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Opportunities and constraints for managed retreat on exposed sandy shores: examples from Emilia-Romagna, Italy

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Abstract

Managed retreat is rarely implemented on exposed sandy coasts because of public interest in beach recreation and the great human-use value of existing beaches and dunes. The feasibility of retreat on the sandy coast of the Adriatic Sea in the Region of Emilia-Romagna was evaluated at a site with a single user facility (a beach concession) backed by public parkland. A conceptual scenario of changes to landforms and habitats was developed for the retreat option. Interviews with key stakeholders revealed perceptions of alternatives for addressing erosion and flooding by managed retreat or by protecting existing features in place.

The beach concession occupies a segment of shore between an eroding (-9.3 m yr^{-1}) washover barrier updrift and an accreting beach downdrift. Landward of the concession is a portion of the Po Delta Park, consisting of a brackish lagoon and marsh and an artificially-created fresh water lake. Shore protection projects have maintained the concession and the integrity of a dike protecting the lake. Allowing retreat to occur would cause (1) loss of the concession in its present location; (2) erosion of the dike, converting the lake to brackish habitat; and (3) migration of the shoreline to a pine forest, campground and residences that are now 500 m from the shoreline. Freshwater and pine forest habitat would be lost, but saltwater wetland and pioneer coastal species would be restored. The beach and campground could still be used as the shoreline migrates inland, but with less fixed infrastructure. Landward facilities could be protected by a ring dike.

At issue is whether normally dynamic and short-term landforms and habitats should be protected as static features in perpetuity and whether human actions should be taken to protect human-created nature (lake, pine forest) against natural evolutionary processes. Stakeholders indicated that managed retreat should occur eventually but existing features should be protected now. The retreat option is compatible with Regional ICZM plans, but differs from the standard engineering designs actually suggested for implementation. The benefits of managed retreat on exposed sandy shores can only be presented in conceptual terms until demonstration projects provide concrete answers, so it is not surprising that the undocumented benefits of a more dynamic shoreline have little appeal relative to maintaining the status quo.

Keywords: Beach use, coastal erosion, managed realignment, sediment budget, wetlands

1. Introduction

Studies of human adaptation to climate change and sea level rise have proliferated with the growing awareness of the potential increased impact of damaging storms, the accompanying coastal erosion and inundation, and the increased levels of risk and economic cost that many coastal communities and ecosystems will face in the future (Abel et al. 2011; Roca and Villares 2012; Niven and Bardsley 2013). Greater attention is now being paid to the advantages of retreating from the coast as an adaptation strategy, rather than implementing defenses to resist shoreline change in situ (Morris 2012; Berry et al. 2013), but implementation of actual adaptation responses by managers is limited, despite the increase in planning options (Niven and Bardsley 2013). As a result, actions to retreat from the coast can be opportunistic (reactive) rather than proactive (Ledoux et al. 2005). Managed realignment schemes have been implemented on low energy coasts, where salt marshes are the dominant natural environment (French, 2006; Garbutt et al., 2006; Rupp-Armstrong and Nicholls, 2007), but examples are lacking on more exposed coasts fronted by beaches, where public interest in beach recreation is great and the land has greater human-use value. Stakeholder resistance can be great, even on low-energy coasts, because information about costs and benefits of managed retreat is lacking (Myatt et al. 2003a). Uncertainty about how climate-related changes will affect the coastal landscape and its use can lead to inaction, but providing scenarios can make future changes more meaningful (Lorenzoni and Hulme 2009). The lack of examples of stakeholder gains and losses when converting stabilized exposed shores to dynamic beaches and dunes is likely to impede acceptance of the retreat alternative on exposed coasts. In the absence of after-action assessments of actual retreat, decisions may have to be made on feasibility assessments (e.g. Nordstrom and Jackson 2013). Determining the potential for accommodating natural processes by allowing the shoreline to retreat involves (1) identifying the rationale for managed retreat; (2) using demonstration sites to document the feasibility of accommodating retreat; (3) identifying the kinds of geomorphic and ecological changes that will occur; and (4) identifying the advantages of allowing those changes to occur.

Primary disadvantages of retreat are that the loss of private properties and income from commercial establishments and the need to eliminate or relocate existing infrastructure may be expensive, and the social costs may be considered unacceptable to stakeholders (Niven and Bardsley 2013). The retreat option should be most feasible where there are few structures or stakeholders directly affected and the costs of compensating owners are minimized (Rupp-Armstrong and Nicholls, 2007). This study was conducted to assess the potential for exercising the retreat option at an open-coast (sandy-beach) site which seems well suited. The site (Figure 1) is on the coast of the Adriatic Sea at Lido di Spina, Province of Ferrara in the Region of Emilia-Romagna. The site is backed by parkland in the Po Delta Park. A single user facility exists at the beach. Our procedure includes identifying (1) the existing management context and key stakeholders; (2) the shore processes and beach/dune characteristics; (3) the physical changes to landforms and habitats that are expected to occur if artificial shore protection methods cease; (4) the advantages and limitations of allowing these changes to occur; and (5) the reasons why implementing the retreat option is difficult, even where conditions would appear suitable.

2. Methods

Existing reports and data sets prepared by the regional government were used to identify key processes responsible for coastal change and future plans for shore protection projects (synthesized in Preti et al. 2009). A topographic chart from 1893-94 and air photos from 1943 and 2008 were used to determine shoreline changes in the past. Topographic profiles contracted by the regional authority in 2006 and 2012 were used to determine recent rates of change and present characteristics of beaches and dunes. Aerial images from Google Earth were used to identify and measure distances from the shoreline and beach/dune contact to human infrastructure. These distances and rates of shoreline change from the profiles were used to estimate when infrastructure would become subject to erosion. Elevations of key features landward of the topographic profiles were determined from LiDAR data taken in 2004 and 2012. The potential for future changes was discussed with key stakeholders in interviews conducted as part of the Risc-kit European Project (van Dongeren et al. 2014) for the Porto Garibaldi-Reno River area. Interviews were conducted as open ended discussions about several key questions centered on coastal risk induced by extreme storm events. The retreat option for the Spina area was mentioned as a possible future alternative. Eight stakeholders were interviewed as representative of public and private sectors. One person each was interviewed in the Regional Land and Coast Protection Service, the Regional Technical River Basin Service, the National Forestry Commission, the Po Delta Park, and the Association of Local Entrepreneurs. Private interests were represented by a local fisherman and two beach concessionaires, including the manager holding the concession for the key beach facility.

