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EXTREME EROSION OF A DUNE CREST WITHIN A SHORT TIMESPAN (JANUARY-SEPTEMBER 2016): THE RECENT CASE IN THE MIGLIARINO - SAN ROSSORE - MASSACIUCCOLI REGIONAL PARK (TUSCANY, ITALY)

Abstract - *Extreme erosion of a dune crest within a short timespan (January-September 2016): the recent case in the Migliarino - San Rossore - Massaciuccoli Regional Park (Tuscany, Italy).* Beach erosion is a process that in the last decades is affecting several coastal areas around the world. Unfortunately the Tuscany coast makes no exception. The factors responsible of this phenomenon are different: some are natural, some other are related to human activities. Usually the latter determine drastic hastening of ongoing processes, mainly because they act over temporal scales much smaller than those typical of the natural factors. In this paper, multiple topographic surveys were carried out along a 5 km long sector of coast located within the boundaries of the Migliarino – San Rossore – Massaciuccoli Regional Park in order to evaluate the evolution state of the area within a 9-months timespan (January 2016 – September 2016). The results emphasize the importance to increase the knowledge about the morphodynamics processes acting on this area based on the resulting retreat that was observed analyzing the data: in just 4 months the crest of a 9 m high dune retreated of about 6 m, which resulted in a volume loss of about 80 m^3/m along the selected transect. This worrying outcome implies the need to manage this sector of coast applying a rather different approach relative to those used thus far. It is paramount to consider each sector of coast as a whole and not separately, that is in accordance with the physiographic unit rather than territorial and administrative limits. In addition, this new approach must also take care of the coastal environment in the direction orthogonal to the coastline, adding into the equation rivers and catchment areas, which are the main source of sediments feeding the beaches.

Keywords - Beach erosion, coastal dune, topographic survey, volume shift, Migliarino – San Rossore – Massaciuccoli Regional Park, Tuscany, Italy

Riassunto - *Erosione molto accentuata della cresta di una duna frontale in un breve periodo di tempo (gennaio-settembre 2016): il recente caso nel Parco Regionale di Migliarino - San Rossore - Massaciuccoli (Toscana, Italia).* L'erosione costiera è un fenomeno che da diverse decine di anni affligge tante aree costiere in tutto il mondo, e purtroppo la costa settentrionale della Toscana non fa eccezione. Tante sono le cause alla base dei processi erosivi, alcune ovviamente naturali, altre legate alle attività antropiche: queste ultime generalmente sono responsabili di brusche accelerazioni dei fenomeni già in atto, proprio perché agiscono su scale temporali molto più piccole rispetto alle cause naturali. Nel presente lavoro, realizzato in un tratto di litorale di circa 5 km di estensione compreso all'interno del Parco Regionale di Migliarino – San Rossore – Massaciuccoli, è stato evidenziato lo stato evolutivo dell'area attraverso l'esecuzione di 4 rilievi topografici in un periodo di tempo di 9 mesi (gennaio 2016 – settembre 2016) allo scopo di sottolineare quanto importante sia aumentare le conoscenze legate ai processi morfodinamici di questa area dal momento che in soli 4 mesi si è avuto un arretramento di circa 6 m della cresta di una duna alta quasi 9 m, con una perdita volumetrica stimata in circa 80 m^3/m. Questi preoccupanti valori implicano la necessità di gestire questo tratto di litorale nel modo più efficace possibile, utilizzando approcci significativamente diversi rispetto a quelli utilizzati sinora. Risulta quindi fondamentale considerare i vari settori di costa non più in maniera separata e distinta tra loro, magari in base ai limiti amministrativi, bensì in termini di unità fisiografica. Inoltre, è indispensabile approcciare la gestione e lo studio delle aree costiere anche in senso trasversale alla linea di riva, coinvolgendo quindi anche i fiumi e i bacini idrografici, sorgente primaria dei sedimenti che alimentano le spiagge. Solo in questo modo è possibile raggiungere un sistema di gestione delle aree costiere che sia efficace e consapevole.

Parole chiave - Erosione costiera, dune costiere, rilievi topografici, spostamento di volume, Parco Regionale di Migliarino – San Rossore – Massaciuccoli, Toscana

1. Introduction

Erosion is a natural process that defines the evolution of coastlines everywhere, it is significantly influenced by natural conditions such as wave and tide processes, sea weather (storms), coastal area geology and morphology, and climate change (Thatcher *et al.*, 2013; Idier *et al.*, 2013; IPCC, 2014). In addition to the natural factors, erosion is also strongly affected by human-related activities such as changes in land use in the hinterland, dam and armored bank construction along the course of the rivers, wetland reclamation, the readjustment and reforestation of mountain slopes to reduce hydrological hazard, and river bed quarrying (Masselink & Hughes, 2003). Sometimes the erosion processes are also augmented and intensified by the construction of piers and seawalls to permit harbor activities, and of groynes and breakwaters that are built to protect specific sectors of the coast (French, 2001). The major difference between natural and anthropogenic factors is the timescale at which they influence the coast: the human impact is usually fast, at times immediate, while the natural processes typically produce long-term modifications.

