16.º SILUSBA
XI CPGZC • 2024, Maputo

XI Congresso sobre Planeamento e Gestão das Zonas Costeiras dos Países de Expressão Portuguesa

DESENVOLVIMENTO DE ABORDAGEM NUMÉRICA DE MÉDIO/LONGO-PRAZO PARA ANÁLISE DE EVOLUÇÕES DE INTERVENÇÕES DE ALIMENTAÇÃO ARTIFICIAL DE PRAIAS

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universidade de aveiro theoria poiesis praxis

1. INTRODUÇÃO

"(…) mais de 200 milhões de pessoas em todo o mundo vivem em áreas costeiras a menos de 5 metros acima do nível do mar."

24% das costas arenosas do Mundo apresentam problemas de erosão e em Portugal 45% das praias arenosas enfrentam o mesmo problema

Portugal, 2014 (fonte: publico.pt)

Inglaterra, 2014 (fonte: newcivilengineer.com)

Austrália, 2020 (fonte: crikey.com)

Video source: https://svs.gsfc.nasa.gov/30082

1. INTRODUÇÃO

ALIMENTAÇÕES ARTIFICIAIS

O conceito baseia-se na tentativa de replicar os processos naturais de formação de praias e dunas e restabelecer o balanço de sedimentos: a areia é depositada no sistema costeiro e a natureza encarrega-se da sua distribuição

Fotografia: https://www.sunshinecoastnews.com.au/

1. INTRODUÇÃO

Springer Link

Original Paper | Published: 13 October 2020

Coastal erosion risk assessment to discuss mitigation strategies: Barra-Vagueira, Portugal

A. M. Ferreira, C. Coelho & P. Narra

Natural Hazards **105**, 1069–1107(2021) | Cite this article

Abstract

Worldwide coastal zones present serious erosion problems that cause loss of territory. This phenomenon exposes people and goods to the threat, being necessary to carry out a well-founded management of these areas. Coastal erosion risk assessment methodologies are an important tool for coastal management. The main goal of the present study was to evaluate and discuss coastal management strategies based on the application of a methodology of

Journal of Coastal Research	SI	95	209–213	Coconut Creek, Florida	2020

Numerical Modelling of Artificial Sediment Nourishment Impacts

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ABSTRACT

Coelho, C.; Ferreira, M., and Marinho, B., 2020. Numerical modelling of artificial sediment nourishment impacts. *In:* Malvárez, G. and Navas, F. (eds.), *Global Coastal Issues of 2020. Journal of Coastal Research*, Special Issue No. 95, pp. 209–213. Coconut Creek (Florida), ISSN 0749-0208.

www.JCRonline.org

In general, coastal erosion problems are related to significant sediments deficits. A possible coastal erosion mitigation strategy involves restoring the sediments balance through artificial nourishments. However, the complexity of the physical processes in the coastal zones challenges the numerical tools prediction capacity. This is usually overcome through numerical modelling of the shoreline evolution and the cross-shore profile along time, as an attempt to anticipate the performance of nourishments operations. The coastal morphology depends on the sediments dynamics and the incident wave climate is considered the main modelling agent responsible for the potential sediment transport capacity. The cross-shore sediment transport is usually associated to the shortterm behaviour of the morphological evolution of the beach (seasonal changes) and the longshore sediment transport is related to the long-term changes (towards an equilibrium state). Typically, these distinct sediment transport components are studied and modelled separately due to the incompatibility of their time scales of interest.

This work was developed to numerically model the impact of artificial nourishments. LTC (Long-Term

A crescente procura por maiores volumes de sedimentos aumentará o custo das intervenções, tornando esses projetos inviáveis para países com recursos financeiros limitados

A capacidade de implementar planos de adaptação à erosão costeira depende dos recursos financeiros dos países

As alimentações artificiais de praias são a medida mais eficaz para reduzir o risco de erosão, mas o desempenho da intervenção depende de vários parâmetros

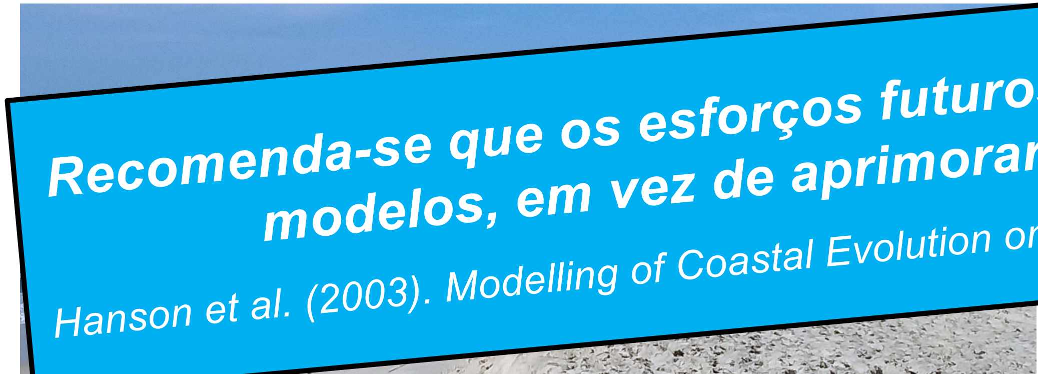
QUAL A EFICIÊNCIA DAS ALIMENTAÇÕES ARTIFICIAIS DE PRAIAS PARA MITIGAR A EROSÃO COSTEIRA NUMA PERSPETIVA DE MÉDIO/LONGO-PRAZO?