3. Study area

3.1 The regional setting

The Emilia-Romagna coast is low-lying and fronted by sandy beaches. Wave energies are normally low, but storms from the south and southeast (Scirocco) and northeast result in high waves and storm-surge levels. The highest storm-surge levels are associated with Scirocco winds, and surge anomalies of up to 0.6 m with a 1 in 2 return period can occur (Masina and Ciavola 2011). Strong northeast winds occasionally follow when the surge levels are still high, like the event that occurred on 24 September 2004, which produced widespread erosion along the whole regional coastline (Ciavola et al. 2007). Most storms have durations of less than 24 hr and a maximum significant wave height of about 2.5 m (Armaroli et al. 2012). The 1 in 2 yr event has a 3.3 m offshore wave height (Armaroli et al. 2009). The largest storm measured at the site occurred on 24-27 September 2004 with a maximum significant breaker height in excess of 5.6 m and a duration of 72 hours (Ciavola et al. 2007). Neap tidal range is 0.3-0.4 m; spring range is 0.8-0.9 m. Net longshore sediment transport is to the north along most of the region, with some local reversals south of the mouths of streams (Preti et al. 2009). Coastal dunes were relatively common in Emilia-Romagna in the past, but many dunes were graded to accommodate beach recreation or truncated by wave erosion coupled with human attempts to maintain fixed positions just landward of the beach. About 85 km of the 130 km-long Emilia-Romagna coast is developed for tourism (Preti et al. 2009).

Beaches in undeveloped and unprotected areas are eroding through interruption of longshore sediment transport by shore-protection structures (primarily offshore breakwaters), diminution of sediment supplies delivered by rivers, and natural land subsidence, exacerbated by extraction of water and gas (Taramelli et al. 2014). Hard shore protection structures are widely distributed and protect over 60% of the regional coastline. The shorelines of developed areas have remained relatively stable recently because of human interventions, which have included widespread beach

replenishment (Armaroli et al. 2012). Over 8.1 million m^3 of sediment were added to the beaches in Emilia-Romagna from 1983 to 2007 (Preti et al. 2009), but unprotected areas are experiencing erosion. Coastal formations landward of the beach and dune are low and flat in developed and undeveloped areas. The coastal strip is often higher in elevation than the land behind it, of which over 100,000 ha is below sea level (Preti et al. 2009).

3.1 Local conditions

A large increase in development at the coast occurred in the 1960s and 1970s. The town of Lido di Spina was created in the 1970s. The Municipality of Comacchio manages the northern-most portion of Lido di Spina (Figure 2) for intensive recreation. The undeveloped segment south of the concession has been managed by the regional government of Emilia-Romagna as a portion of the Po Delta Park since 1988. A sand road parallel to the beach provides access from the developed portion of the town to the concession. The concession consists of a fixed eating establishment and series of cabanas, plus umbrellas and beach chairs deployed in the summer (Figure 3). No roads or facilities exist south of the concession. The lands to the south and west of the concession and sand road are within the Po Delta Park. The nearest developed land is over 500 m west of the shoreline and consists of farm fields, a residential development, and a campground that is built in a dune forested with pine plantings emplaced at the beginning of the 20th Century. The campground can accommodate 2000 people. A sand dike (Figure 2) that was built in the 1970s protects the agricultural land and developed enclaves to the west.

The zone between the beach and the pine forest to the west consists of two bodies of water bordered by marsh and separated hydraulically by a causeway on which a paved shore-perpendicular access road is constructed (Figure 2). The pond to the north (Spina Lake) is fresh water and was artificially created for recreation by dredging a basin and using some of the material for creation of the dike on the seaward and southern sides. The body of water to the south (Bellocchio Marsh) is brackish and bordered by salt marsh. The Gobbino Channel (Figure 2) was artificially created in the 1980s to connect the wetlands to the sea and maintain water quality. The channel is now dredged to maintain hydraulic efficiency. Spina Lake, like Bellocchio Marsh, is managed as a natural area, despite its non-natural origin. The much wider Comacchio Lagoon occurs inside the Po Delta Park but farther landward than the campground. This UNESCO site is connected to the sea through several channels, including the Gobbino. Since 1984 the wetlands have been maintained as a natural site for biodiversity, bird nesting and naturalistic tourism as well as for fishery.

Beginning in the 1990s, longard tubes were used to create short groins and shore-parallel sills between the developed beach at Lido di Spina and the mouth of the Gobbino Channel about 1500 m south of the concession (Figure 2). These structures deteriorated and are no longer functional. Five wood groins were then emplaced just north of the concession and are still effective. The shoreline near the concession is nourished every year by backpassing sediment that has accumulated in the northern part of Lido di Spina. Sand backpassing is considered acceptable because the intensively-used beach on the developed shore of Lido di Spina has a surplus of sediment, and the sediment that is removed eventually returns via longshore sediment transport. The developed beach is over 200 m wide in places and some users complain about the lack of easy access to the water.

