

## Research paper

# Assessing and mitigating the landscape effects of river damming on the Guadalfeo River delta, southern Spain



Rafael J. Bergillos\*, Miguel Ortega-Sánchez

Andalusian Institute for Earth System Research, University of Granada, Avda. del Mediterráneo, s/n, 18006 Granada, Spain

## ARTICLE INFO

## Keywords:

Coastal evolution  
Urbanization  
River damming  
Nourishments  
Management proposals

## ABSTRACT

Deltaic systems are sensitive to natural and human-induced changes as they accommodate numerous activities and have high ecological, economic and social importance. Mediterranean deltas are particularly vulnerable to anthropogenic activities, which alter the coastal land availability. This work addresses the morphological evolution of the Guadalfeo River delta (southern Spain) by analyzing the evolution of the coastline position and the sediment volume on the coast. The evolution of the built-up area, the impact of river damming and the artificial nourishment projects conducted on the coast were investigated and discussed. Bathymetric, topographic and sedimentological measurements were performed from 1999 to 2008, and fluvial and maritime data were analyzed. Based on the results, a situation diagnosis was performed using the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, and management practices were proposed based on a modification of the SWOT analysis. The results indicate that the river regulation has considerably reduced the sediment input into the coastal system and has prevented the advance of a delta that was prograding before dam construction. River damming has also led to severe coastline retreat and has endangered urban developments near the river mouth; furthermore, artificial replenishments have not been effective mainly due to using too fine sediment. We conclude that the best and most practicable strategy for mitigating erosion problems is to bypass sediment from the reservoir in combination with flows drained by the dam.

## 1. Introduction

Deltaic systems are located at the transition between fluvial and maritime environments. Consequently, climatic, sedimentary and tectonic processes have complex interactions in these environments (Coleman & Wright, 1975; Orton & Reading, 1993; Overeem, 2005). Furthermore, deltas are sensitive to both natural and human-driven changes (Syvitski & Saito, 2007). Therefore, investigations of deltaic systems are of great interest because these areas represent a crucial link for understanding the interaction between fluvio-deltaic and marine sedimentation processes (Trincardi, Cattaneo, & Correggiari, 2005).

Mediterranean deltas are particularly vulnerable to sea level rise, which is probably one of the most severe causes of delta retreat worldwide (Duong, Ranasinghe, Walstra, & Roelvink, 2016; Syvitski et al., 2009). In addition to the climatic components of sea level rise, subsidence can be a locally important factor that has a greater effect than climate change in some circumstances. This is a concern in deltaic coasts (with a global population of more than 500 million people), where elevation loss is widespread and the relative sea level rise exceeds the global mean rise (Ericson, Vörösmarty, Dingman,

Ward, & Meybeck, 2006). These facts alter the availability of coastal land and endanger urban, industrial, and agricultural developments (Syvitski et al., 2009).

In recent centuries, human activities, such as channelization, channel deviation and damming, have modified deltaic environments (Anthony, Marriner, & Morhange, 2014; Hood, 2010; Kondolf, Rubin, & Minear, 2014; Yang et al., 2006). In the Mediterranean basin, the potential sediment supply has been reduced by approximately 50% since the middle of the 20th century due to the construction of dams (Poulos & Collins, 2002). In addition, massive developments have been established near river mouths to promote mass tourism as the driving force behind economic development, and most of these developments have significantly transformed the coastal zones (Benoit & Comeau, 2012; Smith, 1991). This expansion is currently being threatened by the aforementioned severe coastline retreat and sea level rise, which endanger the future of many Mediterranean deltas (Jeftic, Keckes, & Pernetta, 1996). Thus, Mediterranean countries share common challenges that include significant development pressures for infrastructure, tourism and housing as well as vulnerability to hazards related to climate change (Nicholls & Hoozemans, 1996).

\* Corresponding author.

E-mail addresses: [rbergillos@ugr.es](mailto:rbergillos@ugr.es) (R.J. Bergillos), [miguelos@ugr.es](mailto:miguelos@ugr.es) (M. Ortega-Sánchez).

Previous studies on Mediterranean deltas focused on the influences of both natural and human-induced changes on the evolution of deltaic systems, such as Ebro (Jiménez & Sánchez-Arcilla, 1993), Po (Simeoni & Corbau, 2009), Nile (El Banna & Frihy, 2009), Rhône (Sabatier, Samat, Ullmann, & Suanez, 2009), Arno (Pranzini, 2001), Ombrone (Pranzini, 1994) and Adra (Jabaloy-Sánchez et al., 2010). To date, works on the Guadalfeo delta have focused on describing the submarine geomorphology and sedimentology (Fernández-Salas et al., 2007; Lique, Arnau, Canals, & Colas, 2005; Lobo, Fernández-Salas, Moreno, Sanz, & Maldonado, 2006), determining marine intrusion (Duque, Calvache, Pedrera, Martín-Rosales, & López-Chicano, 2008), characterizing the delta aquifer's hydrology (Duque, Calvache, & Engesgaard, 2010) and analyzing the evolution of the delta at the millennial temporal scale (Jabaloy-Sánchez et al., 2014). However, few studies have proposed integrated and sustainable management practices for these systems, which are usually managed by different entities. This fact along with the environmental, social and economic value of deltaic areas (Sanchez-Arcilla & Jimenez, 1997; Stanley & Warne, 1993; Trincardi et al., 2005) reveals the importance of this work.

