CHESAPEAKE BAY
RESTORATION: A Bit of History, Value of Salt Marshes, and some ideas on the “Shape” of restoration

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- 17 Million people
- Mixed land uses
- Shallow but seasonally stratified
- Estuary “flushes” slowly (4-6 mo)
- Many rivers connect land to Bay

Large Drainage Basin

14:1

Walt Boynton and Many Colleagues

Chesapeake Biological Lab, Center for Environmental Science, Univ MD
A Famous Chesapeake Bay Painting...1588

- Clearly, fish were important
- Emphasis on shallow waters...and there are lots of these everywhere
- CLEAR WATER and SAV...a clear water benthic dominated painting and likely a benthic dominated ecosystem

From T. De Bry in Hariot 1588
A John Smith Diet

- Traded with natives for corn, venison, fish, oysters, nuts, beans, pumpkins...traded swords for turkeys (a 1 for 1 deal...probably not a good deal for the English)

- Tobacco...“it purges the superfluous phlegm and other gross humours and openeth all the pores and passages of the body” from Harriot who died of a nasal tumor in 1621...the 400 year tobacco wars are still with us.

- Jamestowners preferred a seaman’s diet of pork, beefe, fish, wheat and barley (even with the ever present worms)...not too adaptive even when hungry

- Sturgeon (dried and pounded)

- The Starving Time (winter 1609-1610)...cats, dogs, horses and people...this was a very tough life indeed!

Hoobler 2006
“So transparent are its waters that far out from shore you may see, in the openings of the sea-weed forest, on its bottom the flashing sides of the finny tribe as they glide over the pearly sands.” The Old Plantation by Hungerford (1859)

Water Quality and Habitat Conditions can be much improved...not to the 1832 condition and that may not be the optimal status.
Major Events in Chesapeake Bay History: Science, Management and Politics

1950-60s: Pollution not possible in estuaries because of tidal flushing. The Bay is just fine and productive. Almost no “Estuarine Science” literature available.

1960s: There is nothing ...and we mean nothing...wrong with Chesapeake Bay. Reports of pollution are false and unpatriotic. You can be fired for this sort of loose talk.

1960-70s: The more nutrients we can pour into the Bay the better...farmers know that fertilization is good so lets get on with fertilizing the Bay. About 90% of SAV are gone and the causes are unclear.

1970-80s: So, OK estuaries can be polluted...big deal. The only thing needed for restoration is control of PHOSPHORUS and that’s easy. Restoration efforts need to focus on POINT SOURCES.

1980-90s: Both NITROGEN and PHOSPHORUS from MANY SOURCES are killing Bay habitats ...the bay is nutrient obese and needs a nutrient diet...big time. DIFFUSE SOURCES clearly a major player.

2000-17: Restoration is hard and expensive. Fears that all aspects of the Bay have long memories proven false...Bay is responsive. However, pathways to restored conditions are not simple....expect some surprises.
Let's look at Tidal Wetlands for a moment

Pocomoke River Marshes

We know a good bit about some marsh functions

- wildlife habitat
- nursery functions
- storm protection

What about tidal marshes as important NUTRIENT SINKS…A kidney in the landscape helping us achieve the TMDL?
Naticoke River Marshes
Poplar Island: Salt Marsh Creation from Dredge Spoil
Patuxent River and Bay Tidal Marshes
Tidal Wetlands: Nutrient Loss

Hotspots in the Landscape

Patuxent Tidal Marshes

1.5% of basin landscape removes 48% of N inputs to the upper estuary

5400 Inputs from all sources

2600 N losses via burial and denitrification

2800 Export of N to lower estuary

Units = Kg N/day
Nitrogen Export: For these estuaries, the percent of TN input exported was inversely related to water residence time.

- "Give the bugs enough time and they will get rid of it"  
  Scott Nixon

- N losses were via denitrification and long-term N burial...fisheries losses were small

Nixon et al., 1996
Nitrogen Export: Results from the Patuxent strongly diverged from other sites not characterized by extensive wetlands.

Synthesis Revised?

Nixon et al., 1996
Boynton et al., 2008
Nitrogen Export: And then another Chesapeake system diverged, also having extensive wetlands at the land-sea margin.
Nitrogen Export: And then more systems diverged, all with extensive wetlands

- Ochlockonee Bay
- Norsminde Fjord
- Boston Harbor
- Guadalupe (wet)
- Fourleague Bay, LA
- Narragansett Bay
- N: Adriatic
- Schelde Estuary
- Delaware Bay
- Potomac
- Guadalupe (dry)
- Patuxent
- Choptank
- Baltic Sea

References:
- Nixon et al., 1996
- Boynton et al. 2008
- Fisher and Cornwell, pers comm
- Justic and Day, pers comm
**Synthesis Revised... might be something here**

**Nitrogen Export:** And then more systems diverged, all with extensive wetlands at the land-sea margin.

![Graph showing nitrogen export and residence time](image)

- **Norsminde Fjord**
- **Boston Harbor**
- **Guadalupe (wet)**
- **Narragansett Bay**
- **Fourleague Bay, LA**
- **Breton Sound, LA**
- **Davis Pd, LA**
- **Patuxent**
- **Choptank**
- **Potomac**
- **Guadalupe (dry)**
- **Baltic Sea**

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POSITIVE EFFECTS

- Essential for plant growth. In most estuaries and the open ocean, microscopic plants provide the basic food supply.

- Within limits, increased fertilization increases food supply and production of other organisms.
Ecosystem Responses to Nutrient Degradation and Remediation

- Linear Recovery
- Threshold Recovery
- Hysteresis with Threshold
- Shifting Baseline

Increased algae, hypoxia, turbidity

Increased Nutrient Load
A “Simple” Response to Nutrient Load Reduction

• Waste water treatment plants reduced P-loads by >90% in 30 years

• Algal blooms and bottom $O_2$ responded rapidly

• Underwater grasses also responded in a favorable fashion

(Kemp et al. 2005)
**Complex Response to P-Load Reduction**

- Potomac River tributary
- Time-series of P-loading index includes periods of brief increase and gradual decline
- Phytoplankton chl-a shows response to P-load reduction after decade delay, probably due to slow purging of sediment DIP pools (hysteretic response pattern?)
- Reductions in phytoplankton chl-a improved water clarity until a light threshold was reached allowing growth and survival of submersed plants

*Chris Jones, GMU*
Model of $O_2$ Interactions with P-Cycle

Normoxic Conditions

- $O_2$
- $PO_4^{3-}$
- POP
- FeOOH
- Fe$^{3+}$
- $PO_4^{3-}$

Hypoxic Conditions

- $O_2$
- $PO_4^{3-}$
- POP
- FeOOH
- Fe$^{2+}$
- $H_2S$
Take-Home Points

- Basic ideas of enrichment and restoration are scientifically solid

- Substantial reductions of N and P result in improved water quality and better habitat conditions...the Bay is RESPONSIVE to load changes

- The pathways estuaries follow during degradation and restoration often involve time delays (lags), abrupt changes (thresholds) and other things not yet known or fully understood - or predictable!

- Restoration trends (and hints of trends) have been observed in both small and large Chesapeake systems...very good signs!

- Climate change and variability, continued and adaptive monitoring and analysis, control of diffuse sources all remain major challenges