Inspection of aerial photographs indicates that the buildings at the concession site did not exist in 1984 but there was a parking lot. The concessionaire constructed a restaurant and row of small bathhouses, with much of the improvement occurring from 1999 to present. The backpassing helps protect the concession and provide additional beach space while protecting the dune system to maintain its value as a protective barrier against loss of the sand road and breaching of the dike landward of it. The shore-protection actions at the concession have resulted in a conspicuous seaward bulge in the shoreline (Figure 2). The road along the causeway connects the campground with the concession and the beach (Figure 2). The facilities at the concession (Figure 3) are used by customers who rent beach equipment (umbrellas and chairs) and by visitors to the natural beach to the south of it.

We initially assume that allowing the shore to evolve by natural processes by removing the concession buildings and protection structures at the bulge or allowing them to deteriorate and ceasing backpassing operations would result in (1) initial erosion of the bulge in the shoreline planform, creating a more linear shore and initially facilitating sediment transport to the north; (2) eventual erosion of the dune and road just north of the present bulge and conversion of the formerly stable shore to an overwash barrier similar to the naturally-evolving shore to the south (Figure 4); (3) breaching of the dike, with periodic flooding of Spina Lake, altering its salinity and habitat characteristics; and (4) undermining of the seaward end of the paved access road leading from the campground to the concession.

4. Results

4.1. Identification of stakeholders and their capabilities

The principal stakeholders involved in decisions about coastal management are identified in Table 1. The tiered structure of government responsibilities is similar in form to that of many other countries, here consisting of the national government, the region, the province and the municipality (commune). Despite the hierarchical structure, the province and commune have reduced roles in beach management. One conspicuous difference in the way beaches are managed is the Italian system of awarding concessions to private interests, along with the authority to develop and manage beach resources, which is especially relevant at Lido di Spina. The presence of concessionaires, who can alter the beaches using their own resources, is a key reason for the reduced role of municipalities in direct management of beaches in Italy.

Laws of the Region of Emilia-Romagna affecting the environment include the 1979 “Coastal defence interventions for the protection of civil and industrial buildings and environmental and tourist safeguard,” the 1988 “Creation of the Po Delta Regional Park,” the 2005 “Regulation on the management of protected regional areas and sites in the Natura 2000 network” stemming from the EEC Habitats Directive, and the 2011 “Creation of the management authority in charge of park and biodiversity in the Po Delta Regional Park.” EU-Habitat Directives, including the “Conservation of natural and semi-natural habitats, wild flora and fauna” and “Wild birds preservation” exist, along with other regional resolutions, directives and decrees, including a resolution on “Guidelines for the integrated management of coastal zones” in the Integrated Coastal Zone Management (ICZM) Plan for the region (GIZC-Delibera del Consiglio Regionale 20 January 2005, n.645). As of February 2014 a 100 m setback from the existing shoreline was also being considered, but no action has been taken. The ICZM Plan lists options to (1) reduce subsidence by better control of extraction activities; (2) increase the quantity of sediment delivered by rivers by removing dams, preventing mining of riverbeds and changing land use

from abandoned lands and forests to cultivated areas; (3) favour setbacks for bathing establishments; and (4) reduce expansion of coastal urban areas. These options would reduce erosion rates, protect infrastructure and favour the reintroduction of natural elements, but the options are not likely to be employed because the plan is not binding.

Article 13 of the regional plan for provincial and municipal planning for the conservation of regional landscapes and environment is designed to improve coastal environmental quality by favoring restoration and use of natural elements in relatively undeveloped areas by promoting removal of incongruous uses landward of the beach and accommodating them elsewhere. However, locations where this is applicable are not delimited, nor has the regional authority asked the provinces or towns to take action. The most recent regional plan for coastal defense envisioned the need for 6 million m^3 of sand for beach nourishment and maintenance of existing structures over the 10 years following 2006, but there appears to be no way to set aside the needed funds (Preti et al. 2009). As of 2007, there were no ongoing or planned projects for construction of hard defense structures by the region (Preti et al. 2009), although the municipality of Ravenna constructed breakwaters and groins using their own funds. The Comacchio city council produced a protocol envisioning inland shift of coastal campsites, indicating that an awareness of the need to retreat is building. This protocol is not presently applied.

Spatial plans of the Po Delta Park, base their principles on the 2005, "Regulation of the formation and management of the regional system of protected natural areas and sites of the Natura 2000 network." The Bellocchio-Reno Mouth area is formally identified in the Natura 2000 network as IT4060003 SIC-ZPS. The Po Delta Spatial Plan (master plan) acknowledges that landforms and habitats are dynamic and erosion is an issue but does not address what to do about changes. The seaward limits of the park are now landward of the coastal strip, so park managers can take no action on the beach. Park managers are aware of the losses that are taking place through erosion and subsidence, but the Park has no executive role in undertaking shore protection projects or a budget for projects. The marsh is under the jurisdiction of the park. The National Forestry Commission manages the forest that falls within the park boundaries, including the vegetation around Spina Lake, which is mainly pines planted by the Regional Authorities in the 1970s. The lake is within the State Reserve (Riserva dello Stato), under the jurisdiction of the Forestry Commission-Biodiversity Office of Ravenna. The lake is not formally considered a bird sanctuary but is an important winter stop for several waterfowl species as well as birds living in the pine forest.

The national government owns the beaches in the country, which are part of the “Demanio Marittimo” (public land), but Title 5 of the National Constitution was changed in 2011 to transfer decisions about managing beaches to the municipalities and local concessionaires. Concessionaires pay a fee to the municipality, which is subject to further taxation by some regional authorities. The fee ultimately goes to the national government. Municipalities manage the beach through beach plans and maintenance. They determine the number of concessions and charge concessionaires for commercial use. The legal aspects of concessions are assessed in the EU directive 2006/123/CE, for the free assignment of services within member states through a public procurement. The European Commission has warned the Italian government that assignment of the concessions must undergo a public tender. A Parliament Decree by the Italian government has delayed the initial EU deadline of 2015 to 2020.