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As previously mentioned, beach erosion is a worldwide issue that causes significant losses such as economic setbacks (infrastructure, port, agriculture and tourism), environmental damage (loss of biodiversity, change in plant succession) and social problems (loss of property and territory, different land use) (Gómez-Pina *et al.*, 2002; Boruff *et al.*, 2005; Muñoz-Valles *et al.*, 2011). The Tuscany coast makes no exception: about 73 km out of the 207 km of sandy coasts are currently subjected to erosion processes (Cipriani, 2014). In more detail, an area that experienced exceptional retreat over the last 200 years is located around the River Arno's mouth, where the coastline retreated more than 1 km on the right side and 300 m on the left side (Pranzini, 2001; Bertoni & Sarti, 2011a). The intense erosion of the Pisan coast began in the middle of the XIX century (Pranzini & Sagliocco, 1994): based on the significance of this region, a large number of technical reports and scientific papers were published in order to understand the dynamics of this sector of the Tuscany coast. Several studies attempted to define the evolution of the coastline since the early XX century, with the result of acknowledging and reaffirming a recurrent tendency to a landward retreat of the system (Toniolo, 1910; Toniolo, 1927; Albani, 1940; Borghi, 1970; Vittorini, 1977; Cipriani *et al.*, 2001; Carli *et al.*, 2004; Bini *et al.*, 2008; Casarosa, 2016). The complexity of the issue was also addressed with the support of geological and geomorphological studies (Gandolfi & Paganelli, 1975; Mazzanti, 1983; Della Rocca *et al.*, 1987; Pranzini, 2001; Cammelli *et al.*, 2004; Bertoni & Sarti, 2011a) and sedimentological analyses (Aiello *et al.*, 1975; Cipriani *et al.*, 2001; Bertoni & Sarti, 2011b); up-to-date tracing technologies (Radio Frequency Identification, RFID) were used to track coarse sediments in order to define transport trends (Bertoni *et al.*, 2012a; Bertoni *et al.*, 2013) and sediment abrasion rates (Bertoni *et al.*, 2012b; Bertoni *et al.*; 2016); mathematical models (Noli & Franco, 1989) and modern multi-spectral techniques were employed as well (Ciampalini *et al.*, 2015); at last, consideration was given to an in-depth characterization of the climate state (Rapetti & Vittorini, 1974).

Despite this massive production, the erosion problem of the Pisan coast has not been fully understood yet. Besides, the lack of a true governance able to manage all the information provided by every source either academic or private, which usually work with different methods and timescales, makes it hard to define the actual factors that interfere on the coast. For instance, the inability to cross administrative borders when discussing about longshore sediment distribution is another aspect that concurs to exploit the major deficiency: the lack of sediment budget measurements, which is directly related to the concept of physiographic unit. The paradigm shift that needs to be stressed is that the physiographic unit not only must be considered in the traditional longshore sense, but also cross-shore, starting from the river basins to the alluvial plains and finally to the open sea.

Amid all this confusion the erosion processes are far from slowing down: the aim of this paper is to raise concerns about the state of the coast within River Arno's and River Serchio's mouths providing the immediate results obtained from a series of topographic surveys carried out since January 2016. This dataset may be crucial to understand that the erosion problem needs to be addressed quickly, but with a different approach than before.

2. Study Area

The area where the fieldwork was carried out is comprised between the mouth of River Serchio to the north and River Morto Nuovo to the south, within the Migliarino – San Rossore – Massaciuccoli Regional Park (Fig. 1). The stretch of coast is about 5 km long: although the above mentioned rivers define the extension of the area, the most important sediment source is the River Arno, whose mouth is located about 6 km south of the River Morto Nuovo. The River Serchio is about 126 km long and its sediment discharge is only subordinate to that of the River Arno; the River Morto Nuovo is just 20 km long and it does not contribute to the littoral sediment budget. This area is characterized by a Mediterranean sub-humid climate with arid summers and mild winters (Rapetti & Vittorini, 2012). The mean annual temperature is over 15°C, while the mean rainfall is about 800 mm (Rapetti, 2003). The typical wave direction is from the southwest: major storms also comes from this sector, 240°- 270° N (Cipriani *et al.*, 2001). Based on the data recorded by a wave gauge located offshore the Gorgona Island between 2008 and 2012, calm periods (Hs < 0.5 m) resulted to occur 35% of the time, while waves with height comprised between 0,5 and 2 m occurred 57% of the time; wave height higher than 2 m occurred for the remaining 8% (Casarosa, 2016). The littoral drift is northward-trending on the right side of the River Arno (Aiello *et al.*, 1975; Pranzini, 2001). The Pisan coast is defined as microtidal on regards to the tide regime: the tidal range rarely exceeds 30 cm. The wind regime is in accordance with the typical wave direction within this sector of Tuscany: dominant winds come from SW, so as the extreme events (Rapetti & Vittorini, 1978; Rapetti, 2003). Beaches are typically composed of well-sorted medium sands (Bertoni & Sarti, 2011b); on regards to the composition, quartz content is on average 50% of the total (Gandolfi & Paganelli, 1975).

