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Editorial

Sediment Dynamics in Artificial Nourishments

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Worldwide, coasts present increasing erosion trends, regardless of the investments made to mitigate them. In fact, serious erosion problems relating to significant negative sediment budgets in coastal systems have been identified. Artificial nourishments are a coastal erosion mitigation strategy that allows for these negative budgets to be decreased by adding sediment to the coastal system. However, due to the complexity of coastal processes, after the intervention, sediment dynamics present difficult evaluations. Important technical questions remain without an adequate answer. For instance, guidance for nourishment designs should consider the time needed for the cross-shore profile to reach its equilibrium configuration after the intervention. Other designing characteristics should consider the nourished sediments' longshore transport velocity and the time sand takes to benefit the neighbor beaches under different morphological and hydrodynamic conditions to better define the re-nourishment frequency. It is also important to control the mass center of the nourishment interventions under different longshore sediment transport conditions, understanding the nourished morphological shape and the degree of diffusion of the sediments over time.

The social perceptions of artificial nourishments also depend on the technician's ability to explain what is intended with these coastal interventions. A subaerial reinforcement of a beach may lead to larger recreative areas, with quick positive effects on their recreative use, but the movement of sediments to the submerged bar causes a negative idea of rapid losses and inadequate intervention. On the other hand, reinforcing a submerged bar may increase the beach berm over time due to cross-shore dynamic processes, causing a positive reaction in coastal populations that did not realize that the sediments were previously deposited in the subaqueous portion of the beach profile. The location of the deposition in the profile also depends on the costs of the intervention, the equipment, used and the sediment sources. Sand from maritime sources is simpler to deposit in the submerged part of the profile, while terrestrial sediments are easier to use when reinforcing dunes or beaches. Knowing the existing volumes available and the distances of the sources is also fundamental to define the nourishment strategies over time.

Another relevant topic relating to artificial nourishment interventions is the effective benefit they represent in decreasing the maintenance needs of existing coastal structures or mitigating wave overtopping. In fact, the maintenance of coastal structures and overtopping and flooding events may correspond to high costs that can be diminished by the nourishments, but these positive impacts are scarcely quantified. The engineering, technical, and social aspects of nourishment interventions require scientific knowledge and continuous research. Considering this, the present Special Issue compiles the most updated scientific knowledge on understanding the processes of sediment dynamics following artificial nourishment. This Special Issue promotes discussions on cross-shore and longshore nourished sediment distribution, monitoring works, the impacts of shoreline evolution after nourishments, the longevity of the nourishments, ecological impacts, and the interactions of artificial nourishments with other coastal structures.

Artificial nourishments are presently some of the most applied coastal erosion mitigation interventions [1]. Nearshore nourishments are constructed for shoreline protection from waves, to provide sediment nourishment to the beach profile, and to beneficially use sediment dredged from navigation channel maintenance [2]. According to Kroon et al. [3], sandy nourishments can provide additional sediment to a coastal system to maintain its recreational or safety function under rising sea levels. These nourishments can be implemented at sandy beach systems as valid measures of mitigating coastal erosion in some erosional hot spots; they are also considered measures of adaptation under the present climate change scenario, including the impacts of an increasing sea level [4,5].

This Special Issue provides new insights into the time scales of beach responses to high-magnitude shoreface interventions on different sandy coasts. Monitoring results are shown and discussed in four manuscripts [3–6]. At the Hondsbossche Dunes, the Netherlands, a combination of shoreface, beach, and dune nourishment of 35 million m^3 sand was built to replace the flood protection function of an old sea dike while creating additional space for nature and recreation. Over a five-year period, net volume losses from the project area were less than 5% of the initial nourished sand volume. The dune volume has increased and the dune foot migrated seaward at the entire nourished site, regardless of whether the subaqueous profile gained or lost sediment. Natural forces in the years after implementation provided a significant contribution to the growth in dune volume and related safety against flooding [3]. At the Aveiro coast (Costa Nova-Ílhavo), Portugal, the first monitoring results of a $\approx 2.4 \times 10^6$ m^3 shoreface nourishment, the largest performed in Portugal until now, are presented by Pinto et al. [4] and Mendes et al. [5]. The morphological development, impacts on adjacent beaches due to alongshore spreading and cross-shore redistribution, and the contribution to the sediment budget of the nourished sediment cell were evaluated. The results show rapid morphological change over the placement area, with a decrease of about 40% of the initial volume. Sediment spreading also induced the accretion of the subaerial section of Costa Nova beaches in front of the placement area, reversing their long-term erosive trend [4]. These two study sites show the specificity of each location in the performance and evaluation of nourishments.

