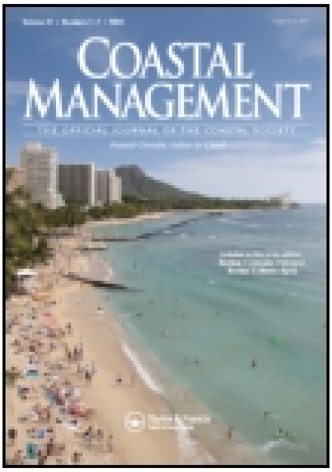

Coastal Management
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ucmg20

Clean Water Act Section 404 and Coastal Marsh Sustainability

Beth Ravit[a] & Judith S. Weis[b]
[a] Center for Urban Environmental Sustainability (CUES), Department of Environmental Sciences, School of Environmental & Biological Sciences, Rutgers University, New Brunswick, New Jersey, USA
[b] Department of Biological Sciences, Rutgers University, Newark, New Jersey, USA
Published online: 05 Sep 2014.

To cite this article: Beth Ravit & Judith S. Weis (2014) Clean Water Act Section 404 and Coastal Marsh Sustainability, Coastal Management, 42:5, 464-477, DOI: 10.1080/08920753.2014.942027

To link to this article: http://dx.doi.org/10.1080/08920753.2014.942027

Coastal Management, 42:464–477, 2014

ISSN: 0892-0753 print / 1521-0421 online
DOI: 10.1080/08920753.2014.942027

Taylor & Francis
Taylor & Francis Group

Clean Water Act Section 404 and Coastal Marsh Sustainability

BETH RAVIT[1] AND JUDITH S. WEIS[2]

[1]Center for Urban Environmental Sustainability (CUES), Department of Environmental Sciences, School of Environmental & Biological Sciences, Rutgers University, New Brunswick, New Jersey, USA
[2]Department of Biological Sciences, Rutgers University, Newark, New Jersey, USA

The "no net wetland loss" goal has not been met in urban coastal regions where conditions continue to exacerbate wetland losses. Under the Clean Water Act (Section 404) the U.S. Army Corps of Engineers and U. S. Environmental Protection Agency share responsibility for regulating placement of fill material in wetlands. The 'no discharge of fill' rules threaten coastal wetlands with continuing losses due to effects of changing climate, including rising sea levels, higher storm surges, and flooding. Where inland migration is limited by development, or where sediment accretion rates are lower than the rate of sea level rise, urban wetlands will be lost unless marsh topography is elevated. We explored regulatory and design approaches in recent Hudson-Raritan Estuary (HRE), San Francisco Bay Estuary and coastal Louisiana restorations, including creation of new marshland using dredge material. Questions related to sea level rise, ecological position within the landscape, or potential effects of extreme storm events were not addressed in the HRE restoration designs; these concerns were taken into account in other regions. We suggest benefits of marsh 'replenishment' should be acknowledged in Federal regulatory policy and that consistent policies supportive of low-lying coastal marsh preservation in all regions should be enacted.

Keywords climate change, coastal wetland, Clean Water Act, restoration, sea-level rise, Section 404, tidal marsh, urban

Introduction

Loss of wetlands in the contiguous 48 states is well documented; intertidal estuarine wetlands suffered an increase in losses in the 2004–2009 Department of Interior Survey time period compared to losses between 1998–2004 (Dahl 2011). Salt marsh stability is the result of an intricate balance between hydrology, vegetation, and sediment loadings and these continuing losses are the result of both environmental and anthropogenic pressures on coastal marsh systems.

Address correspondence to Beth Ravit, Center for Urban Environmental Sustainability (CUES), Department of Environmental Sciences, School of Environmental & Biological Sciences, Rutgers University, 14 College Farm Road, New Brunswick, NJ 08901, USA. E-mail: ravit@envsci.rutgers.edu

Environmental factors contributing to the loss of coastal wetlands include flooding, herbivory, and excess nutrient loadings. Peat collapse due to marsh plant death after flooding can decrease topographic elevations, converting vegetated marsh into open water (DeLaune, Nyman, and Patrick 1994). "Marsh dieback" can result from herbivory by mud crabs (*Sesarma reticulatum*) released from predation due to overharvesting of crab-eating fishes (Holdredge, Bertness, and Altieri 2009). Deegan et al. (2012) found that excessive nutrients—common in northeastern urban estuaries due to older combined sewer overflow (CSO) system discharges and fertilizer runoff—can cause salt marsh loss. Experimental nutrient-enriched streams grew taller marsh grasses that produced fewer roots and rhizomes that normally help stabilize marsh creek edges, leading to the collapse of creek banks and conversion of salt marsh into lower elevation mudflat. High nutrients also increased microbial decomposition of plant material, further destabilizing creek banks. Modeling of mid-Atlantic marshes suggests that in enclosed basins tidal flat widths affect marsh loss. Waves generated in tidal flats increased erosion of the flats' bed, which increased erosion of the marsh, widening the tidal flats, and further increasing wave energy (Mariotti and Fagherazzi 2013). This positive feedback loop appears to be exacerbated by "sediment starvation" caused by dredging and damming, common activities in urban estuaries. In addition to environmental stressors, land use activities are a major factor in the loss of urban marshes. Since colonial times coastal wetlands were drained for crop production and filled for housing, transportation, industrialization, and landfills. Achieving the goal of "no net wetland loss" articulated by President George H. W. Bush has been a difficult task (Beck 1994; Hough and Robertson 2009), particularly in urban coastal regions where combined development pressures and environmental conditions contribute to wetland loss (Bies 2006; Lotze et al. 2006).

