Payment for Ecosystem Services From Oyster Reef Restoration: Possibilities for Chesapeake Bay

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Maryland Oyster Advisory Commission

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Outline

- Demand for Ecosystem Services
  - Eutrophication in Chesapeake Bay
  - Nutrient Reduction Approach
    - TMDL's
    - Nutrient Trading
- Supply of Ecosystem Services
  - Oyster Aquaculture (Not discussed here)
  - Oyster Reef Restoration (Our focus)
- Policy Implications

Chesapeake Bay Water Quality Impaired by High Nutrient and Sediment Loads

The Washington Post

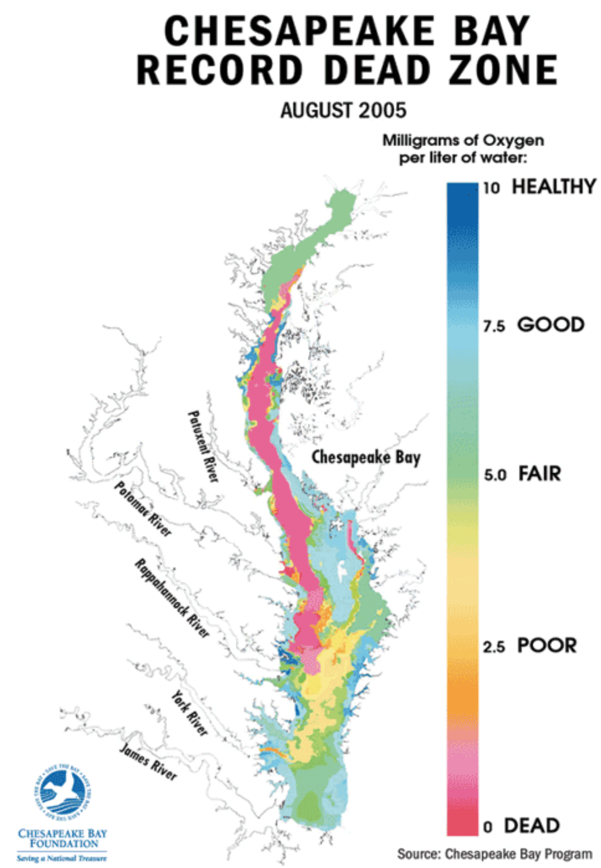
Alarming 'dead zone' grows in the Chesapeake

