IS CRASSOSTREA VIRGINICA GULF OYSTER REEF A SUSTAINABLE RESOURCE SUBJECT TO EQUIVALENT CARBON CREDIT TRADING ON THE WORLD CAP & TRADE MARKET?

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Abstract: A healthy Crassostrea Virginica Gulf Oyster can armor itself with 5 – 6 times its own flesh weight in shell over the organism's lifespan. Oyster and mussel shell composition is stated to average 95% Calcium Carbonate, which has been called the major longterm sink for atmospheric Carbon Dioxide. Oyster reef habitat sequesters Carbon Dioxide at rates orders of magnitude greater than equivalent acreage of newly planted forest. Under a 'shell neutral', balanced shell budget regime of oyster cultch planting and harvesting, sustainable reef production can be shown to bind atmospheric CO_2 and to buffer coastal waters against the effects of regional acidification. An economic model of international 'Cap & Trade' mercantilism is presented, showing potential profitability of oyster shell and other lime-rich cultch planting versus new afforestation, biofuel production, and all other projects subject to carbon sink accreditation. Harvested oyster shell and other planted cultch materials should be considered as a direct macroeconomic variable in the calculation and trading of CO_2 sequestration 'Carbon' Credits on the world market.

In September of 2018, during the course of an oyster lease survey on bedded leases in Terrebonne Parish of Louisiana, a dredge sample produced a healthy, mature oyster, whose flesh weighed 3 ounces, and whose shell weighed 1.1 lbs.

Figure 1

The Gulf oyster Crassostrea virginica, which has evolved to repel oyster drills, drumfish, oyster flatworms, raccoons and crabs, can armor itself with 5 to 6 times its body weight in shell.

Figure 2

A great variety of cultch materials had been spread on the Madison Bay leases over several years, including cracked brick, crushed concrete, Rangia cuneata clamshell, broken cinder block, and shucking house oyster shell, all materials high in Calcium Carbonate by nature.

Pediveliger stage oyster spat can be found setting on substrates as diverse as sunken wood, crab traps, oil field scrap, creosote piles and burnt paint cans, but tend to thrive upon living reefs in the presence of dissolved Calcium. To survive, seed oysters build shell rapidly, and for this purpose, they may employ the help of a mysterious enzyme catalyst, and a truly archaic prokaryote bacteria which produces that catalyst for the benefit of the whole earth.

The oyster and its ancestors have evolved since early in the Cambrian period, alongside another ancient organism, Escherichia coli (E. Coli) of major media infamy. The anaerobic prokaryote E. Coli has persisted in mutualistic accord within the relatively warm systems of multiple animal phyla, and serves as a splendid example of convergent evolution. Its ribosomes can bind both alpha and beta forms of Carbonic Anhydrase, making it the only known organism to do so. Carbonic Anhydrase is the catalytic key to bivalve shell formation. It is placed in the oyster's mantle tissue, to regulate and accelerate interconversion between CO2 and Bicarbonate, and thence toward deposition of Calcium Carbonate. (1) (2)

Sequestration and Buffering Reactions from Dissolved CO_2
Carbonic Acid Cycle and Calcium Carbonate Shell Formation

$CO_2(g) + H_2O$ < - > $CO_2(aq) + H_2O$	(CO_2 dissolved in sea water)
$CO_2(aq) + H_2O$ <-Carbonic Anhydrase-> H_2CO_3 (rapid, reversible catalysis)	(water & carbonic acid)
$H_2CO_3 + H_2O$ < - > $H^+ + HCO_3^-$	(hydrogen ion & bicarbonate)
HCO_3^- < - > $H^+ + CO_3^{2-}$	(resolves to carbonate)
$CO_3^{2-} + Ca^{2+}$ < - > CaCO3	(calcium carbonate mineralization and buffering of surrounding waters)

The simplified chemistry presented here will ignore free ionic capacities, partial vapor pressures and equilibria for purposes of clarity and brevity

