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RECENT SHORT-TERM EVOLUTION OF A VENICE LAGOON SALT MARSH (ITALY)

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ABSTRACT: Rizzetto F. & Tosi L., *Recent short-term evolution of a Venice lagoon salt marsh (Italy).* (IT ISSN 0349-3356, 2011)
The recent geomorphological evolution of a Venice lagoon salt marsh was identified through the analysis of high resolution aerial photographs taken from 1938 to 2007, and compared with the yearly time series of relative sea level rise (RSLR) measured in Venice in the same period. The investigations pointed out a significant retreat of the southern salt marsh margin and modifications of the marsh drainage network. In the last century, relative sea level variations, decrease of sediment input, and hydrodynamic processes were responsible for erosion in large portions of the Venice lagoon tidal flats. In contrast with this general trend, the studied salt marsh was able to offset RSLR. Although this behavior reflected the system's local response to many factors, relations between geomorphological modifications and sea level changes appeared clearly evident.

RIASSUNTO: Rizzetto F. & Tosi L., Evoluzione recente di una barena situata nella Laguna di Venezia (Italia). (IT ISSN 0349-3356, 2011)
L'evoluzione geomorfologica recente di una barena situata nella Laguna di Venezia è stata studiata attraverso l'analisi di foto aeree ad alta risoluzione scattate dal 1938 al 2007 ed è stata poi confrontata con i valori annuali di sollevamento relativo del livello del mare (RSLR) registrati a Venezia nello stesso periodo. Le indagini hanno evidenziato un significativo arretramento del margine meridionale della barena e modificazioni dei suoi ghebi. Nell'ultimo secolo le oscillazioni del livello del mare, la diminuzione dell'apporto di sedimenti ed i processi idrodinamici hanno provocato erosione generalizzata nelle piani tidali della Laguna di Venezia. In contrasto con questa tendenza, la barena in esame è riuscita a contrastare il RSLR. Sebbene tale comportamento sia stato condizionato da molti fattori, è apparsa chiaramente evidente una stretta relazione tra le principali modificazioni morfologiche e le oscillazioni del livello marino.

Key words: salt marsh, tidal creeks, sea level, Venice Lagoon.

Parole chiave: barena, ghebi, livello marino, Laguna di Venezia

1. INTRODUCTION

Coastal wetlands exist in a dynamic equilibrium between forces that lead to their establishment and maintenance and forces that lead to their deterioration (DAY J.W. *et al*., 1999).
One of the most important processes currently affecting coastal wetlands is relative sea level rise (RSLR). Marshes survive rising water levels only if they are able to accrete at a rate sufficient to offset RSLR (CAHOON D. *et al*., 1995). In addition to long-term sea level variations, salt marsh evolution is influenced by short-term fluctuations, such as those caused by tides. In fact, during the flood events the accelerating sea level rise promotes a rapid increase not only in water depth, but also in deposition rate on the marsh platform; on the other hand, the expanding tidal prism can enhance erosion and an expansion of the channel network, reducing the marsh area (ALLEN J.R.L.,1997).
The present paper documents the evolution, in the last seventy years, of a natural salt marsh located in the Venice Lagoon (Italy), and points out the role of sea level variations in influencing its modifications.
The study was carried out through the joint analysis of several high resolution aerial photographs taken from 1938 to 2007 (which documented the tidal channel changes) and the 1938-2007 yearly time series of the RSLR (including eustacy and natural and human-induced subsidence) measured at the Venice tide gauge station (CARBOGNIN L. *et al*., 2009).

2. GENERAL CHARACTERISTICS OF THE STUDY AREA

The lagoon of Venice, covering an area of about 550 km^2, is the widest in Italy and the most important survivor of a larger system of lagoons that characterized the north Adriatic coast in Roman times.
In the whole basin, water circulation is mainly guaranteed by a semidiurnal tide, with a range of about 1.4 m, and by the *bora* and *scirocco* winds, from NE and SE respectively, which trigger mixing and transport processes and locally create wind waves responsible for re-suspension of sediments in lagoon shallows (UMGIESSER G. *et al*., 2004). In addition, along the navigable channels wave motion is also induced by boat traffic, which causes local erosion.