1. INTRODUÇÃO

Qual a eficiência das alimentações artificiais de praias para mitigar a erosão costeira numa perspetiva de médio/longo-prazo?

MÉTODO DE INVESTIGAÇÃO:

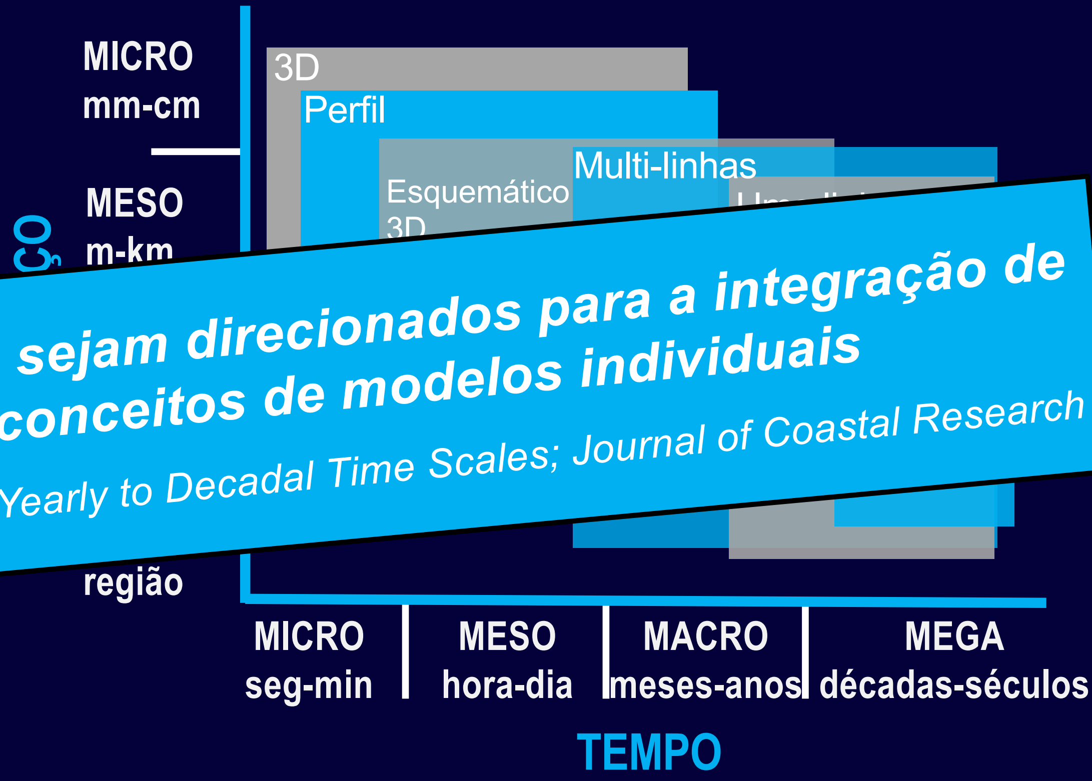
Abordagem baseada na modelação numérica



Processos longitudinais: Evolução da linha de costa (anos a décadas)

Processos transversais: Evolução do perfil de praia (dias a meses)

Classificação dos modelos numéricos de evolução das zonas costeiras (baseado em Larson, 2005)



Recomenda-se que os esforços futuros sejam direcionados para a integração de modelos, em vez de aprimorar conceitos de modelos individuais

Hanson et al. (2003). Modelling of Coastal Evolution on Yearly to Decadal Time Scales; Journal of Coastal Research

2. OBJECTIVOS & METODOLOGIA

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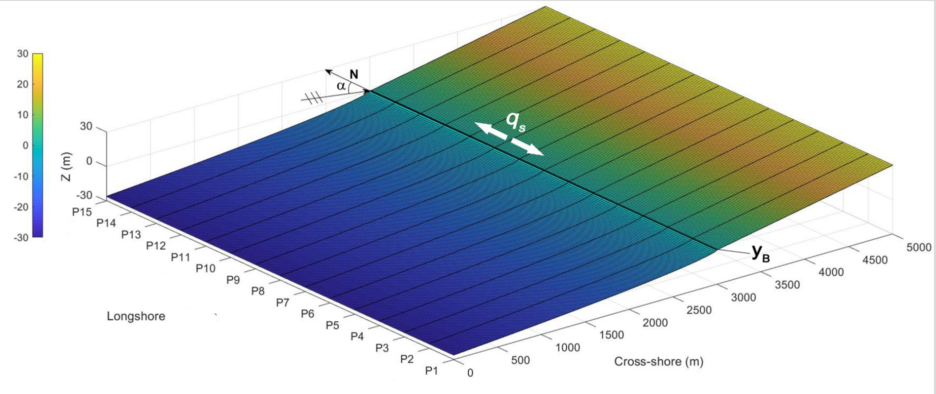
Contribuir para melhorar o conhecimento sobre o desempenho de intervenções de alimentação artificial de praias:

- **Melhorar as capacidades de modelação numérica numa perspetiva de médio/longo-prazo**
- **Aplicar o modelo para estudar intervenções de alimentações artificiais de praias**