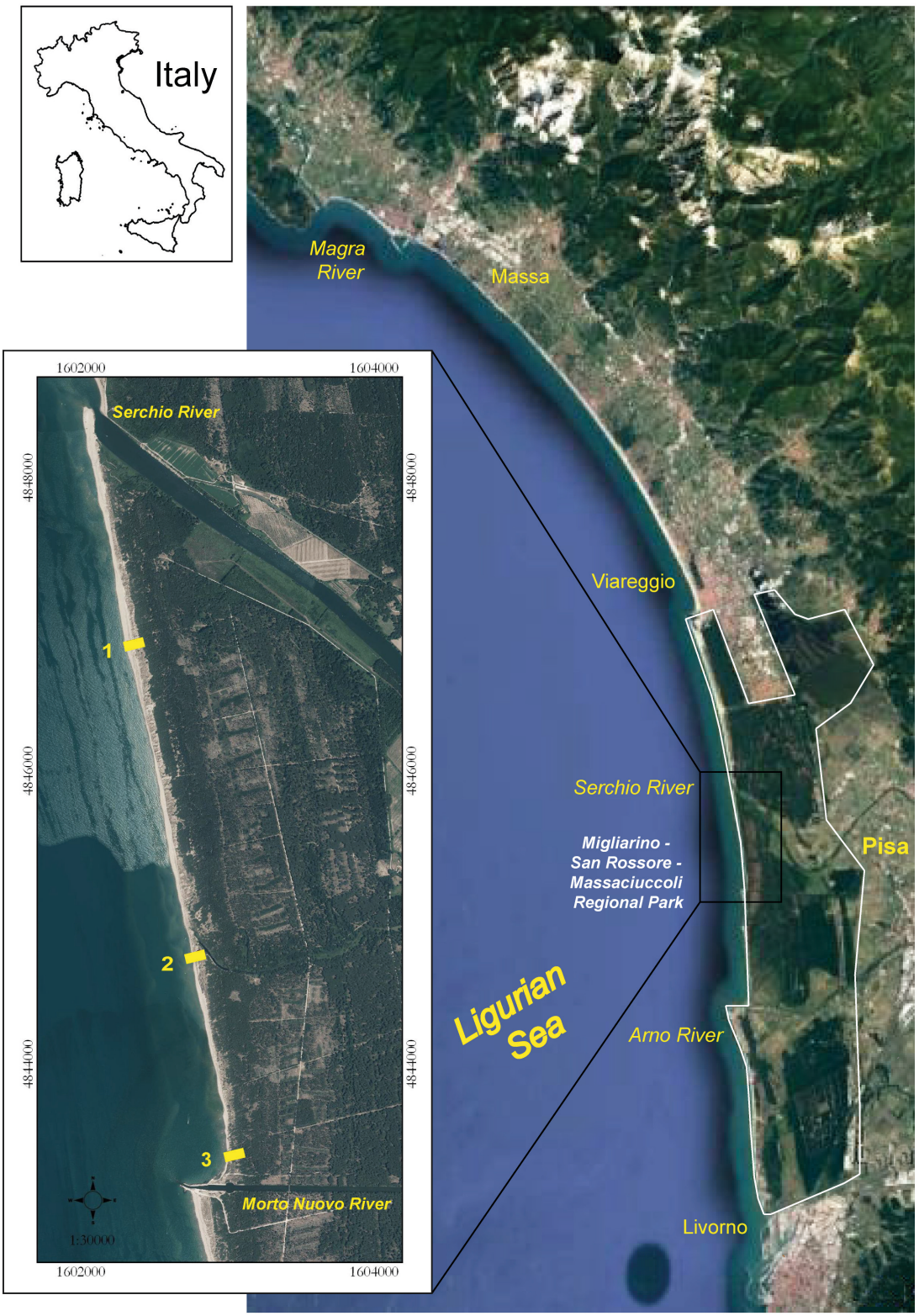

Fig. 1 - Geographic localization of the Migliarino – San Rossore – Massaciuccoli Regional Park. The zoom-in points out the study area; the numbered dots trace the exact position of the sectors where the transects were carried out.