In an effort to stop losses caused by filling of wetlands, the Clean Water Act (CWA), Section 404 a, b gave joint responsibility for regulating placement of fill material in wetlands and open waters of the coastal zone to the U.S. Army Corps of Engineers (USACE) and the U. S. Environmental Protection Agency (USEPA) (Federal Register 2002; Ruhl and Gregg 2001). The CWA prohibits *discharge of materials*, including soil or sand, into wetlands and open waters unless authorized by a permit issued under Section 404 (NRC 2001). Prohibiting discharges of fill material has been an important regulatory tool since the 1990s (Hough and Robertson 2009), and coastal restoration projects are often the result of permit-required mitigation compensation for wetland impacts as required by Section 404. It is important to note that the purpose of Section 404 was not to specifically protect wetlands; rather the goal was to regulate the discharge of fill materials into wetlands (Swords 1992), which is an important distinction. Despite the benefits provided by the "no discharge" prohibition, there is one significant wetland category that is threatened by adherence to these regulations—low-lying coastal wetlands and proposed coastal wetland restorations that are likely to be subject to the effects of rising sea levels, higher storm surges, and flooding (CCSP 2009; Craft et al. 2009; Fischman 1991; Jones, Bosch, and Strange 2009; Nicholls and Cazenave 2010; Törnqvist and Meffert 2008).

Coastal marsh sustainability is determined by three factors (Figure 1): (1) ability of marsh surface elevations to rise at a rate comparable to SLR; (2) rate of marsh seaward boundary erosion; and (3) space for marsh migration landward (Jones, Bosch, and Strange 2009; Tol, Klein, and Nicholls 2008). To preserve wetlands, legal scholars have described steps that might be taken to facilitate inland migration of wetlands (Flischman 1991; Sax 1990). In highly developed urban estuaries where landward migration is precluded by extensive development the limited options available that would support survival of coastal wetlands include engineering to keep rising waters out (Nicholls 2003), a controversial

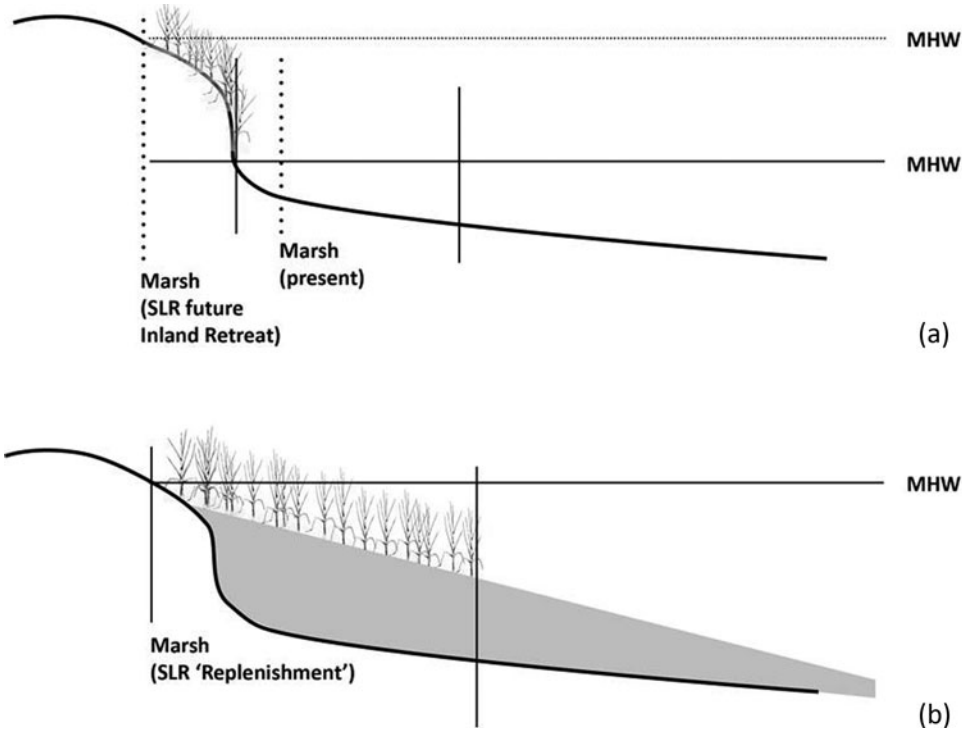

Figure 1. Schematic representation of marsh response to sea-level rise (SLR): (a) unblocked inland retreat or drowning and (b) "replenishment" of marsh through addition of new substrate.

option in the case of NY/NJ harbor (Coch 2012; Hill 2012) or extending marshes into existing mudflats and/or open waters through placement of new substrate (Weinstein and Weishar 2002). However, under Section 404 regulations, placement of new substrate in wetlands or open waters would require mitigation for wetland fill.

Therefore, the current Section 404 regulations create an interesting conundrum because successful urban coastal marsh restorations may require the addition of material to elevate marsh surfaces. There are different restoration techniques that involve the reconfiguration of the surface substrate:

1. **Reestablishment of tidal hydrodynamics.** Tidal restrictions due to dikes, levees, and other water-control structures lead to a reduction in porewater salinity and lowering of the water table. Breaching of dikes and modifications to tide gates or other water control structures in order to reestablish tidal flushing regimes has resulted in the reestablishment of native salt marsh vegetation at many restoration sites. This type of restoration does not necessarily involve physical alteration of surface elevations, except in areas where tidal creeks are restored. However, historic dewatering of a site often contributes to subsidence that can lower marsh surface elevations to heights that will only support open mud flats (Yuill, Lavoie, and Reed 2009).

2. **Restoration through eradication of invasive plants (*Phragmites*) and revegetation with native plant species (*Spartina alterniflora*).** Invasive plants can be eradicated using herbicides, burning, and manual harvesting. These techniques are expensive and difficult to implement, and in the case of herbicide application, multiple applications over several growing seasons may be necessary. In addition, some invasives (*Phragmites*) increase marsh surface elevation (Rooth and Stevenson 2000), and so the restoration process may also involve mechanical lowering of the marsh surface by physically removing the top foot or more of marsh and plant material prior to planting of *Spartina*.
3. **Island enlargement**. Placement of fill or dredged material (beneficial reuse), followed by planting of marsh grasses can restore marshes that have disappeared due to "drowning" as a result of subsidence of the marsh surface and/or rising sea levels.