This paper addresses the morphological evolution of the Guadalfeo delta (southern Spain) primarily through analyzing the evolution of the coastline position and the main human interventions in the system: urban developments, river damming and artificial nourishments. The urban evolution was studied through the built-up area; the impact of river damming that occurred in 2004 on the coast was investigated using fluvial and maritime data along with bathymetric, topographic and sedimentological measurements; and the effectiveness of artificial nourishment projects was examined. Based on the results, the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis was performed (Helms & Nixon, 2010), and different management practices were proposed.

## 2. Study site

The Guadalfeo River basin is located in southern Spain, has an area of 1252 km<sup>2</sup> and drains into the Mediterranean Sea (Fig. 1). This basin

includes the highest peaks on the Iberian Peninsula (~3400 m.a.s.l.) and is fed by one of the highest hydrological energy systems along the Spanish Mediterranean coast.

From a geological and geomorphological point of view, three units of this basin can be distinguished: (1) the south side of the Sierra Nevada, which is mainly composed of Nevado-Filábride complex (mica-schist and graphitic mica-schist) and presents large topographic gradients; (2) the Sierra de la Contraviesa, which has a more advanced geomorphology, is composed of Alpujárride complex (quartzites, phyllites and schists) and presents a greater variety of hill-slope processes with frequent gully and mass movements; and (3) the Sierra de Lújar, which despite its rocky nature and poorly developed soils due to recurrent wildfires, presents signs of gully processes associated with non-terraced almond crops (Millares, Polo, Moñino, Herrero, & Losada, 2014b). The sedimentology of the entire catchment consists of a large amount of Neogene-Quaternary deposits with a broad range of sediment sizes (Jabaloy-Sánchez et al., 2014).

The basin is semi-arid, and the hydrological dynamics are affected by the presence of the Sierra Nevada. The trunk river descends from the crest line of the Sierra Nevada in the eastern part of the basin (Fig. 1). The longitudinal profile slope varies from 2.5% in the southern Sierra Nevada and Sierra de la Contraviesa to approximately 0.9% downstream of the reservoir (Bergillos, Rodríguez-Delgado, et al., 2015). Topographic gradients lead to important bed load contributions that accumulate in the Guadalfeo River (Millares, Polo, Moñino, Herrero, & Losada, 2014a). The annual precipitation data show significant spatial gradients (Table 1), and the average annual rainfall in the basin is 586 mm, with minimum and maximum values of 500 and 1000 mm, respectively (Millares et al., 2014a; Millares, Gulliver, & Polo, 2012).

In 2004, the river was dammed 19 km upstream of its mouth, regulating 85% of the basin runoff (Nevot Pérez, 2004). During the construction of the dam in 2002, a total of 379,352 m<sup>3</sup> of sediment was extracted from the natural topography to create a basin for the reservoir; this sediment was deposited in the submerged part of the studied stretch of beach. The capacity of the Rules' Reservoir (117 hm<sup>3</sup>) was intended for the following purposes: irrigation (40%), supply to

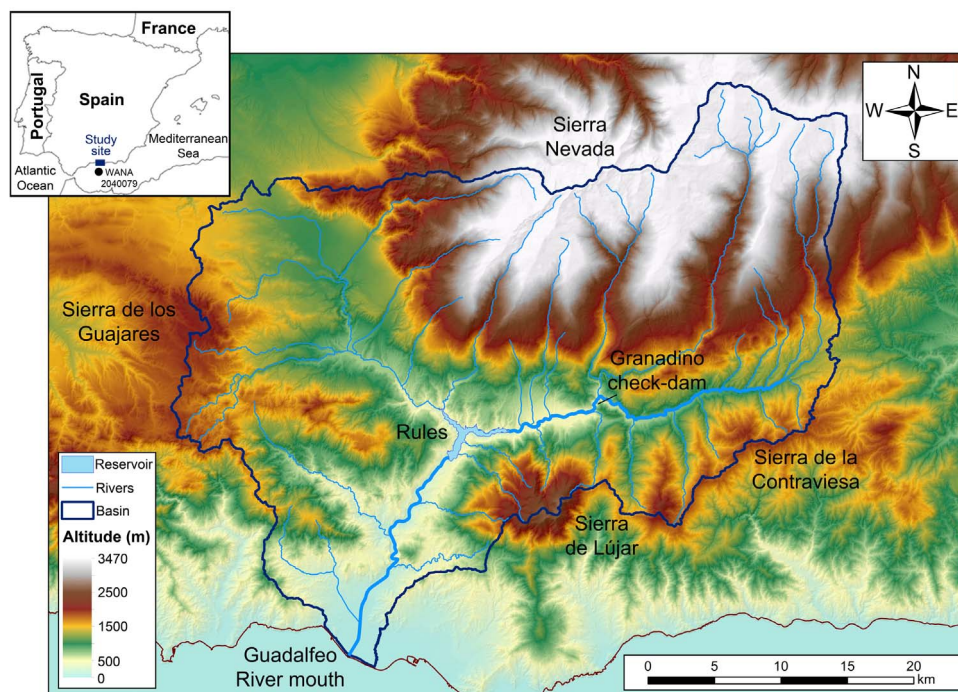


Fig. 1. Location of the study site and the WANA point 2040079 (upper-left panel). Delimitation of the basin and locations of the Rules' Reservoir, the Granadino check-dam, the Sierra Nevada, the Sierra de la Contraviesa, the Sierra de Lújar, the Sierra de los Guajares and the Guadalfeo River mouth.

Download English Version:

<https://daneshyari.com/en/article/5115166>

Download Persian Version:

<https://daneshyari.com/article/5115166>

[Daneshyari.com](https://daneshyari.com)