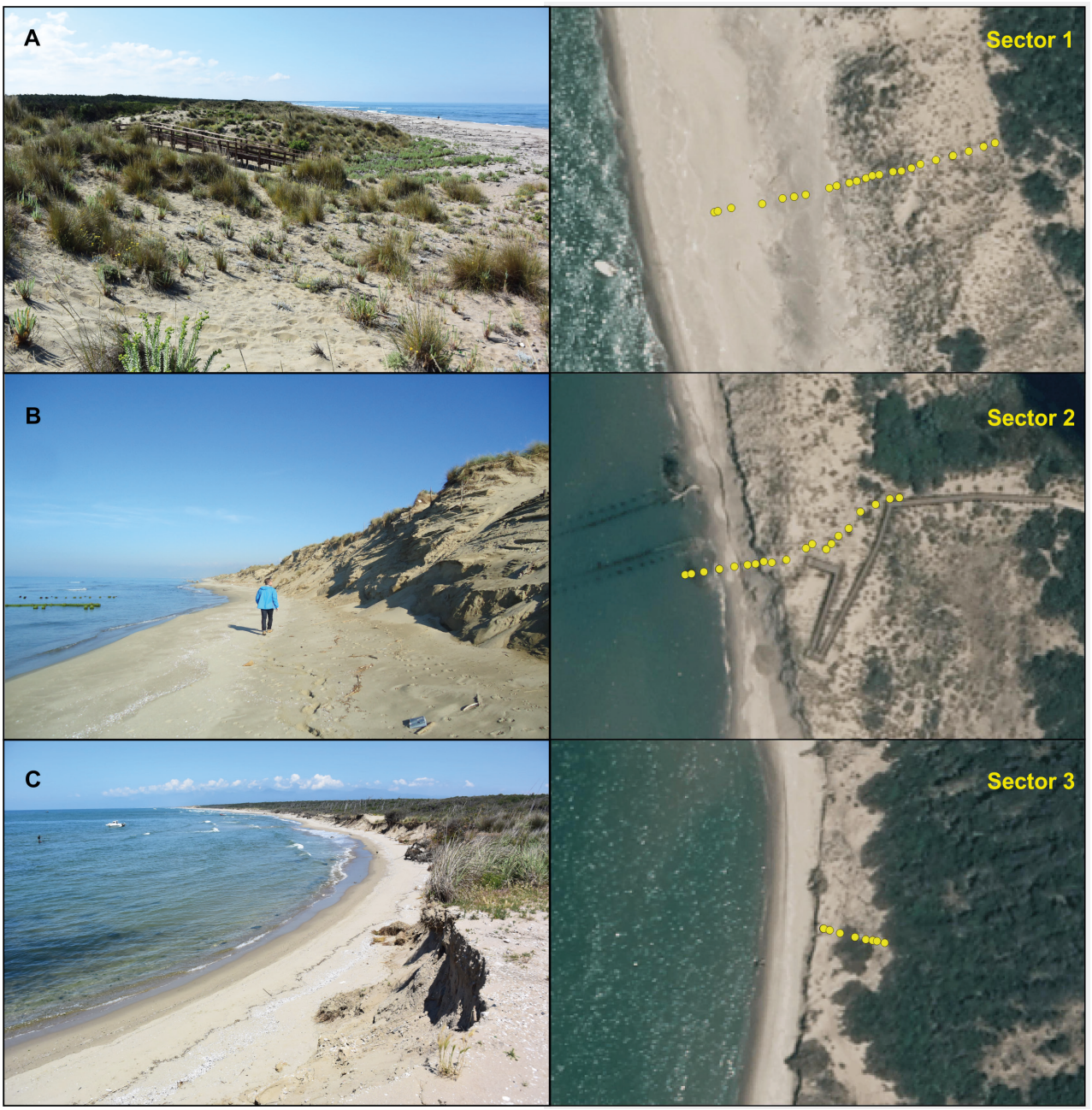

Fig. 2 - The study area can be subdivided into 3 sectors characterized by different morphologies and evolution state: A) the northern sector; B) the central sector; and C) the southern sector. The dashed lines represent the position of the transects.

As a whole, the dune field in this sector of the Migliarino – San Rossore – Massaciuccoli Regional Park is characterized by transverse dunes. South of the River Serchio the dunes are well structured morphologically, being constituted by frontal dunes, semi-mobile dunes and steady dunes (Bertoni & Sarti, 2011b), with maximum dune height of about 4.5 m (Fig. 2a). The vegetation is continuous and covers the whole dune field. Seaward of the frontal dunes, sparse vegetation often buried by wood and waste material brought by river floods define the presence of the embryonic dunes, which are still preserved in this sector. To the south the situation changes dramatically: the dunes are up to 9 m high, but they are subjected to strong erosion processes (Fig. 2b). In some places wave action led to a complete loss of the frontal dune and part of

the semi-mobile dune especially during storms (Fig. 2c), thus hampering the formation of the typical vegetation succession and interfering in the stability of the dunes (Ciccarelli *et al.*, 2012; Ciccarelli, 2014; Ciccarelli, 2015; Bertoni *et al.*, 2014a; Ruocco *et al.*, 2014). Large blowouts (up to 40 m wide) also punctuate this sector of the dune field: here vegetation is almost completely absent. No tourist infrastructures nor human activities are reported within the investigated area, with the exception of a concrete groin built to protect the mouth of the River Morto Nuovo and of a wood walkway built to reduce pedestrian trampling over the dune crest.

3. Methodology

Three sectors were selected within the area under investigation in order to cover as much as possible the different configurations of the dune field, especially in terms of geomorphological characteristics and evolution state (Fig. 2): in detail, the northern sector, about 1.5 km south of the River Serchio's mouth, is currently in accretion or in equilibrium (Sector 01); the central sector, located midway through the area just across the wood walkway, is experiencing erosion processes that are eroding the high frontal dunes (Sector 02); at last, the southern sector, about 200 m north of the River Morto Nuovo's mouth, is subjected to erosion processes that already wiped out the frontal dunes and are now striking the semi-mobile dunes (Sector 03). A transect was traced out in each sector to serve as a reference to assess the topographic evolution within the time frame of the research, which spanned nine months, from January 2016 to September 2016. In particular, four topographic surveys were carried out: January 2016, March 2016, June 2016 and September 2016 (Tab. 1). The transects (named 01, 02 and 03 to coincide with the sectors where they were traced out) covered the area comprised within the transition between steady dunes to semi-mobile dunes and the shoreline. The survey was performed using a Leica RTK-GPS 500, 1 mm of instrument error (reference: Universal Transverse Mercator projection, Datum WGS 84). A point was recorded at each significant slope variation along the beach profile. The resulting data were processed by Q-GIS software, profile rendering was realized using Profiler 2.3, a *macro* for Microsoft Excel developed by Mouncef Sedrati of the Université de Bretagne-Sud (Lorient, France). Sea-weather characterization was gathered by a wave gauge located offshore the Gorgona Island (Tab. 1). Wave condition plots indicate that 6 storms with wave height over 4 m occurred within the time frame of the research, all coming from southwest (Fig. 3), which confirms that major high-energy events are expected from that direction in this sector of the Tuscany coast. Additional minor storms (3 m > maximum wave height > 4 m) occurred mainly in winter (January and February), while in the rest of the time just twice (mid-April and mid-June) an event reached the threshold of 3 m as maximum wave height.