A nearshore nourishment project was completed during the summer of 2021 in Harvey Cedars, NJ, USA, with 67,500 m^3 of dredged sediment from Barnegat Inlet placed along approximately 450 m of beach at a depth of 3–4 m [6]. Altering the cross-shore profile geometry due to the introduction of new sediments induces a non-equilibrium situation with respect to the local wave dynamics [6]. In fact, hydrodynamics are changed by nourishment interventions that alter the bottom characteristics, inducing different wave propagation conditions, namely refraction and breaking. These types of effect need to be better understood, and potential increases in the concentrations of suspended sediments, mainly during intervention works, which may represent relevant environmental impacts, must be evaluated.

This Special Issue also represents an important step in compiling updated knowledge about monitoring works and example situations in which the interactions with coastal structures are described. Two manuscripts [7,8] describe the relationships between nourishments and existing coastal structures, and they also combine the monitored information and the different characteristics of the materials used in the nourishment operation (sand and gravel). The capacity to distinguish the different effects of sediment grain sizes is highlighted as an important research topic due to the complexity of the processes relating to different sand characteristics and the ability to model those processes.

This Special Issue also contributes to numerical modelling research, which is also applied in cost–benefit assessments, ecological impacts, and laboratory works. It is poorly understood how the placed sediments' morphology and depth influence nearshore processes operating on wave-dominated coasts [2]. Ferreira et al. [9] also state that it is essential to understand and adequately model the shoreline response after a nourishment operation in order to support the definition of the best intervention scenarios. Numerical modelling can help in understanding processes and anticipating behaviours. Johnson et al. [2] investigated the wave fields, sediment transport, and morphological responses to three common nearshore nourishment shapes, a nearshore berm (elongated bar), undulated nearshore berm, and small discrete mounds, using numerical experiments. The simulation results indicate that shallower, more continuous berms attenuate the most wave energy, while deeper, more diffuse placements retain more sediment. Sancho et al. [10] aimed to compare and identify the most effective intervention in terms of reducing beach erosion or even promoting beach accretion forced by local wave conditions, supported by a shoreline evolution model calibrated with in situ field data. Ferreira et al. [9] studied the effects of artificial nourishment on the longshore sediment transport and consequently on the morphological evolution at the intervention site and nearby areas over a time span of 5 years. In a different approach, Guimarães et al. [11] used 3D movable bed physical modelling to test the impacts of beach nourishment on hydrodynamics, sediment transport, and morphodynamics. Nourishments may also have ecological consequences. This Special Issue presents a study referring to the possible interaction between nourishments and the success of invading species [12]. It is suggested that direct communication between environmental regulators and scientists is crucial for improving both scientific research and environmental management policies [12].

Measures to mitigate coastal erosion usually present negative aspects and thus, when a coastal intervention is performed, is it desirable to define a solution that presents low levels of negative physical impacts while being simultaneously economically attractive. Supported by the results of models, an integrated cost–benefit methodology is presented to analyse the performances of artificial nourishments [1]. The approach presented by Coelho et al. [1] encompasses a shoreline evolution model (to estimate maintained, gained, or lost coastal areas over time) and a cost–benefit evaluation (combining the monetary benefits of land use and the ecosystem services of the territory with the costs of the artificial nourishment interventions, depending on their sand volumes along time). Thus, the performance of an artificial nourishment should be analysed by assessing the effectiveness of different scenarios from physical, social, environmental, and economic perspectives.

In general, the sediment dynamics of nourished sediments are deeply evaluated in this Special Issue, which aims to contribute to scientific knowledge about the permanence of sediment at the deposition site and the frequency required for new nourishments. The variety of research topics presented in this Special Issue are demonstrative of the importance of artificial nourishment as a coastal erosion mitigation strategy and the complexity of the processes involved in this type of intervention. The monitoring works highlight the diversity of parameters to monitor, and the site-specific conditions reveal the difficulty of defining common behaviours while also demonstrating the interactions with other coastal structures and the importance of the materials considered in the intervention. Monitoring is also supporting in modelling works, which are increasingly relevant in projecting future scenarios for adequate long-term planning. The obtained modelling results improve the understanding of nearshore nourishment shapes and can support decision makers in identifying the most appropriate construction technique or intervention scenarios for future nearshore nourishment projects. Consequently, the research presented in this Special Issue can support decision makers in identifying the most proper management action where coastal erosion problems persist and nourishment interventions are required.

Conflicts of Interest: The author declares no conflict of interest.

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