LTC (Coelho, 2005)

Evolução da linha de costa - Processos longitudinais

$$\frac{dy_B}{dt} = -\frac{1}{D_B + D_C}\frac{\partial Q_s}{\partial x}$$

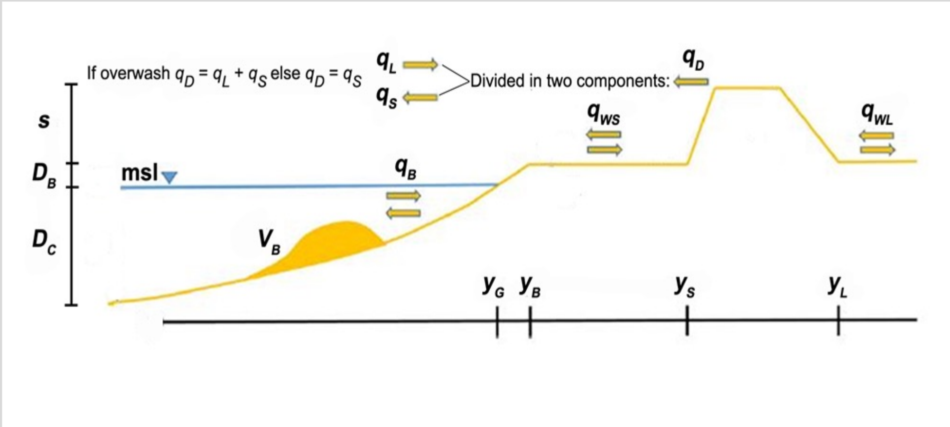


+

CS-Model (Larson *et al.*, 2016)

Perfis transversais - Processos transversais

$$\frac{dy_B}{dt} = \frac{1}{D_B + D_C}(-q_{WS} - q_B + q_S)$$



2. OBJECTIVOS & METODOLOGIA

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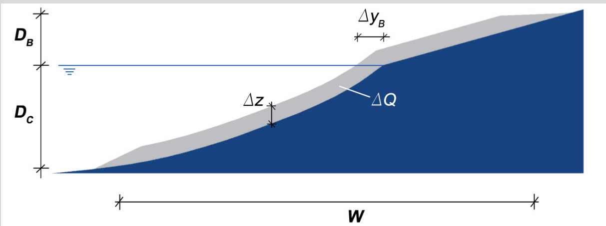
LTC

- **Dados** — Parâmetros de cálculo (sedimentos, água, vento, etc.)
- **Fronteira** — Condições fronteira do domínio de cálculo
- **Ondas** — Parâmetros da agitação marítima ao largo
- **Coord** — Batimetria e topografia do domínio de cálculo

Executar o modelo

***ΔQ* gradientes de transporte longitudinal de sedimentos**



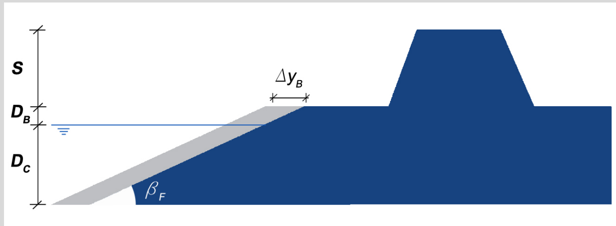
Variação *ΔZ* em cada ponto do domínio do LTC → **ΔY_B em cada perfil transversal**

CS-MODEL

- **Dados** — Parâmetros de cálculo (sedimentos, água, vento, etc.)
- **Ondas** — Parâmetros da agitação marítima ao largo
- **Perfis** — Características morfológicas de cada perfil transversal

Executar o modelo

***ΔQ* transporte de sedimentos transversais**



Variação *ΔZ* em cada ponto do domínio do LTC → **ΔY_B em cada perfil transversal**

x NCAL

2. OBJECTIVOS & METODOLOGIA

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Combinar os processos longitudinais e transversais de transporte de sedimentos, considerando as interações que ocorrem, quer na zona submersa, quer na zona emersa do domínio costeiro.