"Replenishment" has been an acceptable response for beaches and sand dunes lost due to storm surges and rising sea levels (Finkl 1996; Slott, Murray, and Ashton 2010; Stive, Nicholls, and Devriend 1991), although this policy is not without controversy (Hoagland, Jin, and Kite-Powell 2012; Speybroeck et al. 2006) due to the cost and need for continual addition of new substrate. In order to forestall loss of coastal marshes should "replenishment" of salt marshes be considered as well? Should five decades of wetland no fill policy be revisited to consider requiring placement of fill material in open marshes or open waters if a coastline is at risk? To probe these questions we examined three recent urban marsh restorations in the Hudson-Raritan Estuary (HRE), restoration practices in San Francisco Bay Estuary and coastal Louisiana.

Hudson-Raritan Estuary (HRE) Restorations

Evidence is accumulating (Miller et al. 2013; Williams 2013) that suggests the northeastern U.S. coastline is especially vulnerable to sea-level rise (Gornitz, Couch, and Hartig 2002; Kirshen et al. 2007; Sallenger, Doran, and Howd 2012; Zervas 2009). Exacerbated by local temperatures projected to increase 1.5–3.5°F (winter) and 2.5–4°F (summer), northeastern U.S. sea-level rise (SLR) is predicted to be greater than projected global averages, threatening long-term sustainability of the region's coastline and with the subsequent loss of existing estuarine wetlands (CCSP 2009; Gornitz, Couch, and Hartig 2002; Karl, Melillo, and Peterson 2009; Miller et al. 2013; Strauss et al. 2012). The HRE's urban wetlands are not accreting new sediment fast enough to match rising seas (Gornitz, Couch, and Hartig 2002; Kirshen et al. 2007; Nicholls and Cazenave 2010; Scavia et al. 2002; Stammermann and Piasecki 2012; Yin, Schlesinger, and Stouffer 2009) and the density of regional development precludes significant landward migration (Kennish 2001).

Three HRE restoration projects (for detailed site history and descriptions see Ravit, Weis, and Rounds, in press) illustrate the three types of restoration activities described above. These restorations were completed between 2010–2012 prior to the SuperStorm Sandy storm surge event: Jamaica Bay, NY marsh island restorations (JB); Jersey City, NJ Lincoln Park West marsh (LP); and the Kane Wetland Mitigation Bank in the NJ Meadowlands District (KWMB). Although the restoration sites and project objectives differed substantially, all three projects dealt with creation of low marsh topography and replanting of native low marsh *Spartina alterniflora*; the two NJ projects included reestablishment of tidal hydrodynamics and removal of invasive *Phragmites australis*.

Were the HRE restorations "successful"? We suggest the answer to this depends on the definition of "success" and timeframe, as well as the accuracy of predicted changes in local coastal hydrology. Until fairly recently it has been common to judge U.S. salt marsh restoration "success" using habitat structural targets (vegetation cover, biotic community composition often compared to an undisturbed reference site), rather than shoreline protection features, sedimentation versus SLR, or erosion targets (Kirwan & Megonigal 2013; Pethick 2002), and this is the case with the three HRE projects. We found no evidence that projected SLR, more frequent extreme storm events or surges, marsh positioning with the larger landscape, or projected rates of sediment deposition were factors taken into account in the design or evaluation of these three restorations. It appears that financial considerations, the desire for low marsh habitat drove restoration design decisions at these three HRE sites.

At the completion of construction it is premature to conclude what the long-term ecological trajectory of the HRE restorations will be, since development of mature salt marshes requires multiple decades (Morgan and Short 2002; Neckles et al. 2002; Warren et al. 2002; Williams and Orr 2002; Williams, Orr, and Garrity 2002; Zedler and Callaway 1999). There are no monitoring plans and/or requirements to evaluate the long-term sediment accretion rates or the ability of these restorations to keep pace with local SLR. However, after initial placement of dredge material on the JB marsh islands subsidence rates of 50% were observed, requiring additional dredge material to achieve low marsh elevations (L. Baron, USACE, personal communication).

Of the three projects, it appears that LP most closely met project short-term targets established to determine restoration "success," including cover of low marsh *Spartina alterniflora*. The KWMB has a 20-year active management and long-term monitoring permit requirement due to the novel use of a 7,000-m Hessko-concertina berm around the marsh perimeter (Mazzei 2010), selected because the footprint of a more typical earthen berm would have reduced the number of mitigation banking credits for sale (R. Mogensen, former EarthMark Project Manager, personal communication). At the time of this writing, monitoring requirements had not yet been established for all of the JB restoration initiatives (D. Riepe, American Littoral Society, personal communication).

The KWMB suffered significant damage from SuperStorm Sandy, which required dewatering of the site, replanting, and repairs to the damaged berm. LP and JB marsh islands appear to have escaped damage associated with Sandy (LBG 2012 and USACE 2013d, respectively). However, invasive *Phragmites* was expanding in high marsh areas of LP and erosion of sand from the adjacent golf course was occurring (LBG 2012); premature removal of protective fencing in March, 2103 to meet a required project end date may have contributed to significant marsh loss when young *Spartina* plants were grazed and uprooted by geese (C. Alderson, NOAA, personal communication).

The topography of the three sites was graded predominately for low marsh, mudflats, or open water. Dredge material brought onto JB marsh islands and LP sites was not utilized to create a high marsh buffer, and none of the designs or permit requirements included high marsh that would allow migration upward by low marsh in response to SLR. When higher elevation scrub-shrub vegetation was planted at LP, survival and coverage did not meet restoration targets, which is common when trying to engineer elevations and hydrology for high marsh vegetation (NRC 2001). At KWMB the option of bringing in additional material to raise marsh elevations acknowledged to be too low even for low marsh, as well as to fill the berm gabions, was rejected; the original restoration design was modified through the addition of channels, expansion and deepening of surface waters to produce more fill from material excavated onsite.

Restoration Approaches in Other Regions

While the three HRE salt marsh restoration projects did not take SLR into consideration, this is not the case in all regions of the United States. At the national level NOAA held a workshop for the northeastern region in 2010, and the Workshop Report (NOAA 2011) states "sea level rise in particular poses new threats that need to be incorporated into restoration planning." This workshop developed guidance on incorporating SLR into site-specific restoration plans using background information that includes: tidal elevations, site elevation/surface topography, bathymetry, habitat/vegetation zones, barriers to inland migration, the rate of wetland accretion, freshwater inflows, water velocities and depths, suspended sediment concentrations, and potential flooding from storm events. NOAA recommended that at a minimum, projects plan for the current SLR rate (designated the "low" scenario); however, the "medium" and "high" SLR rates should also be considered and the risks assessed for each design alternative. To allow for inland migration of the restored marsh, projects should include a transition/buffer zone that incorporates gradual slopes and barriers to migration should be removed where possible. We note that although NOAA does have an advisory role to the USACE for Section 404 permits, the USACE has final authority regarding coastal wetland permit applications and permit requirements (MOA 1992).

