Can Strategies for Habitat Restoration and Sediment Management Coexist in the Face of Global Climate Change?

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Introduction and Background: The evolution of continental coastlines and ocean islands throughout the world was driven by millennia of changing global climate and by shifting land elevations and positions due to geologic activity. These changes affected sediment mobilization, deposition, and erosion, and largely defined the geomorphology of the world's river basins, coastal sand dunes, estuaries and coral reefs. Sediment sinks occur where coastal geometry reduces tidal and wave energies, appearing and disappearing behind protective structures such as reef outcrops, in estuaries and embayments, on shallow-sloping coastlines or in deeper water below the turbulence caused by major storms. In the modern era, the effects of human activities have begun to challenge natural forces for supremacy. Sediment processes have been interrupted by the damming and redirection of rivers, "land claim" such as coastal developments, managed ports and harbors, erosion control structures, and other infrastructures. These man-made infrastructures and their management requirements have wrought both intended and unintended profound changes in geomorphology and hydrodynamics. These alterations have created conditions requiring Sisyphean levels of dredging and management to maintain "desirable" socioeconomic conditions, and significantly altered habitats, and thus the structure and functioning of affected ecosystems.

Increasingly, however, coastal managers (and ecosystems) must adapt not only to these localised dynamic issues, but also to global anthropogenic changes, driving climate change, ocean warming, sea level rise, ocean acidification, eutrophication, invasive species and habitat loss. Coastlines, islands and ecosystems will naturally realign in response to these changes, so it is reasonable to conclude that the long-term costs of maintenance dredging and shoreline preservation and defense construction projects will increase. The same concerns apply to the restoration of damaged habitat or construction of new ecological habitat for mitigation or offset of coastal infrastructure projects. The ecological goals for such work (e.g., supporting native vegetation, or encouraging repopulation of indigenous fishes and coral reef ecosystems) may not be achievable or sustainable in the face of rapid human-induced climate change and the dramatic changes in sea level anticipated within the next century. For example, in some regions, it is possible that the pace of climate change may already make the concept of restoration moot; that is, it may not be possible to overcome the forces of sea level rise, increasing sea surface temperatures, and ocean acidification to preserve, protect, or restore certain coral systems. Faced with the possibilities of rapid changes in erosional or depositional forces, the fate of sediment in, for example, estuaries, is of critical concern because it represents the foundation for long-term, stable functioning of aquatic ecosystems. When, as is the case for the Water Framework Directive, regulatory requirements are focused on the restoration of "baseline" conditions defined by morphological and ecosystem structures that may no longer be viable in a changing climate, failure is likely.

Discussion: If morphological and ecosystem structural changes are inevitable, it is essential to ensure that we do all we can to maintain and enhance essential functions whilst allowing for the continuing utilisation of coastal systems. Over the next century, the profound influence of ever more intense human activities on natural processes begs the question: can management strategies for natural and man-made aquatic habitat and protection of coastal infrastructure (e.g., commercial ports, utility infrastructure, and transportation routes) coexist with the threat posed by sea level rise and changes in sedimentation? Are we investing valuable time and effort on projects for which the outcomes are not achievable or sustainable?

Policy and management interventions must be guided by a sound understanding of how systems may respond to reversible and irreversible natural and anthropogenic change, singly and in combination; where knowledge is uncertain, approaches should be flexible and adaptive. Yet, few restoration and management strategies reviewed considered the possible consequences of global climate change. This paper briefly summarizes our current understanding of climate change forces, including sea level rise, and locations around the world where these forces are expected to pose the greatest challenge. Examples of coastal and island projects that may be in jeopardy of achieving their goals will be discussed. We offer strategies for engineers and scientists to consider when, inevitably, responding to the challenges.