Tab. 1 - Sea-weather characterization during the topographic surveys: *wave* refers to the average wave height during the duration of the survey; *max height* refers to the maximum wave height recorded during the duration of the survey (data provided by Servizio Idrologico Regionale). Based on the modest tidal range that characterizes this sector of the Ligurian Sea, tide influence is negligible and not taken into account.

Survey	Wave (cm)	Max height (cm)
January 25, 2016	40	60
March 10, 2016	48	54
June 23, 2016	23	25
September 09, 2016	34	39

To further discuss the data obtained by the topographic surveys, a simple but effective way to assess volume shifts during the time frame of the fieldwork is the method that defines the volume as cubic meter per linear meter (m^3/m). Intuitively, this method is not extremely accurate, but it still provides an approximation of sediment displacement on the investigated sectors of the coast, which is useful to highlight the evolution state of the area.

4. Results

A 9-months-long investigation, which is in general terms too short a time frame to evaluate the evolution state of a coastal area, did not prevent to observe some major modifications to the beach and the dune field along this sector of the Migliarino – San Rossore – Massaciuccoli Regional Park. A quick glance over the three transects enables to point out a few general trends. To the north the backshore is wider (about 80 m) and gets narrower southwards: in the central sector is almost 70 m wide, whereas it is just less than 20 m in the southern sector (Fig. 4). Transect 01 is characterized by the presence of embryonic dunes at an elevation of about 2 m; dune crest height is just over 7 m. No embryonic dunes are reported along Transect 02; the dune is significantly higher, reaching almost 9 m. Again, transect 03 is completely different based on the absence of the frontal dune – embryonic dune system: here surface elevation is just 3.5 m.

The comparison between the four surveys for each transect also raised some concerns. Unfortunately the January's survey for transects 02 and 03 was recorded along a different trace relative to the next three as the