San Francisco Bay (USACE South Pacific Division; USEPA Region 9)

In California, practioners involved in marsh restoration in San Francisco Bay (SFB) Estuary are taking rising sea levels into account and urging an adaptive management approach (Calloway et al. 2007). Orr, Crooks, and Williams (2003) investigated the sustainability of SFB marshes and found that vertical accretion models suggest marshes in San Pablo Bay will be sustainable under moderate SLR (3–5 mm yr^{-1}) with average sediment supply (c. 100 mg L^{-1}). The Bay Institute proposes use of a "horizontal levee" that would incorporate a brackish marsh at the landward edge of a tidal marsh restoration design. As marsh plant root systems expand, the brackish marsh would accrete and accelerate vertical growth of the marsh plain, allowing it to keep pace with SLR (brackish, back-marsh networks existed naturally as part of shoreline wetland ecosystems, but have been destroyed to make way for development). In order to build the "horizontal levee" sediment dredged from flood control channels would be beneficially reused and recycled wastewater from water treatment plants would be used for irrigation.

Louisiana (USACE Mississippi Valley Division; USEPA Region 6)

Another section of the country concerned about SLR and marsh restoration is the Gulf Coast, where a chronic deficiency of Mississippi River sediment, subsidence, and SLR are contributing to severe marsh losses. Coastal marsh restoration projects are abundant in Louisiana, which has lost 1,883 mi sq^2 of wetlands over the last 80 years, and where $17.9 billion will be spent on marsh creation (Reed and Wilson 2004). In 1998, after extensive studies and evaluation of a number of Louisiana coastal restoration projects it was determined that local individual restorations could not restore wetlands already replaced by open water, and an ecosystem scale approach to restoration was needed. The State of Louisiana and the Federal Agencies adopted a new coastal restoration plan, "Coast 2050: Toward a Sustainable Coastal Louisiana." The underlying principles of the plan are to mimic and restore the natural processes that built and maintained Louisiana's coast. This approach necessitates basin-scale activities to restore more natural hydrology, as well as sediment introduction. The plan proposes ecosystem restoration strategies that would result in efforts greater in scale than any previously attempted. The Coast 2050 plan has as its first goal achieving vertical marsh accumulation.

To meet this goal the restoration will use sediment and water from the Mississippi and Atchafalaya Rivers to maintain and rebuild elevations that will include cypress swamps, marshes, and barrier islands. Pumped sediment diversions (up to 250,000 ft^3 sec^{-1} during high-river events) and pumped dredged sediments will be employed to rapidly build wetlands that would be maintained through sediment diversions. Although questions have been raised about deleterious effects of these diversions and high nutrient concentrations in diverted waters, the balance of evidence indicates that additional nutrients could benefit plant production and the diversions could be effective in restoring wetlands if designed to maximize sediment inputs (Morris, Shaffer, and Nyman 2013).

Beneficial Reuse of Dredge Material

There are precedents for placing fill material in wetlands to counter subsidence and SLR and to enhance native vegetation (Edwards and Proffitt 2003; Ford, Cahoon, and Lynch 1999; Slocum, Mendelssohn, and Kuhn 2005). Spraying a thin layer of dredged sand (23 mm) onto a subsiding *Spartina alterniflora* marsh and shallow pond resulted in a three-fold increase in vegetation and rhizome growth into the pond area. There are other examples of beneficially reusing dredge material to preserve coastal wetlands in California (Coastal Conservancy 2012; LTMS 2012); Texas (USACE Galveston District 2012); and Louisiana (USACE 2010), and a number of other beneficial reuse projects have been completed by the USACE in fourteen additional states (Costa-Pierce and Weinstein 2002).

There is evidence that marshes constructed with dredged materials may not be as biologically diverse as naturally occurring marshes and that their ecological functionalities differ. In a beneficial reuse similar to the Jamaica Bay project, over 2 million m^3 of dredged material was used as fill for Louisiana barrier marsh island restorations (Fearnley 2008). Soil bulk density, moisture content, total soil carbon and percentage of nitrogen were all lower in restored marshes than in a natural marsh reference site, while pH was much higher (8.33 versus 6.41) than in the natural marsh (Fearnley 2008 and references therein).

Streever (2000) reviewed many studies and concluded that mean values for aboveground and belowground biomass, sediment organic carbon, polychaete and crustacean densities may differ in dredged material versus natural marshes. It is clear that restored marshes provide habitat for birds, but limited data suggest that dredged material marshes may support a less diverse community of birds than natural marshes (Melvin and Webb 1998), although Armitage et al. (2007) found similar avian populations in restored and reference sites. Even though dredged material marshes may not be exactly equivalent to natural marshes, they are clearly preferable to marshes that are so low they are in danger of being submerged.

Reuse of dredged material is driven by the need to find cost effective means for the USACE to keep America's waterways navigable (USACE 2010), although energy-intensive pumping of dredged sediments for coastal restoration will likely become more expensive in the future (Day et al. 2005). Federal law authorizes the beneficial use of dredged material for habitat development (Yozzo, Wilber, and Will 2004), and this may result in expanding existing marshes and/or increasing marsh elevations. The State of New Jersey specifically "discourages" filling in open water areas and "filling wetlands areas is prohibited" (NJDEP 1997), although dredge materials generated by the NY/NJ Harbor Deepening Project were used in LP, the first NJ wetland restoration to permit beneficial reuse of dredged material, a positive step. However, the Federal mandate is driven by the need to dredge, rather than the need to preserve coastal marshes. When a dredging project is completed, the source of new substrate is gone, although dredging of navigation channels will likely continue to generate materials for beneficial reuse.

