Valuation and Payment For Ecosystem Services From Large Scale Oyster Restoration

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*The opinions expressed in this presentation are solely the authors, and do not represent those of NOAA Fisheries

Outline

- Overview of Value of Ecosystem Services
- Focus on Nutrient Removal
- Payment for Ecosystem Services

Oyster Ecosystem Services

- Food (The Oyster Fishery)
- Habitat
  - For Oysters (see above)
  - For Other Commercially Valuable Species
  - For Other Recreationally Valuable Species
  - For Other Species That Indirectly Support the Above
- Shoreline Stabilization/Protection
- Nutrient Cycling/Removal
  - Sequestration
  - Denitrification
- Other Estuarine Processes
  - e.g. Link to jellyfish population – swimming, boating, waterfront values; Water clarity
- Non-Use Value

Recreationally Valuable Habitat

- Hicks, Haab and Lipton (2004)
  - Used NMFS MRFSS Survey data

Table 6. Total Yearly Fishing Trips and WTP for the Oyster Restoration Project in the Chesapeake Bay (2003).

		Scenario 1		Scenario 2	
Mode	Trips	WTP per Trip	Total WTP	WTP per Trip	Total WTP
Shore	1,801,742	$0.08	$131,386	$0.20	$328,465
Private Rental	3,688,236	$0.13	$458,132	$1.32	$4,651,803
Party Charter	171,360	$0.31	$48,741	$0.79	$124,211
Totals			$638,259		$5,104,478

Non-Use Value: Willingness-to-pay for Oyster Reef Restoration

- Hicks, Haab and Lipton
  - Special Add-On Phone survey questions from MRFSS (Also Mail Survey – not presented here)

TABLE 6b					
Aggregate Median Willingness to Pay Per Acre from Phone Survey: By State					
	Delaware	Maryland	New Jersey	North Carolina	Virginia
1000 Acres	$23,547	$160,764	$141,194	$15,244	$92,146
2500 Acres	$14,913	$119,203	$99,311	$10,911	$63,580
5000 Acres	$6,288	$56,788	$40,367	$5,981	$27,796
10000 Acres	$2,804	$19,637	$16,735	$3,378	$12,736

Focus on Nutrient Cycling/Removal

- TMDL is a game-changer
  - w/o TMDL
    - Nutrient Cycling/Removal Benefit
      - Difficult to link to things we value (e.g., more fish)
      - Public good
    - w/TMDL
      - Nutrient caps are presumably set to capture public good benefits
      - Allowance for increased assimilative capacity and/or nutrient trading facilitates markets and payment for ecosystem services

Maximize Net Economic Value

Value =
Harvest + Denitrification + Sequestration

$$\text{Harvest} = (p_H - c_H(1 - (\frac{O - x}{K}))x$$

$$\text{Denitrification} = p_N \theta (\frac{O - x}{K})$$

$$\text{Sequestration} = p_N [O(\frac{r(1 - \frac{O}{K}) + \varepsilon - \mu}{1 + \exp(-h(\frac{O}{2} + B - S))} - \varepsilon) - x]$$

There Are Complex Dynamics (from Jordan-Cooley et al. 2011)

Oysters

$$\frac{dO}{dt} = O\left[\frac{r\left(1-\frac{O}{k}\right)+\varepsilon-\mu}{1+\exp\left[-h\left(\frac{O}{2}+B-S\right)\right]}-\varepsilon\right]-x$$

Shell

$$\frac{dB}{dt} = O\left[\frac{\mu-\varepsilon}{1+\exp\left[-h\left(\frac{O}{2}+B-S\right)\right]}+\varepsilon\right]-\gamma B$$

Sediment

$$\frac{dS}{dt} = -\beta S + C\exp[-\eta(O+B)]\exp[-\frac{F_0(O)}{y_0}\exp[\frac{y_0-\mathrm{Cexp}[-\eta(O+B)]}{y_0}]]$$

