology to face the actual threats to the Portuguese coast is also suggested. This methodology is mainly based on coastal monitoring and available morphodynamic modelling tools.*

Key words: *coastal erosion, SLR, beach monitoring, operational morphodynamic modelling*

Palavras-chave: erosão costeira, SNMM, monitorização de praias, modelação morfodinâmica operacional

Sea level rise (SLR) related phenomena are complex and produce a range of environmental problems. As sea level rises, water depth increases and waves reach the coast with higher energy (eventually dissipated by breaking before reach the coast for lower depths) and therefore their erosion potential capacity is aggravated since they can transport greater quantities of sediments. It is now clear that due to climate change and consequent adaptation, the development of novel solutions to address coastal defense, as an alternative to traditional structures (seawalls, groynes and breakwaters), is needed. The innovative approaches seek to strengthen the benefits of traditional natural defenses, such as beaches and natural dunes. These novel approaches are typically characterized by lower environmental impacts, lower costs and easier implementation, and include: submerged breakwaters made of geotextile tubes or other innovative materials and structural forms; artificial or reinforced sand dunes; beach drainage systems; beach nourishments; and creation of ⎵ zones.

According to Bruun's rule (Bruun, 1962), as sea level rises, sediment is carried offshore, and shore must recede to provide sand to raise the profile (considering constant sediment size). A new concept introduced by Dean (1987) stipulates that wave asymmetry causes size variations in onshore transported sediments, raising the profile and moving the shoreline. According to Dean's concept equilibrium (Dean, 1987), shorelines can either retreat or advance in response to sea level rise. A relationship capable of explaining past and estimate future coastal changes for projected rates of sea level rise has to account for all phenomena that significantly affect shorelines. Dean and Houston (2016) propose a new approach to estimate the shoreline area change, adding to the estimated retreat of Bruun's rule other effects related to sedimentary sources and sinks. Indeed, coastal retreat is beyond the capabilities of simple approaches based on beach equilibrium profiles, that are applied to analyze this problem. According to Cooper and Pilkey (2004), the comparison between results from works applying the Bruun's Rule and known erosion rates never have demonstrated agreement.

This work discusses the applicability of approaches based on equilibrium beach profiles (eg. Taborda and Ribeiro, 2015) for estimation of retreat due to SLR, using beach profiles measurements at two different Portuguese coastal stretches (Fig. 1). It also presents the main characteristics of a technological platform that is being implemented to assess coastal morphodynamics along the NW Portuguese coast.

Measured beach profiles show relevant differences in shape and slope faces. For set a) the slope varies between 3° and 7°, and for set b) slope varies in the range of 4° to 10°. If these slopes could be assumed

near the equilibrium profile, according the concept of Bruun's rule, this means that for a SLR of 1 m, retreats would vary between 8 m and 19 m for set a) and between 6 m to 14 m for set b).

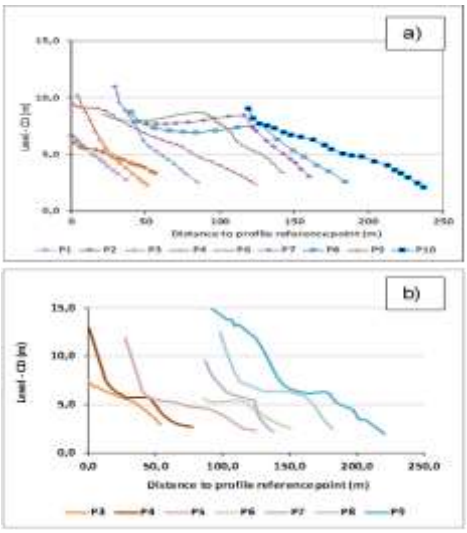

Fig. 1. Beach profiles measured at two different coastal stretches: a) campaign C4 at NW coast and b) campaign C11 at Centre Portuguese coast.

Considering the high uncertainty and simplifications associated with retreat estimations based on Bruun's rule approaches, for assessing either adaptation measures to be taken in the short term, or planning mitigation measures to face long term scenarios of SLR, comprehensive alternatives are required. They must include the most advanced and available technologies and do a special effort of continuous monitoring of the present morphodynamic trends.

Thus, if frequently beach profiles measurements are available, the assessment of the dominant erosion trends and the developing of proper simulations based on advanced morphodynamic models like XBeach (Roelvink et al. 2010) will be possible. Fig 2 presents an example of the impact of a hypothetical storm at the NW coast (stretch a) P6).

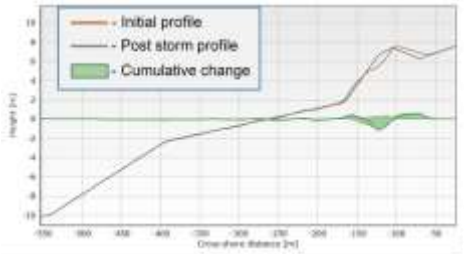

Fig. 2. Results of XBeach morphodynamic model occurring at spring tide combined with a storm surge of 1 m.

Moreover, different models and data sources can be plugged together recurring to proper technological platforms.

In conclusion, the proposed approach constitutes an appropriate source for preparedness and knowledge of a complex phenomenon that is treating the Portuguese coast and should be a concern of both research institutions and all stakeholders that have their activities dependent from a vulnerable coastal zone. Moreover, if protection measures will be required a possible combination of different alternatives complementing each other, as shown in Fig. 3, should be equated and studied to be implemented in the Portuguese coast.

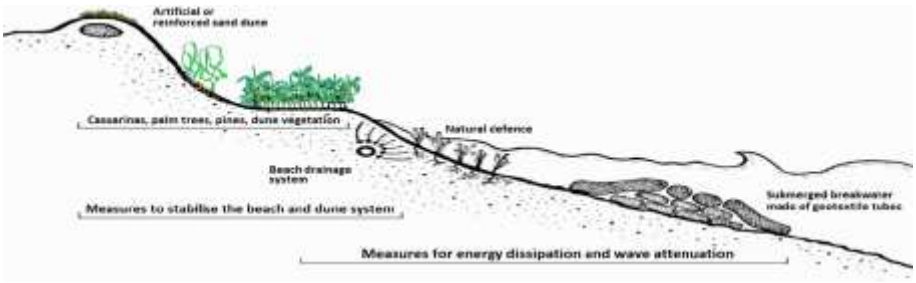

Fig. 3. Suggested approaches combined to maximize energy dissipation and wave attenuation with the goal of stabilizing the beach and the dune system.

References:

Bruun, P. (1962). Sea-level rise as a cause of shore erosion. J. Waterway. Harbours Div. 88,117–130.

Cooper, J. A. G. & Pilkey, O.H. (2004). Sea-level rise and shoreline retreat: time to abandon the Bruun Rule. Global and planetary change, 43(3-4), 157-171.

Dean, R.G. (1987). Additional sediment input to the nearshore region. Shore Beach 25 (3-4), 76-81.

Dean, R.G. & Houston, J.R. (2016). Shoreline response to sea level rise. Coastal Engineering, 114, 1–8.

Taborda, R. & Ribeiro, M.A. (2015). A simple model to estimate the impact of sea-level rise on platform beaches. Geomorphology, 234, 204-210.

Roelvink, D., Reniers, A. J. H. M., Van Dongeren, A., Van Thiel de Vries, J., Lescinski, J., & McCall, R. (2010). XBeach model description and manual. Unesco-IHE, Deltares and Delft University of Tecnhology. Report June, 21, 2010.