A Marsh "Replenishment" Approach

Given the existing uncertainties of climate-related coastline and hydrologic changes, longer time frames for restoration monitoring, *in situ* adjustments in response to changing and/or unpredicted conditions, and a greater emphasis on placement within a landscape setting are needed. Federal and state regulations (NOAA 2000) governing beach replenishment are in place and NOAA has recommended that SLR be considered when designing tidal wetland restorations (NOAA 2011). Therefore, we propose that the USEPA and USACE remove coastal wetland restoration projects from Sect 404 regulations and develop Federal guidelines that would support permitting of wetland "replenishment" with appropriate fill material when urban coastal wetlands are threatened by environmental factors or when urban coastal wetlands are being created/restored. Such guidelines would need to address complex issues, such as what constitutes acceptable fill material(s) and material sources for a specific site; allowable concentrations of contaminants given existing local background contaminant levels; restoration site and/or substrate procurement environmental impacts; project integration with existing Coastal Management Plans; cost and cost sharing; plus other regulatory issues.

The overall hydrology of natural marshes is determined by a balance between tidal amplitude, elevation, surface and ground water interactions, macropore structure, and hydraulic conductivity (Nuttle and Hemond 1988). These interactions are affected by distance from creek banks, and so marsh interior hydrology can differ significantly from creek bank hydrology (Montalto, Steenhuis, and Parlange 2006). Regardless of the type of coastal wetland project (preservation, creation, restoration, mitigation bank) we suggest the following be considered as Federal permitting requirements:

1. ***Hydrology***. A wetland restoration plan should include a model that analyzes the interaction of local relative SLR, based on consensus scientific predictions at the time of permitting, and site hydrology over an extended time period (minimum 30 years). The model should include a predicted site hydrologic trajectory as a basis for monitoring and hydrologic adaptive management over time if the model proves to be inaccurate.
2. ***Topography.*** To sustain hydrologic patterns means taking into account potential rise in sea level, rates of future sediment deposition, and potential subsidence of any fill material(s); grain size and the proportion of clay to sand ratio in dredge material will affect drainage and compressibility of fill substrates. Topographic designs should reflect elevations required for the site to be sustainable over the 30-year time frame should the modeled SLR occur. A sediment source evaluation, which contains calculations of future sediment deposition to the restoration site, should be included in the model. A high marsh buffer placed within the overall landscape context that could convert to low marsh should SLR meet or exceed the model projection should be part of the overall restoration design. Requirements that

site elevations are maintained over the modeled time frame should be included in all permits in addition to vegetation structure monitoring.

3. ***Legal/Regulatory***. Changes should be made in the types of mitigation projects/sites allowed. Stop permitting projects that LOWER marsh surfaces, even if they remove invasive *Phragmites* in the short term. If offsite material is required to reach needed elevations for restored high and low marsh, a Section 404 permit requirement to provide mitigation for wetland "fill activities" ***should not be triggered***. There is also the need to define the level of "clean" required for offsite fill materials, especially in urban environments where sediments often contain high background concentrations of historic contamination. A rigorous Public Comment process should be employed that will allow regulators to determine whether fill material is necessary and appropriate for a specific site.
4. ***Long-Term Monitoring and Funding.*** Permit requirements and a funding mechanism for monitoring, maintenance, and repairs beyond the commonly permitting five year period are needed. Monies could be required to be held in escrow or a long-term bond issued to ensure the sustainability of a restored marsh and cover the costs of necessary repairs or maintenance to keep pace with SLR. We also propose that public projects not be required to automatically select the low cost bid, but should have the option of taking into account construction costs that may be higher in the short term due to importation of offsite material that would enhance greater future sustainability.

We acknowledge that encouraging placement of fill material in marshes could create unanticipated consequences, including further loss of wetland habitat if inappropriate fill activity is permitted. We also acknowledge that there are many documented instances in the NY/NJ region where fill material was employed without adequate oversight (for examples and details see Encap Project n.d.; Overpeck Project n.d.). Bringing in offsite material requires significantly more monitoring and testing to ensure that the material is clean. It is also problematic that there is no universally agreed standard with respect to future sea level or tidal surge elevations and it is unknown how important a factor SLR is in the sustainability of a specific site.

Conclusions

Without a consistent Federal regulatory policy that requires accounting for projected SLR when designing coastal wetlands, the decision to build at low elevations (low marsh, mudflats, open water) can be made on a case by case basis for financial reasons, size constraints, the challenges of successfully engineering more complex high marsh hydrology/topography, or arbitrary habitat preferences. We note that USACE does have the authority to approve permits allowing fill materials to be placed in wetlands. However, use of this authority does not appear to be consistent among USACE Divisions/USEPA Districts and granting such approvals without requiring compensatory mitigation could be politically sensitive without updating current Federal wetland policy. We also note that the USACE has issued two guidance documents (2009, 2011) related to SLR. This guidance included three probability curves (high, intermediate, and low) that SLR will occur at a certain rate (G. Woolley, USACE, personal communication). USACE will be incorporating greater ratios of high marsh into their future designs to increase marsh migration potential, which has not previously been considered to any great extent (G. Woolley, personal communication). However, as long as coastal wetland restorations are regulated under Sect

404 decisions will be made with respect to "placement of fill" rather than with respect to "marsh nourishment."

Wetland restoration is an Art on its way to becoming a Science (NRC 2001). Each restoration project is unique and restoration practioners can "only learn by doing" (C. Alderson, NOAA, personal communication). While researchers continue to study the trajectory and functions of restored marshes, environmental stressors and a changing climate are subjecting low lying coastal marshes to inundation and erosion, resulting in continuing wetland losses. Without the ability to migrate inland or accrete new sediments, urban coastal acreage will be lost unless adaptive planning policies and regulations designed to increase marsh surface elevations are implemented. Restoration professionals and regulators are now acknowledging that SLR is occurring and will affect long-term coastal marsh sustainability, and this knowledge needs to be consistently integrated into regulatory permits. Federal permitting decisions need to take into account broader geographic areas, expanded time frames, and projected effects of a changing climate. Data suggest that dredged material marshes can provide some of the functions of natural marshes, but probably do not replace all of the functions of lost natural marshes. However, in spite of these concerns, if there is stringent oversight from regulatory agencies and a transparent public comment process, use of "replenishment" to preserve coastal wetlands can be regulated. A "design build" restoration approach would allow changes to elevations and hydrology based on site conditions discovered during construction. In short, we believe the prohibition against fill in wetlands and open water should be changed using *purpose dependent* regulatory guidelines—follow CWA fill regulations to prevent further development, but support "replenishment" where coastal marshes are drowning or eroding.