3. RESULTADOS

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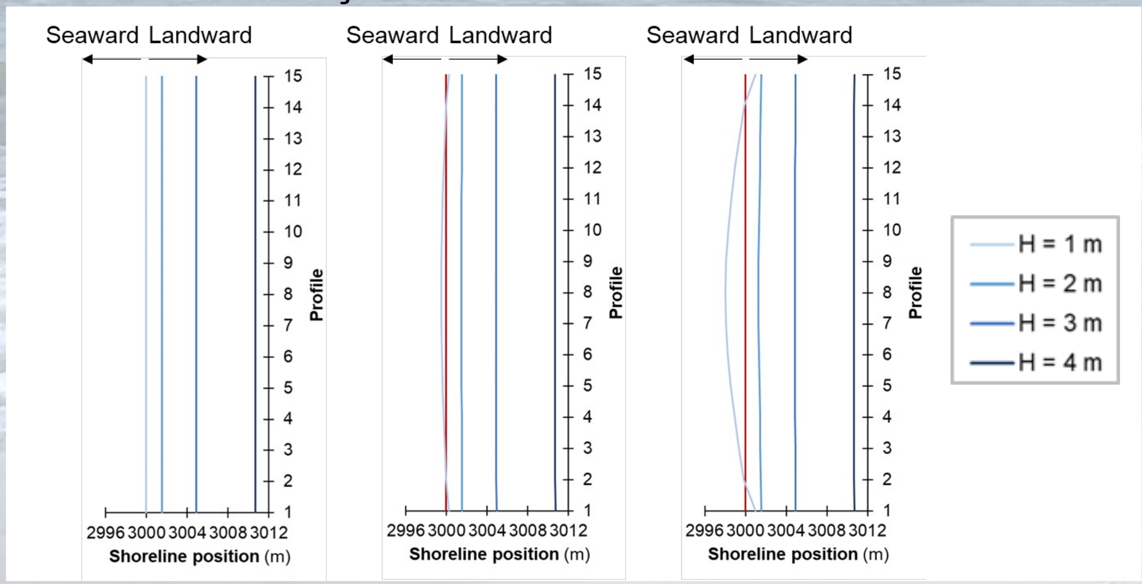
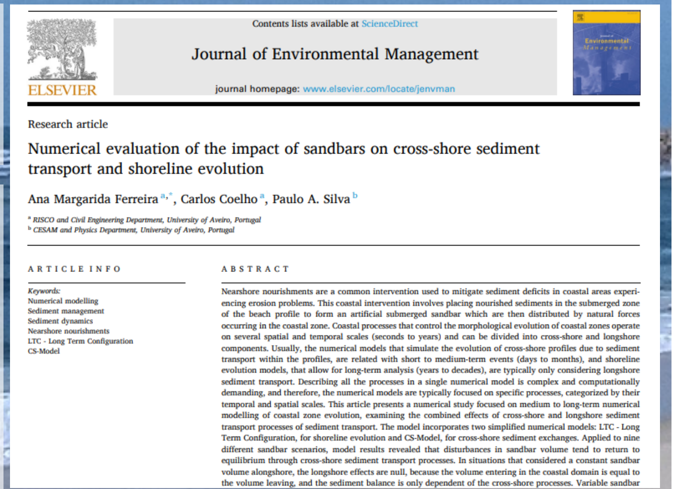
DINÂMICA BARRA-BERMA

OBJECTIVO: Investigar o impacto da dinâmica barra-berma na evolução da posição da linha de costa. Útil para apoiar o projeto de alimentações de sedimentos na zona submersa das zonas costeiras.

Posição da linha de costa no final da simulação em função da altura de onda, considerando alimentações artificiais na barra submersa





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journal homepage: www.elsevier.com/locate/jenvman

Research article

Numerical evaluation of the impact of sandbars on cross-shore sediment transport and shoreline evolution

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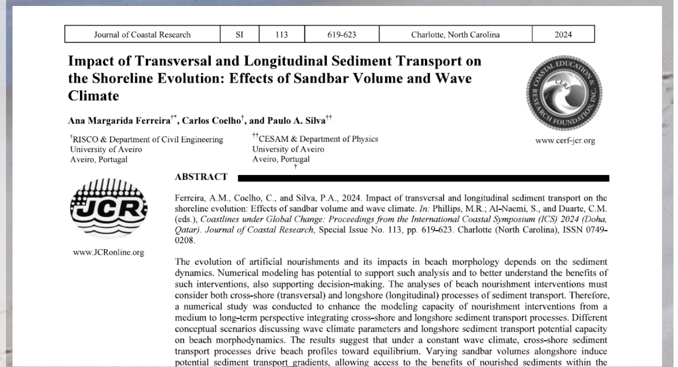
ARTICLE INFO

Keywords:
Numerical modelling
Sediment management
Sediment dynamics
Nearshore nourishments
LTC - Long Term Configuration
CS-Model

ABSTRACT

Nearshore nourishments are a common intervention used to mitigate sediment deficits in coastal areas experiencing erosion problems. This coastal intervention involves placing nourished sediments in the submerged zone of the beach profile to form an artificial submerged sandbar which are then distributed by natural forces occurring in the coastal zone. Coastal processes that control the morphological evolution of coastal zones operate on several spatial and temporal scales (seconds to years) and can be divided into cross-shore and longshore components. Usually, the numerical models that simulate the evolution of cross-shore profiles due to sediment transport within the profiles, are related with short to medium-term events (days to months), and shoreline evolution models, that allow for long-term analysis (years to decades), are typically only considering longshore sediment transport. Describing all the processes in a single numerical model is complex and computationally demanding, and therefore, the numerical models are typically focused on specific processes, categorized by their temporal and spatial scales. This article presents a numerical study focused on medium to long-term numerical modelling of coastal zone evolution, examining the combined effects of cross-shore and longshore sediment transport processes of sediment transport. The model incorporates two simplified numerical models: LTC - Long Term Configuration, for shoreline evolution and CS-Model, for cross-shore sediment exchanges. Applied to nine different sandbar scenarios, model results revealed that disturbances in sandbar volume tend to return to equilibrium through cross-shore sediment transport processes. In situations that considered a constant sandbar volume alongshore, the longshore effects are null, because the volume entering in the coastal domain is equal to the volume leaving, and the sediment balance is only dependent of the cross-shore processes. Variable sandbar



Journal of Coastal Research	SI	113	619-623	Charlotte, North Carolina	2024

Impact of Transversal and Longitudinal Sediment Transport on the Shoreline Evolution: Effects of Sandbar Volume and Wave Climate

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www.cerf-jcr.org

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ABSTRACT

Ferreira, A.M., Coelho, C., and Silva, P.A., 2024. Impact of transversal and longitudinal sediment transport on the shoreline evolution: Effects of sandbar volume and wave climate. *In:* Phillips, M.R.; Al-Naemi, S., and Duarte, C.M. (eds.), *Coastlines under Global Change: Proceedings from the International Coastal Symposium (ICS) 2024 (Doha, Qatar)*. *Journal of Coastal Research*, Special Issue No. 113, pp. 619-623. Charlotte (North Carolina), ISSN 0749-0208.

