Anthropocene 19 (2017) 35–44

Contents lists available at ScienceDirect

Anthropocene

journal homepage: www.elsevier.com/locate/ancene

Marginal deltaic coasts in transition: From natural to anthropogenic along the southern Romanian cliffed coast

Ștefan Constantinescu[a,*], Liviu Giosan[b]

[a] University of Bucharest, Faculty of Geography, Romania
[b] Geology & Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA

ARTICLE INFO

Keywords:
Deltas
Cliffed coast
Erosion
Developed coast
Danube
Black Sea

ABSTRACT

In natural conditions marginal deltaic coasts benefit from sediment input from upcoast deltas via longshore drift and current-driven transport. This study investigated changes in the pattern and variability of both the shoreline and nearshore zone along the southern Romanian coast located downdrift of the Danube delta. We employed modern and historical cartographic materials to compare the baseline behavior before and after large coastal engineering works were emplaced in the last half century. From the early 20th century until 1960, the shoreline was largely progradational and the nearshore depositional indicating that the coast had a positive sediment budget. After 1960, and especially after 1980, a general erosional state took over the region as the jetties of the expanding Constanta and Midia Port increasingly blocked the bulk of the southward-directed Danubian longshore drift. Further development of ports and seaside resorts also led to a less coherent, fragmented coastal dynamics masking any potential effects of far-field anthropogenic changes in the Danube delta from reduced fluvial discharge or changes in longshore drift. The beach protection structures in seaside resorts did not successfully address the general state of sediment starvation. We conclude that the southern Romanian shore cannot provide a good example for protecting other marginal deltaic coasts with sensitive sediment budgets. An interactive map created in this study provides a starting point for future work to better understand the link between deltas and major ports connected with them.

1. Introduction

Large sediment-rich rivers build expansive deltas but also feed with sediment long stretches of their downcoast. A classic example is the chenier plain coast constructed west of the Mississippi delta with sediment eroded from reworking lobes (Gould and McFarlan, 1959; Penland and Suter, 1989) and offshore Mississippi muds transported onshore during storms (Draut et al., 2005). Similarly, reworking of Danube delta lobes has resulted in significant sediment transfer downcoast leading to barrier spit growth (Fig. 1) separating a series of successive lagoons (Giosan et al., 2006a, 2013). Farther downcoast Danubian sediment was detected on beaches all along the southern region of the Romanian coast decreasing gradually from north to south (Spătaru, 1990). However, fine grained sediments from the Danube can reach along the coast well beyond the Romanian coast (Stanev and Peneva, 2001 and references therein).

Before any significant anthropogenic interference, a series of successive cliffed sectors with headlands with or without rocky submarine platforms fronted by narrow, poorly developed pocket beaches alternated with baymouth barriers (e.g., Brătescu, 1933, 1935). At depths beyond ca. 4 m, Danubian sediment was thought to be dominant whereas local sediment sources were important for the upper foreshore. Such sources included sand from biogenic shell production and limestone fragments from the coastal cliffs and rocky platforms and fines from eroding loess cliffs accumulating in the surf zone (e.g., Spătaru, 1990).

Deltas across the world suffer from large deficits of sediment primarily due to damming their feeding rivers (Giosan et al., 2014). Does this deficit extend to marginal deltaic coasts? Do such coasts fare better than non-deltaic counterparts during the transition from natural to developed? Or does the construction of coastal protection structures take over? Using historic charts, we explore these questions for the southern sector of the Romanian Black Sea coast (Fig. 1). The fate of this marginal deltaic coasts under human development depends both on the availability of fluvial sediment, either delivered directly by river plumes (Constantin et al., 2016) or reworked at the deltaic coast and on submarine Danube delta, as well as on local sources. Depletion of natural sediment sources is now countered by beach nourishment with

* Corresponding author.
E-mail address: stefan.t.constantinescu@gmail.com (Ș. Constantinescu).

http://dx.doi.org/10.1016/j.ancene.2017.08.005
Received 10 December 2016; Received in revised form 14 August 2017; Accepted 23 August 2017
Available online 31 August 2017

