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Coastal evolution and littoral cells distribution in Northern Tuscany (Italy)

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This paper deals with a 64-km-long coastal physiographic unit located in the northern littoral of Tuscany (Italy). The investigated area recorded important erosion problems in last century due to the reduction in sediment input from rivers and to the feeding effect of ports and shore protection structures. Vertical aerial photographs and direct field surveys (with RTK-GPS and total station) were used for the reconstruction of coastline changes at medium-long temporal scales.
The littoral is a microtidal environment and most frequent and severe storms approach from the 245º direction, with maximum one year recurrence Hs values between 3.5 and 4.0 m, less frequent and severe storms approach from the 180º and 200º directions.
Concerning coastal evolution for the 1938-2005 period, important accretion was recorded updrift of two harbours (300 at Viareggio and 100 m at Carrara port in a convergence area (100 m at Marina di Pietrasanta), whereas severe erosion occurred downcoast of Carrara harbour (-130 m at Marina dei Ronchi) and at the northern (unprotected) side of the Arno River mouth (with maximum values of 400 m).
Locally breakwaters and groins were implemented to solve erosion problems but the structures only – and not always - solved problems at local scale shifting erosion downdrift.
Coastal compartmentalisation controlled the longshore distribution of erosion/accretion patterns and it was strongly forced by natural and human structures and coastal orientation in relation to wave approaching fronts. Three main littoral cells were formed by four natural limits: i) Punta Bianca Promontory, which works as a fixed absolute limit; ii) Marina di Pietrasanta, a convergent, free limit; iii) the Arno River Mouth, a divergent limit; and, iv) Livorno harbour, which works as an absolute fixed southern limit.
In it is important to highlight that human structures interfere with natural sediment transport within major cells creating small sub-cells. This way, the general natural trend determined by coastal compartmentalisation is only slightly affected by human structures which give rise to erosion/accretion areas within most important cells. In detail, the most important structures are Carrara and Viareggio ports which constitute artificial, fixed limits which allow little transport in a given direction, depending on their protrusion and wave characteristics. They allow periodic, almost unidirectional, transport that, according to field observations, takes place along narrow zones parallel to the shoreline, extending to a variable depth (6–10 m), depending on wave conditions and bottom morphology. Furthermore, bypassing of limits takes place locally as a consequence of bed load sand transport onto longshore bars and only fine sediments bypass the structures. In detail, Carrara port only permits transport in one predominant direction (southward) and Viareggio port probably records a bi-directional transport, even if prevails the northward directed one. Last, obtained results are useful to improve the understanding of coastal processes to manage littoral sediment transport in a sustainable manner and to minimise needs for structural interventions. For this is sufficient to identify independent cells and partially dependent sub-cells for shoreline management units, if not adverse impacts will be inevitability transmitted to the downdrift unit.