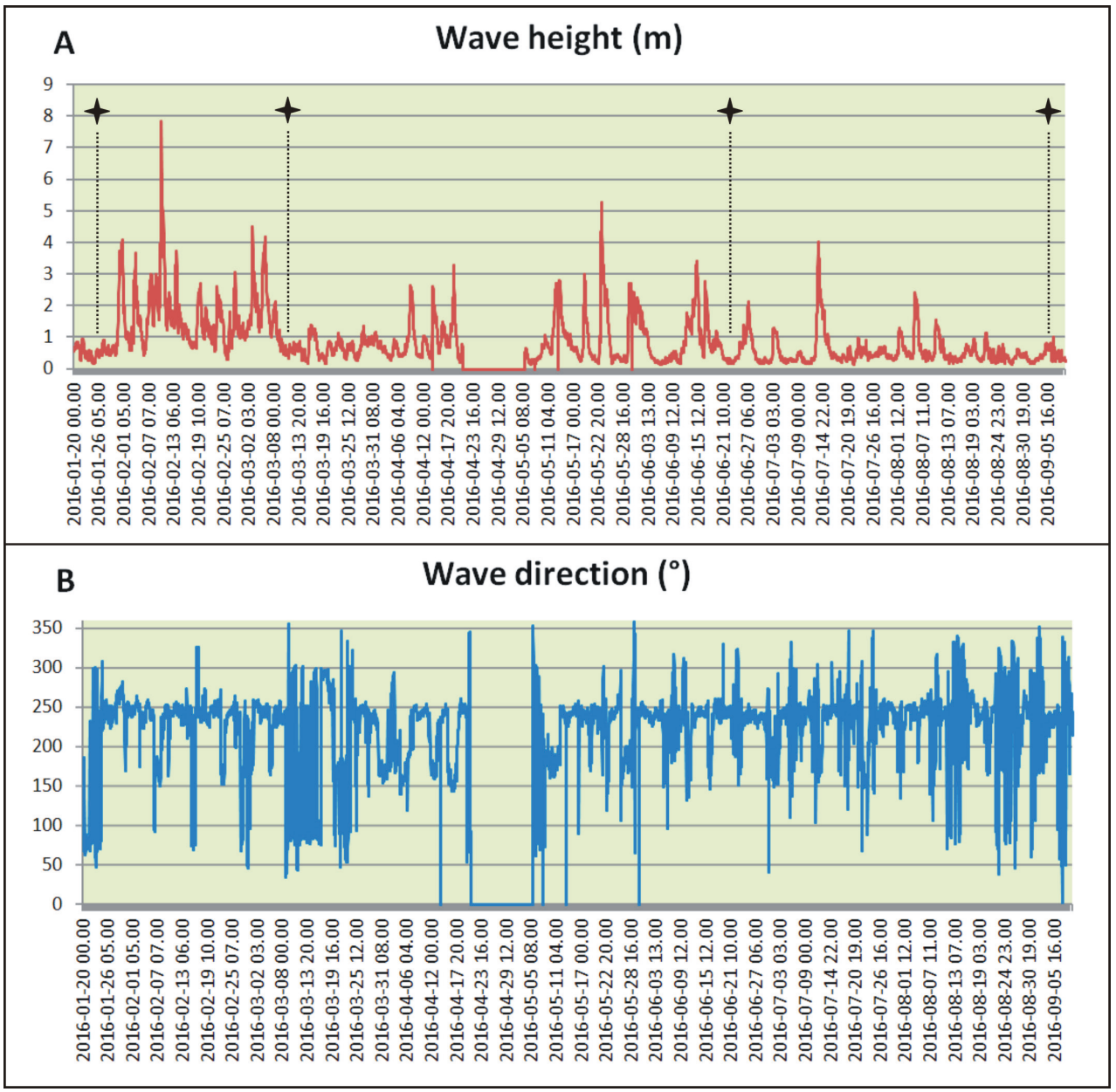

Fig. 3 - Sea-weather characterization within the time frame of the investigation. A) Wave height (expressed in m) recorded between January and September 2016; B) Wave direction (expressed in °) recorded between January and September 2016. The black symbols mark the timeline of the topographic surveys. The data were measured by the wave gauge located offshore the Gorgona Island; the gap between April 21 and May 5, 2016 is due to technical maintenance of the device. Wave data were provided by Servizio Idrologico Regionale.

collapse of the dune prevented the operator to reach that same spot in later months: thus, the January's survey is not included in Fig. 4 along transects 02 and 03. The northern sector virtually showed no differences throughout the time frame of the investigation. Beach width, embryonic dune position and frontal dune height did not change considerably. Major variations occurred along Transect 02, where a huge retreat can be easily observed: within just 4 months (from March 2016 to June 2016) the backshore profile shifted landward of almost 10 m. The retreat is far more impressive on regards to the dune profile: as a matter of fact, the dune crest moved landward of about 6 m in that same time span, along with a crest height decrease of almost