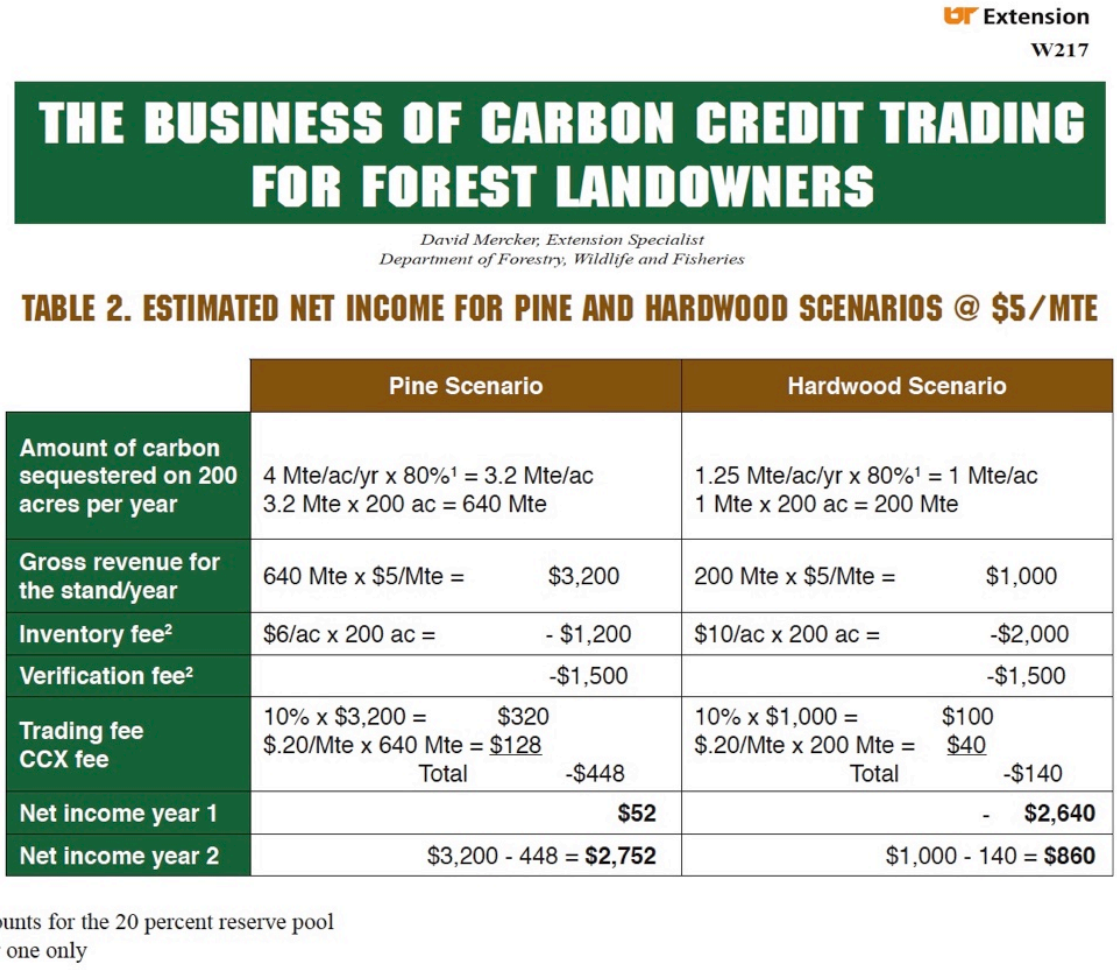
Figure 3

Carbonic Anhydrase in both alpha and beta forms, genetically encoded in E. Coli, acts as the critical catalyst, greatly increasing the effectiveness of the sequestering reaction in finally depositing Calcium Carbonate. A single zinc atom has the most important effect and placement within Carbonic Anhydrase molecules, which can alternatively be termed 'metalloenzymes'. Indeed, even our folklore memorializes the Zinc of Gulf oysters, because optimal Zinc levels are necessary to men's testosterone production and prostate health. Here in Louisiana we say it and post it on our bumper stickers 'Eat Oysters, Love Longer'.