In the last century, erosion, scarce fluvial sediment supply, loss of material through the inlets, and RSLR (enhanced by human-induced land subsidence) were responsible for the reduction and disappearance of a large portion of Venice lagoon salt marshes, except for some located in the northern basin, which preserve their original characteristics and are locally growing (CIAVOLA P. *et al*., 2002; CAPPUCCI S. *et al*., 2004). Their survival mainly depends on the flooding water turbidity and on the presence of sea grass that reduces wave and tide actions and favors the entrapment of sediments and their deposition on the marsh surface (BELLUCCI L.G. *et al*., 2007).
One of these intertidal well preserved landform, i.e. the San Felice salt marsh, was chosen as study area. It is located north of the Lido inlet (Fig. 1) at the confluence of two tidal channels, i.e. the Gaggian and the San Felice. It is crossed by a meandering-dendritic network of tidal blind-ended creeks, extending from the San Felice Channel to the north, which allow the distribution of water and suspended sediments on the marsh platform during tidal flow and their return to the surrounding lagoon during ebb tide. Moreover, many ponds are present in the northern zone.
The San Felice salt marsh is composed of clayey sandy silt and is mainly colonized by halophytic species. Its elevation ranges from 0.0 m to about 0.7 m a.s.l. and generally decreases from south to north; consequently, the northern part can be considered a marsh flat.
The presence of the jetties at the Lido inlet, built at the end of the 19th century, has greatly reduced and disturbed the sediment input from the sea to the marsh platform and enhanced high energy processes close to the inlet (DAY *et al*., 1999).

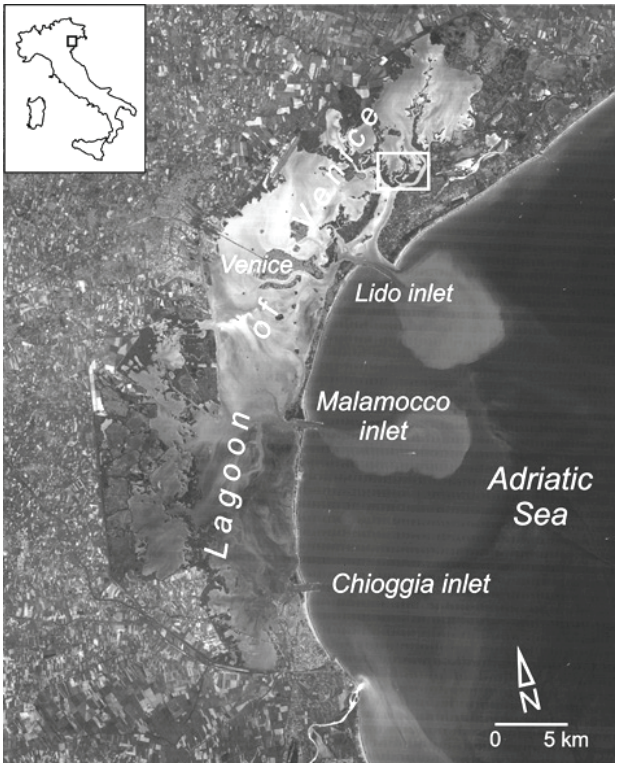

Fig. 1, Location of the study area.
Ubicazione dell'area studiata.

3. DISCUSSION

In the last seventy years the investigated area suffered significant geomorphological modifications (Fig. 2).
As regards the southern salt marsh margin, close to the San Felice Channel, a general retreat, estimated up to about 38 m in the western sector and up to 24 m in the eastern one, occurred over the whole period.
Expansion of the tidal creek network was produced by tributary addition, mainly in correspondence of channel bends where the bottom shear stress arises, and headward erosion of the existing creeks, as the higher values of shear stress are registered in correspondence of the channel tips (PETHICK J.S., 1969; STEEL T.J. & PYE K., 1997; FEOLA A. *et al*., 2005). Other channel modifications