References

Armitage, A. R., S. M. Jensen, J. E. Yoon, and R. F. Ambrose. 2007. Wintering shorebird assemblages and behavior in restored tidal wetlands in southern California. *Restoration Ecology* 15 (1): 139–148.

Beck, R. E. 1994. The movement in the United States to restoration and creation of wetlands. *Natural Resources Journal* 34:781–822. http://home.heinonline.org/(accessedOctober10,2012).

Bies, L. 2006. Wetlands management in the United States. *Wildlife Society Bulletin* 34 (3): 894–896.

Callaway, J. C., V. T. Parker, M. C. Vasey, and L. M. Schile. 2007. Emerging issues for the restoration of tidal marsh ecosystems in the context of predicted climate change. *Madroño* 54(3). Special Issue: Ecological restoration in a Changing World: Case Studies from California. pp. 234–248.

CCSP. 2009. Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. J. G. Titus (Coordinating Lead Author), K. E. Anderson, D. R. Cahoon, D. B. Gesch, S. K. Gill, B. T. Gutierrez, E. R. Thieler, S. J. Williams (Lead Authors). U.S. Environmental Protection Agency, Washington, DC, 320 p.

Coastal Conservancy. 2012. Elkhorn Slough Tidal Marsh Enhancement Project. City of Watsonville, Monterey County, California. http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2006/0610/1006Board09_Parsons_Slough_Wetlands.pdf. (accessed July 2, 2013).

Coch, N. K. 2012. Hurricane flood protection in NYC-Now is not the time for multiple surge barriers. Discussion of: Hill, D. 2012. The lessons of Katrina, learned and unlearned. *Journal of Coastal Research* 28 (2): 324–331.

Costa-Pierce, B. A., and M. P. Weinstein. 2002. Use of dredged materials for coastal restoration. *Ecological Engineering* 19:181–186.

Craft, C., J. Clough, J. Ehman, S. Joye, R. Park, S. Pennings, H. Guo, and M. Machmuller. 2009. Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services. *Frontiers in Ecology and the Environment* 7 (2): 73–78. doi:10.1890/070219.

Dahl, T. E. 2011. Status and trends of wetlands in the conterminous United States 2004 to 2009. U.S. Department of the Interior; Fish and Wildlife Service, Washington, DC, 108 p.

Day, J. W., J. Barras, E. Clairain, J. Johnston, D. Justic, G. P. Kemp, J.-Y. Ko, et al. 2005. Implications of global climatic change and energy cost and availability for the restoration of the Mississippi delta. *Ecological Engineering* 24:253–265.

DeLaune, R. D., J. A. Nyman, and W. H. Patrick, Jr. 1994. Peat collapse, ponding and wetland loss in a rapidly submerging coastal marsh. *Journal of Coastal Research* 10 (4): 1021–1030.

Deegan, L. A., D. S. Johnson, R. S. Warren, B. J. Peterson, J. W. Fleeger, S. Fagherazzi, and W. M. Wollheim. 2012. Coastal eutrophication as a driver of salt marsh loss. *Nature* 490: 388–392.

Edwards, K. R., and C. E. Proffitt. 2003. Comparison of wetland structural characteristics between created and natural salt marshes in southwest Louisiana, USA. *Wetlands* 23 (2): 344–356.

Encap. The Encap Project. http://www.northjersey.com/specialreports/encap.html (accessed May 13, 2013).

Fearnley, S. 2008. The soil physical and chemical properties of restored and natural back-barrier salt marsh on Isles Dernieres. *Journal of Coastal Research* 24 (1): 84–94.

Federal Register. 2002. Rules and Regulations 67 (90): 31129–31143.

Finkl, C. W. 1996. What might happen to America's shorelines if artificial beach replenishment is curtailed: A prognosis for southeastern Florida and other sandy regions along regressive coasts. *Journal of Coastal Research* 12 (1): R3–R9.

Fischman, R. L. 1991. Global warming and property interests: Preserving coastal wetlands as sea levels rise. Faculty Publications. Paper 658. http://www.repository.law.indiana.edu/facpub/658 (accessed December 15, 2013).

Ford, M. A., D. R. Cahoon, and J. C. Lynch. 1999. Restoring marsh elevation in a rapidly subsiding salt marsh by thin-layer deposition of dredged material. *Ecological Engineering* 12:189–205.

Gornitz, V., S. Couch, and E. K. Hartig. 2002. Impacts of sea level rise in the New York City Metropolitan Area. *Global and Planetary Changes* 32:61–88.

Hill, D. 2012. The lessons of Katrina, learned and unlearned. *Journal of Coastal Research* 28 (2): 324–331.

Hoagland, P., D. Jin, and H. L. Kite-Powell. 2012. The costs of beach replenishment along the U.S. Atlantic coast. *Journal of Coastal Research* 28 (1A): 199–204.

Holdredge, C., M. Bertness, and A. Altieri. 2009. Role of crab herbivory in die-off of New England salt marshes. *Conservation Biology* 23:672–679.

Hough, P., and M. Robertson. 2009. Mitigation under Section 404 of the Clean Water Act: where it comes from, what it means. *Wetlands Ecologic Management* 17:15–33.

Jones, A. S., C. Bosch, and E. Strange. 2009. Vulnerable species: the effects of sea-level rise on coastal habitats. In *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*, 43–56. Washington, DC: U.S. Environmental Protection Agency.

Karl, T. R., J. M. Melillo, and T. C. Peterson, eds. 2009. Global Climate Change Impacts in the United States. Cambridge University Press. www.globalchange.gov/usimpacts (accessed October 20, 2012).

