Chapter 8

General Conclusions

The main conclusions obtained with this thesis have been presented in previous chapters. This chapter presents the most innovative aspects of the thesis including some suggestions for future research.

Overwash events were comprehensively measured including confined flows in washover lobes and unconfined flows in washover plains. This thesis presents unique and detailed measurements of overwash sediment transport coupled with the associated oceanographic conditions. For the first time, fluorescent tracers were used in overwash flows, both surface samples and shallow corers were taken and analysed, thus allowing a three dimensional study of the flows. The distinctive sediment dynamics both for washover lobes and plains were defined. Sedimentary processes on washover lobes are characterised by confined overwash flow on the mouth and channel that causes mouth erosion, onshore sediment transport and fan deposition. These sedimentary processes occur uniformly during the entire overwash event. Unconfined overwash flow on washover plains are not uniform and three evolutionary stages can be identified during the overwash event: Stage 1, characterised by crest accretion; Stage 2, where the dominant process is onshore transport; and Stage 3, that occurs when the washover reaches dynamic equilibrium.

The factors governing overwash events were determined based on studies performed at two different time scales (short-term and medium-term). The main factors governing the occurrence of non-storm overwash on the study area were: (i) typical winter waves, (ii) spring high tides, (iii) absence of well-developed beach berms, and (iv) washover crest/mouth below a certain elevation. The comparison between the available data from the literature and the measurements made during the overwash fieldwork campaigns, demonstrated that non-storm overwash may attain the same order of magnitude of sediment transport as the storm overwash. The oceanographic thresholds for the occurrence of overwash were established using results from the medium-term studies that included storm and non-storm situations. A wave power threshold was determined for the occurrence of non-storm overwash with equinoctial tides (P>20,000 $Jm^{-1}s^{-1}$); it has a probability of exceedence of 14%. A higher wave power threshold was determined (P>50,000 $Jm^{-1}s^{-1}$) for the occurrence of overwash with neap and regular spring tides; it has a probability of exceedence of 4%. The existence of a beach berm, was one of the most important factors inhibiting the occurrence of overwash. It was found that overwash sedimentation increased exponentially with the decrease in beach volume. The shape of the exponential trend depends on the oceanographic conditions and the coastal resilience. The exponential relationship is innovative but it needs further research. The crest elevation is a key factor for overwash occurrence (as found in intensive fieldwork campaigns) but comparative studies need to be made at contrasting crest elevations (developed foredune *versus* washover crest) to better evaluate this parameter.

The relative role of overwash was determined based on the data resulting from a 3 year monitoring study of a frequently overwashed area. Swash processes were dominant in the short-term barrier island volume variations (83% of volume variation) at the study area. However, for the overall studied period the process that mostly contributed to barrier accretion was overwash (88% of the total accretion). The sediments that were deposited by overwash on the landward side of the washover plain were not subsequently eroded by lagoon processes. The events in barrier evolution may be resumed as a sequence composed of three stages: (1) during Stage 1 the geomorphologic changes of the barrier are rapid and dominated by complete overwash that leads to dune destruction and to the formation of a wide and low washover plain; (2) during Stage 2 the washover dynamics is dominated by frequent overwash, including non-storm overwash; and (3) at Stage 3 morphologic changes are slow, overwash is not common, and aeolian processes dominate the washover dynamics promoting dune development and vertical barrier accretion. To completely understand the role of overwash in the formation of the barrier islands, it would be necessary to investigate the history of formation of the current barriers. For that, it is necessary to extend the field of research to the internal structure of the barrier islands (for example with Ground Penetrating Radar).

The washover textural signature was defined in a comparative study with other adjacent sedimentary environments (dune, beach, and tidal inlet). The washover plain exhibited distinct textural characteristics from the beach, dunes and tidal inlets. The barrier sub-environments textural groups that were defined were: AEOLIAN, BEACH BAFS, FLOW DECAY, and OVERWASH. On the contrary, the washover crest and terminus exhibited textural characteristics that were closer to those of the beach berm; this was attributed to the flow decay at those locations. This work complements other studies about the possibility of distinguishing overwash deposits from other coastal deposits, and provides additional information for paleo-environmental studies and numerical modelling. The relation between the textural signature and the magnitude of the flow, needs further research.

A classification of washover dynamics was obtained using aerial photographs of the Ria Formosa. This classification is based on the identification of the mechanisms for washover formation and disappearance as well as the overwash evolutionary trend. The mechanisms of washover formation were: (1) depressions in dune elevation; (2) structural erosion; (3) inlet dynamics; (4) washout; and, (5) human interventions. The disappearance mechanisms were: (1) dune development; (2) berm development; (3) structural erosion; (4) inlet dynamics; and, (5) human interventions. The overwash evolutionary trend is defined with the combination of the variation of occurrences and dimensions of the washovers. The trend may be towards an increase or a decrease in overwash processes, or not possible to define in case there is a change in coastal morphology or prevailing mechanisms. The present classification may seem unnecessary for those areas where overwash dynamics are dominated by hurricanes and major storms. For other barriers, such as the study area, the proposed classification provides a systematic analysis that allows a comparison between different barrier islands. The present classification includes the most important processes identified within this study, however it is important to note that it should be tested and improved by its application to other systems. The dominant processes for the Ria Formosa washovers were found to be inlet dynamics for washover formation and dune development for their disappearance. The number and dimensions of the Ria Formosa washovers diminished during the last part of study period, thus presenting a general trend for a decrease in the overwash importance. A significant connection between overwash and tidal inlet dynamics was found with this thesis. This reveals the necessity to perform integrated overwash studies, where the coastal processes are analysed as complex, complementary, and interdependent. Other mechanisms were identified and should be further investigated with short-term and medium-term studies, particularly the interactions between structural erosion-overwash and human interventions-overwash.

One of the aims of this thesis was to improve the scientific knowledge of overwash sedimentary dynamics. The application of the findings for coastal management purposes was not an objective of this thesis. However, overwash processes are extremely important for integrated coastal studies and management strategies, especially for barrier islands. In natural parks, such as the case of the study area, soft engineering interventions and actions promoting biodiversity are often required for coastal conservation. The ecological impacts of overwash were not studied but when conservation campaigns are made (e.g. restrictions to bird nesting areas, maintenance of dune vegetation, recovery of salt marsh areas), overwash vulnerability has to be considered since its occurrence promotes dramatic geomorphologic changes. The conclusions of this thesis allow an improvement of coastal hazard maps, set-back lines, and land use planning, and provide valuable information for the location, timing and design of coastal management interventions (such as fencing, nourishment and inlet relocation or stabilisation).