Influence of dunes on alternate bar migration in a sandy gravel river: the Loire (France)

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ABSTRACT

The control exerted by dunes on the formation and migration of alluvial bars has been identified on several large rivers. With only a few exceptions, none of the many field investigations carried out on dunes examined the influence of their migration on bar dynamics. The exceptions are studies by Ashworth et al. (2000) and Villard and Church (2005) who provided a comprehensive analysis of dune-bar. However, the interactions between dunes and alternate bars are seldom investigated. These macroforms consist in consecutive diagonal fronts with low slope riffles located upstream. Their spatial pattern varies from simple- to multiple-row configurations depending on the width-to-depth ratio of the channel.

In the downstream reaches of the River Loire (France), near the city of Nantes, several secondary channels allow the study of interactions between alternate bars and superimposed dunes since they are disconnected during low flows. In one of these channels, hydraulics, high frequency bathymetrical surveys and sedimentary sequences were analyzed to detail the influence of dune migration on the dynamics of five alternate bars during a 4-year flood event.

Bathymetrical surveys performed demonstrate that height and length of dunes varied according to a counterclockwise hysteresis. Although the height and length of dunes were higher during the falling limb of the hydrograph than during the rising limb, the evolution of these parameters was more important during the rising limb, specifically just before the flood peak. For these flow conditions, the increase in dunes length was significant while the increase in height was moderate. During the peak discharge, the height and length of dunes strongly increased on most of the bars while the morphological response of dunes to discharge variation differed according to the bar considered after the flood peak. Consequently, the average dune steepness was characterized by a clockwise hysteresis during the same flood event. The results show that the average steepness of the dunes is equal to 0.023. This value is low in comparison to the minimum value of steepness 0.06 commonly admitted for equilibrium dunes and can be attributed to a depth limitation. In terms of hydraulics, values of the roughness parameter (ks) proposed by Van Rijn (1984) increased on bars in the downstream direction during the flood peak. The lateral evolution of the height of dunes on each alternate bar was also analyzed. Bars located near a geometrical discontinuity of the channel banks show a strong correlation between the height of dunes and distance from the bank. In other words, the increase in dunes' height is more important for high flow depths located near the bank opposite to the bar. This can be attributed to the lateral variation of flow depth associated with the transverse slope of these bars. On the other bars (located in a straighter part of the channel) this trend was not observed. Due to high values of Shields mobility parameter, the sediments of the bars were easily reworked and a lateral spreading governed by a re-direction of dunes towards the inner part of the channel was observed after the

flood peak. This process also influences the sedimentary products associated with the bars (Rodrigues et al. 2012).
Results given are the basis of a conceptual model of alternate bars/dunes interactions for unsteady flow conditions in large sandy gravel rivers.

REFERENCES

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