E. Coli also lives in a mutualistic relationship with the warm blooded mammals and birds of our world, within whose digestive tract it thrives and works to buffer against blood acidification for the whole creature. Feces of coastal predators are a primary food source for the oyster, who takes in the E. Coli, providing another relatively warm place for it to survive. E. Coli, in turn, produces the Carbonic Anhydrase which makes possible the rapid shell formation and pH buffering in which oysters excel.

Many of us may be familiar with regulatory schemata that the state of California is allowing for monetizing carbon sequestration projects in that state and nationwide. Carbon credits can be converted to cash within such diverse regimes as new afforestation, reforestation, croplands reclamation, wind, solar and geothermal projects, etc. The California Air Resources Board (CARB) regulations have required compliance for great numbers of industrial and agricultural endeavors.

University of Tennessee Extension Service promotes pine forestation net income based upon a figure of $5 per metric ton equivalent (mTe). (3)



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THE BUSINESS OF CARBON CREDIT TRADING FOR FOREST LANDOWNERS

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TABLE 2. ESTIMATED NET INCOME FOR PINE AND HARDWOOD SCENARIOS @ $5/MTE

	Pine Scenario	Hardwood Scenario
Amount of carbon sequestered on 200 acres per year	4 Mte/ac/yr x 80%[1] = 3.2 Mte/ac 3.2 Mte x 200 ac = 640 Mte	1.25 Mte/ac/yr x 80%[1] = 1 Mte/ac 1 Mte x 200 ac = 200 Mte
Gross revenue for the stand/year	640 Mte x $5/Mte = $3,200	200 Mte x $5/Mte = $1,000
Inventory fee[2]	$6/ac x 200 ac = - $1,200	$10/ac x 200 ac = -$2,000
Verification fee[2]	-$1,500	-$1,500
Trading fee CCX fee	10% x $3,200 = $320 $.20/Mte x 640 Mte = $128 Total -$448	10% x $1,000 = $100 $.20/Mte x 200 Mte = $40 Total -$140
Net income year 1	**$52**	- **$2,640**
Net income year 2	$3,200 - 448 = **$2,752**	$1,000 - 140 = **$860**

[1] = accounts for the 20 percent reserve pool
[2] = year one only

Figure 4

Figure 4 shows an example of this Tennessee Extension Service information for farmers wishing to maximize economic value through reforestation efforts The table displays the kinds of calculations to be considered in such a monetization scheme.

The ‘Gold Standard’ International ‘super’ Non-Governmental Organization reports average price for ‘agro-forestation’ mTe compensation at $9.90 for the year 2015. (4)

