



# The Guadiana Estuary

## – a journey through time

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The River Guadiana has the fourth largest drainage basin of any river in the Iberian peninsula: it is 67,039 km<sup>2</sup> in area, rising in Spain at Campo de Montiel, province of Ciudad Real, and draining between Vila Real de Santo António (Portugal) and Ayamonte (Spain). The river flows for 810km, of which 550km is in Spanish territory, 150km in Portugal and 110km serving as a border between the two countries (see Fig 1).

The Guadiana estuary is a mesotidal estuarine system (tidal amplitude ranges from 1.3m to 3.5m) located in a temperate climate area with moderate, humid winters and hot, dry summers. Its tidal limit is near the village of Mértola, approximately 70km from the mouth.

The estuary occupies an area of 22km<sup>2</sup> and its average depth is 6.5m. Freshwater inputs to the estuarine zone vary sharply depending on rainfall and water retention in dams. In the last five years, mean monthly freshwater flow at Pulo do Lobo (80km upstream) has varied abruptly from 3,000 m<sup>3</sup>s<sup>-1</sup> in the winter and 0.01 m<sup>3</sup>s<sup>-1</sup> in the summer. In addition, the estuary receives reduced freshwater inputs from some tributaries, while other inputs include sewage, mainly near the mouth, from the cities of Vila Real de Santo António (13,880 inhabitants) and Ayamonte (17,500 inhabitants). A total of 1.92 million people inhabit the Guadiana River basin, 88% of whom are in Spain.

The physical characteristics of the Guadiana estuary were essential in defining the historical and cultural context of this region. The extended navigability of the estuary was fundamental to establishing trade routes with Mediterranean civilisations, namely the Phoenicians, Greeks and Carthaginians. These civilisations created several commercial harbours along the Guadiana, namely in Mértola, Alcoutim, Castro Marim and Ayamonte. In these locations, the human presence dates back as far as the Neolithic (12000 to 4000 BC) and the Chalcolithic periods (4000 to 3100 BC). Later, the Romans (II BC to V AD), the Alans (V to VI AD), the Visigoths (VI to VIII AD) and the Arabs (VIII to XIII BC) successively settled in this Iberian region until the delineation of the continental Portuguese territory in the 13th century. The predominant north-south direction of the estuary was intrinsically linked to the definition of the Portuguese and Spanish



Fishing in the Guadiana Estuary.

territories, as it served as a natural border in its last 50km.

Ore extraction and cereal production along the surrounding areas of the estuary turned Mértola into the most important trading centre, up to the Portuguese conquest in 1238. Copper, iron and manganese were the main ore resources, but silver and gold were exploited as well. With the Portuguese conquests, the economic importance of the Guadiana estuary decreased sharply. In the 15th and 16th centuries, cereals were shipped to the Portuguese forts in northern Africa, and it was only in the late 19th century that all the regions around the estuary experienced a new economic revival.

In the late 18th century, the Portuguese Prime Minister, Marquis of Pombal, ordered the construction of a new city, Vila Real de Santo António, located near the river mouth. The main goals were political, economical and strategic-related but primarily to face the strong economic development of the Spanish city of Ayamonte, on the opposite margin. The prosperity of Ayamonte derived from intense fishing activity, mainly focused on sardine, in the Gulf of Cadiz and Bay of Montegordo, attracting both Spanish and Portuguese fishermen. However, Vila Real de Santo António only prospered in the late 19th century due to a strong development of ore

extraction, fisheries, and of preserves and shipyard industries.

Ore extraction, specifically of copper, began in 1858 in rediscovered Roman mines at Minas de São Domingos. The village of Pomarão was founded to facilitate the distribution of ore coming in trains from the mines. Cargo ships transported the ore to the estuary mouth, where it was re-transferred to bigger ships destined for England and Germany. The mining activity lasted until 1965, and its ending caused a deep economic and demographic recession. Between 1961 and 1971, the county of Mértola lost 50% of its population, which migrated either to Lisbon, the capital of Portugal, or abroad. Currently, the upper estuary is one of the poorest regions in the European Union.

The fisheries activity developed in the late 19th century through investment by Spanish, Italian and Greek entrepreneurs, who promoted the tinned fish industry, mainly of sardine and tuna. Truly, Vila Real de Santo António is the birthplace of the Portuguese tinned fish industry, where the tinning of tuna was pioneered in 1865. Tinned fish soon became one of the most important export goods in Portugal, mainly during World War II, similar to wine and cork. The fisheries started to decline in the 1960s and today no tinned fish industry remains in the village.

From 1929 to 1937, a "wheat campaign" was imposed by the Portuguese government in an attempt to make Portugal self-sufficient and end its reliance on US and Canadian imported wheat. During this period, economic activity increased along the estuary, especially in Alcoutim, where the wheat was distributed and fertilizers were received. However, the wheat campaign was carried out on poor soils, leading to their complete exhaustion once the traditional rotation system of cultures and resting of soils was abandoned. Today, tourism is the main economic activity, not only in the Guadiana estuary but in all of the Algarve, the southern Portuguese region (see Figure 2).