A concession is a form of long-term lease to provide a service, not to own the property. Many concessions are family businesses that have existed for decades because, once awarded, the concession was automatically renewed until the concessionaire did not re-apply for it. Following the EU directive, the Italian government changed the duration of the lease to 90 years then to 20 years. The beaches are nominally public, but they essentially become privatized through the concession process. Concessionaires provide amenities in the form of food, drinks, changing facilities, toilets and beach umbrellas, and they groom beaches, removing natural and human litter and surface shells and pebbles that they think users will not like. For the last few decades, concessionaires in Emilia-Romagna have bulldozed beach sand into temporary dikes on the backshore to protect against winter storm surges and then grade the dikes down to form recreation platforms in the spring in preparation for the summer tourist season (Preti et al. 2009; Harley and Ciavola 2013). These ongoing actions underscore the perception of the beach as human infrastructure.

The concession at the study site is frequently damaged by storms and restored before the summer season. Even if the establishment is damaged several times a year, the owner considers it economically worthwhile to rebuild the damaged structures and continue to improve facilities and is willing to protect the establishment if the regional government does not provide protection. The concessionaire is now having a groin built using his own financing.

Users of the beaches in the region include local (Italian) and foreign visitors (frequently Austrian, German, French, Swiss, Dutch and eastern Europeans). Most visitors arrive at the shore after evidence of the winter storms and human adjustments to them have been eliminated by grooming activities and the beaches in developed areas are already converted to flat, featureless platforms. Italian beach users are accustomed to the cultural transformations made by concessionaires and consider them an integral part of the beach experience. Foreign users can show a greater preference for naturally-functioning beaches without these amenities (Polomé et al. 2005).

4.2. Evolution of the shoreline up to present time

Comparison of maps of 1893-94 with aerial photographs through time (Calabrese et al. 2010) provide an overview of the dramatic changes in the form of the shoreline adjacent to and north of the mouth of the Reno River (Figure 5). The delta at the mouth of the river was farther seaward in 1893-94, and the river was deflected north, placing the river mouth about 4.1 km south of the present day concession. The locations of the concession, Bellochio Marsh and Spina Lake were seaward of the shoreline at that time (Figure 5). A diminution in the amount of sediment delivered to the coast via the Reno River in the 20th century occurred because of dams, levees, streambed mining, increase in land devoted to forest, decrease in arable land, and erosion control works on slopes (Preciso et al. 2012). By 1943, the delta shoreline eroded by about 0.8 km, causing accretion north of it and contributing sediment to form the Bellocchio Marsh and an accretion bulge in the shoreline about 0.7 km south of the present concession. A long spit extended north, deflecting the discharge point of the river to a position about 0.3 km south of the bulge. The shoreline of Lido di Spina that was north of the present day concession was about 0.4 km landward of its present position in 1943. By 2008 (Figure 5), the southern portion of Lido di Spina accreted; the spit had eroded; and the river discharged into the sea about 5.0 km south of the concession. The accretion bulge near the concession migrated about 0.8 km from its location in 1943 to its present location (Figure 2), but the bulge is less conspicuous than in 1943. The

shoreline near the discharge point of the river is farther landward than in 1893-94 due to continued erosion of the delta.

The two segments of coast north and south of the bulge in the shoreline are now evolving on different trajectories, determined by different management approaches to shoreline change. Rates of change 2006-2012 (Figure 6) reveal how the location of the concession now separates the eroding and accreting segments. The short-term stability of the concession appears to be based on human attempts to stabilize the shore rather than natural resistance to erosion, as indicated by the erosion 820 m north of the concession site at Profile Line PR9 (Figure 2), where sand is not added to artificially increase beach width. Managers in the park have allowed natural processes to occur south of the concession, resulting in an eroding washover barrier transgressing the marsh surface landward of it (Figure 4). The morphology of the shore at this barrier (Figure 7C) differs from the human-modified shores north of the concession (Figure 7A,B). The elevations of the backshores at all three profile locations should be similar, but the backshore 375 m north of the concession (Figure 7B) is periodically rebuilt to include a sacrificial dune (revealed in the 2006 profile), and the backshore at the developed beach 1,500 m north of the concession is wider because of its grooming to maintain a flat, wide recreation platform. All sites are fronted by a bar, but the volume of the bar appears to have diminished between 2006 and 2012. The reduction in volume of the bar will likely contribute to a decrease in sediment bypassing around the accretion bulge to the accreting segment downdrift while the shore protection structures at the concession remain in place. The volume of the washover platform on the barrier fronting Bellochio Marsh appears to be less than in 2006 (Figure 7).

4.3 Potential future changes under the retreat alternative

The rapid erosion that is now occurring south of the bulge implies that removal of sediment from the concession site would be rapid following removal of the groins and buildings and suspension of backpassing. Periodic transport of sediment to the south under the influence of the Bora winds and transport to the north under the influence of the Scirocco winds would help smooth the bulge, creating a more linear shoreline and a more efficient transport surface for net transport to the north. Wave erosion of the dune and eventually the sand dike just north of the concession would initially deliver sediment to the beach and then to the developed beach in Lido di Spina farther north. The sediment budget would eventually be less than in the past, but the accretion that occurred between 1943 and 2008, while erosion occurred farther south, indicates that this would not be a problem for a while. Eventual elimination of the dike would result in overwash into Spina Lake. Periodic storm overwash into Spina Lake would bury vegetation and introduce saline water to the fresh water habitat on its eastern shore. Breaching of the overwash barrier could result in formation of an inlet, which would speed conversion of the lake into brackish or salt water habitat. The rapid retreat of the shoreline south of the concession in the recent past indicates that the sediment budget is greatly reduced from the time when the Reno River was a significant source. It is not likely that the long-term rate of change is relevant under these conditions. Given the present rate of erosion of 9.3 m yr^{-1} south of the concession (PR 13 and 15 on Figure 6), the shoreline could reach the campground in just over 50 years.