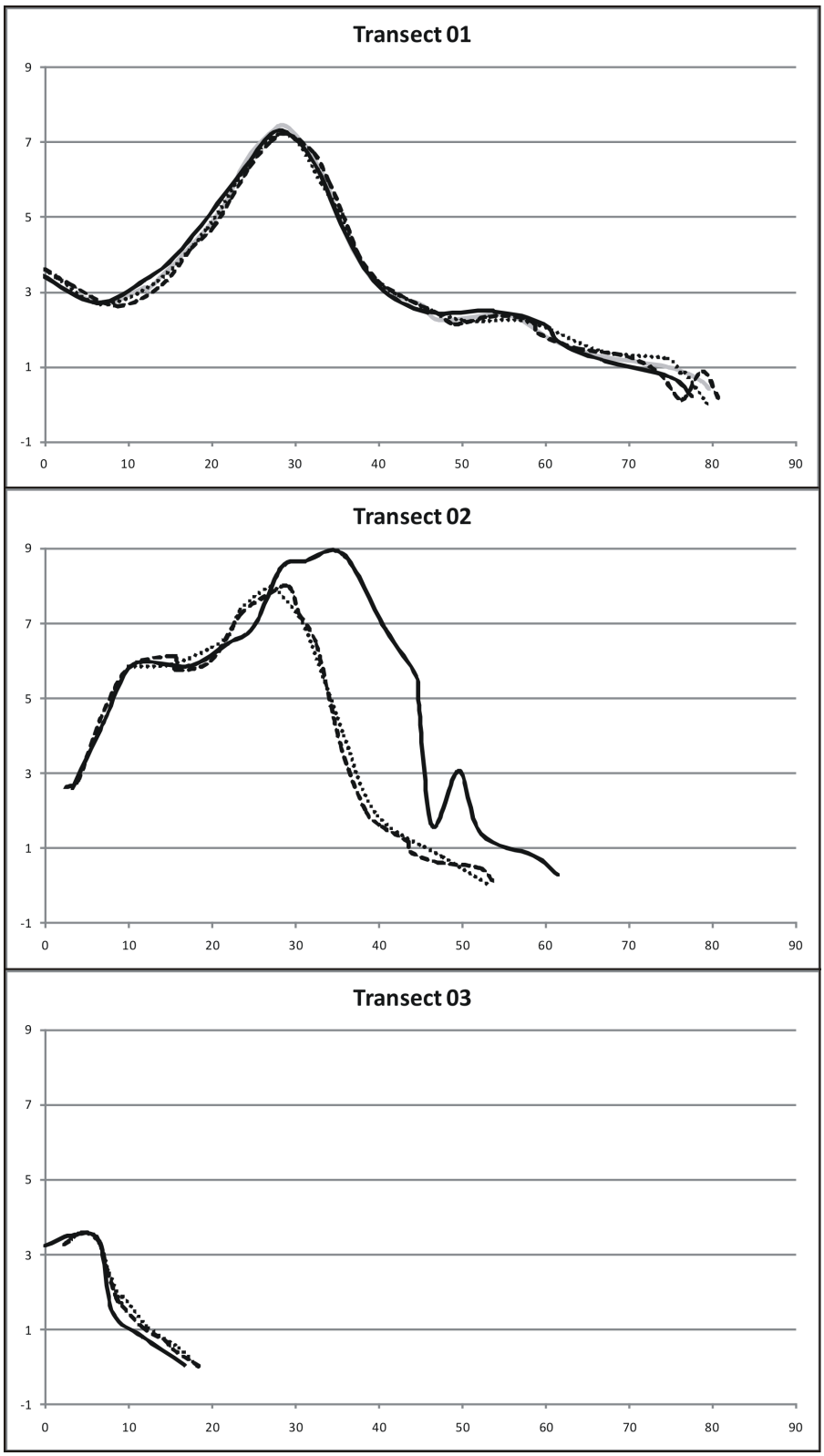

Fig. 4 - Beach profiles for each transect measured during the topographic surveys. Gray continuous line: January 2016 (only for Transect 01); black continuous line: March 2016; black dashed line: June 2016; black dotted line: September 2016.

Tab. 2 - Volume computation for each transect within the time frame of the investigation (January 2016 to September 2016). *Length* refers to the extension (m) of the beach profile along which the volume has been calculated; *volume* refers to the volume of sediments above 0 m elevation expressed as m^3/m; *average* refers to the average volume per linear meter (expressed in m^3/m).

	Transect 01			Transect 02			Transect 03		
	Length	Volume	Average	Length	Volume	Average	Length	Volume	Average
January 2016	80	254	3.2	-	-	-	-	-	-
March 2016	78	255	3.3	52	273	5.3	14	24	1.7
June 2016	81	252	3.1	44	187	4.3	16	27	1.7
September 2016	80	257	3.2	43	192	4.5	16	28	1.8

1 m (Fig. 4). The southern sector did not experience considerable modifications in terms of beach width and dune height: the only difference is a decrease of the steepness of the eroding dune, from 0.85 in March 2016 to 0.57 in June 2016 and September 2016.
Volume computation (expressed as m^3/m) basically confirmed the tendencies that were already brought out by the analysis of the topographic surveys (Tab. 2). Transect 01 did not experience any significant difference either in sediment volume and in the average volume along the profile. As expected based on the retreat pointed out by the topographic surveys, a harsh volume decrease occurred between March 2016 and June 2016 along Transect 02; during the summer, a little increase is observed (about 5 m^3/m). The marginal difference in beach profile evolution that was evidenced by the topographic surveys along Transect 03 transpires also in volume computation: just a modest volume increase is reported between March 2016 and June 2016, which was expected based on the presence of an accumulation at the toe of the eroding dune (Fig. 4). Volumes do not vary during the summer months.

5. Discussion

As previously mentioned, the erosion processes in this sector of the Pisan coast have been thoroughly reported and discussed (e.g., Vittorini, 1977; Pranzini, 2001; Bini *et al.*, 2008), therefore nothing apparently new occurred along the shoreline in the first ten months of 2016. Regardless, serious concerns raised because of the extreme retreat observed on the frontal dune in the central portion of the investigated area (Transect 02), which is something not so frequent even in a site where the coastline is receding significantly. As a matter of fact, within a 3-months timespan a 9 m high frontal dune retreated about 6 m, with an estimated volume loss of about 80 m^3/m along the transect (Fig. 5). In this case the observed retreat is even more concerning because the sediments wiped out during the storms were not moved backwards on the backdune area, where a huge accumulation should be expected (Fig. 4), rather they were transported either northwards in accordance with longshore drift direction and offshore. The former case is serious for the site, but at least the sediments that were removed there are going to accumulate and eventually benefit other sectors of the coast; conversely, the latter is worse because sediments lost offshore cannot be naturally brought back onto the shore and must be considered out of the system. Therefore, a huge retreat occurred along Transect 02, but it led to a massive erosion of the seaward side of the high frontal dune rather than an actual landward shift of the coastline, which can be estimated in just less than 10 m. The ensuing concerns are quite obvious because while coastline shifts are dynamic and frequent over time in both directions, the collapse of a portion of a coastal dune is an irreversible process.
In the other sectors the situation is rather different (Fig. 4). To the north (Transect 01) there were virtually no modifications along beach profiles, which might be explained with an apparent equilibrium state. This does not mean that the erosion processes are not active or their influence is lessened in the area. Rather, it means that this is a sediment transfer zone, where sand does not accumulate and moves through this sector of coast northwards according to the direction of the littoral drift. As a matter of fact, the length of each profile is constant during the time frame of the observations. Beach width is not constant along the coast though. Southwards it gets significantly narrower (Tab. 2): the decrease can be ascribed to the landward shift of the coastline because the position of the frontal dunes does not change. Further to the south (Transect 03) the backshore is just 5 m wide and the frontal dunes are not even present anymore: erosion processes are already consuming portions of the semi-mobile and steady dunes, which formed the steep, 2 m high cliff at the back-end of the backshore (Fig. 2c). As well as Transect 01, no major differences can be observed along Transect 03 analyzing the comparison between the surveys that were carried out within the time frame of the investigation. The reduction of cliff steepness is the only appreciable variation, which was likely determined either by the collapse of sediments from the top of the dune and by the accumulation of eroded sand coming from the upflow direction; beach

