Phosphorus availability and salinity control productivity and demography of *Thalassia testudinum* in Florida Bay.

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FCE LTER Marine Sites

P decreases SW to NE
Salinity variability increases

Fourquean & Zieman. 2002. *Biogeochemistry*
P decreases SW to NE
Salinity variability increases

Elevated P from groundwater
Highly variable salinity

Price et al. 2006. Hydrobiologia
Objectives

Analyze long-term data spanning a seven year collection of biomass, density, and productivity measurements of *T. testudinum*.

Determine how aboveground and belowground components of biomass and growth change as a function of nutrients and salinity.

Examine relationships between aboveground and belowground biomass, productivity, and ramet demography.
Data Collections

Collected 6x annually
- Ramet density
- Aboveground biomass
- Leaf initiation & growth
- Leaf N and P content

Single collection
- Ramet, rhizome, & root mass
- Ramet age distributions

Long-term salinity archives
- Water Quality Monitoring Network, SERC, FIU
- Everglades National Park
Methods

*Thalassia* leaf productivity
Methods

**Thalassia** belowground productivity

Determination of population structure

Belowground productivity estimated from recruitment rate, assuming equilibrium population structure.
Seasonality

\[ Y = \bar{Y} + \alpha \sin(\text{DOY} + \phi) \]

\( \bar{Y} \) = mean of the time series
\( \alpha \) = amplitude of the sine wave
\( \phi \) = phase angle
\( \text{DOY} \) = day of year in radians

\( \bar{Y} \pm 95\% \) confidence interval and \( \alpha \) describe site means and seasonality.
### Results

**Thalassia** characteristics by site

<table>
<thead>
<tr>
<th>Site</th>
<th>Foliar P (%)</th>
<th>Foliar N (%)</th>
<th>Ramet density (m²)</th>
<th>Dry mass (mg ramet⁻¹)</th>
<th>Total mass (g m⁻²)</th>
<th>Pₛ biomass ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprigger Bank</td>
<td>0.134</td>
<td>2.05</td>
<td>221</td>
<td>Leaves: 213 Ramet: 71.6</td>
<td>355</td>
<td>148</td>
</tr>
<tr>
<td>Bob Allen Keys</td>
<td>0.061</td>
<td>2.53</td>
<td>295</td>
<td>Leaves: 54.1 Ramet: 62.1</td>
<td>227</td>
<td>18.4</td>
</tr>
<tr>
<td>Duck Key</td>
<td>0.050</td>
<td>2.31</td>
<td>612</td>
<td>Leaves: 30.8 Ramet: 38.1</td>
<td>167</td>
<td>35.4</td>
</tr>
<tr>
<td>Little Madeira</td>
<td>0.078</td>
<td>2.29</td>
<td>525</td>
<td>Leaves: 55.6 Ramet: 28.7</td>
<td>153</td>
<td>18.2</td>
</tr>
<tr>
<td>Trout Cove</td>
<td>0.085</td>
<td>2.46</td>
<td>470</td>
<td>Leaves: 59.9 Ramet: 79.3</td>
<td>153</td>
<td>41.8</td>
</tr>
</tbody>
</table>
Results

Leaf Emergence Rate

<table>
<thead>
<tr>
<th>Location</th>
<th>$r^2$</th>
<th>PI (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprigger Bank</td>
<td>0.44</td>
<td>25.6 (47.6 – 17.5)</td>
</tr>
<tr>
<td>Bob Allen Keys</td>
<td>0.33</td>
<td>35.5 (52.6 – 25.6)</td>
</tr>
<tr>
<td>Duck Key</td>
<td>0.36</td>
<td>32.3 (55.6 – 22.7)</td>
</tr>
<tr>
<td>Little Madiera</td>
<td>0.37</td>
<td>27.8 (45.5 – 20.0)</td>
</tr>
<tr>
<td>Trout Cove</td>
<td>0.32</td>
<td>28.6 (47.6 – 20.4)</td>
</tr>
</tbody>
</table>

LER and seasonal amplitude are correlated with foliar P.
Results

Standing Crop and Aboveground Production vs. P

Leaf standing crop and productivity are correlated with foliar P
Results

Relative Growth Rate and Salinity

Duck Key

Bob Allen Keys

Sprigger Bank

Trout Cove

Little Madiera

Salinity (psu)

Relative Growth Rate (mg g\(^{-1}\) day\(^{-1}\))

\(r^2 = 0.41\)

\(r^2 = 0.46\)

\(r^2 = 0.40\)

\(r^2 = 0.32\)

\(r^2 = 0.29\)

Highly variable salinity reduced the predictability of RGR
Results

Residual Analysis of Predicted vs. Observed Relative Growth Rate

RGR was depressed at low and high salinities
Seasonal Amplitude in Aboveground NPP vs. Salinity Variability

Seasonal amplitude of ANPP increased with salinity variability
Results

Population Structure, Mortality, and Recruitment

<table>
<thead>
<tr>
<th>Location</th>
<th>Median Mortality Rate ($M$) $\pm$ Standard Error</th>
<th>$R_0$ and $R_G$ Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprigger Bank</td>
<td>$0.81 \text{ y}^{-1} \pm 0.26$</td>
<td>$0.89, 1.04$</td>
</tr>
<tr>
<td>Bob Allen Keys</td>
<td>$0.27 \text{ y}^{-1} \pm 0.05$</td>
<td>$0.29, 0.30$</td>
</tr>
<tr>
<td>Duck Key</td>
<td>$0.28 \text{ y}^{-1} \pm 0.07$</td>
<td>$0.44^<em>, 0.44^</em>$</td>
</tr>
<tr>
<td>Little Madiera</td>
<td>$0.74 \text{ y}^{-1} \pm 0.13$</td>
<td>$0.64, 0.82$</td>
</tr>
<tr>
<td>Trout Cove</td>
<td>$0.37 \text{ y}^{-1} \pm 0.09$</td>
<td>$0.63^<em>, 0.61^</em>$</td>
</tr>
</tbody>
</table>

Low rates of mortality and recruitment where P availability is low
Results

Aboveground and Belowground Productivity

Belowground productivity is 23% - 37% of aboveground productivity
Results

Above vs belowground mass allocation correlated with P
Belowground NPP correlated with leaf standing crop but not P
Belowground RGR correlated with leaf standing crop and P
Indices of total productivity correlated with P
Results

Current Recruitment Rates and Long-Term Mortality Rates

Recruitment strongly correlated and mortality weakly correlated with leaf mass, NPP, and P
Conclusions

**P availability** controls on *Thalassia testudinum* include:

- Biomass allocation to photosynthetic structures
- Indices of NPP
  - Leaf emergence rates
  - ANPP and aRGR, and to a lesser extent BNPP and bRGR
- Recruitment and mortality of ramets

NPP and mortality are strongly tied to the standing crop of leaves.

Belowground NPP allocation is approximately a third of total NPP.

**Salinity extremes** depress site-specific RGR, and the frequency of extreme salinity events appears to be a factor controlling NPP.
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