CARBON FIXATION BY CULTURED CLAMS

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Eat a clam, save the Earth

Photo: Florida DACS

Every clam you eat represents about 3 grams of carbon removed from the atmosphere.

ABSTRACT

Northern hard clams, *Mercenaria mercenaria*, are commercially cultivated in Florida, USA. The shells of the clams mineralize carbon as calcium carbonate ($CaCO_3$), providing a long-term sink for atmospheric carbon dioxide. In addition to the clams sold to the market, there are discarded or dead clam shells, plus shells of associated organisms such as oysters (*Crassostrea virginica* and *Ostrea equestris*). We quantified all shell and fragments (over 5 mm) harvested by clam farmers near Cedar Key, Florida, including associated taxa collected with the clams and the culture material (mesh bags). The $CaCO_3$ content was quantified by coulometry and shell production was standardized per time, per harvested clam, and per unit area. Each harvested clam represented an estimated 2.93 g of mineralized carbon, including non-harvested shell ($CaCO_3$ is 12% carbon by weight). Clam leases in full production produced about 8965 kg of mineralized carbon per hectare per year, and the Florida clam industry produced about 534 metric tons of mineralized carbon in 2008.

INTRODUCTION

The culture of clams, oysters, and other molluscan shellfish is considered sustainable, in part because shellfish feed on natural populations of plankton, rather than requiring added feed. To this, we can also add long-term carbon fixation as an environmentally benefit of shellfish aquaculture.

Carbon dioxide (CO_2), a major greenhouse gas, dissolves in water and is incorporated by shell-producing organisms into calcium carbonate ($CaCO_3$). $CaCO_3$ from mollusks and other organisms can persist indefinitely as limestone. In contrast, the carbon contained in most plant and animal tissues return to CO_2 in a few years, at most. Molluscan shellfish aquaculture, therefore, has two products: food for humans, and long-term storage of greenhouse gases.

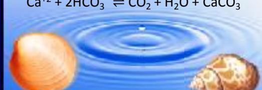
Shellfish aquaculture practices, however, do not produce merely the shells of the product species, but also attached or associated shell-bearing animals, such as other bivalves, snails, and barnacles. Under best management practices, shellfish aquaculture is conducted in areas that did not previously support large shellfish populations, so most of the associated shell can be considered production that would not have otherwise occurred. This study was conducted to quantify shell production and carbon association with culture of the northern hard clam, *Mercenaria mercenaria*, at Cedar Key, Florida.

Carbon dioxide dissolves in seawater

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

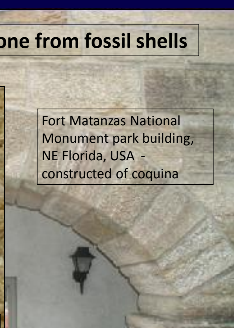
Mollusks mineralize carbonate

$$Ca^{+2} + 2HCO_3^- \rightleftharpoons CO_2 + H_2O + CaCO_3$$



COQUINA - limestone from fossil shells

close-up of coquina



Fort Matanzas National Monument park building, NE Florida, USA - constructed of coquina

Acknowledgements

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Clam Farming in Florida

- Northern hard clams, *Mercenaria mercenaria*, are acquired as juveniles from commercial hatcheries.
- Clams are cultivated in mesh bags on the bottom in state lease areas (lease areas were selected by the state based on lack of prior commercial mollusk populations).

- After a grow-out period of 12-18 months, mesh bags with clams are harvested. Clams are sorted and graded, and rejected clams, dead shells, and other species are discarded.

$CaCO_3$ Shell from Clam Farming

Source of Shell	Fate of Shell
1. shells of harvested market clams	1. distributed to restaurants & retailers
2. dead & rejected clams	2. recycled as oyster reefs*
3. other bivalves & shelled organisms in bags	3. recycled as oyster reefs*
4. oysters & other shelled organisms on bags	4. recycled as oyster reefs*

*some become roadway material or accumulate around processing areas

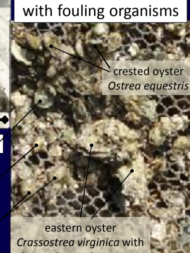
Sample Collection

- 1 clam bag = 1 sample: N = 36
- market clams counted, subsample measured to estimate total shell weight
- all other shell material (retained on 5 mm mesh) from in clam bag collected
- bags with fouling organisms also collected

Sample Processing

1. Freeze samples to kill tissues
2. Warm-water tissue maceration to remove most soft tissues
3. Bleach to remove remaining tissues
4. Dry/weigh shells & bags
5. Acid-wash bags to dissolve attached shell
6. Dry/re-weigh bags to estimate attached shell mass

Clam grow-out bag, after harvest



Close-up of clam bag with fouling organisms

Calculating Carbon per Clam Bag

a) harvested clams → A. count clams, measure subsample, use size-weight relationship to estimate shell mass

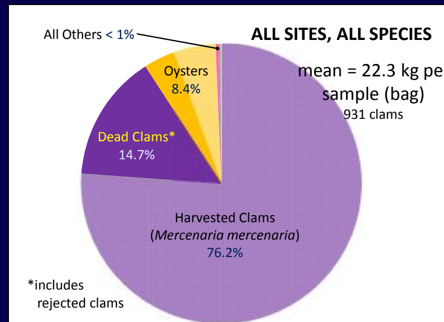
b) dead /culled clams & other loose shell → B. process, dry, & weigh

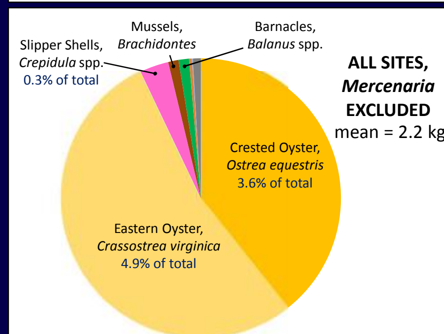
c) oysters attached to bags → C. dry & weigh bags, acid-wash, reweigh

Sum **A** through **C**
multiply by 0.96 (fraction of shell that is $CaCO_3$)
and 0.12 (C as fraction of $CaCO_3$)

Results

- Harvested clams accounted for about 3/4th of the shell material over 5 mm
- Most non-harvested shell is dead or rejected hard clams, *Mercenaria*
- Remaining shell is mainly from oysters (below)





By the Numbers

- 921 clams per bag in these samples
- 22.5 kg of shell ($CaCO_3$ only) per bag
- 8965 kg /ha/year = (7170 kg/lease/y)
- including associated shell, 24.4 g of $CaCO_3$, or 2.9 g carbon, are fixed per clam
- 541 metric tons of carbon fixed in 2008 by Florida clam farms

Clearly, we must eat more clams.