Fig. 5 - The configuration of the dune along Transect 02 in February 2016 (A) and in June 2016 (B). The extreme erosion of the frontal portion of the dune is clearly appreciable. The dots point out the position of the same object in each picture.

recovery during fair-weather periods might contribute to that small accumulation as well. A similar evolution was reported by Armaroli *et al.* (2013) on a dune system along the Emilia-Romagna coast (northern sector of the Adriatic Sea): the Authors defined this peculiar development as a *discrepant response* of the dune after storms in opposition to the standard mechanism usually characterized by an increase of cliff steepness after high-energy events. The difference between the two cases is that the collapse of the upper portion of the dune in the Adriatic site was clearly observed, whereas the position of the dune crest in the Ligurian site did not change after the storms. This implies that the sediments accumulating at the dune toe should be coming from the upflow sector of the beach (longshore) rather than from the backdune along the cross-shore direction. The high erosion processes emphasized by the jetties at the mouth of the River Morto Nuovo affected Sector 3 in the last decades determining a huge retreat of the coastline relative to the upflow sector just south of the river's mouth (Fig. 1). The intense retreat, along with the jetties, is now responsible of a screen effect of this portion of beach, which is probably no more directly hit by incident waves during the major high-energy events, as they typically come from southwesterly directions (Fig. 3). The energy of the waves is likely reduced by the jetties: the waves propagate in the downflow side of the river through diffraction processes, which are also responsible of the pronounced bending of the coastline (Fig. 1). Therefore, the erosion effect, which are so severe elsewhere along the coast of the Regional Park, are not as serious in this sector.

As previously mentioned, the volume decrease along Transect 02 is brutal: even though the beach profile is shorter by almost 10 m, which would apparently explain the reported volume loss, the average values are decreasing as well, which means that volume actually decreased regardless of beach profile length (Tab. 2). The strong storm occurred in early May 2016 might be responsible of this huge retreat (Fig. 3a). Prior to the March 2016 survey a few major storms did strike the Pisan coast, but they did not affect the dune profile significantly; the effect of the series of high-energy events occurred in winter 2016 might be felt on the system as a follow-up, that is the weakening of the frontal dune in terms of stability due to intense scouring at the toe. Beach recovery after storms cannot be feasible on such a frontal dune, which led to its collapse after the following strong storm (early May 2016). The slight volume increase recorded after the summer months along each transect is likely determined by wave action during extended fair-weather periods, which is usually responsible of a modest accretion on the beachface. As a matter of fact, just one major storm (barely reaching 4 m of maximum wave height) occurred after the June 2016 survey (Fig. 3a).

6. Conclusions

The present paper highlights the serious health state of the coastal dune system within the Migliarino – San Rossore – Massaciuccoli Regional Park. Even though the erosion processes along this sector of the Pisan coast have already been described, an actual episode of collapse of a portion of the frontal dune was never recorded and measured before. Topographic surveys evidenced a 6 m retreat of the dune crest in the central sector of the investigated area, which was located between River Serchio's and River Morto Nuovo's mouths. Such a retreat is impressive because it occurred on a 9 m high frontal dune in just less than 3 months (March – June 2016): a quick assessment of the volumes involved provided an estimation of about 80 m^3/m lost along Transect 02. Basically, volume computation reflects the evolution of the beach profile within the time frame of the surveys.

This dataset confirms the retreating trend of this stretch of the Pisan coast, but it also implies a novel notion about its evolution: based on the massive collapse measured on the frontal dune, the system is likely getting more unstable over time and in no way it will recover the former configuration. Since the approach used to manage this coastal area did not provide a definite outcome so far, it would be beneficial a paradigm shift that involves the use of a different approach, which would be integrated with all the components (territory, local authorities, scientific community) and multidisciplinary (geology, biology, engineering, economy). Employing low-cost, integrated engineering devices to collect extensive, real-time datasets may be the first step to an up to date monitoring system (Bertoni *et al.*, 2014b; Pozzebon *et al.*, 2016). Along with innovative technical solutions, it will be crucial to manage the coast as an environment influenced by processes acting along the shoreline as well as on the drainage basin and along river courses. The transversal scale must be taken into account as much as the longitudinal scale, which must be always considered in terms of physiographic unit, as opposed to the local site approach too often used in the past. Future interventions should reduce the use of hard structures (breakwaters, groynes) and look to viable options such as sediment by-passing or back-passing, where city limits or territory boundaries do not factor in the decision-making process. Anyhow, a wise management of the sand is paramount for a better management of the coastal area as a whole: even taking into consideration the *managed retreat*, which claims that the system should be allowed to evolve without human interference and the efforts should be moved to a conscious landward re-alignment of the shoreline especially on natural settings such as the Migliarino – San Rossore – Massaciuccoli Regional Park (Nordstrom *et al.*, 2015;

Nordstrom *et al.*, 2016), sand redistribution needs to be properly managed.

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