Kennish, M. J. 2001. Coastal salt marsh stems in the U.S.: A review of anthropogenic impacts. *Journal of Coastal Research* 17 (3): 731–748.

Kirshen, P., C. Watson, E. Douglas, A. Gonitz, J. Lee, and Y. Tian. 2007. Coastal flooding in the northeastern United States due to climate change. *Journal of Mitigation and Adaptation Strategies for Global Change*. Special issue Northeast United States Climate Impact Assessment. pp. 1–22.

Kirwan, M. L., and J. P. Megonigal. 2013. Tidal wetland stability in the face of human impacts and sea-level rise. *Nature* 504:53–60.

LBG. 2012. Lincoln Park Wetland Restoration Year 2 Monitoring Report. Jersey City, Hudson County, New Jersey. Submitted to New Jersey Department of Environmental Protection Office of natural Resource Restoration, Trenton, NJ and National Oceanic and Atmospheric Administration Restoration Center, Highlands, New Jersey. Prepared by the Louis Berger Group, Inc., Morristown, NJ.

Lotze, H. K., H. S. Lenihan, B. J. Bourque, R. H. Bradbury, R. G. Cooke, M. C. Kay, S. M. Kidwell, M. X. Kirby, C. H. Peterson, and J. B. Jackson. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. *Science* 312:1806–1808.

LTMS. 2012. Long-Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region. Prepared by San Francisco Bay Conservation and Development Commission, San Francisco Bay Regional Water Quality Control Board, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency. http://bayplanningcoalition.org/wp-content/uploads/2013/04/LTMS-12-Year-Review-Draft-Final-Report.pdf (accessed July 2, 2013).

Mazzei, V. J. Jr. 2010. Engineering Report. NJDEP Kane Mitigation Bank Project Files. OPRA Request (accessed April 15, 2013).

Mariotti, G., and S. Fagherazzi. 2012. Critical width of tidal flats triggers marsh collapse in the absence of sea-level rise. *PNAS* 110 (14): 5353–5356.

Melvin, S. L., and J. W. Webb, Jr. 1998. Differences in the avian communities of natural and created *Spartina alterniflora* marshes. *Wetlands* 18 (1): 59–69.

Miller, K. G., R. E. Kopp, B. P. Horton, J. V. Browning, and A. C. Kemp. 2013. A geological perspective on sea-level rise and its impacts along the U.S. mid-Atlantic coast. *Earth's Future*. doi:10.1002/2013EF000135

MOA. 1992. Clean Water Act Section 404(q) Memorandum of Agreement Between the Department of Commerce and the Department of the Army. http://www.usace.army.mil/Portals/2/docs/civilworks/mous/MOU_DeptComm_DA.pdf (accessed January 6, 2014).

Montalto, F. A., T. S. Steenhuis, and J.-Yves Parlange. 2006. The hydrology of Piermont Marsh, a reference for tidal marsh restoration in the Hudson river estuary. *Journal of Hydrology* 216:108–128.

Morgan, P. A., and F. T. Short. 2002. Using functional trajectories to track constructed salt marsh development in the Great Bay Estuary, Maine/New Hampshire, USA. *Restoration Ecology* 10 (3): 461–473.

Morris, J. T., G. P. Shaffer, and J. A. Nyman. 2013. Brinson Review: Perspectives on the influence of nutrients on the sustainability of coastal wetlands. *Wetlands* 33:975–988.

Neckles, H. A., M. Dionne, D. M. Burdick, C. T. Roman, R. Buchsbaum, and E. Hutchins. 2002. A monitoring protocol to assess tidal restoration of salt marshes on local and regional scales. *Restoration Ecology* 10 (3): 556–563.

Nicholls, R. J. 2003. Case Study on Sea-Level Rise Impacts. Organization for Economic Co-Operation and Development. Paris, France. http://www.oecd.org/env/cc/

Nicholls, R. J., and A. Cazenave. 2010. Sea-level rise and its impact on coastal zones. *Science* 328:1517–1520.

NJDEP. 1997. The Management and Regulation of Dredging Activities and Dredged Material in New Jersey's Tidal Waters. New Jersey Department of Environmental Protection, Trenton, NJ.

NOAA. 2000. State, Territory, and Commonwealth Beach Nourishment Programs—A National Overview. OCRM Program Policy Series. Technical Document No. 00–01. March 2000. Office of Ocean and Coastal Resource Management. National Ocean Service. National Oceanic & Atmospheric Administration. U.S. Department of Commerce. http://coastalmanagement.noaa.gov/resources/docs/finalbeach.pdf (accessed May 14, 2013).

NOAA. 2011. NOAA Restoration Center, Northeast Region. Planning for Sea Level Rise in the Northeast: Considerations for the Implementation of Tidal Wetland Habitat Restoration Projects. Workshop Report. 43 p.

NRC. 2001. National Research Council. Compensating for Wetland Losses Under the Clean Water Act. National Academy Press. Washington, DC.

Nuttle, W. K., and H. F. Hemond. 1988. Salt marsh hydrology: Implications for biogeochemical fluxes to the atmosphere and estuaries. *Global Biogeochemical Cycles* 2 (2): 91–114.

Orr, M., Crooks, S., and P. B. Williams. 2003. Will restored tidal marshes be sustainable? In *Issues in San Francisco Estuary Tidal Wetlands Restoration*. L. R. Brown (ed.), San Francisco Estuary and Watershed Science 1(1). Article 5. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art5 (accessed December 15, 2013).

Overpeck Project. http://www.northjersey.com/news/environment/specialreports/A_windfall_from_waste-added.html?page=all (accessed May 13, 2013).

Pethick, J. 2002. Estuarine and tidal wetland restoration in the United Kingdom: Policy versus practice. *Restoration Ecology* 10 (3): 431–437.

Ravit, B., Weis, J. W., and D. Rounds. 2014. Is urban marsh sustainability compatible with the Clean Water Act? *Environmental Practice*. In press.

Reed, D. J., and L. Wilson. 2004. Coast 2050: A new approach to restoration of Louisiana coastal wetlands. *Physical Geography* 25 (1): 4–21.

