Dredged Material for Tidal Marsh Restoration: Lessons from Poplar Island
The Importance of Nutrient Availability

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History of Tidal Marsh Restoration Using Dredged Material

- 40+ years of tidal marsh restoration using dredged material
- Methods, recommendations and expectations based largely on projects utilizing sandy substrate – low nutrient availability
- Differing trajectories or no trajectory in different marsh restoration projects
- Substrate type can influence outcomes

Hypothetical trajectories toward functional equivalency (Zedler and Calloway 1999)
Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island

- Beneficial use – dredged material placement/remote island habitat restoration
- Substrate: upper Bay dredged material resulting from maintenance dredging of the approach channels...
- except Cell 4D, where sand was used to test designs and planting methods
- Total area = 694 ha (1715 acres), with approximately half tidal marsh and half upland habitat, subdivided into containment cells
- Tidal marshes are 80% low marsh, 20% high marsh
- Marshes developed sequentially as they are filled, creating an age range of 0 – 15 years
- Perimeter dike (2.7 m MSL)
- Various inlet structures
Fine-grained dredged material = high nutrient availability

- *Millimolar* concentrations of NH$_4^+$
- Wide range in initial concentrations, due to length of period prior to vegetation establishment
- N availability declines over time
Morphological Effects of Nitrogen on Marsh Vegetation

Poplar Island:
- Rapid plant establishment
- Robust growth
- Low RSR

Marschner 1995

Darby & Turner MEPS 2008
Ecological Effects of Nitrogen on Marsh Vegetation

- Increased rates of fungal infection
- Increased grazing pressure
- Lodging
- Dieback

➤ Can limit biomass production (top-down control) and may contribute to dieback
Poplar Island Biomass Trajectories

Aboveground

Belowground

- Expected trajectories due to changes in nutrient availability
- Little nutrient recharge from depth in dredged material due to compaction (diffusional transport) and drier conditions
Poplar Island Biomass Trajectories

- Higher AG biomass in DM marsh (green)
- Higher BG biomass in sand marsh (blue)
- RSR initially <1 in DM marsh, >1 in sand marsh
- AG declining in DM marsh, but BG also declining, so likely due to top-down rather than bottom-up control

➢ Significance: BG plant material more likely to be retained and contribute to elevation gain
Adjustment to SLR in Poplar Island Marshes

- Transgression very limited at Poplar Island due to dikes, and inorganic sediment inputs are low.
- Organic matter production dominant contributor to elevation gain.
- Implications for elevation change?
Elevation Monitoring at Poplar Island

- Surface elevation table (SET)
  - 36 on-site
  - 3 in reference marsh

- Rate of elevation change in dredged material marshes not significantly different from sand marsh (Cell 4D), despite lower RSR
- Poplar Island marshes >2x natural reference marsh
- Poplar Island marshes > SLR at Annapolis > reference marsh
Lessons Learned for Marsh Restoration with Fine-grained, Nutrient Rich Dredged Material

- Plant establishment – take advantage of rapid growth (grid configuration)
- Elevation gain – use inlet and protective structures that promote biomass retention
- Management - controlled burns to reduce grazing and pathogen pressure
- Grading – slopes to prevent ponding
- Thin layer placement – consider nutrient amendment

Substrate characteristics have significant ecological consequences that should be considered in order to design and manage for maximum resilience.
Ongoing Work

- Closer examination of drivers of marsh elevation change, including both field measurements and modelling
- Fire as a management tool to suppress grazing and disease in the marshes
- Effect of dieback on *S. alterniflora* genetics
- Geomorphology and channel design (Nardin)
Questions?

Photo credits USFWS, MES, UMCES
Why would pH be a Problem?

Iron sulfides, including pyrite, form in Chesapeake Bay sediments when sulfide produced by sulfate-reducing bacteria interacts with iron oxide minerals which are abundant in the bay.

Upon exposure to oxygen during drying and “crust management”, low pH arises because of pyrite oxidation:

$$4\text{FeS}_2 + 15\text{O}_2 + 8\text{H}_2\text{O} \rightarrow 2\text{Fe}_2\text{O}_3 + 8\text{H}_2\text{SO}_4$$
Upper Chesapeake Bay Dredged Material

- Concerns for tidal marsh: pH...