July 24, 2011

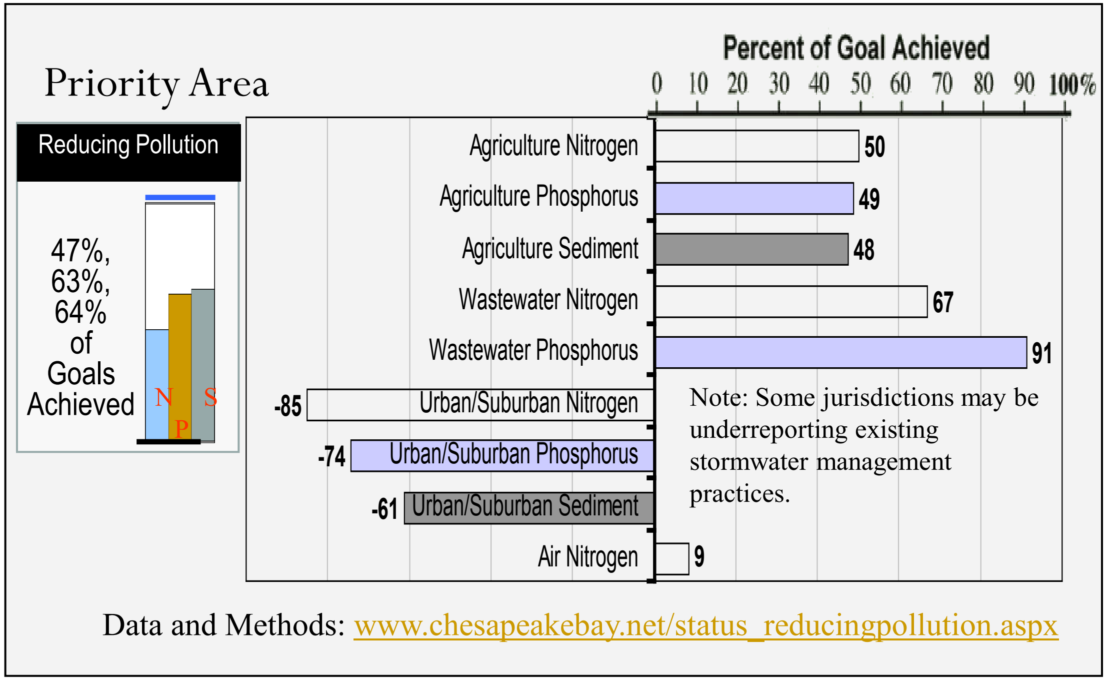
LIGHT FOR ALL THE BALTIMORE SUN

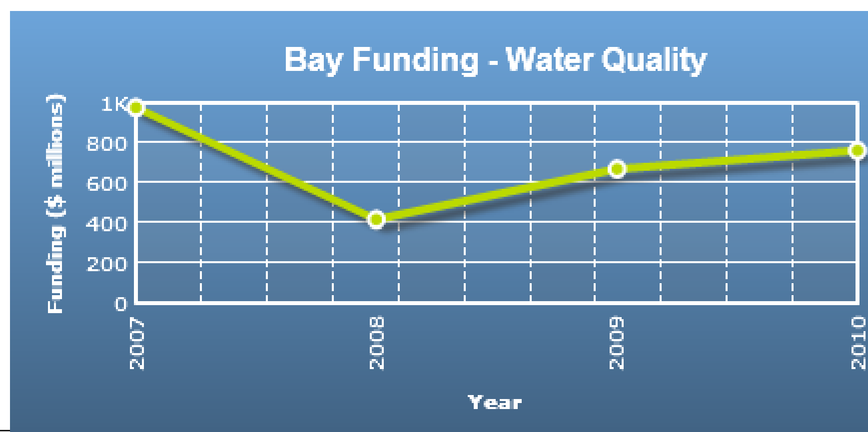
August 3, 2011

Bay's record 'dead zone' keeps growing



Chesapeake Bay Nutrient Reduction is Costly and Progress is Not Being Made





CB TMDL on Nutrient Trading

- **10.2 Water Quality Trading**
  - EPA recognizes that a number of Bay jurisdictions already are implementing water quality trading programs. EPA supports implementation of the Bay TMDL through such programs, as long as they are established and implemented in a manner consistent with the CWA, its implementing regulations, and EPA's 2003 *Water Quality Trading Policy and 2007 Water Quality Trading Toolkit for NPDES Permit Writers.*
- **Trading Analysis**
  - Chesapeake Bay Commission and Linden Trust has current contract with RPI (economic consulting firm) to analyze the potential cost savings from differently structured trading programs (e.g., within basin vs. across basins)

Challenges for Oysters in Trading

- Need to be listed as an acceptable BMP with associated efficiencies (nutrient removal) similar to other BMP's (e.g., cover crops, buffers, etc.)
- In Maryland, nutrient trading only allowed for offsets (i.e., allowing for future growth once the TMDL has been met).
  - Nutrient Trading market will be thin

CB TMDL on Filter Feeders

- **10.7 Filter Feeders**
  - Filter feeders play an important role in the uptake of nitrogen and phosphorus from the Chesapeake Bay and have the potential to significantly improve water quality if present in large numbers
  - The organisms of interest for their ability to improve water quality are the native Eastern oyster, *Crassostrea virginica, and menhaden fish, Brevoortia tyrannus.*
  - EPA is basing the TMDL on **the current assimilative capacity** of filter feeders **at existing populations** built into the calibration of the oyster filter feeding submodel of the Chesapeake Bay Water Quality and Sediment Transport Model.
  - If future monitoring data indicate an **increase in the filter feeder population**, the appropriate jurisdiction's 2-year milestone **delivered load reductions can be adjusted** accordingly.

Two Opportunities for Payment for Ecosystem Services

- Oyster Aquaculture
  - Principally for market production with potential for small payment for nutrient removal
  - Lipton and DePiper (2010)
    - PES can increase firm viability
  - Others (e.g., Stephenson et al.)
    - Scale issues, maybe local impacts
- Reef Restoration
  - Principally for nutrient removal and sequestration
  - Focus of this presentation
  - Optimal reef management

Approach

- Reef growth modeled with von Bertalanffy function from EIS (Volstad & Dew), alternative specifications are currently being tested
- Nutrient removal and sequestration from Kellogg et al. (2011) for entire reef based on 5-6 year old reef
- Ecosystem services assumed proportional to reef size (our assumption)
    - Diminishing returns to denitrification and net sequestration due to reef growth curve
- Reef manager seeks to maximize net present value of reef
    - Strategically harvests a % of sustainable growth
        - w/o contract & penalty
        - with contract & $10,000 penalty