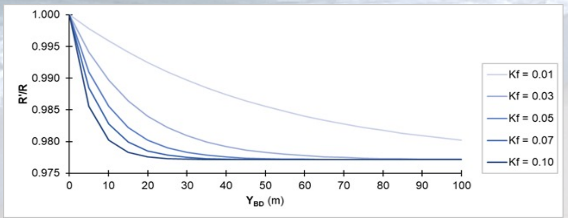
The evolution of artificial nourishments and its impacts in beach morphology depends on the sediment dynamics. Numerical modeling has potential to support such analysis and to better understand the benefits of such interventions, also supporting decision-making. The analyses of beach nourishment interventions must consider both cross-shore (transversal) and longshore (longitudinal) processes of sediment transport. Therefore, a numerical study was conducted to enhance the modeling capacity of nourishment interventions from a medium to long-term perspective integrating cross-shore and longshore sediment transport processes. Different conceptual scenarios discussing wave climate parameters and longshore sediment transport potential capacity on beach morphodynamics. The results suggest that under a constant wave climate, cross-shore sediment transport processes drive beach profiles toward equilibrium. Varying sandbar volumes alongshore induce potential sediment transport gradients, allowing access to the benefits of nourished sediments within the

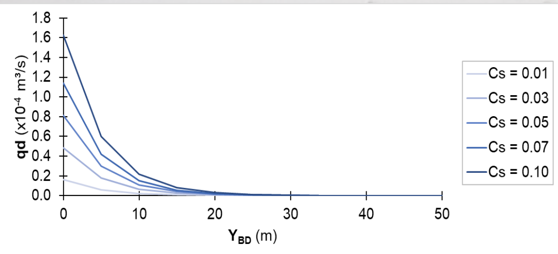
3. RESULTADOS

EROSÃO DA DUNA POR IMPACTO DA ONDA

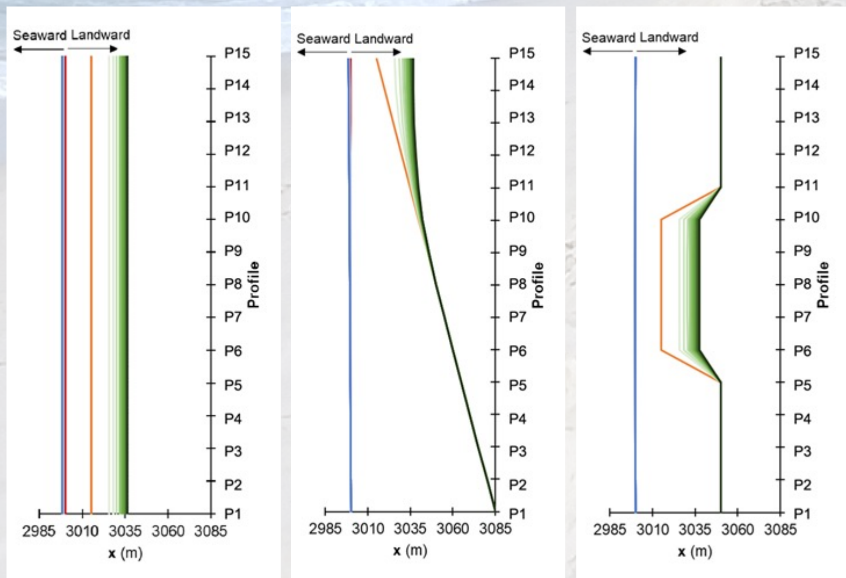
OBJECTIVO: Investigar a eficiência do reforço dos sistemas dunares através de alimentações artificiais de sedimentos, com base na análise da evolução da posição da linha de costa e posição da duna.

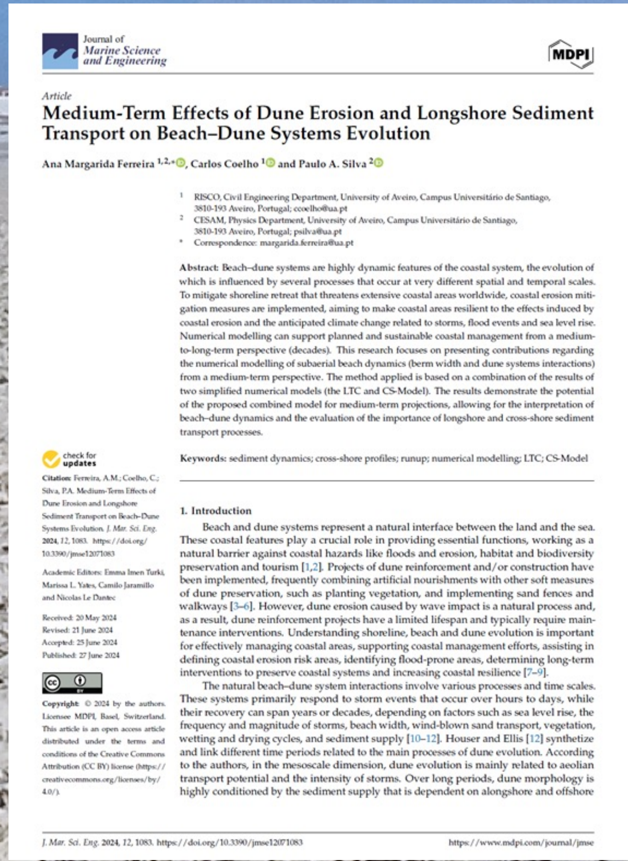
Transporte de sedimentos da duna para a berma, por impacto da onda, em função da largura da berma