Erosion of the bulge in the shoreline would eventually undermine the seaward end of the paved access road. The seaward portion of the road would form an outcrop on the beach and interfere somewhat with longshore transport under calm conditions, but it would be periodically broken up by storm waves. The landward portion of the road and causeway would remain as a barrier to water flow between Bellocchio Marsh and Spina Lake. Artificial removal of the access

road and its elevated causeway and dike to reinitiate natural processes (or placement of drainage culverts under the road) would allow the two basins to join as a contiguous salt marsh and increase the tidal prism through the inlet to the south. Placement of culverts under the road would improve tidal flushing and not prevent use of the beach by visitors from the campground. Temporary or moveable facilities could be provided at the beach for user convenience and not restrict further options for managed realignment. The beach available to campers would have the characteristics of the beach that is now south of the concession, rather than providing a choice between a natural beach and a groomed beach.

4.4. Stakeholder concerns about shoreline changes

The person interviewed from the Regional Land and Coast Protection Service considered the suggestions of ICZM as difficult to accomplish. He noted that the developed coast is stabilized, with limited space and limited capacity for adaptation. Proposing managed retreat, even if the beach remains wide for tourists, would result in complaints for cultural reasons. He acknowledged that having a set-back strategy can allow for retreat in a planned and shared way while providing more sediment and more space for tourists that can favour nature and retain economic value. He noted that relocating activities would be easier, if citizens are convinced that participation is done with inclusion of the needs of all stakeholders. He thought that managed retreat south of the developed beach would probably happen eventually, hopefully in a way that allows nature to adapt. He considered the area beautiful but fragile and threatened by retreat, so it should be defended, at least for now.

The coastal manager working for the Regional Technical River Basin Service considered the beach north of the concession as the final protection from flooding of low areas landward and continued to request finances to nourish the beach and restore the wooden groins and artificial earth embankment. The proposed alternatives of the Regional Technical River Basin Service for managing the shoreline between the Reno River mouth and the southern portion of Lido di Spina are identified in Table 2, for comparison with our projected managed retreat alternative. No formal plans or decisions have been made, but the options posed do not indicate that managed retreat is on their agenda.

The representative of the National Forestry Commission indicated that the Commission wants to continue to maintain Spina Lake as a fresh water bird sanctuary, and maintain the forest for the species that now exist within it. Maintaining Spina Lake and preventing salt water flooding of the pine forest farther landward would require maintaining the integrity of the dike north of the concession. The representative thought that loss may be inevitable but it should be slowed now, even if structures are necessary. He mentioned a submerged barrier to reduce wave energy and nourishment or dune rebuilding, recognizing that these are short-term solutions (5-10 years) that would require consideration of other (unspecified) alternatives. He thought that the shore has a value that cannot survive on its own and could not be re-created elsewhere. He echoed the common feeling that wetlands dissipate storm energy and should be promoted. He suggested that geomorphic engineering could be used to create wetland-type environments in the agricultural areas but that long time periods were required to maintain nature.

The representative of the Po Delta Park was interested in retaining open spaces without buildings and infrastructure, while allowing tourist use and agricultural and fishing activities. The concern was that the natural environment (beach, wetlands and dunes) must be re-created to have a buffer zone between the developed area and the sea, and buildings should be moved

landward to transform the coastal area into a natural landscape. Thinking about managed retreat was considered important, because it is inevitable.

All stakeholders with commercial interests had similar concerns about the encroaching sea and the need to protect against it. The fisherman was mainly concerned about canal flooding. The concessionaire at the site of interest noted that structures protect the concession and also create a headland that protects the entrance to the campground and Spina Lake and Bellocchio Marsh. He is replacing damaged structures and placing rocks and sand bags on his own initiative because the Region does not have funds to provide protection. He accepts using private money but indicates that a medium to long-term shared project would be better. He suggests that interventions need not be huge but should maintain what is there at present. Doing nothing would expose the area to problems generated elsewhere, including sand starvation resulting from human structures on the adjacent shoreline. He believes that the state of the art in coastal management has advanced, so workable options can be developed. Otherwise, he thinks the sea will reach the camping village in 4 to 5 years, and the natural environment will be lost.

5. Discussion

Restoration of natural elements by removing the structures at the concession and finding provisions to accommodate the use elsewhere is compatible with Article 13 in the Regional ICZM guidelines and the set-back zone recommended for protection of biodiversity, maintenance of ecosystems and adaptation to climate change. ICZM planning has identified comprehensive management options for the study area, but these options differ from the protection alternatives initially suggested (Table 2) that represent standard engineering designs. The concession location provides a good test of the way managed retreat could be done and a way of helping overcome inertia in implementing it. Against this option is the prevailing mood to protect tourist activities, inhabitants and infrastructure and maintain the perceived natural assets of dunes and salt marsh and maintain water quality in inland lagoons. Reluctance to retreat from the coast is not limited to local interests. The EU directives (e.g. Nature 2000) underscore the value and scarcity of natural habitats, but there is some doubt about the right strategy to protect them.

Persons interviewed indicated that managed retreat could eventually be achieved in the land south of the developed beach because the area is not urbanised; there is space to move tourist and economic activities landward; and the retreat option is likely the only solution to address erosion and avoid regular interventions to restore infrastructure frequently damaged by storms. Despite these advantages, they did not feel that retreat could be implemented now and it was important to retain existing natural and human uses and functions. They did not want to lose natural areas even if space is available for wetlands to form naturally or through restoration efforts in cultivated fields.

The concessionaire plays a key role in management because of (1) his strategic location between eroding and accreting beach segments; (2) his position between the beach and the dike that maintains Spina Lake and protects landward areas from flooding; and (3) his willingness and ability to pay for shore protection. The makeshift structures he employs are not based on formal coastal engineering design criteria and have a high potential for failure or unwanted side effects. His presence reinforces the precedent of maintaining the shore for active human use, and his actions to protect against erosion delay difficult decisions by other stakeholders about long-term management. There is only one private stakeholder who would be immediately affected by

managed retreat, but he represents a tradition that would be supported by many other concessionaires in Italy.

