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The Tagus estuary

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The estuary of the Tagus river is one of the largest estuaries in Europe covering an area of about 320 km^2. It is located in the Portuguese west coast, in the metropolitan area of Lisbon, and due to its social and economic context and environmental characteristics it is the Portuguese most relevant estuary. The estuary comprises along its margins 11 municipalities with about 1.6 million inhabitants (Tavares *et al.*, 2015). It hosts the Port of Lisbon, the national leader in the movement of vessels (in number and in GT), and the Tagus Estuary Natural Reserve considered one of the most important sanctuaries for birds in Europe.

The estuary has a peculiar morphology characterised by a wide inner bay with extensive tidal flats (about 43% of the total estuarine area) that connects to the ocean by a narrow and deep fault-controlled channel. The Tagus estuary is a mesotidal system with tidal amplitudes of 1.5 m (neap tide) and 3.2 m (spring tide) at Lisbon that are amplified within the estuary due to resonance (Fortunato *et al.* 1999). In average conditions, the upstream limit of the salt-water intrusion is about 50 km from the estuary mouth and the dynamic influence of the tide reaches 80 km upstream. The average discharge that reaches the estuary is about 370 $m^3\ s^{-1}$ (Neves, 2010), largely controlled by several large dams built in the Tagus River and its tributaries. The estuary narrow inlet channel restricts the upstream propagation of ocean waves, while the elongate shape of the inner bay in the prevailing wind direction favours local generation of waves (Freire and Andrade 1999).

The estuarine bottom sediments are mainly from fluvial and local origin (Freire *et al*., 2007). Fine-grained riverine sediments are mainly distributed along the tidal flats and salt marshes. Sands from local sources are found along the deeper channels and on beaches. The presence of marine sediments is limited to the estuary mouth and inlet channel. Sedimentation rates of the Tagus estuarine marshes varies between 0.4 and 2.2 cm $year^{-1}$ and are higher in the upstream areas (Silva *et al.*, 2013). A sediment retention within the estuary of 0.6 $\times 10^6$ ton $year^{-1}$ is estimated (Portela, 2004). The maintenance dredging in the main estuary access channel (sands and gravel) was about 2 x 10^6 m^3 between 1998 and 2007; the estimated annual value in the inner domain is about 0.9 x 10^6 m^3, mainly of fine sediments (Portela, 2011).

The estuarine fringe is densely occupied including some of the most important infrastructures, equipment and strategic services on national level. Occupation contrasts between margins can be found: in the northern side urban (34% of the total margin area) and industrial/port facilities (24%) are dominant, while agriculture (35%) and isolated towns occupy the most area of southern margin (Rilo *et al.*, 2012). The estuary geomorphology, the hydrodynamic characteristics and the territory occupation promote high risk of the margins to floods as confirmed by the impact of past occurrences. A regional geodatabase of historical flood occurrences in the Tagus estuary indicates that the probability of occurrence of one or more flood events in one year is about 26% (Rilo *et al.*, 2015).

The most recent flood event with the highest impact along both Tagus estuarine margins occurred on February 27, 2010, associated with the Xynthia storm, which had tragic effects in the western coast of France (Freire *et al.*, 2016). The event promoted considerable damages in the waterfront of five municipalities in the Lisbon Metropolitan Area, in different territorial contexts as urbanised and productive agricultural areas.

In estuaries, the management of flood risk needs an integrated view considering the multiplicity of hazard-forcing factors and the territorial and social complexity. An innovative approach to support flood risk management in estuaries is presented at a local scale. The approach includes a decision-making supporting framework constructed for the high risk areas, considering the emergency planning and response to floods, based on a real-time forecast and an early-warning system (Fortunato *et al.*, 2017).

References

Fortunato AB, Oliveira A, Baptista AM, 1999. On the effect of tidal flats on the hydrodynamics of the Tagus estuary. Oceanol Acta 22(1): 31-44

Fortunato AB., Oliveira A, Rogeiro J., Costa R., Gomes JL, Li K, Jesus G, Freire P, Rilo A, Mendes A, Rodrigues M, Azevedo A. Operational forecast framework applied to extreme sea levels 1 at regional and 2 local scales. Journal of Operational Oceanography, Volume 10, 2017 - Issue 1: 1-15

Freire P and Andrade C, 1999. Wind-induced sand transport in Tagus estuarine beaches. First results. Aquatic Ecology, 33(3), 225–233

Freire P, Taborda R, Silva AM, 2007. Sedimentary Characterization of Tagus Estuarine Beaches (Portugal). A contribution to the sediment budget assessment. Journal of Soils and Sediments, 7 (5), 296-302

Freire P, Tavares A, Sá L, Oliveira A, Fortunato AB, Santos PP, Rilo A, Gomes, JL, Rogeiro, J, Pablo R, Pinto PJ, 2016. A local scale approach to estuarine flood risk management. Nat. Hazards. Natural Hazards, 84(3), 359 1705-1739

Neves FS, 2010. Dynamics and hydrology of the Tagus estuary: results from in situ observations. 210p, PhD thesis, Universidade de Lisboa, Portugal. Unpublished. Available on-line at http://repositorio.ul.pt/handle/10451/2003

Portela LI, 2004. An approximate sediment budget for the Tagus estuary. In: 3rd International SedNet Conference: The future of sediment management in Europe, 3 pp. European Sediment Research Network

Portela LI, 2011. Dragagens nos portos comerciais de Portugal Continental: dados preliminares. In: 7as Jornadas Portuguesas de Engenharia Costeira e Portuária, Porto, 6 e 7 de Outubro de 2011, 9 pp

Rilo A, Freire P, Ceia R, Mendes RN, Catalão J, Taborda R, 2012. Human effects on estuarine shoreline decadal evolution. Geophysical Research Abstracts, Vol. 14, EGU2012-10863, 2012, EGU General Assembly 2012

Rilo AR, Freire P, Santos PP, Tavares AO, Sa´ L, 2015. Historical flood events in the Tagus estuary: contribution to risk assessment and management tools. In: Pedofillini et al (eds) Safety and reliability of complex engineered systems, natural hazards. CRC Press, Taylor and Francis Group, London, pp 4281–4286

Silva TA, Freitas MC, Andrade C, Taborda R, Freire P, Schmidt S, Antunes C, 2013. Geomorphological response of the salt-marshes in the Tagus estuary to sea level rise. In: Conley,

D.C., Masselink, G., Russell, P.E. and O'Hare, T.J. (eds.), Proceedings 12th International Coastal Symposium (Plymouth, England), Journal of Coastal Research, Special Issue No. 65, pp. 582-587, ISSN 0749-0208

Tavares AO, Santos PP, Freire P, Fortunato AB, Rilo A, Sá L, 2015. Flooding hazard in the Tagus estuarine area: The challenge of scale in vulnerability assessments. Environ Sci Policy 51:238–255