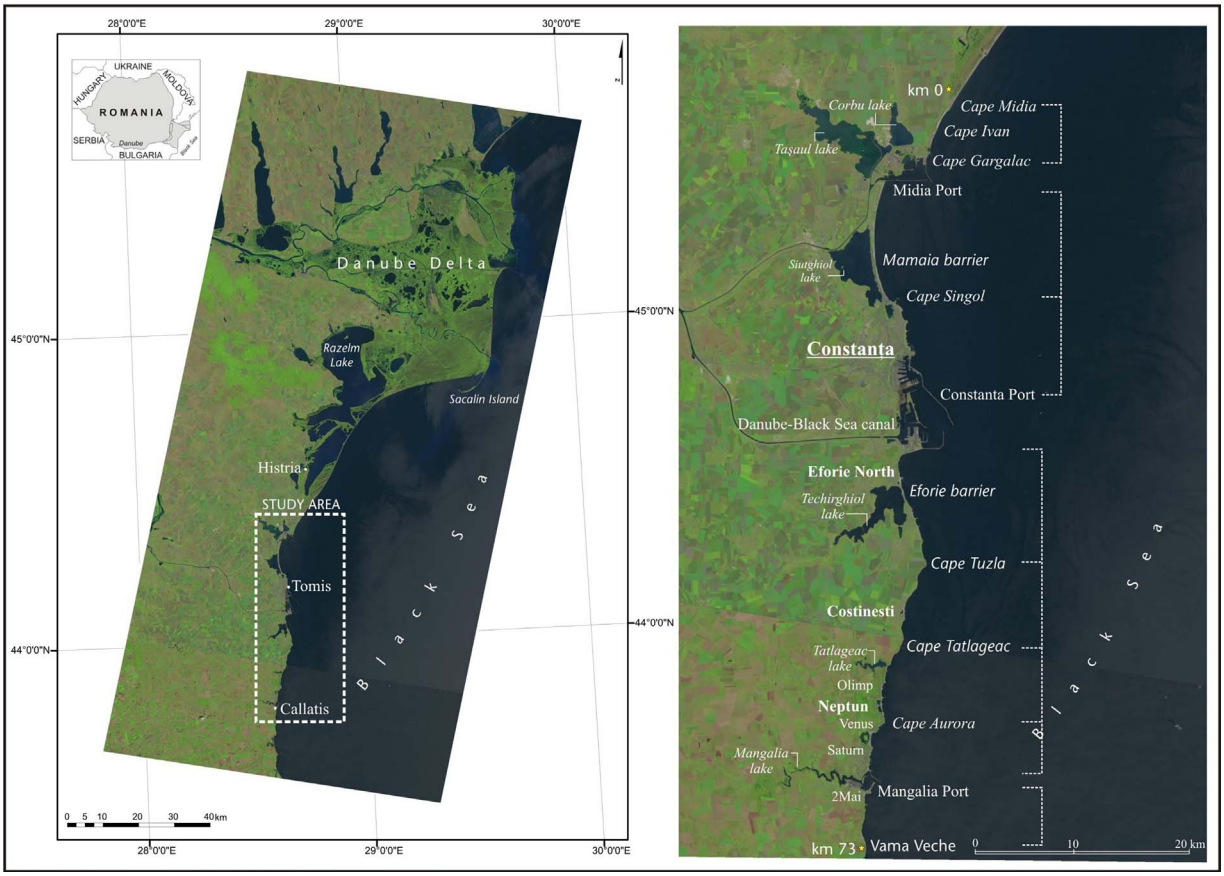

Fig. 1. Romanian Black Sea coast with our study area.

relict shelf sands, a finite resource (Halcrow, 2011). However, only a restoration of natural routes and mechanisms for fluvial sediment delivery and local production, respectively, can provide a sustainable solution for coastal erosion in the long run. Here we explore the pattern and variability of both the shoreline and nearshore zone changes along the southern Romanian coast (Fig. 1) using modern and historical cartographic materials. We compare the baseline behavior before any significant direct human intervention with recent changes to detect and analyze the effects of anthropogenic modifications over the last half century.

2. Background

Erosion of coastal cliffs is an irreversible process: once eroded they cannot be restored to the original position (Sunamura, 1992). In contrast, on sedimentary coasts, progradation can follow erosion (e.g., Davidson-Arnott, 2010). This fundamentally erosive nature of the rocky coasts makes it difficult to reconstruct their evolutionary history and the interlinked factors that conditioned it, such as lithology, morphology, hydroclimate and human activity (e.g., Sunamura, 1977, 1983, 1992; Andriani and Walsh, 2007; Dickson et al., 2007). The impossibility of restoration conflicts with human development along rocky coasts, which requires the shoreline to be stable (Nordstrom, 2000; Brown et al., 2011).

This region of the western Black Sea coast was opened to trade since ancient times, when ancient Greek city-colonies such as Histria, Tomis (the modern Constanta) or Callatis (the modern Mangalia) developed. Direct engineering pressure at the coast began in the second half of the twentieth century when new ports and coastal defense structures were built changing the coast's configuration and affecting directly the availability and transport of sediments.

The southern region of the Romanian coast is an 80 km long cliff shore extending between Midia and Vama Veche (Fig. 1) that is interrupted by coastal barrier lagoons. Several early studies (Vâlsan, 1926, 1935; Brătescu, 1933, 1935) described the region's geomorphic characteristics in qualitative terms. Shoreline change has been described quantitatively in Constantinescu (2012, 2017). However, shoreline variability is just a secondary effect of a more complex nearshore region evolution, whose dynamics is evaluated for this region, for the first time. Our work aims to analyze shoreline and nearshore patterns and rhythms by comparing the oldest available maps and charts for the region to recent satellite, aerial photos and bathymetric surveys.

2.1. Geology

A Sarmatian (upper Miocene) limestone usually outcrops at the base of the sea-cliffs (Fig. 2; Photo 1) followed by a horizon of Villafranchian (upper Pliocene-lower Pleistocene) clay, reddish-green in color, overlain by a thick layer of Pleistocene loess (10–20 m) and soil (Fig. 2). At the northern end of the study region (Cape Midia to Cape Ivan) Jurassic limestones outcrop instead. Within the loess there are several paleosols (Conea, 1970). This lithological sequence favors landslides and subsurface seepage as dominant processes for cliff erosion. In some sectors where the limestone does not rise above sea level, high rates of erosion are typical (Photo 1). In the northernmost sector of the cliffed coast (Cape Midia-Cape Singol; Fig. 1), the dominant sedimentary source for beaches is the Danube via the longshore drift, whereas south of the Port of Constanta, the Danubian contribution is secondary and the beach is predominantly maintained by mollusks shell fragmentation and cliff erosion. In the later sector, mineral content analyses have shown the presence of more than 90% CaO and less than 10% SiO2, (JICA, 2006). The mean diameter of beach sediments increases from the north (0.22 mm at Mamaia) to the south (0.58 mm at Vama Veche) reflecting the change in sediment source with Danubian fine sediments in the