Evolução da posição da linha de costa e duna





Journal of Marine Science and Engineering

MDPI

Article

Medium-Term Effects of Dune Erosion and Longshore Sediment Transport on Beach–Dune Systems Evolution

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Abstract: Beach–dune systems are highly dynamic features of the coastal system, the evolution of which is influenced by several processes that occur at very different spatial and temporal scales. To mitigate shoreline retreat that threatens extensive coastal areas worldwide, coastal erosion mitigation measures are implemented, aiming to make coastal areas resilient to the effects induced by coastal erosion and the anticipated climate change related to storms, flood events and sea level rise. Numerical modelling can support planned and sustainable coastal management from a medium-to-long-term perspective (decades). This research focuses on presenting contributions regarding the numerical modelling of subaerial beach dynamics (berm width and dune systems interactions) from a medium-term perspective. The method applied is based on a combination of the results of two simplified numerical models (the LTC and CS-Model). The results demonstrate the potential of the proposed combined model for medium-term projections, allowing for the interpretation of beach–dune dynamics and the evaluation of the importance of longshore and cross-shore sediment transport processes.

Keywords: sediment dynamics; cross-shore profiles; runup; numerical modelling; LTC; CS-Model

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Citation: Ferreira, A.M.; Coelho, C.; Silva, P.A. Medium-Term Effects of Dune Erosion and Longshore Sediment Transport on Beach–Dune Systems Evolution. *J. Mar. Sci. Eng.* **2024**, *12*, 1083. https://doi.org/10.3390/jmse12071083

Academic Editors: Emma Imen Turki, Marissa L. Yates, Camilo Jaramillo and Nicolas Le Dantec

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1. Introduction

Beach and dune systems represent a natural interface between the land and the sea. These coastal features play a crucial role in providing essential functions, working as a natural barrier against coastal hazards like floods and erosion, habitat and biodiversity preservation and tourism [1,2]. Projects of dune reinforcement and/or construction have been implemented, frequently combining artificial nourishments with other soft measures of dune preservation, such as planting vegetation, and implementing sand fences and walkways [3–6]. However, dune erosion caused by wave impact is a natural process and, as a result, dune reinforcement projects have a limited lifespan and typically require maintenance interventions. Understanding shoreline, beach and dune evolution is important for effectively managing coastal areas, supporting coastal management efforts, assisting in defining coastal erosion risk areas, identifying flood-prone areas, determining long-term interventions to preserve coastal systems and increasing coastal resilience [7–9].

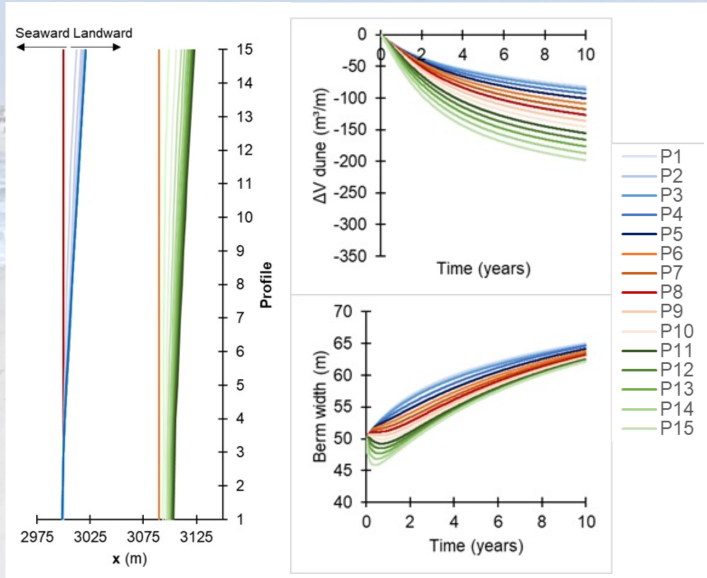
The natural beach–dune system interactions involve various processes and time scales. These systems primarily respond to storm events that occur over hours to days, while their recovery can span years or decades, depending on factors such as sea level rise, the frequency and magnitude of storms, beach width, wind-blown sand transport, vegetation, wetting and drying cycles, and sediment supply [10–12]. Houser and Ellis [12] synthetize and link different time periods related to the main processes of dune evolution. According to the authors, in the mesoscale dimension, dune evolution is mainly related to aeolian transport potential and the intensity of storms. Over long periods, dune morphology is highly conditioned by the sediment supply that is dependent on alongshore and offshore