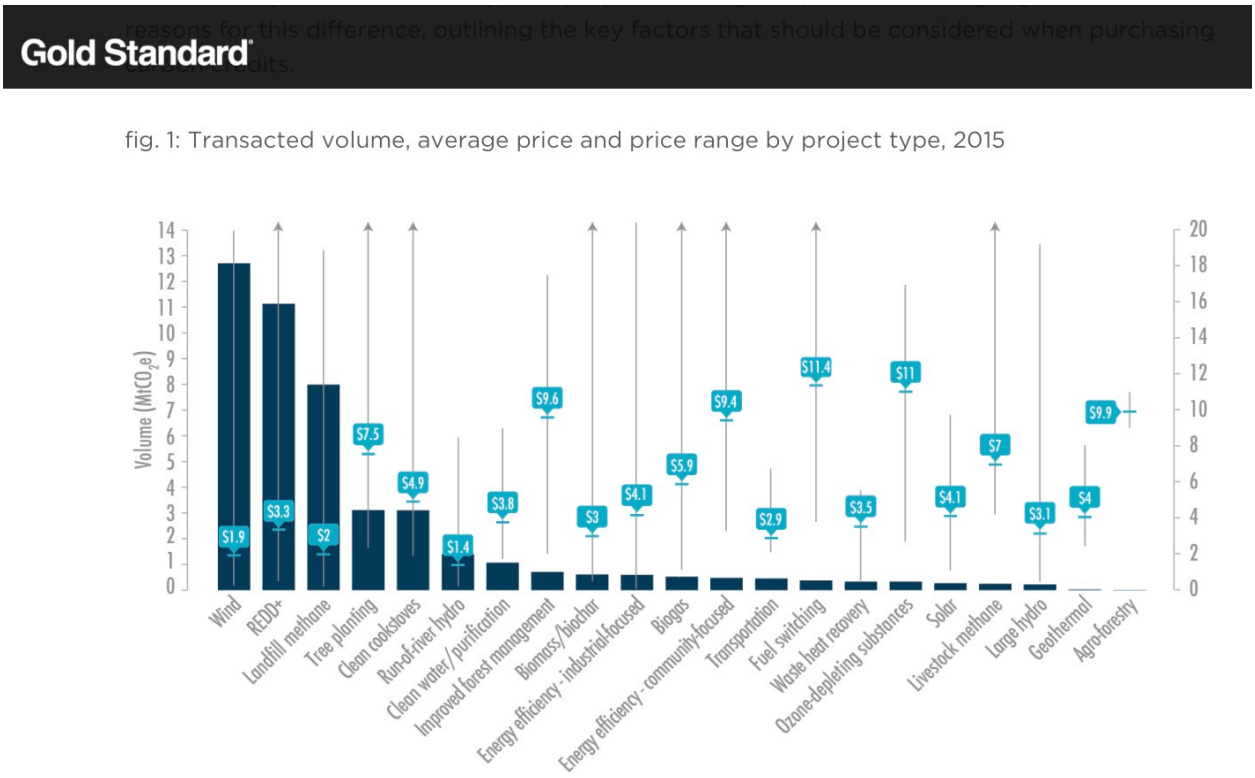

Figure 5

California’s Compliance Offset Program has calculated credits up to $15 per mTe in 2017 through its promotions for reforestation efforts. Considering the acreage destroyed in recent, catastrophic forest fires, one must wonder which entities should be liable for the valued burned and for the newly-released CO2 unsequestered into the world’s atmosphere.

This figure ($15.10) per mTe also shows up in calculations used by the Intercontinental Exchange (ICE), rapidly becoming the world's clearinghouse for futures and crypto trading in the carbon credit space. (5)

