Tidal Restoration Reduces CH$_4$ Emissions in Salt Marshes: A Case Study from Casco Bay, Maine

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** Special Shout Out to Hollie Emery and Wally Fulweiler**
Schematic of GHG Budgets in Saltmarshes

(from Johnson et al., in press)
It follows that CH$_4$ emissions rates are variable as well...
Salinity vs CH$_4$ Flux

Poffenbarger et al., (2011)
Purpose of This Talk

- Generate CH4 emissions factors associated with tidal restoration.
- Identify a potential vegetation proxy for CH₄ emissions.
- Explore the carbon benefits associated with tidal restoration at Long Marsh, Harpswell ME.
MAINE ~5600 km Coastline
82 km$^2$ Salt Marsh
128 km$^2$ Eelgrass Beds
MAINE SALT MARSH GEOMORPHOLOGY

(From Kelley et al., 1988)
Maine Coastal Compartments
(after Jacobson et al., 1987)
Sebascodegan I.
Harpwell, ME

Famous Maine Saying:

“You can’t get they’ah from he’ah.”
Long Marsh, Harpswell ME

- Old Road Crossing
- Dredge Spoils
- Undersized Culvert
Mouth of Long Reach Creek
pre and post restoration

Undersized Culvert, 2009

Expanded Culvert, 2014
Pre-Post Restoration:
Typha Mortality and Salinity Change

Before (July 2013)

GW Salinity = 8 PSU

After (July 2014)

Pore Water Salinity = 26 PSU
Post Restoration: Typha Mortality (July 2015)

Transitional Zone = Dead Typha
Study Design

- Pre- and Post-Restoration Monitoring (CBEP)
  2013, 2014 thru 2018
  - Vegetation Composition
  - Marsh Elevation
  - GW salinity and hydrology

- CH4 Emissions at Range of Salinities (Bates)
  - 2015, 2016, 2017 (?)
  - Static Chamber Field Sampling and GC-FID Analysis
  - Carbon benefits:
    CH4 emissions of fresh site * Area fresh lost * Time
Typha Mortality and Vegetation Change

Area live *Typha*:

- **2013 (pre):** 3.37 ha
- **2015 (post):** 0.26 ha
Vegetation Response

Salinity index based on Verrill 2015
CH4 SAMPLING SITES

FRESH
BRACK
TRAN W
TRAN E
SAL

July, 2015

Salinity (ppt)
- 1.00 - 6.00
- 6.01 - 16.0
- 16.1 - 22.0
- 22.1 - 27.0
- 27.1 - 30.0
Chamber Results: CH₄ (ppm) vs Time

**Fresh C1 (8/14/15)**

\[ y = 0.0186x + 1.9245 \]
\[ R^2 = 0.7243 \]

**Fresh C1 (7/29/15)**

\[ y = 0.1553x + 3.0821 \]
\[ R^2 = 0.9892 \]

**Saline C1 (8/14/15)**

\[ y = 9E^{-05}x + 1.7478 \]
\[ R^2 = 0.0014 \]

**Brack C1 (8/14/15)**

\[ y = 0.0047x + 1.7188 \]
\[ R^2 = 0.7688 \]
Long Marsh (in Blue)

(modified after Poffenbarger et al., 2011)
Average CH$_4$ Flux for Each Site
July, August & October

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<th>Site</th>
<th>July</th>
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Flux (µmol CH$_4$/m$^2$/hr)
Carbon Benefits (Reduction in CH$_4$ Emissions)

- Avg CH$_4$ flux in Typha = 61.8 umoles CH$_4$/m$^2$ hr

- Restoration resulted in loss of Typha habitat (3.1 ha)

- “3-Month” Reduction in CH$_4$ emissions since restoration
  ~ 70 kg CH$_4$ (~1750 kg CO$_2$e)
128 Candidate Restoration Sites

Tidal Restrictions

Field Data 2012
- Yes
- No
Preliminary Conclusions

1. Avg CH$_4$ flux in Typha = 61.8 umoles CH$_4$/m$^2$ hr

2. Avg CH$_4$ flux in transitional areas = 6.4 umoles CH$_4$/m$^2$ hr

3. Typha = Good proxy for salinity and CH$_4$ emissions.
   - 1.5 years after tidal restoration, Typha die-back was thorough and accompanied by minimal CH$_4$ emissions.

4. At Long Marsh, “3-month” reduction in CH$_4$ emissions of ~70 kg.
Questions?
Maine Coastal Compartments
(after Jacobson et al., 1987; Kelley et al., 1988)

- Back Barrier Marshes (26.4 km²)
- Stream Valley Marshes (27.4 km²)
- Small Fringing Marshes (20.6 km²)
- Isolated Marshes (4.5 km²)
- Arcuate Embayments
- Indented Shoreline
- Cliffed Shoreline
- Island-Bay Complex
Tidal Restrictions
Reducing Conditions in Flooded Soils

From https://microbewiki.kenyon.edu/index.php/Central_Metabolism_(Flooded_soils)
Elevation Profiles from LIDAR

Old Road Crossing

Undersized Culvert
**CH₄ Flux Measurements**

At each site-
- 3 collars (to seat 3 chambers)
- Gas sampled 7x over 40 mins
  (after Emery and Fulweiler, 2014)

[CH₄] measured via GC-FID using a Supelco Carboxen 1006 PLOT Column, in the EGL at Bates.

Final flux calculations using Ideal Gas Law and surface area.
Research Questions

- How does restoration of salt marsh hydrology impact CH4 emissions, salinity, and vegetation?
- Over what time-scales?
Remove Tidal Restrictions = Recovery

(from Burdick et al., 1997)
Long Marsh, Harpswell ME
Impact of Tidal Restrictions

- Reduce salt water flooding/Freshen the salt marsh
- Change vegetation
- Increase water on marsh
- Reduce sediment inputs
- Decrease in fish and nutrient exchange with adjacent estuary

- Expect an increase CH$_4$ emissions (Where? How much? Why?)