A NEW METHODOLOGY TO ASSESS SURFING CHANGES DUE TO COASTAL WORKS

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INTRODUCTION

Managing conflicts between multiple users of the coastal zone is a challenge for modern coastal engineering. In the context of surfing, changes in beach morphology resulting from the implementation of coastal protection measures have a direct impact on wave-breaking patterns and consequently on surfing conditions.

This study proposes a novel methodology to evaluate surfing conditions on sandy beaches. The purpose of this methodology is to provide a comparative tool for assessing the impact of permanent changes in the beach morphology on the surfing conditions for various levels of expertise.

The framework quantifies the surf resource availability in the current situation and compares it with a future situation after the proposed intervention, accounting for: (1) current morphological conditions in terms of wave breaking intensity, breaking length and peel angle; (2) wave climate and sea level, determining the overall availability of surfable conditions; and (3) seasonality of both, wave climate and beach morphological state and the type of surfer according to the skill level.

METHODS

Surfability is defined as a Boolean variable that determines whether a wave or sea state is suitable for surfing. Given that most wave databases provide data on significant wave height (H_s), peak period (T_p), and mean wave direction (θ_m), the range of variation of these variables for which the sea state is surfable must be determined. In the literature, there are reference values to evaluate the surfability of a wave or sea state (e.g., Espejo et al., 2014). However, the unique characteristics of a beach make local surfers the most reliable reference for determining optimal surfing conditions. Therefore, consultation with local surfers and surf schools is recommended as they may know the ideal surfing conditions to establish values of wave heights and directions that allow surfing in that particular spot. Since the wave steepness increases with wave height, the minimum surfable period scales with the wave height and hence ($T_{p,min} = f(H_s)$).

Surfing levels are defined based on two key parameters, the breaking wave height (H_b) and the angle between the wave fronts and the breaking line, defined as peel angle (α_b). Table 1 presents the defined surfing levels based on these parameters.

The next step is to propagate the waves timeseries to the coast and determine the breaking wave height and peel angle for each surfable sea state and the occurrence of surfable conditions. This requires a propagation model able to resolve the propagation of the wave fronts so the peel angle can be obtained. In this study, the OLUCA-MC (González et al., 2007), a monochromatic REF-DIF model has been used, assuming that surfers tend to wait for the biggest waves of the set, that best approximate to monochromatic waves. For each propagated sea state case, the length of surfable zone is determined at each point of the break line.

Level	Description	Surf conditions
1: Beginners	Not able to slide down the wall, they su rf the broken section of the wave.	$0.5\, m \le H_b < 1\, m$
2: Average	Able to slide down the wall of the wave.	$1\, m \le H_b < 2\, m$ AND $50^\circ \le \alpha_b < 90^\circ$
3: Advanced	Capable of generating pumping speed and performing manoeuvres.	$2\, m \le H_b < 3\, m$ AND $30^\circ \le \alpha_b < 90^\circ$ OR $1\, m \le H_b < 2\, m$ AND $\alpha_b < 50^\circ$
4: Experts	Capable of riding laterally on very large waves at angles of up to 20°.	$H_b \ge 3\, m$ AND $20^\circ \le \alpha_b < 90^\circ$ OR $2\, m \le H_b < 3\, m$ AND $\alpha_b < 30^\circ$

Table 1 – Defined surfing levels. Adapted from Hutt et al. (2001).

With the intention of providing consistent long-term statistics a 30 years wave hindcast has been propagated to evaluate the surf climate. Considering that the timeseries contains more than 250 thousand cases, it is not computationally feasible to propagate every sea state to obtain H_b and α_b and subsequently calculate the surf length for the different skill levels. Therefore, a cluster of representative cases considering different wave parameters and sea levels were simulated and the surfing conditions reconstructed at the surf zone based on the radial basis functions interpolation technique (RBF, see Camus et al., 2011). Figure 1 presents the flowchart of the described calculation procedure.

STUDY CASE

As a pilot case, we applied the described framework to the beach of La Concha in the mouth of Suances estuary, Cantabria, North Spain. It's an embayed sandy beach about 750 m long and characterized by a mean sediment size of $D_{50} = 0.3\, mm$, subject to the dynamics of the North Atlantic swells, and the tidal currents at the estuary mouth that generates several sand bars. As a result, the type of breaking waves attracts a wide spectrum of users, from surf schools to seasoned professionals. Furthermore, these dynamics poses dangerous hazards to navigation at the river mouth entrance. To mitigate these problems, the extension of one of the breakwater is proposed, as shown in Figure 2. The Figure 2a shows the current bathymetry and 2b the future bathymetry estimated by using numerical models, equilibrium formulations, and physical modeling.