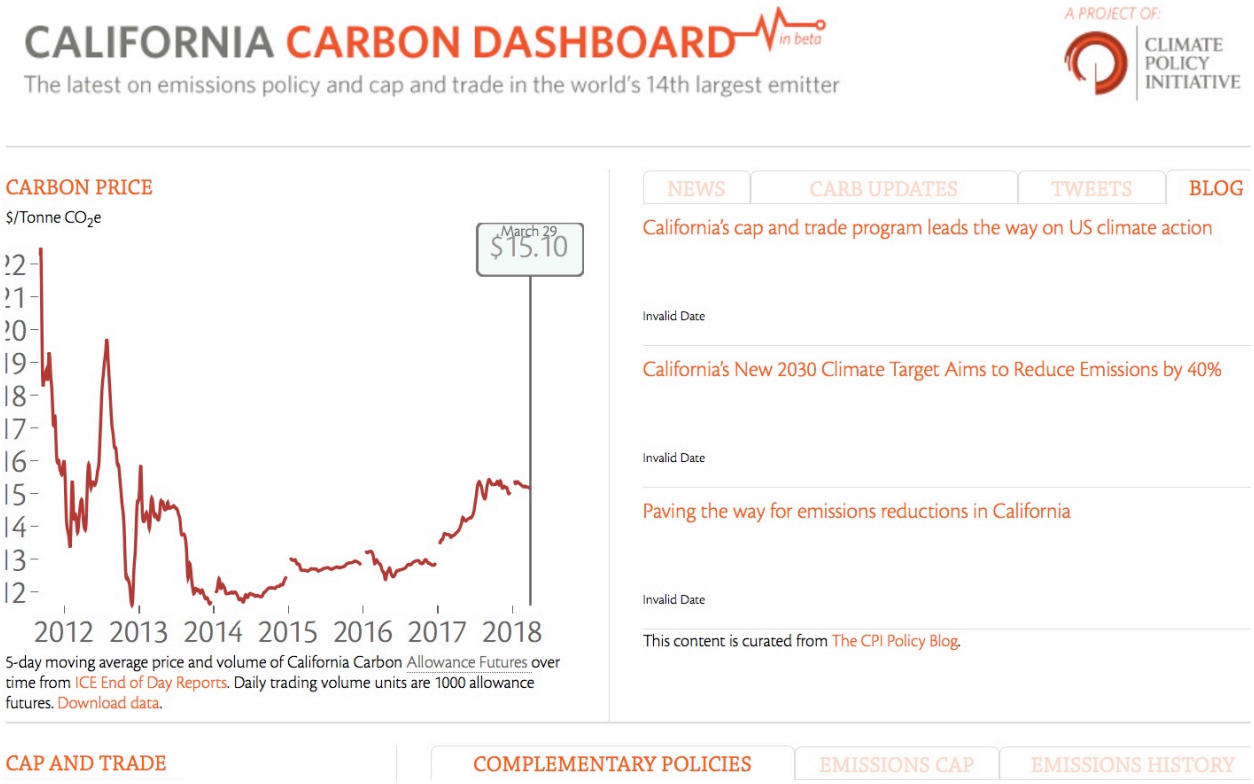

Figure 6

In 2014, USDA scientists have proposed mTe remunerations in ‘New Afforestation’ acreage as high as $50 - $100. (6)

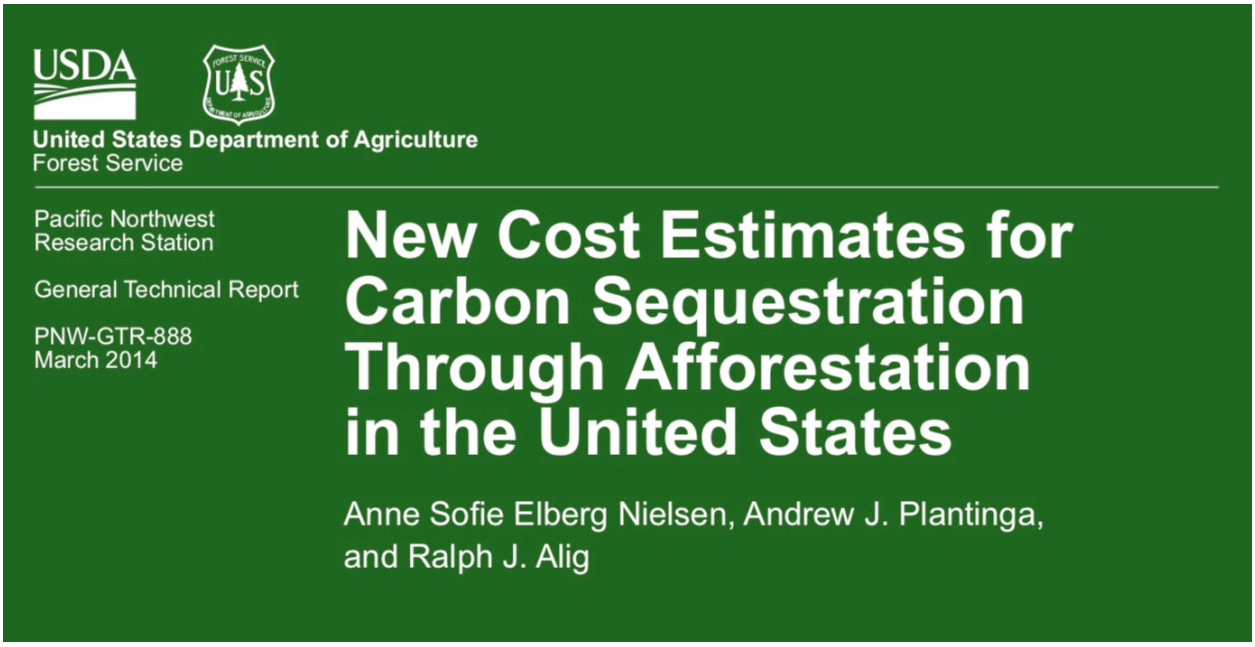

Figure 7

Live pine trees are mostly composed of water, but when they burn, trees release pure CO_2. Calcium Carbonate, however, has been said to be “the major long-term sink for atmospheric carbon dioxide”. (7) Marine shellfish deposits of all kinds are the principal source of lithographic strata in the form of limestones, caliches, dolomites, marbles, etc., making $CaCO_3$ the fourth most plentiful mineral compound comprising the Earth’s surface.