Whereas, from the late 19th century, mining and tinned fish industries were the most deleterious activities around the Guadiana estuary, at present, water abstraction and water retention by dams are probably those of most concern as regards the estuary. Since the mid-1950s, the Guadiana basin has been intensively dammed, allowing the development of extensive irrigation areas, electricity production and other public and industrial demands. The Alqueva dam was the last to be built; its floodgates were closed on February 8th 2002 and river flow regulation increased from 75% to 81%. This dam is located approximately 150km from the Guadiana river mouth and creates, at its maximum capacity (152m level), one of the biggest artificial lakes in Europe, with an area of 250 km<sup>2</sup>, a perimeter of approximately 1,100km and a total capacity of 4.13 x 10<sup>9</sup> m<sup>3</sup>. With this dam, the Portuguese government aims, besides controlling the Guadiana river flow, to reinforce the capacity of hydroelectric energy production, to develop the tourist potentialities of the area, to promote the regional employment market, to organise intervention in environmental and patrimony domains, to fight physical desertification and climate change, and to modify the agriculture specialisation model of southern Portugal, by implementing an irrigation area of 110,000ha.



Tourism infrastructure under construction on the Guadiana Estuary.



Guadiana Estuary, Algarve, Portugal.

Other important constructions in the Guadiana estuary during the 1970s were of two jetties that stabilised the once highly dynamic river mouth, but they drastically changed local sediment dynamics. The main consequence was the interruption of the predominantly eastward littoral drift and sediment deposition in the river mouth, especially in the Spanish margin. However,

due to sediment retention in dams and lower freshwater flows, coastal erosion is expected to be enhanced in the future.

The company in charge of the Alqueva dam construction intensively monitors the water quality in the Alqueva reservoir. However, the impact of altered river flow on downstream ecosystems is significant. The first changes were observed on the

phytoplankton community. Before the Alqueva dam construction, phytoplankton exhibited a typical uni-modal cycle, with a biomass maximum during spring, corresponding to the diatom bloom, and a summer cyanobacteria bloom. From 2002 onwards, cyanobacteria dominated the phytoplankton community, not only during summer months, but in the autumn and winter as well. Cyanobacteria dominance in the estuary represents a serious concern to local populations, given that many species can produce potent toxins, responsible for gastrointestinal, dermatological and neurological problems.

The impacts of the altered river flow are also evident on fish populations. The main consequence is a reduced use of the Guadiana estuary as a habitat by freshwater fishes and as a spawning ground for marine species. Several barbel endemic to the southern Iberian peninsula are today classified as threatened, and other species occurring in brackish and freshwater are considered vulnerable, such as allis shad (*Alosa alosa*) and twaite shad (*Alosa fallax*). The cyprinid *Anacypis hispanica*, an endemic once abundant in the Guadiana basin, is today threatened with extinction. Damming, water abstraction for agricultural irrigation systems, habitat degradation, polluted effluents and introduction of exotic competitors are the probable causes of these losses. Other problems, namely overfishing and damage of spawning grounds by sand and gravel extraction, have caused the disappearance of the sturgeon *Acipenser sturio* from the Guadiana basin: the last sturgeon was caught in the early 1980s. Coastal fisheries are also affected by the Guadiana river flow. In years of low river discharge, sardine landings decreased by 69%, from 886 to 279 tonnes, whilst landings of carnivorous fish increased by between 112 and 128%, relative to years of high freshwater flow.

Damming and water abstraction are not the only threats to the Guadiana estuary. Agricultural, industrial and urban pressures are not significant in the Guadiana, compared to other Iberian estuaries. However, the lack of land use and proper management is responsible for other problems, for instance the increased probability of forest fires

occurring. The lack of management results from very complex socio-economical problems: the upper estuarine region is one of the poorest in the European Union and manpower is scarce due to the ageing of local populations. Nevertheless, tourism infrastructure is planned for the lower Guadiana estuary. One such development is already under construction in the Spanish margin and this tourist resort will host 20,000 inhabitants and will be equipped with houses and hotels, shopping centres, golf courses and a marina, representing an enormous change in land and estuary use.

In order to avoid the massive construction of tourism infrastructure and to compensate for the loss of biological diversity, the creation of a Biosphere Reserve – the International Natural Park of the Lower Guadiana – was proposed by Almargem, a local environmental organisation. Currently, the only protected landscapes around the Guadiana estuary are the Natural Reserve of Castro Marim and Vila Real de Santo António, located in the river mouth, and the Natural Park of the Guadiana Valley, occupying an area of 70,000ha around the village of Mértola. A 'demo-site' is also being implemented in the Guadiana estuary with the support of UNESCO's International Hydrological Program, to demonstrate how it is possible to mitigate and restore the functioning of estuaries and coastal areas impacted by dam construction, using ecohydrological solutions. This is a new approach to achieving sustainable water management, based on the study of functional inter-relationships between hydrology and biota at the catchment scale.

The future environmental sustainability of the Guadiana estuary will rely on an ecohydrological approach being taken in the Guadiana basin as a whole. This approach is being adopted in the estuary with the aim of proposing management measures that will diminish the threats the estuary faces.

A conjunction of effort between universities, NGOs, local populations, local and regional authorities, basin managers and even tourism entrepreneurs is essential if real environmental sustainability in the Guadiana estuary is to be achieved.

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