Even if no private owner is directly affected, loss of land perceived to have value to society as a whole can impede efforts to implement managed retreat programs (Goeldner-Gianella 2007). The general feelings at Lido di Spina are: "If it exists now, it should be protected" and "We like what we already have." These results are similar to preference studies conducted in Italy to evaluate shore protection options (Polomé et al. 2005).

The rapid rate at which the marsh, the artificial Spina Lake, the shoreline bulge at the concession and the beach at Lido di Spina south were created in the recent past introduces some interesting questions. Should such dynamic and short-term features be protected as static features in perpetuity, and should human actions be taken to protect human-created nature in a way that does not reflect natural evolutionary processes and in a location where the habitats would not exist otherwise? A stronger case could be made for maintaining human-use values on the basis of "traditional uses" if the cultural features had existed earlier than the last few decades, and a stronger case could be made for protecting endangered natural species if they occurred within their proper niche.

Allowing the region to revert to natural coastal processes will result in change in exposure to wave action and flooding, loss of existing natural habitat, and loss of economic opportunity by the concessionaire, all of which will result in demands for compensation or mitigation. The increase in exposure of shorefront structures and landforms to wave action may be perceived negatively because of the past stigma against erosion, but reworking of coastal landforms is the primary means for them to achieve equilibrium with natural processes. The compensation and mitigation for losing freshwater habitat in Spina Lake and portions of habitat in the pine forests is the restoration of saltwater wetland and pioneer coastal species. The larger Comacchio Lagoon well landward of the study area would still remain available as freshwater wetland.

Conflicts arising from debates about coastal retreat are not only related to nature versus private property and development interests but also nature versus nature. Loss of terrestrial or freshwater habitat, particularly habitat protected by environmental regulations, can be an important barrier to managed realignment (Goeldner-Gianella 2007; Rupp-Armstrong and Nicholls 2007). Attempting to protect natural areas from natural processes establishes an interesting precedent. The case can be made that human actions have accelerated erosion (e.g. by extracting water and gas, reducing sediment inputs from streams or building shore protection structures). Those actions contribute to a more dynamic coast where shore protection projects have not been implemented. The freshwater bird sanctuary and the pine forest are human artifacts. It can be argued that freshwater habitat at the coast is not coast-dependent and therefore is less critical than the habitat that would replace it. It can also be argued that the pine plantations would be replaced by a vegetation type with greater value for conservation (Doody 1989; Sturgess and Atkinson 1993).

Removal of defenses from one portion of a flood prone region to favor retreat can result in the belief that flood risk will increase in other parts of the region (Jones and Clarke 2014). Protection of human facilities (other than the concession structures) from flooding can be achieved by building a new dike landward to form a ring levee around the developed areas. In the process, the new dike can be built to be shorter and stronger. Actions in the United Kingdom and Germany have demonstrated the advantages of moving dikes landward, building them larger,

and allowing the formerly protected land to provide a buffer between the sea and the protected enclave (Nordstrom et al. 2007; Rupp-Armstrong and Nicholls 2007).

The rapid rate of retreat at the study site implies that a decision would have to be made four or five decades in the future about whether to maintain the new landward dike or allow the shoreline to continue to migrate into the campground. Rejecting the retreat option because it would force another decision later would preclude the opportunity to gain the experience provided by observing the effects of retreat now, which would make for better-informed future decisions here and elsewhere. Stakeholders are more likely to accept a management realignment project the longer it has been in the public domain (Myatt et al. 2003b), so having a viable demonstration project available in the first place is a critical issue. Rejection of the retreat option is largely based on the assumption that the functions and services provided by the existing situation are better than those that will be provided in the future. Seeing what happens under managed retreat will provide more useful information than hypothesizing unknown future values. In any case, adaptive management could be used if retreat is allowed and the benefits are not realized.

The most important concern for stakeholders can be the level of protection afforded their property (Jones and Clarke 2014). Lack of public funds to compensate stakeholders is another major impediment to implementation of managed retreat (Goeldner-Gianella 2007). Difficulties associated with these issues are minimized at the site because there is a single private stakeholder affected. The concessionaire does not own the property, which introduces the paradox of having to compensate him for leaving public land. Economic compensation could occur by allowing for expansion of the campground. Alternatively, the local government could decide not to renew the lease in 20 years without compensation.

Visitors would still use the beach if it were managed purely for nature. Willingness to pay surveys at a nearby beach (Lido di Dante, Figure 1) revealed that undeveloped (natural) areas can have a higher economic value than developed areas next to them (Polomé et al. 2005). This result was attributed to the many foreign visitors who preferred a more natural experience. Attraction of foreign visitors has a more beneficial effect on the international balance of payments than local visitors, who spend the money in the same country (Houston 2013). Visitors would not spend money at the beach if goods and services were not available there, but they would likely still spend money in the campground or Lido di Spina. The biggest economic gains may be in the savings accrued from reduced shore protection efforts.

One of the keys to acceptance of managed realignment, with its naturally functioning environments, is instilling an appreciation of nature in a visit to the beach. It is likely that many visitors to modern-day coasts (in Italy and elsewhere) are not aware of their natural environmental heritage, and it is not surprising that they would have no interest in reinstating it by allowing nature to prevail unfettered by human interventions. The overriding beach heritage value in Italy now appears to be a cultural one, which would strongly reinforce the desire to maintain beaches as flat recreation platforms. The concession is a single island of cultural use embedded in a large area of natural or semi-natural function. The campground is not necessarily associated with a primitive nature experience as campgrounds often are in other locations. At present, it is not clear to what extent a natural beach experience will be appreciated or accepted in Italy, but the current use of the beach and the expectations of Italian tourists are deterrents to acceptance of the retreat option.