Objective Function in Words

- Maximize net present value over t periods =

  Price of nitrogen removed * denitrification

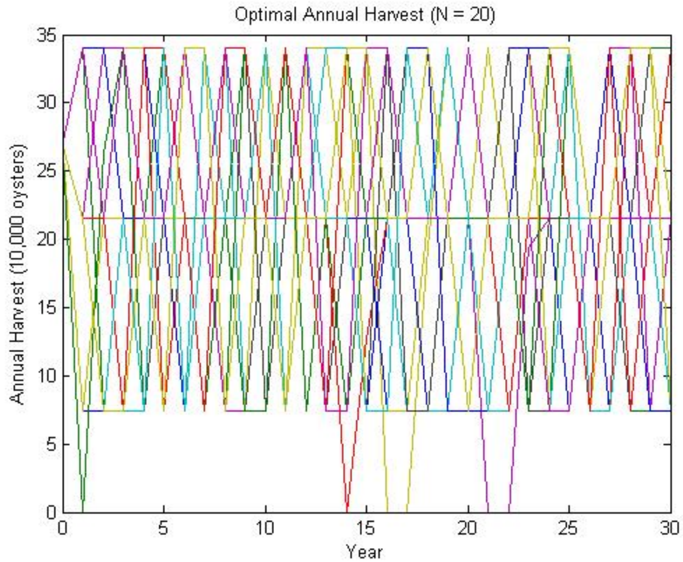
  + Price of nitrogen removed * net sequestration

  + Price of oysters * number of oysters removed

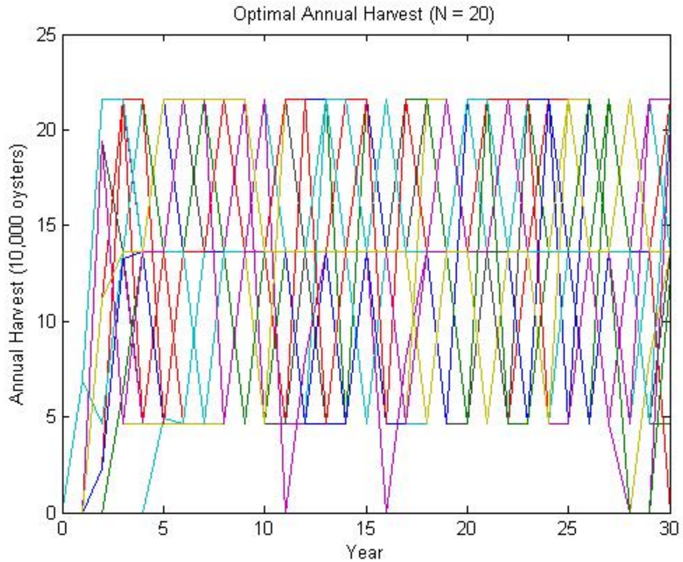
  - Cost of harvest
- Subject to
  - Reef growth function
  - Contracted nitrogen removal amount
  - Penalty for failing to meet contract
- Monte Carlo simulations
  - Truncated normal
    - Random Shocks [-1.43, -0.68, 0, 0.68] (units are reef age in years)
    - ~ N(0,1/4)