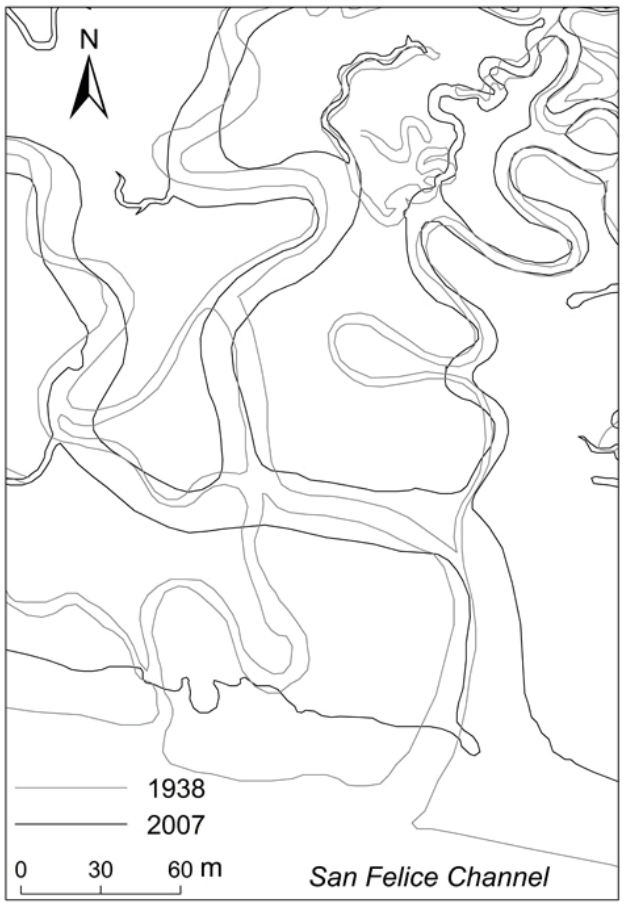

Fig. 2, Detail of the tidal creek modifications occurred from 1938 to 2007.
Dettaglio delle variazioni morfologiche dei ghebi verificatesi dal 1938 al 2007.

consisted of sinuosity changes, enlargement of some important creeks, meander migration, and variations of shape and distribution of pans.
Comparison between salt marsh evolution and RSLR trend (Fig. 3) over the whole period pointed out that sea level variations significantly influenced geomorphological changes.

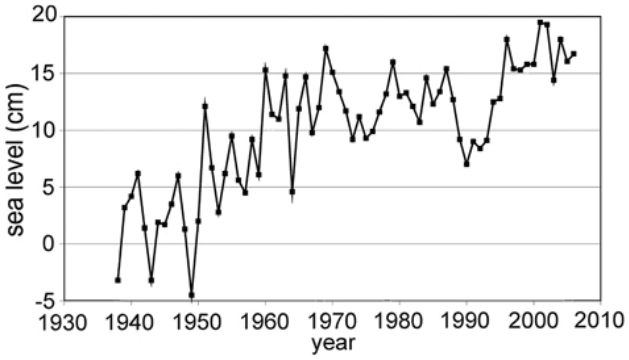

Fig. 3, Venice tide gauge data from 1938 to 2007.
Variazioni del livello marino misurate a Venezia dal 1938 al 2007.

From 1938 to 1970 groundwater exploitation was responsible for high subsidence, which increased RSLR rates. This process was particularly intense between 1950 and 1970 and determined a severe retreat of the salt marsh margin, increase of channel width, decrease of channel sinuosity, headward extension of creeks, and formation of new ones.
After 1970 lower RSLR rates were measured because the groundwater extraction was regulated. However, minor sea level fluctuations were identified: (a) between 1970 and 1990 RSLR rates slowed down, (b) in the period 1990-2001 RSLR grew again, (c) from 2001 and 2007 new steady conditions appeared. Since 1970, margin shift was in agreement with RSLR, showing retreat when RSLR increased and stabilization when sea level was stable. On the other hand, modifications of the tidal creek network were only partially in agreement with RSLR, showing planform morphological variations also during periods of quite steady sea level conditions. This behavior reflected the local response to many other factors, such as tides, sediment availability, vegetation growth and density, and wave action. However, results from this study pointed out that RSLR alone was responsible for a large part of the geomorphological modifications occurred over the whole period.

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