OBSERVATION AND MODELING OF CRESCENTIC BARS IN BARCELONA EMBAYED BEACHES

F.Ribas[1], R. Garnier[2], A. Falqués[2], J. Guillén[1], E. Ojeda[1], D. Calvete[2].

[1]Institut de Ciències del Mar (CMIMA-CSIC), P. Marítim de la Barceloneta 37-49, 08003 Barcelona, Spain. ribas@cmima.csic.es, jorge@cmima.csic.es, eojeda@cmima.csic.es,
[2]Appl. Physics Dept., Uni. Politècnica de Catalunya, Jordi Girona 1-3, Campus Nord UPC, 08034 Barcelona, Spain. rgarnier@fa.upc.edu, falques@fa.upc.edu, calvete@fa.upc.edu,

Shore parallel sand bars can display a number of different shapes, the most common being a rectilinear or featureless one (linear bar; see Fig. 1 A). Quite often they show a wavy shape in plan view called crescentic shape where shallow sections alternate along the bar with deep sections called rip channels (see Bogatell beach in Fig. 1 B). For wave incidence perpendicular to shore, crescentic bars are associated to cellular flow with strong rip currents at the channels and weaker onshore return flows at the shallower sections. They have been observed on many beaches but systematic field studies are scarse (for instance, see van Enckevort et al., 2004), especially on embayed beaches. Crescentic bars are formed during intermediate beach conditions and wiped out during dissipative conditions (large wave height). They are not observed in reflective beach states.

Although the formation of crescentic bars has been often attributed to the hydrodynamic forcing by infragravity edge waves it is nowadays well accepted that the most plausible cause is a positive feedback between breaking waves, currents and the evolving morphology (Deigaard et al., 1999; Falqués et al., 2000; Caballeria et al., 2002; Reniers et al., 2004). All these modeling studies describe the generating mechanism but almost none of them make a prediction of the beach configuration and wave conditions under which the bar is crescentic and the conditions under which the bar remains rectilinear. Caballeria et al. (2002) suggested a non-dimensional parameter ($\sqrt{gH_b}/w_s$, g being gravity, H_b being wave height at breaking and w_s being settling velocity) that might govern the transition between crescentic and linear bar shape (the latter being dominant for large values of $\sqrt{gH_b}/w_s$) but this issue remains an open problem from the modeling point of view. Another limitation of our present knowledge on crescentic bars is the lack of quantitative comparisons between field observations and model results (an example can be found in van Enckevort et al, 2004).

The beaches on the waterfront of Barcelona have been monitored with an Argus video system since November 2001. In two of these beaches, Bogatell and Barceloneta, a single shore-parallel bar is usually present, which occasionally becomes crescentic (see Fig. 1). This system is therefore an ideal lab to test models for crescentic bar formation. The aim of the present research is to investigate the formation and evolution of crescentic bars in the embayed beaches of Barcelona, comparing field observations with model predictions. Special attention is paid to the conditions under which shore-parallel bars are linear and the conditions under which they become crescentic.

As a first step, the nearshore bars observed in Bogatell and Barceloneta beaches during the last four years are described using Argus video images (the methodology can be found in van Enckevort et al, 2004). An example of well developed crescentic bar in Bogatell beach has been shown in Fig. 1, with three clear undulations spaced every 200 m. The wave conditions leading to crescentic bar events are studied in detail using data from an offshore buoy. Subsequently, the observed well-developed crescentic bar events are simulated with two numerical models in order to compare quantitatively their results with the field observations. A linear stability model (Calvete et al., 2005) and a nonlinear 2DH morphodynamic model (Garnier et al., 2006) are used to describe the initial formation and further evolution of crescentic bars. As an example, Fig. 2 shows a result of the nonlinear model for a domain with the same alongshore length as Bogatell beach (600 m) and a similar mean beach profile. Waves approach the shore perpendicularly with a significant height of 1.4 m and a period of 6 s. In the graph, light gray corresponds to shallow areas and dark gray represents the channels. Although the model still has some simplifications that are being removed (e.g. periodic boundary conditions rather than groin simulation), the number of predicted rips (3) is quite consistent with observations (2 well formed and maybe a third one). Hence the spacing between rips of about 200 m is rather well predicted. The small arrows in the graph represent the 2DH flow field coupled with the emerging morphology, resembling the observed systems of rip currents that coexist with crescentic bars in natural beaches.

A detailed description of the crescentic bar events observed in Barcelona city beaches during the last four years will be given in the final contribution (characteristics of the morphological patterns, the wave conditions and the beach configuration). Afterwards, these field observations will be compared quantitatively with the results of the two models presented above in order to gain deeper understanding about the physical processes leading to crescentic bar formation and evolution.

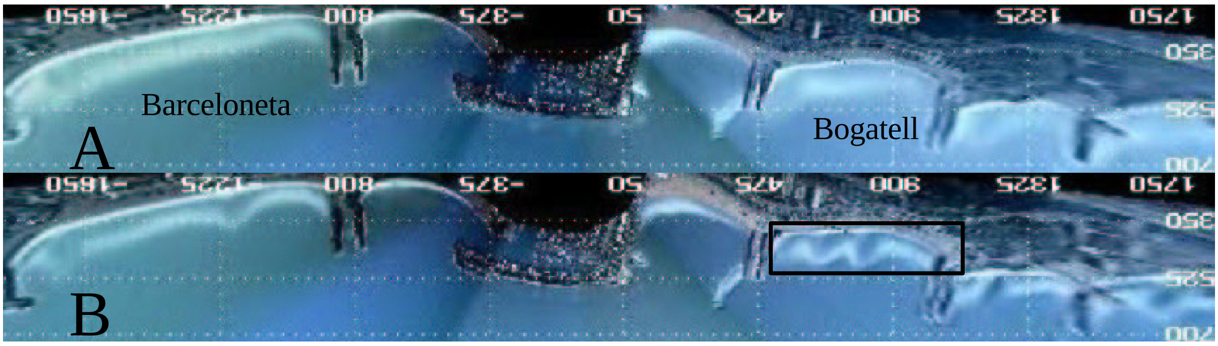

Fig.1: Argus time-exposure video images of Barcelona city beaches. Panel A: Linear shore-parallel bars in Barceloneta and Bogatell beaches. Panel B: Well-developed crescentic bar in Bogatell beach.

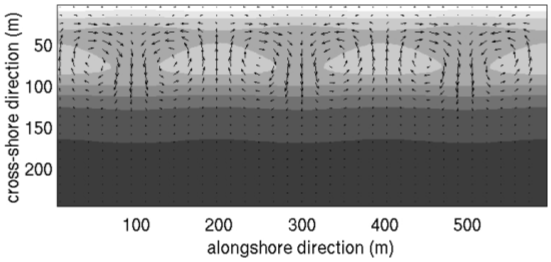

Fig.2: Model simulation of a crescentic bar formation in Bogatell beach using a nonlinear model.

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