Crassostrea virginica and other bivalve species build their shells with 95% Calcium Carbonate. (8) Oyster reefs may offer dissolved Calcium for shell formation, and healthy pelagic waters contain a measurable vapor pressure of CO_2. Oyster scientists of the University of New Orleans have quantified harvest estimates in a ‘Shell Neutral Modeling Approach’, devoted to maximizing sustainable practices in our Louisiana State Oyster Seed Grounds, by which lime-rich cultch materials are broadcast for oyster spat set and growth of seed stock. (9)

The Louisiana Oyster Cultch Project (2013 – 2016) (10) estimated 200 $yds.^3$ of shell or other cultch bedded to each acre of state seed grounds. In such a harvesting regime, landings could be calculated for final shell mass and converted to mTe at a rate of around 0.378 metric tons CO_2 per $yd.^3$ of bleached shell, which could represent 75.6 mTe total sequestration per acre. Tennessee's 'Pine Scenario' project has only offered 4 mTe carbon credit per year per acre. Gulf oyster 'shell neutral' harvesting processes might be said to represent almost 19 times more carbon sequestration per acre than do worldwide reforestation / afforestation projects, and therefore much greater relative profits in Cap & Trade credits.

Oyster Shell Mass per Metric Ton Equivalent CO_2

- 1 yd^3 Bleached Oyster Shell weighs 1 US Ton
  (Louisiana Dept. Wildlife & Fisheries working figure)

- 1 US Ton x .95 (Proportion of $CaCO_3$ in oyster shell) = 0.95 US Tons

- 0.95 US Ton/yd^3 x 0.907 (mT/US Ton) = 0.86 mT / $yd.^3$

- Molar Mass CO_2 = 44
  Molar Mass $CaCO_3$ = 100
  Proportion of CO_2 in $CaCO_3$ = 44 / 100 = .44

- 0.86 mT x 0.44 (Molar Conv. Factor) = 0.378 mTe CO_2

- 1 $yd.^3$ Bleached Oyster Shell represents 0.378 mTe CO_2 for the purpose of establishing Carbon Trade credits?

- Multiply times average dollar credits (CARB, Gold Standard, USDA, etc.)

Figure 8

Thus, one cubic yard of bleached oyster shell 'represents' the equivalent of 0.378 metric tons of sequestered CO_2.

Under a 'Shell Neutral' regime of bedding cultch for new oyster 'afforestation', it is proposed that carbon sequestered to shell in growing oyster stock be considered a tradeable commodity on the world Cap & Trade market.

Lime-Rich Oyster Cultch Choices

- Oyster Shell & Crushed (1.5") Oyster Shell
- Crushed Limestone
- Crushed (#610) Concrete
- OysterCrete™ (Portland Cement, Fly Ash, Oyster Shell)
- Cracked PaveStones (Sand, Pea Gravel, Portland Cement)
- Cracked Brick
- Broken Cinder Block

Decomposed Granite (CaO Component) &
Terra Cotta (Roman Empire technology) other possibles

Figure 9

Louisiana State agencies have reported that natural oyster shell for planting has increased in price over the past 5 years, from roughly $15 per cubic yard ($yd.^3$) to between $25 and $35 per cubic yard ($yd.^3$). This has resulted in increased costs to maintain Louisiana oyster fishing grounds, public and private alike. Modern oyster culture requires water bottom management and sustainable cultch regimes so that the species can remain as both a primary food source and an important operator in the act of carbon sequestration and coastal acidification buffering. It is hoped that public and private oyster interests work toward crop sustainability in part, by claiming international carbon compliance offset profits for all of the work done by our favorite seafood.

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