Optimal Harvest Path Simulations

No Contract/No Penalty

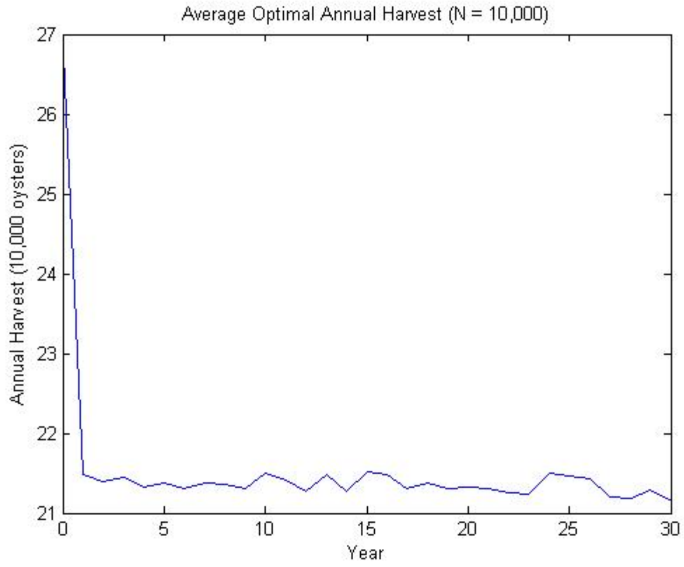


Contract w/Penalty

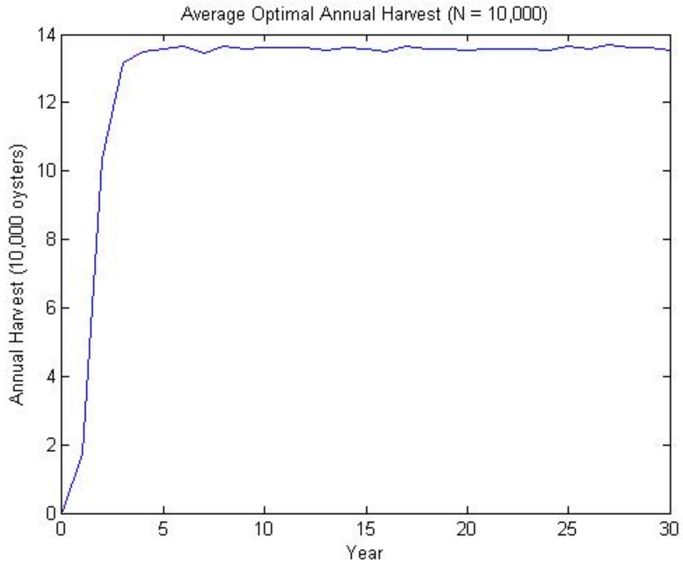


Average Optimum Harvest

No Contract

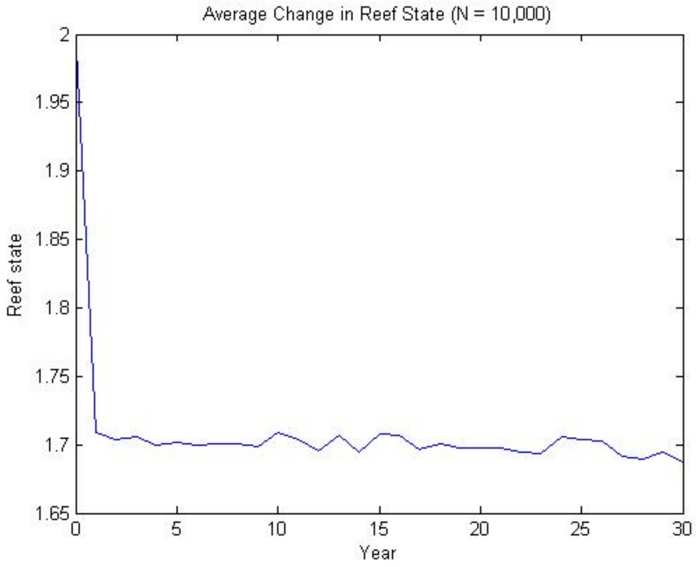


Contract

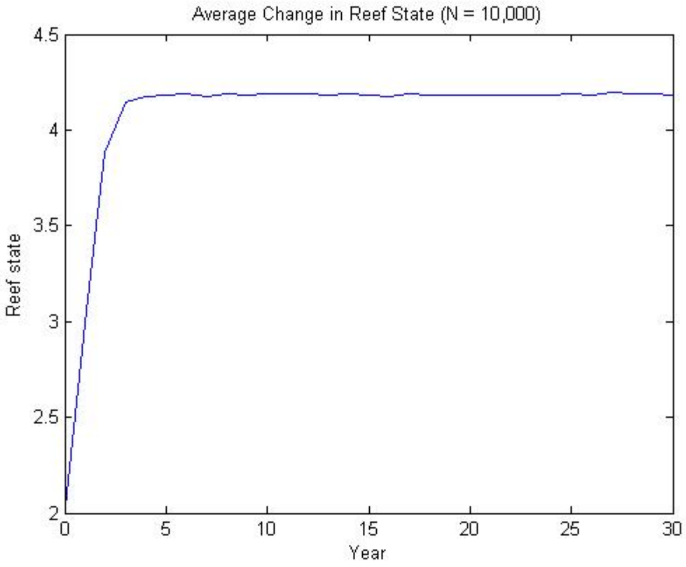


Change in Reef State (Relative Age)

No Contract



Contract



Comparison of results

Model	N price $/kg	Avg. N removed Kg/hectare	Avg. yearly oysters harvested (#)	Total NPV
No Contract				
	$6	406	215,000	$275,734
	$12	407	215,000	$327,000
$10,000 Penalty				
	$6	535	128,000	$195,000
	$12	535	126,000	$262,000

Summary & Conclusions

- Reefs need to be actively managed in terms of removals to maximize benefits
- If no contract and enforcement, oysters are harvested more aggressively, desired nutrient removal levels may not be achieved
- Enforced contract (w/penalty) results in switch in how reef is managed
- Future research – better reef growth function
- **Policy – Establish a market framework for municipalities and other entities to enter into contracts with public/private oyster reef managers to increase assimilative capacity**

Questions/comments?