GUADIANA RIVER ESTUARY

Investigating the past, present and future

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Preface

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Estuaries are some of the most dynamic and complex environments in the world. The places where rivers meet the sea are subject to cycles of constant change – from the waves and currents that move particles of sand and mud every second, to the daily ebb and flow of the tides and the more dramatic effects of periodic floods, droughts and storms. Over thousands of years, estuaries are created, destroyed and re-created by sea-level changes. Few of the earth's landforms enjoy such a brief and varied existence.

The complex interplay between terrestrial, fluvial, coastal and marine realms makes estuaries unique in terms of their landscapes and biodiversity. The mixing of salt and fresh water in estuaries is physiologically challenging to plants and animals, both aquatic and marine. Species inhabiting the transitional zones between land and sea have evolved to deal with these challenges in often surprising ways, adapting their lifecycles and metabolisms to take advantage of the rich resources that estuaries provide. Per square metre, estuaries rank among the most productive habitats worldwide (McLusky & Elliott 2004).

Estuarine resources have sustained human communities for millennia. Estuaries remain critical to human existence today, providing areas for transport and trade, aquaculture and fisheries, breeding grounds for birds, salt production, flushing of wastes, power generation, recreation, spiritual and aesthetic values. As rivers meet the coast, they drop their sediment load in intertidal zones, creating nutrient-rich mudflats, saltmarsh and mangrove habitats. Human societies have long relied on these newly created areas of land for agriculture and industrial purposes.

With their abundant supplies of food and timber, availability of freshwater and access to the open sea, estuaries launched the ships of the European 'Age of Discovery' and became epicentres for globalisation. This did not, however, translate into a universal societal appreciation and protection of the unique qualities of estuarine environments. Intense industrial exploitation around the world has left estuaries with a persistent legacy of pollution, both in terms of chemical compounds and the transfer of invasive species through international trade. In many ways, estuarine systems are the vanguards of the kinds of environmental changes that are expected to affect many other systems into the future.

Estuarine sediments, as well as being substrates for living biota, sequester vast quantities 'blue carbon'. Each year, release of this carbon from mangrove, saltmarsh and seagrass sediments through coastal degradation has been estimated to cause between 6-42 billion US dollars in economic damage (Pendleton et et al., 2012). Coastal zones have immeasurable value as buffers to rising sea levels, but find themselves at increasing risk of 'coastal squeeze' as their naturally dynamic landforms and ecosystems are constrained by immovable engineering structures. Coastal sedimentation processes have changed dramatically through

river regulation and dam construction, reducing sediment supply and altering biogeochemical cycles. Scientists have been very active in trying to understand these processes of change so that the mistakes of the past need not be repeated. However, it is rare for a single estuarine system to be intensely studied by multiple scientific disciplines and for the resulting information to be gathered together in a single, easily-accessible place.

This book represents the culmination of decades of multidisciplinary scientific research on the Guadiana River and its iconic estuary. The Guadiana has the fourth largest drainage basin in the Iberian Peninsula, covering some 66,900 km^2. The river rises in the mountains of Cuenca Province of Spain and flows in a generally westward direction before veering south to meet the Atlantic Ocean. Compared to other major rivers of the Iberian Peninsula, the Guadiana has a relatively low fluvial discharge and high seasonal variability, thanks to its largely Mediterranean climate. Seasonal variation in river flow has increased in recent decades due to river regulation and water extraction for agriculture (Rocha et al., 2012).

The Guadiana estuary extends upstream some 70 km to the town of Mértola, with saltwater influence extending to Alcoutim, approximately 35 km upstream of the river mouth. Most of this meso-tidal estuary is constrained within a steep-sided valley composed of Palaeozoic greywackes and schists. Only the last few kilometres of the estuary escape geological control and fan out into a complex of saltmarshes, tidal creeks, mudflats, sand barriers and beaches. Historical maps show that this section of the Guadiana estuary has silted up rapidly over the last 200 years (Morales 1997). In Chapter 1, Erwan Garel describes his extensive research into the hydrodynamic processes that have created and continue to reshape the Guadiana's estuarine environment.

Sea-level rise poses a major risk to the present-day environment of the Guadiana estuary (Ferreira et al., 2008), including to its socio-economic potential and to important industries such as tourism. In Chapter 2, Tomasz Boski places these present threats within the context of longer-term changes in the coastal environment. The Guadiana estuary has been the site of detailed studies of how complex estuaries evolve with sea level rise (e.g. Boski et al., 2002), providing vital information for anticipating and managing changes in the future.

Some of the most intact coastal ecosystems in southern Iberia are to be found in the Guadiana estuary. Direct human impacts here have been limited historically by the estuary's location on a fiercely-defended political border between Spain and Portugal. At least 460 plant species are recorded in the estuary, including several rare and endemic species. The wetlands of Castro Marim are a declared site of international significance for waterbirds under the Ramsar Convention. The river's name itself is thought to be a mixture of the Arabic *wadi* and the Latin *anas*, meaning 'river of ducks'. Ana Gomes and Sarita Camacho introduce the rich biodiversity harboured by the estuary in Chapter 3, focussing on some of the lesser known plant and animal species that support the area's productive ecosystems.

Estuaries do not end immediately upon reaching the coast, but create a large transitional zone where river water enriched with terrigenous material mixes with seawater. These zones are often crucial for marine life and the maintenance of healthy fisheries. Isabel Mendes and Francisca Rosa describe the environments of the Guadiana continental shelf in Chapter 4, tracing the origins of the sediments and describing environmental changes caused by recent human activities in the river basin.

Saltpans are a major feature of the present-day landscape of the estuary. Salt production has a long tradition in the low-lying salinas around Castro Marim, Vila Real de Santo Antonio and Ayamonte. Their important historical, economic and environmental roles are discussed by Noa Sainz and Tomasz Boski in Chapter 5, including an exploration of their future under changing economic and climatic circumstances.

Since prehistoric times, the Iberian Pyrite Belt has provided mineral wealth to the rulers of southern Iberia. The Guadiana estuary bisects the area of ancient mining activity, forming a natural barrier between the historical regions of Andalucía and the Algarve. At times in their history, these areas have enjoyed harmonious relations and a thriving interchange of ideas, goods, people and culture. At other times, political tensions between the kingdoms of Portugal and Spain transformed the Guadiana into a military frontier, watched over by forbidding fortresses. In Chapter 6, Pedro Morais and Rita Domingues take us on a historical journey through this evolving landscape.

Mining activity since ancient times has left its mark in the form of heavy metal contamination in the sediments of the Guadiana estuary. While mineral extraction has diminished more recently, new sources of contamination are emerging through technological and societal change, often with unanticipated biological effects on estuarine species and food chains. Maria-João Bebbiano, Maria Gonzalez-Rey and Cristina Veiga-Pires delve into past, present and future contaminants in the Guadiana estuary in Chapter 7.

The authors are united in their deep appreciation for the Guadiana estuary and hope that you, the reader, will also be inspired to consider the uniqueness, richness and vulnerability of this marvellously muddy place.

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