6. Conclusions

Allowing natural processes to occur where humans have reduced sediment budgets and increased subsidence rates can result in more rapidly migrating shorelines characterized by more frequent overwash, fewer stable dunes and more frequent erosion and inundation of landward features. Naturally functioning areas will thus be different from the more stable natural landscapes seen in the past and the human-natural hybrids that have replaced them. Favoring managed retreat places emphasis on maintenance of the process of shoreline evolution with its changing mix of goods and services through time. Management then becomes less about human actions to protect facilities in place than human actions to accommodate access to sites that offer new opportunities. Change is not the same as loss, although it will be perceived as loss until the values of the new features are appreciated.

The benefits of managed retreat from exposed sandy shores can only be presented in conceptual terms until demonstration projects provide concrete answers. It is not surprising that the undocumented benefits of a more dynamic shoreline would have little appeal and attempts are made to maintain the existing inventory of natural and cultural features, even as many stakeholders acknowledge that this maintenance will be temporary.

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Table 1. Regional and local authorities involved in coastal management and discussions about shore protection plans at Lido di Spina.

Department/individual	Authority, interests and concerns
National level	
Forestry Commission	Manages forests in national parks: Concerned with environment, biodiversity, wetlands, migratory birds and other species.
Army	Manages military base and finances protection projects: Maintains firing range at Reno River mouth
Region of Emilia-Romagna	
Regional Council	Passes laws and finances interventions: Concerned with well-being of population, economics
Civil Protection	Conducts emergency interventions and requests financing: Concerned with emergency response plans, guidelines for local councils, procedures for hydraulic and hydro-geological risks and plans for strengthening civil protection, manages emergencies.
Coast and Land Protection Service (CLPS)	Plans and conducts interventions: Collaborates with TRBS on regional and urban planning and river basin management; programs and monitors interventions for coastal protection; prepares plans for coastal protection; prepares studies and monitoring plans.
Geological Survey (SGSS)	Collects and disseminates data and consults: Creates a support tool for ICZM, collects and organizes coastal data, evaluates coastal evolution and land use, impact of climate change and exposure to natural hazards.
Technical River Basin Service (TRBS)	Plans and conducts interventions and requests funds: Designs and implements interventions for coastal defence (dredging, nourishment); manages urgent interventions; manages public lands and resources through licences.
ARPA (environmental agency)	Plans and requests funds for interventions and forecasts storms: Concerned with hydro-geological monitoring; sea state modelling; conducts research; measure/process field data; report on coastal evolution and interventions.
Inter-Regional	
Po Delta Park	Manages projects to protect environment and biodiversity: Concerned with environmental issues, biodiversity, tourism, sustainability of human activities; mediating conflicts, scientific studies and education.
Provincial Authority	
Province of Ferrara	Addresses bathing issues: Monitors water quality, obtains funds from national government for routine beach operations.
Local authorites	
Port Authority Ravenna	Navigation, dike control: Concerned with dredging, filling and spoil disposal.
Municipalities of Comacchio and Ravenna	Develops beach plans and conducts small interventions: Concerned with managing and maintaining beach, determining number of concessions and monitor concessions. addressing flooding, road maintenance.
Individuals/ centers	
Beach concessionaires	Maintain beaches and construct facilities for beach users: Concerned with economic activity (at beach and campsites); protecting facilities and public access.
Farmers (incl. aquaculture)	Use and maintain semi-natural resources: Concerned with economic activity and use of land, protecting facilities and public access, maintaining water quality.
Scientists/researchers	Provide scientific insight: Concerned with gathering data and evaluating interventions.

Table 2. Alternative scenarios for managing erosion and hazards south of the developed beach at Lido di Spina, assuming a 25 year project. Alternatives, other than the retreat option, are synthesized from scenarios developed by the Technical River Basin Service for discussion.

Alternative	Objectives	Outcome	Major stakeholder interests and concerns
Business as usual	1. No intervention between river and the first groin at Jamaica 2. No modification to the dike	1. Natural processes prevail south of concession 2. Concessionaire continues interventions	1. No direct public monetary cost (+) 2. No interference with current coastal dynamics (+) 3. Irreversible land loss to erosion, including habitats (-) 4. Increased flood risk due to loss of dike (-)
Re-enforce Dike	1. Protect human infrastructure behind dike	1. Elevation of existing dike raised, surface armored 2. Concessionaire continues interventions	1. High public monetary cost (-) 2. No short-term interference with coastal dynamics (+) 3. Irreversible land loss seaward of dike (-) 4. Decrease flood frequency inland (+)
Soft engineering	1. Increase beach sediment budget via nourishment from opportunistic source (e.g. navigation dredging) 2. Backpass sediment 3. Build artificial dune/dike with woody debris toe protection 4. Build timber groins to retain fill	1. Position of beach maintained 2. Lost dune recreated; recreational walkway added 3. Marsh erosion reduced	1. Decrease need for mining offshore borrow areas (+) 2. Decrease flood risk due to dune (+) 3. Conversion of marsh to freshwater habitat (-) 4. Reduced nourishment cost from opportunistic source (+) 5. Dune improves aesthetics of landscape (+) 6. Increase in visitors due to aesthetics and walkways (+) 7. Ongoing maintenance to reestablish beach/dune system (-) 8. Biological impacts in borrow and fill areas (-)
Hard engineering (breakwater)	1. Construct offshore submerged breakwater from river mouth to concession 2. Small nourishment north of concession	1. Shoreline retreat rate reduced 2. Water quality problem between breakwaters and shoreline possible	1. Highest direct public monetary cost (-) 2. Interference with current coastal dynamics (-) 3. Downdrift end effects of structures (-) 4. Ongoing maintenance cost (-) 5. Reduced visual impact (+) 6. Poor circulation behind structures (-) 7. Potential settling on clay substrate (-) 8. New (invasive) habitat on breakwaters (+/-)
Hard engineering (seawall)	1. Stabilize the shoreline 2. Build discontinuous seawall (clay core, geotextile/ vegetated cover, armor stone seaward); dredge flow channels through marsh and seawall	1. Potential loss of beach 2. Shoreline retreat prevented 3. Land loss inland prevented 4. Flood risk reduced or prevented 5. Structure has long life span	1. Lowest direct public monetary cost (+) 2. Loss of beach and dune and their habitat (-) 3. Interference with current coastal dynamics (-) 4. Alteration of marsh (-) 5. No recreational value of the area (-)

Figure captions

Figure 1. Study area.