Need to Determine Model Parameters and How They Might Vary

Deterministic Dynamic programming

- CompEcon Toolbox for Matlab

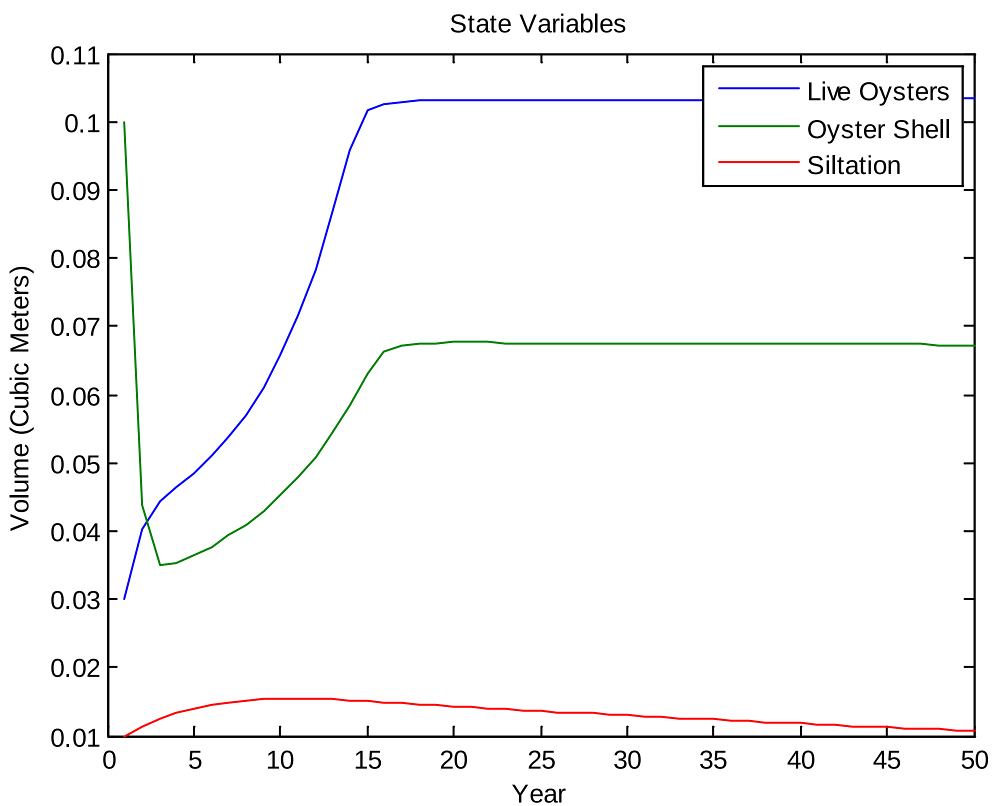
Table 3
A sample set of reasonable parameters.

Parameter	r	K	μ	ε	γ	η	y_0	F_0	β	h	C
Value	1	0.3	0.4	0.94	0.7	3.33	0.02	1	0.01	20	0.02

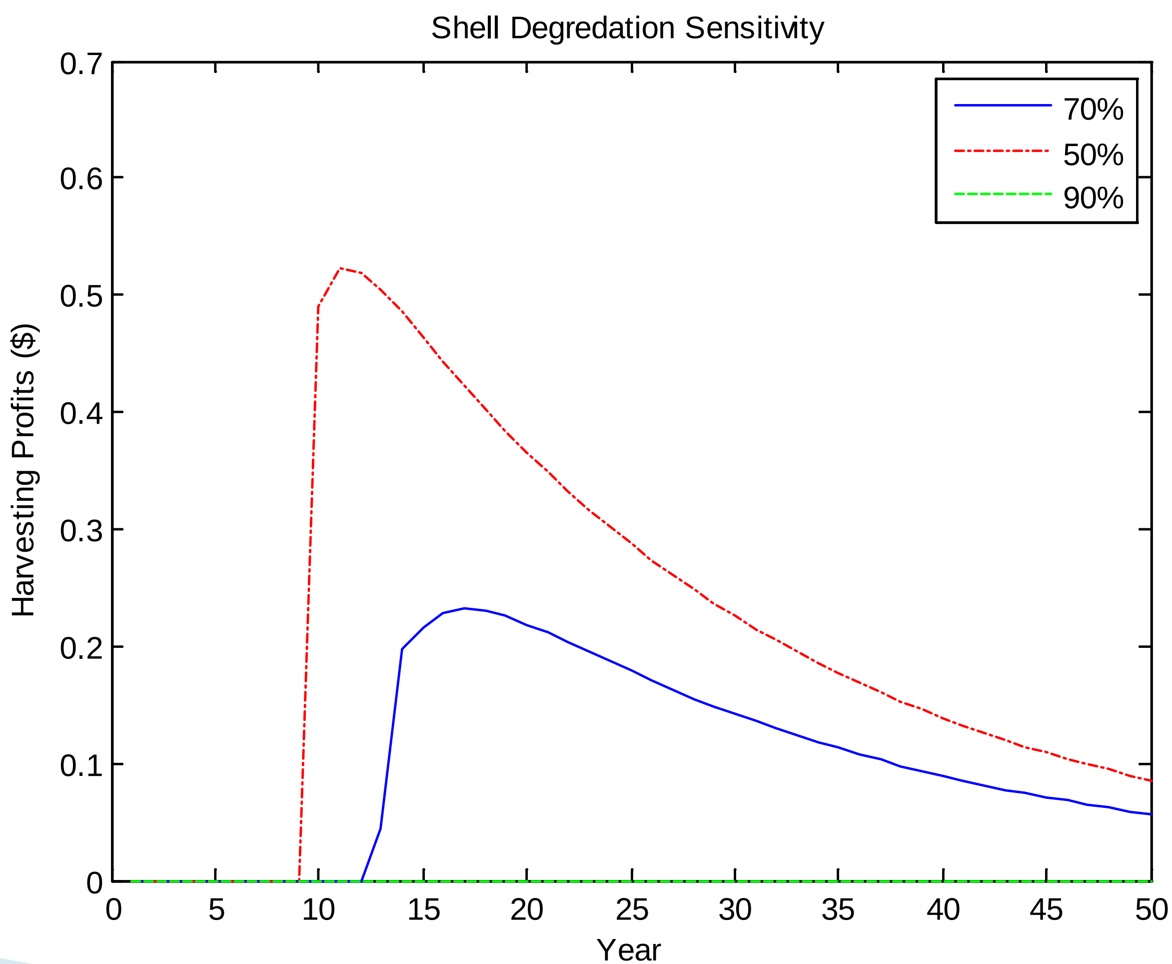
Jordan-Cooley et al. (2011)

