Beneficial Reuse and Morphological Restoration

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Introduction:
Sediments are a fundamental resource in coastal areas, especially in systems affected by sea level rise and erosion.
Wind, wave and tide driven sediments can settle and be stabilized by vegetation and other organisms creating a variety of structuring and self-preserving valuable habitats such as: beaches, dunes, salt marshes, eel-grass prairies, inter-tidal flats. At the same time the new structures can improve hydro-morphological processes and local conditions in terms of complexity, biodiversity and resilience.
But when these so called *Confined Ontic Open Systems*, COOS, are affected by lack of sediment supply or confinement they are irreversibly demolished and their sediments washed away by erosion[1],[2],[3].
The possibility of creating hydro-morphological and biological COOS using sediments from maintenance dredging is presented and discussed on the bases of the works conducted in the Venice Lagoon along the last 22 years.

Fig. 1: Natural salt marshes *above* and artificial *below*.

Methods:
The main line of action for the Venice Lagoon Morphological Restoration has been the reuse of sediments from maintenance dredging for creating intertidal salt marsh habitat through the activation of naturalization processes of the sediment fill.
Along the last 22 years 14 million m^3 have been reused building 94 salt marsh fill units and their evolution have been monitored for documenting their evolution and also for managing and deciding ri-naturalization measures (such as sediment recharge or removal for improving top soil elevation, dredging of internal tidal creeks and ponds for reducing confinement).
Other techniques, such as jet-spraying over subsiding salt marshes and sediment fences at the edge, have been adopted for restoring the natural salt marshes.

Results:
When the specific volume and the degree of confinement of the fill unit (the new morphological structure) is adequate, its surface will adapt to a dynamically stable elevation (around mean high tide) with an accretion rate sufficient to compensate the local sea level rise with the available tidal transport of suspended sediments.
Habitat conditions similar to natural salt marshes (in terms of halophytic vegetation structure, and number of endangered nesting bird species) are reached and maintained in a period of about 5-10 years and five different evolution stages can be distinguished.

Fig. 2: Detregani (Venice) sediment fill after one year, *on the left*, and ten years, *on the right.*

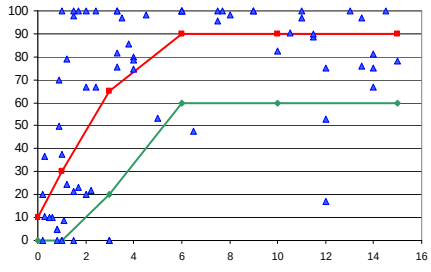

Fig. 3: Halophytic vegetation cover *(% of total surface)* in 70 sediment fills of different ages *(years)*: points below the green line are units that need re-fill or removal of sediments, points above the red line are well naturalized units.

Discussion:

The restoration of salt marshes with partially confined sediment fills, reusing sediments from maintenance dredging, has proven to be a simple and effective measure, based on the progressive exposure of sediments to tidal flow, during the top soil settlement.
External confinements and wave protections, made of wood or stone and geo-textile, has to be reduced in elevation to the mean high tide and, after soil stabilization; the confinement can be completely removed from the borders not impacted by wind and motor boat waves.
To complete the lagoon restoration it is necessary to continue to install artificial structures, made of dredged sediments or sand from borrow areas at sea, in selected places: the cluster of these self-preserving structures is essentially a wider scale COOS, a new habitat that can protect tidal flats and artificial channels intercepting and dissipating waves energy, guiding and confining tidal flow, reducing remobilization of polluted sediment and harbour siltation.

References:

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