J. Mar. Sci. Eng. 2024, 12, 1083. https://doi.org/10.3390/jmse12071083 https://www.mdpi.com/journal/jmse

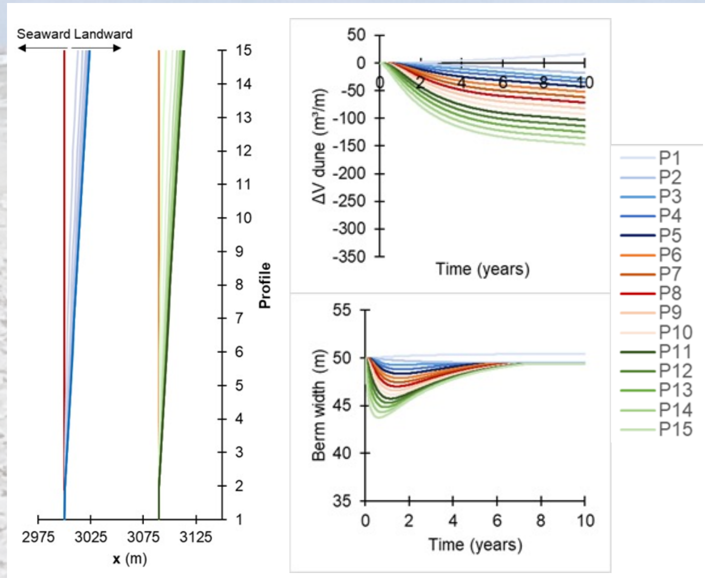
TRANSPORTE EÓLICO DE SEDIMENTOS

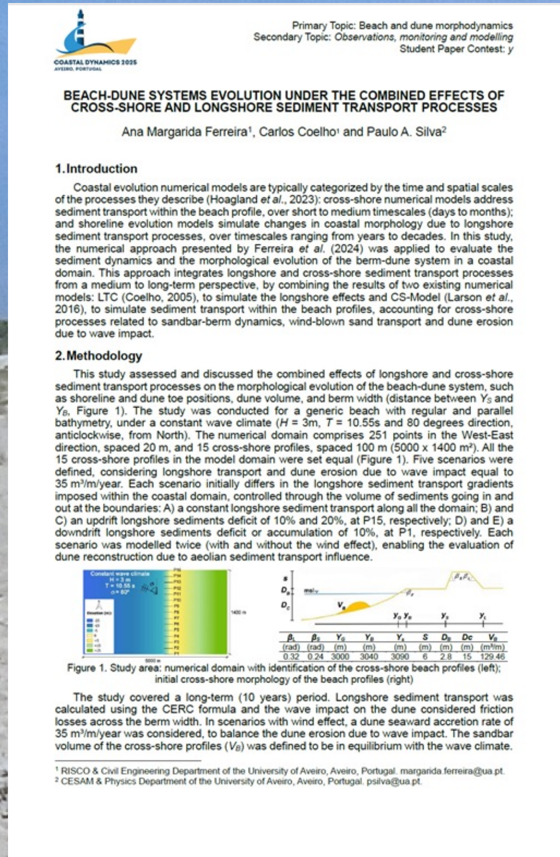
OBJECTIVO: Investigar a evolução da posição da linha de costa e do sistema dunar, considerando o efeito da erosão da duna induzida pelo impacto das ondas e os processos de transporte eólico de sedimentos.

Evolução morfológica sem efeito da ação do vento



Evolução morfológica considerando o efeito da ação do vento





COASTAL DYNAMICS 2025 AVEIRO, PORTUGAL

Primary Topic: Beach and dune morphodynamics
Secondary Topic: *Observations, monitoring and modelling*
Student Paper Contest: *y*

BEACH-DUNE SYSTEMS EVOLUTION UNDER THE COMBINED EFFECTS OF CROSS-SHORE AND LONGSHORE SEDIMENT TRANSPORT PROCESSES

Ana Margarida Ferreira[1], Carlos Coelho[1] and Paulo A. Silva[2]

1. Introduction

Coastal evolution numerical models are typically categorized by the time and spatial scales of the processes they describe (Hoagland *et al.*, 2023): cross-shore numerical models address sediment transport within the beach profile, over short to medium timescales (days to months); and shoreline evolution models simulate changes in coastal morphology due to longshore sediment transport processes, over timescales ranging from years to decades. In this study, the numerical approach presented by Ferreira *et al.* (2024) was applied to evaluate the sediment dynamics and the morphological evolution of the berm-dune system in a coastal domain. This approach integrates longshore and cross-shore sediment transport processes from a medium to long-term perspective, by combining the results of two existing numerical models: LTC (Coelho, 2005), to simulate the longshore effects and CS-Model (Larson *et al.*, 2016), to simulate sediment transport within the beach profiles, accounting for cross-shore processes related to sandbar-berm dynamics, wind-blown sand transport and dune erosion due to wave impact.