Parameters	p_H	p_N	θ (Kellogg et al. 2013)	ρ	c_H
Value	$29 (bu)	$10 (lb)	61 (g m^{-2})	5%	$6.91

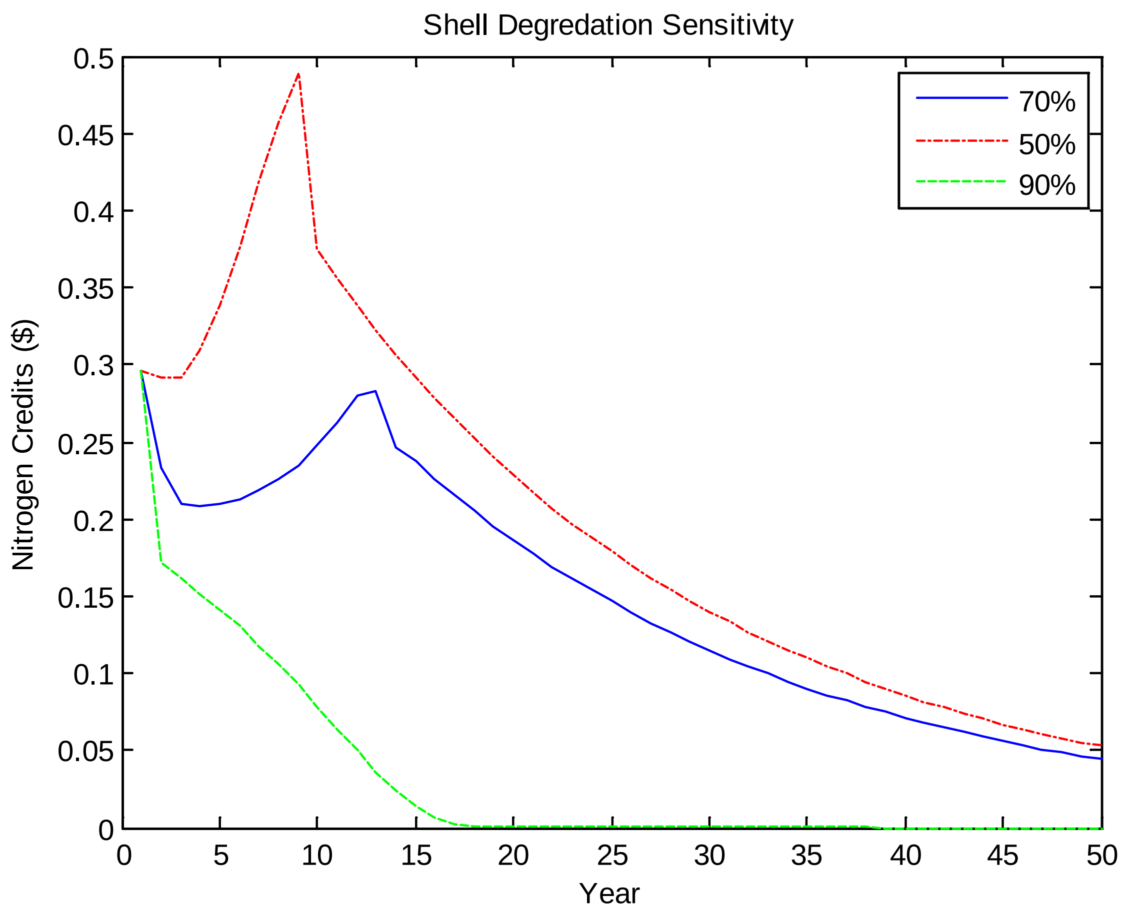
Simulate Oyster Reef Over 50 Years



It is Optimal to Sustainably Harvest The Restored Reef After 9-13 Years



Add Denitrification & Sequestration



Conclusions and Challenges

- Total private value of oyster reef (harvest + nutrient credits) can be significant % of reef creation costs
- Sustainable harvest (i.e. at very low level) is compatible (optimal) as part of ecosystem restoration
- Technical Challenges
  - Need oyster reef growth function under varying environmental conditions (salinity, depth, etc.)
  - Need denitrification/sequestration as function of reef size also under varying environmental conditions
  - Harvest damage
- Policy Challenges
  - Trading versus Offsets
  - Accepting BMP Efficiencies

Questions or Comments?