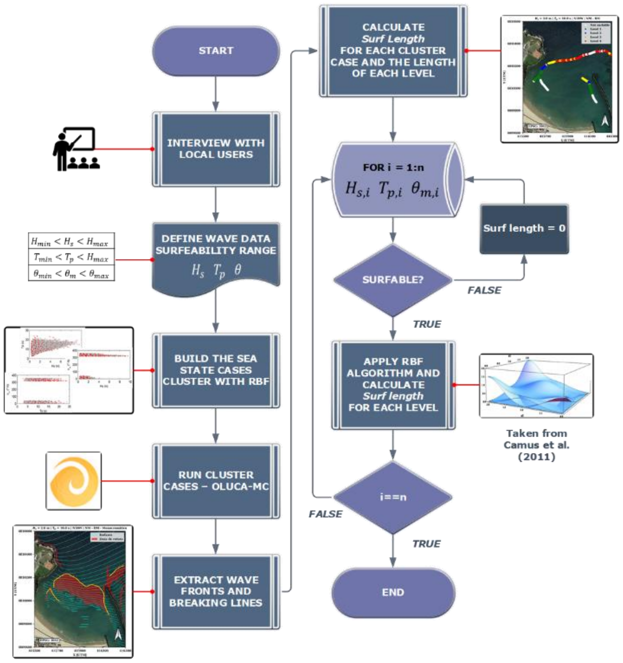

Figure 1 - Stablished framework flowchart.

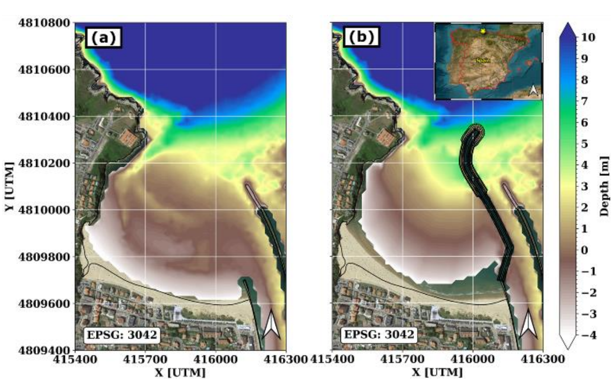

Figure 2 - Study site: La Concha Beach, Suances, Spain. (a) Current beach condition. (b) Future beach condition considering the construction of the breakwater.

After consulting various local users, it was concluded that those sea states within the range of $10°N \leq \theta_m \leq 90°$ in deep waters, and $H_s > 0.5\,m$ are surfable. For waves with $H_s > 0.5\,m$, the minimum required peak period is set at $T_p > 5\,s$, whereas for $H_s > 2.5\,m$, the minimum peak period is extended to $T_p > 8\,s$. Therefore, using a linear relationship, the minimum peak period for a given H_s is given by: $T_{p,\ min,\ i} = 1.25H_{s,\ i} + 4.25$. Hourly time series of waves (H_s, T_p, θ_m), tides and surges from early 1979 to the end of 2019 were used to estimate the surf climate at the study site.

RESULTS

Applying the methodology to both the current and future situation with the extended breakwater, the results show that the total length of the surfable zone decreases from an overall average of approximately 920 m in the current situation to 570 m in the future situation, i.e., a 38% reduction. In absolute terms, level 2 (average surfer) loses the most lineup, approximately 250 m. When expressed as percentages, the reductions of the lineup ranges between 55%, 48%, 64% and 3% for levels 1, 2, 3 and 4 respectively.

The seasonal analysis depicts summer as the months with the lowest loss of surfable area, when surf schools are most active, with a reduction of 27%. Contrary, during the winter, when intermediate to expert surfers are most active, is when the highest average reduction of 46% occur. The monthly analysis showed that the new morphology will limit the variation of the available surfable area for all months and for the whole year.

The results will be discussed in the presentation.

CONCLUSIONS

The new equilibrium beach that will be shaped will be much more stable morphologically as the dynamics of the inlet decouple from the beach. Therefore, the variations in the annual and monthly mean values of the lineup length will be much smaller. In addition, the reduction in the lineup length (38% in total) and virtually all surf levels will be negatively affected.

ACKNOWLEDGEMENTS

The authors acknowledge the support of the Regional Ministry of Universities, Equality, Culture and Sports of the Government of Cantabria (Contract-Program between the Government of Cantabria and the University of Cantabria) under Grant PID2021-127994OB-I00 FutureBeach Project and the ThinkInAzul programme supported by MCIN/Ministerio de Ciencia e Innovación with funding from European Union NextGeneration EU (PRTR-C17.I1) and by Comunidad de Cantabria.

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