2. Methodology

This study assessed and discussed the combined effects of longshore and cross-shore sediment transport processes on the morphological evolution of the beach-dune system, such as shoreline and dune toe positions, dune volume, and berm width (distance between Y_S and Y_B, Figure 1). The study was conducted for a generic beach with regular and parallel bathymetry, under a constant wave climate (H = 3m, T = 10.55s and 80 degrees direction, anticlockwise, from North). The numerical domain comprises 251 points in the West-East direction, spaced 20 m, and 15 cross-shore profiles, spaced 100 m (5000 x 1400 m²). All the 15 cross-shore profiles in the model domain were set equal (Figure 1). Five scenarios were defined, considering longshore transport and dune erosion due to wave impact equal to 35 m³/m/year. Each scenario initially differs in the longshore sediment transport gradients imposed within the coastal domain, controlled through the volume of sediments going in and out at the boundaries: A) a constant longshore sediment transport along all the domain; B) and C) an updrift longshore sediments deficit of 10% and 20%, at P15, respectively; D) and E) a downdrift longshore sediments deficit or accumulation of 10%, at P1, respectively. Each scenario was modelled twice (with and without the wind effect), enabling the evaluation of dune reconstruction due to aeolian sediment transport influence.

β_L (rad)	β_S (rad)	Y_G (m)	Y_B (m)	Y_s (m)	S (m)	D_B (m)	Dc (m)	V_B (m³/m)
0.32	0.24	3000	3040	3090	6	2.8	15	129.46

Figure 1. Study area: numerical domain with identification of the cross-shore beach profiles (left); initial cross-shore morphology of the beach profiles (right)

The study covered a long-term (10 years) period. Longshore sediment transport was calculated using the CERC formula and the wave impact on the dune considered friction losses across the berm width. In scenarios with wind effect, a dune seaward accretion rate of 35 m³/m/year was considered, to balance the dune erosion due to wave impact. The sandbar volume of the cross-shore profiles (V_B) was defined to be in equilibrium with the wave climate.

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4. CONCLUSÃO

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IMPACTO PARA A COMUNIDADE CIENTÍFICA

Com baixo esforço computacional (1 ano ≈ 10 minutos de simulação), o modelo permite análises de médio/longo prazo (anos a décadas) desenvolvidas para escalas regionais (quilómetros).

Modelos numéricos desenvolvidos com o objetivo de combinar processos longitudinais e transversais de transporte de sedimentos numa perspetiva de médio/longo-prazo

CoSMoS-Coast (Vitousek *et al.*, 2017);
LX-Shore (Robinet *et al.*, 2018);
GenCade (Ding *et al.*, 2019)

↓

Apenas descrevem a evolução da linha de costa e não consideram os processes de transporte que ocorrem na zona emersa.

COCCONED (Antolínez *et al.*, 2019)

↓

Não considera os processos relacionados com transporte eólico de sedimentos e dinâmica barra-berma.

Palm20 (Palalane *et al.*, 2020)

↓

Não garante uma completa integração dos processos longitudinais e transversais de sedimentos.

4. CONCLUSÃO

IMPACTO PARA A SOCIEDADE

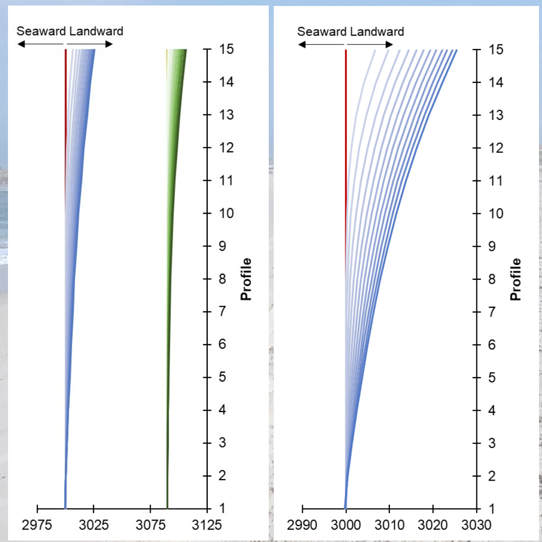
Auxiliar a gestão costeira e o estudo de medidas de mitigação da erosão costeira, como alimentações artificiais de praias, apoiando o projeto da intervenção e a otimização dos recursos.

Evolução dos parâmetros morfológicos:

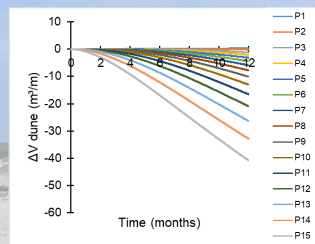
- Posição da linha de costa;
- Posição da duna;
- Volume da duna;
- Volume da barra submersa;
- Número de galgamentos;
- Largura da berma.

Resultados do modelo – Evolução de parâmetros morfológicos

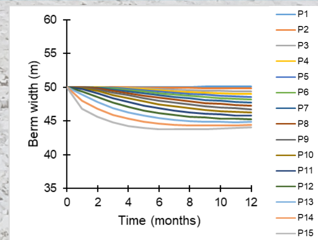
Posição da linha de costa e duna



Volume da duna



Largura da berma



4. CONCLUSÃO

United Nations Office for Disaster Risk Reduction

"We may not be able to prevent natural hazards (...). But we can decide where people live, how buildings are constructed and what plans and are in place ***to get people away from danger."***

Photo source: x.com/UNOceanDecade

XI Congresso sobre Planeamento e Gestão das Zonas Costeiras dos Países de Expressão Portuguesa

OBRIGADA PELA ATENÇÃO!

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