Rooth, R. E., and J. C. Stevenson. 2000. Sediment deposition patterns in Phragmites australis communities: Implications for coastal areas threatened by rising sea level. *Wetlands Ecology and Management* 8:173–183.

Ruhl, J. B., and R. J. Gregg. 2001. Integrating ecosystem services into environmental law: A case study of wetland mitigation banking. *Stanford Environmental Law Journal* 365. http://home.heinonline.org/ (accessed October 10, 2012).

Sallenger, A. H. Jr., K. S. Doran, and P. A. Howd. 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America. *Nature Climate Change*. doi: 10.1038/NCLIMATE1597 (accessed November 26, 2012).

Sax, J. L. 1990. The fate of wetlands in the face of rising sea levels: A strategic proposal. *UCLA Journal of Environmental Law & Policy*. http://scholarship.law.berkeley.edu/facpubs/1783 (accessed December 15, 2013).

Scavia, D., J. C. Field, D. F. Boesch, R. W. Buddenmeier, V. Burkett, D. R. Cayan, M. Fogarty, et al. 2002. Climate change impacts on U.S. coastal and marine ecosystems. *Estuaries* 25 (2): 149–164.

Slocum, M. G., I. A. Mendelssohn, and N. L. Kuhn. 2005. Effects of sediment slurry enrichment on salt marsh rehabilitation: Plant and soil responses over seven years. *Estuaries* 28 (4): 519–528.

Streever, W. 2000. *Spartina alterniflora* marshes on dredged material: A critical review of the ongoing debate over success. *Wetlands Ecology and Management* 8:295–316.

Slott, J. M., A. B. Murray, and A. D. Ashton. 2010. Large-scale responses of complex-shaped coastlines to local shoreline stabilization and climate change. *Journal of Geophysical Research-Earth Surface* 115:F03033. doi:1029/2009JF001486

Speybroeck, J., D. Bonte, W. Courtens, T. Gheskiere, P. Grootaert, J.-P. Maelfait, M. Mathys, et al. 2006. Beach nourishment: An ecologically sound coastal defence alternative? A review. *Aquatic Conservation: Marine and Freshwater Ecosystems* 16:419–435.

Stammermann, R., and M. Piasecki. 2012. Influence of sediment availability, vegetation, and sea level rise on the development of tidal marshes in the Delaware Bay: A review. *Journal of Coastal Research* 28 (6): 1536–1549.

Stive, M. J. F., R. J. Nicholls, and H. J. Devriend. 1991. Sea-level rise and shore nourishment—A discussion. *Coastal Engineering* 16 (1): 147–163.

Strauss, B. H., R. Ziemlinski, J. I. Weiss, and J. T. Overpeck. 2012. Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States. *Environmental Research Letters* 7. doi:10.1088/1748–9326/12/014033 (accessed October 10, 2012).

Swords, D. C. 1992. The comprehensive wetlands conservation and management act of 1991: A restructuring of Section 404 that affords inadequate protection for critical wetlands. 53 La. L. Rev. http://digitalcommons.law.lsu.edu/lalrev/vol53/iss1/8 (accessed December 15, 2013).

Tol, R. S. J., R. J. T. Klein, and R. J. Nicholls. 2008. Towards successful adaptation to sea-level rise along Europe's coasts. *Journal of Coastal Research* 24 (2): 433–442.

Törnqvist, T. E., and D. J. Meffert. 2008. Sustaining coastal urban ecosystems. *Nature Geoscience* 1:805–807.

USACE. 2010. Louisiana Coastal Area (LCA), Louisiana Beneficial Use of Dredged Material Program. Final Programmatic Study Report. http://www.lca.gov/Studies/budmat.aspx (accessed July 2, 2013).

USACE. 2011. Sea-Level Change Considerations for Civil Works Programs. Circular No. 1165–2–212. Expired September 30, 2013.

USACE. 2012. Galveston District Public Affairs Office. http://www.army.mil/article/88355/What_is_the_Corps__Beneficial_Use_Program_/ (accessed July 2, 2013).

USACE. 2013. http://www.nan.usace.army.mil/Missions/CivilWorks/ProjectsinNewYork/EldersPointJamaicaBaySaltMarshIslands.aspx (accessed February 1, 2014).

Warren, R. S., P. E. Fell, R. Rozsa, A. H. Brawley, A. C. Orsted, E. T. Olson, V. Swamy and W. A. Niering. 2002. Salt marsh restoration in Connecticut: 20 years of science and management. *Ecological Restoration* 10(3):497–513.

Weinstein, M. P., and L. L. Weishar. 2002. Beneficial use of dredged material to enhance the restoration trajectories of formerly diked lands. *Ecological Engineering* 19:187–201.

Williams, P. B., and M. K. Orr. 2002. Physical evolution of restored breached levee salt marshes in the San Francisco Bay Estuary. *Ecological Restoration* 10 (3): 527–542.

Williams, P. B., M. K. Orr, and N. J. Garrity. 2002. Hydraulic geometry: A geomorpnic design tool for tidal marsh channel evolution in wetland restoration projects. *Ecological Restoration* 10 (3): 577–590.

Williams, S. J. 2013. Sea-level rise implications for coastal regions. *Journal of Coastal Research* SI63:184–196.

Yin, J., M. E. Schlesinger, and R. J. Stouffer. 2009. Model projections of rapid sea-level rise on the northeast coast of the United States. *Nature Geoscience* 2:262–266.

Yozzo, D. J., P. Wilber, and R. J. Will 2004. Beneficial use of dredged material for habitat creation, enhancement, and restoration in New York–New Jersey Harbor. *Journal of Environmental Management* 73:39–52.

Yuill, B., D. Lavoie, and D. J. Reed. 2009. Understanding subsidence processes in coastal Louisiana. *Journal of Coastal Research* SI 54:23–36.

Zedler, J. B., and J. C. Callaway. 1999. Tracking wetland restoration: Do mitigation sites follow desired trajectories? *Restoration Ecology* 7 (1): 69–73.

Zervas, C. 2009. NOAA Technical Report NOS CO-OPS 053. Sea Level Variations of the United States 1854–2006. U.S. Dept. of Commerce National Ocean Service Center for Operational Oceanographic Products and Services. Silver Spring, MD.