Hydro-sedimentary dynamics of the Rance estuary: processes, evolution and management

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Abstract:

The Rance estuary is a relatively small low-discharge steep-sided ria, located along the Brittany coast in northern France, with a maximum spring tidal range of 13.5 m. Taking advantage of this hyper-tidal regime, the first operational tidal power station (TPS) in the world (and currently the second largest) was built at the estuary mouth and has been in operation since the 1960s. In addition to the TPS, the Rance estuary is characterized by its complex morphology and the configuration of its uppermost limit (Chatelier lock).

Net siltation and sediment accumulation have been reported in the basin since the 1980s by various studies based on field measurements. However, the impact of the TPS on hydrodynamics, sediment transport and morphodynamic is still unquantified. In addition, the relevance of each physical process driving hydrodynamics and sediment dynamics in this complex system is still unclear.

This PhD thesis aims to better understand hydro-sedimentary dynamics in this highly engineered system by the presence of a tidal power plant on its mouth and a lock on its uppermost limit. To this goal, a complementary approach accounting for both field measurements and numerical modeling was deployed. On the one hand, field surveys of hydro-sedimentary variables were carried out to calibrate and validate the numerical models. On the other hand, 2D and 3D hydro-sedimentary numerical models were developed in the TELEMAC-MASCARET modeling system. The developed numerical models showed to be invaluable and complementary tools to define a sustainable management plan that conciliate electricity production and environmental impacts.

Research outcomes and recommendations from this thesis can be extrapolated to existing and future projects involving estuarine systems presenting anthropogenic structures such as dams and tidal power plants, namely Sihwa lake, Bristol channel, Pentland Firth and others.

Key words: Hydrodynamics; Sediment transport; Morphodynamics; Renewable tidal energy; the Rance estuary; Numerical modelling; Field measurements.