Figure 2. Shore characteristics at Lido di Spina from Google Earth images (August 2010, March 2011). The Comacchio Lagoon is off the image to the west.

Figure 3. Concession at Lido di Spina, looking south in June 2014, showing unreworked fill at right and shore protection structures at left. The buildings are in the background behind the beach umbrellas and chairs.

Figure 4. The shore in the Po Delta Park 1 km south of the concession in Figure 3, looking north.

Figure 5. Shoreline locations between the Reno River and Lido di Spina. The 1893 shoreline was determined from a topographic chart issued by the Italian National Military Geographic Institute at a scale of 1:25,000, geo-referenced using a 1978 technical regional chart. Photo interpretation scale for the other shorelines is 1:5000.

Figure 6. Rate of shoreline change in study area between 2006 and 2012, revealing the significance of the concession location between the eroding and accreting segments. Data were obtained from topographic profiles by the Region of Emilia-Romagna (e.g. Figure 7).

Figure 7. Topographic profiles drawn from 2006 and 2012 data obtained by the Region of Emilia-Romagna. Locations are indicated in Figure 2. Zero is Genoa mean sea level, the national datum standard in Italy.

Fig. 1

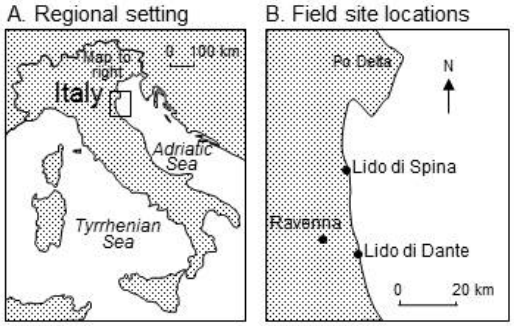

Fig. 5

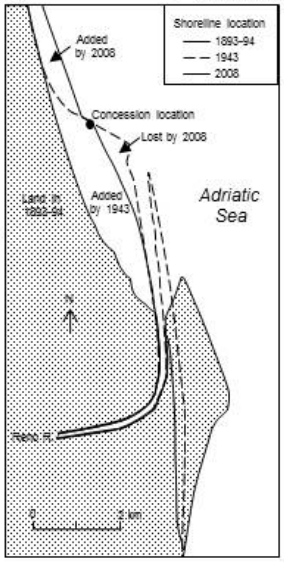

Fig. 2

Fig. 3

Fig. 4

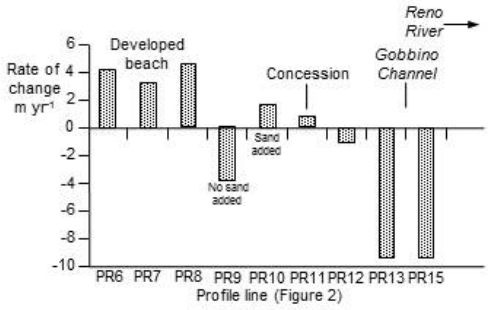
Reno
River
Developed
beach
Concession
Gobbino
Channel
Rate of
change
m yr⁻¹
6
4
2
0
-2
-4
-6
-8
-10
Sand
added
No sand
added
PR6 PR7 PR8 PR9 PR10 PR11 PR12 PR13 PR15
Profile line (Figure 2)

Fig. 6

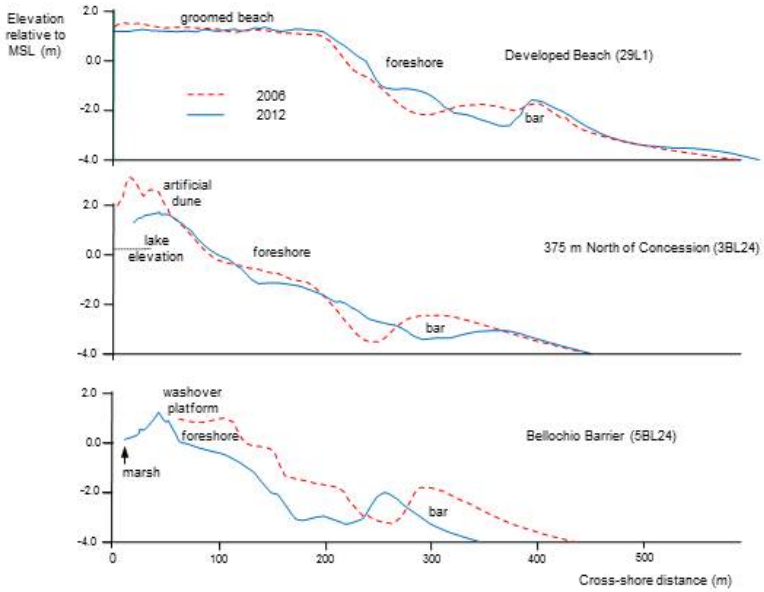
Elevation
relative to
MSL (m)
groomed beach
foreshore
Developed Beach (29L1)
2006
2012
bar
artificial
dune
lake
elevation
foreshore
375 m North of Concession (3BL24)
bar
washover
platform
foreshore
Bellochio Barrier (5BL24)
marsh
bar
2.0
0.0
-2.0
-4.0
0
100
200
300
400
500
Cross-shore distance (m)

Fig. 7