Rapid recovery of sediment nutrients in Mosquito Lagoon’s restored reefs

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Knowledge gap in oyster reef recovery

Placement of loose oyster shell

Placement of loose oyster shell

Weeks

2-5 months +

6-8 Months

2 years

226 % in fisheries value
Knowledge gap in oyster reef recovery

Recovery of Biogeochemical cycling?
Elemental Cycling

Controls community structure and ecosystem functioning

Degradation

Mineralization

Carbon

Nitrogen

Phosphorus

Ammonium

Nitrate

Phosphate

Biological uptake

Carbohydrates

Proteins

Fats
Biogeochemical hotspots

- Biotic factors (filter feeding and microbial transformation)
- Abiotic factors (hydrodynamics and deposition)
Research questions

1) When do sediment nutrient pools in restored reefs reach the levels measured in natural reefs?

2) Do nutrient pools differ between dead, restored and natural oyster reefs?

3) How do sediment nutrients relate to reef biophysical properties?
Methods

• UCF Biology’s Mosquito Lagoon restoration program
• (May 2017) Before restoration, 1-week, 1-month, 6-months, 9-months and 12-months post-restoration (June 2018)
• Surface layer (0-5 cm) of sediment
• Linear mixed effects models in R
  • Reef type and time as fixed effects and reefs 1-4 as random effects
• Restored reef sediments 75% increase from pre-restoration to twelve months, dead reefs 12% and natural reefs 32%
Nitrogen – ammonium ($\text{NH}_4^+$)

- 1-month post-restoration $\rightarrow$ significant increase
- After 12 months, 136% increase in restored reefs
- negative % change in dead and natural reefs

<table>
<thead>
<tr>
<th>LME Model p values</th>
<th>$\text{NH}_4^+$</th>
</tr>
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<tbody>
<tr>
<td>Treatment</td>
<td>0.082</td>
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<tr>
<td>Time</td>
<td>$&lt;0.001$</td>
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<td>Treatment:Time</td>
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<tr>
<td>Random Reef</td>
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Nitrogen – total (organic + inorganic)

• After 12 months, 78% increase in restored reefs

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<tr>
<th>LME Model p values</th>
<th>Total N</th>
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<td>Treatment</td>
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Reef biophysical properties

- Recorded at 6, 9 and 12 months
- live oyster densities (# oysters 0.25 m$^{-2}$)
- shell lengths (mm)
- reef height (mm)

- Track sediment nutrients with development of reefs

- As oyster density, shell length, and reef height increases biodeposition and structural complexity increases
Reef biophysical properties

- Correlation coefficients between sediment nutrients and biophysical characteristics
- Bold p < 0.05, bold and italics p < 0.01

**Significant correlations:**
- Organic matter
- Total nitrogen
- Total phosphorus

<table>
<thead>
<tr>
<th>Months</th>
<th>OM</th>
<th>DOC</th>
<th>TC</th>
<th>NO$_3^-$</th>
<th>NH$_4^+$</th>
<th>TN</th>
<th>SRP</th>
<th>TP</th>
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<tbody>
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<td>0.043</td>
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<td>Reef</td>
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- Oysters can contribute to sediment nutrient increase
Biophysical parameters to $\text{NH}_4^+$

- 33% increase in $\text{NH}_4^+$
- 146% increase in oyster density
- 79% increase in shell length
- 36% increase in reef height
Monitoring sediment nutrients

Total Nitrogen (g kg\(^{-1}\))

- Before
- 1-week
- 1-month
- 6-months
- 9-months
- 12-months

Time Post-restoration

Organic Matter (g kg\(^{-1}\))

- Before
- 1-week
- 1-month
- 6-months
- 9-months
- 12-months

Time Post-restoration

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Monitoring sediment nutrients

• Total Carbon/Total Nitrogen Analysis
  • UC Davis analytical services $90 set up cost plus $36/sample
  • UVM $20/sample
  • 20 reefs sampled twice per year with 5 samples per reef
  • 200 samples per year = $7,380 per year

• Organic Matter Content
  • 8ft polycarbonate tube $30
  • Beakers/ceramic cups $100
  • Precision balance
    • $500 to $1,500
  • Drying oven
    • $400 for 20L and $700 for 85L
  • Benchtop muffle furnace
    • $1,400 to $3,500
  • $ 2,300 - 5,700 total

• Indicator of ecosystem health
• Compare results to other restored reefs
Acknowledgements

NSF Coupled Natural Human Systems Grant
Aquatic Biogeochemistry Lab
Coastal and Estuarine Ecology Lab
Field Help