Linking science to management: 
Search for a Miner’s Canary

– Describe the spatial and temporal dynamics of the genus *Halimeda* in the seagrass beds in the FKNMS.

– Evaluate the mass production and correlate it with nutrient availability.

– Evaluate the potential use of *Halimeda* as an indicator for changes in productivity and acidification.
Why Halimeda?

• Calcareous green macroalgae are the dominant non-vascular flora found in seagrass in the FKNMS (Fourqurean and Rutten 2001).

• Seagrass monitoring program show that calcareous green species of the genus *Halimeda* are increasing in the FKNMS. (Collado-Vides et al 2005, 2007).
Why Halimeda?

*Halimeda* is a genus of considerable importance in coral reef areas including seagrass beds, contributing both organic production and significant amounts of calcareous sediment.

Deposition of calcium carbonate by marine algae (in shallow and deep sea environments) is an important aspect of the global carbon cycle (blue carbon).

Carbonate sediments produced by the Codiacean genus *Halimeda* make a major contribution to reef mass in regions such as the Bahamas, Tahiti and the Great Barrier Reef.

Good indicators for historic climatic reconstructions.

Spatial Distribution of Calcareous Green Algae

Collado-Vides et al 2005
30 sites in the FKNMS studied during 2005-2006 and a long term study in Sprigger Bank
Halimeda in the FKNMS

Halimeda incrassata
Halimeda monile
Halimeda tuna
Halimeda discoidea
Halimeda scabra
Halimeda simulans
Halimeda gracilis
Halimeda lacrimosa
Halimeda opuntia
Spatial distribution

*Halimeda* is widely distributed in the FKNMS seagrass beds.
### 31 sites along the FKNMS

<table>
<thead>
<tr>
<th>DW g/m²</th>
<th>Mass</th>
<th>CaCO₃</th>
<th>Biomass</th>
<th>Mass</th>
<th>CaCO₃</th>
<th>Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>41</td>
<td>33</td>
<td>8.2</td>
<td>341</td>
<td>273</td>
<td>68.2</td>
</tr>
<tr>
<td>S. D. mean</td>
<td>10</td>
<td>8.3</td>
<td>2.1</td>
<td>88.5</td>
<td>70.8</td>
<td>17.7</td>
</tr>
<tr>
<td>Max</td>
<td>336 SP</td>
<td>269</td>
<td>67</td>
<td>1013 SP</td>
<td>810</td>
<td>203</td>
</tr>
</tbody>
</table>

### Sprigger Bank FL Bay

<table>
<thead>
<tr>
<th>DW g/m²</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>103.3</td>
</tr>
<tr>
<td>Max</td>
<td>260.92</td>
</tr>
<tr>
<td>Min</td>
<td>8.65</td>
</tr>
</tbody>
</table>

**Puerto Morelos Mexico**

Tussenbroek and Djik 2005
Halimeda CaCO₃ production

<table>
<thead>
<tr>
<th></th>
<th>SP</th>
<th>SU</th>
<th>FA</th>
<th>WI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Growth</td>
<td>6.65</td>
<td>20.14</td>
<td>6.52</td>
<td>3.50</td>
</tr>
<tr>
<td>Density</td>
<td>29.53</td>
<td>49.48</td>
<td>5.76</td>
<td>15.30</td>
</tr>
<tr>
<td>CaCO₃/m²/y</td>
<td>157.10</td>
<td>797.25</td>
<td>30.04</td>
<td>42.84</td>
</tr>
<tr>
<td>Grand mean</td>
<td>256.81</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

50 - 2323 g CaCO₃ m⁻²/y world wide reports.


23 g m⁻²/y on a backreef the Florida Keys (Bosence et al., 1985)

1000 g m⁻²/y in the Marquesas Keys (Hudson 1985).

225 g m⁻²/y 200 Km from Marquesas Keys (Davis and Fourqurean 2001)

815 g m⁻²/y Puerto Morelos Mexico (Tussenbroek and Djik 2005)
Distribution and morphometric variability as a function of distance from shore

<table>
<thead>
<tr>
<th>Distance from shore</th>
<th>Close</th>
<th>Mid</th>
<th>Long</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundant</td>
<td>Fewer</td>
<td>Fewer</td>
<td></td>
</tr>
<tr>
<td>More mass</td>
<td>Less mass</td>
<td>Less mass</td>
<td></td>
</tr>
<tr>
<td>Short size</td>
<td>Short size</td>
<td>Larger</td>
<td></td>
</tr>
</tbody>
</table>

**Graphs:**
- Distribution of dry weight in g/m² across different distances from shore.
- Distribution of number of plants/m² across different distances from shore.
- Distribution of thallus length in cm across different distances from shore.
Nutrient correlations

Collado-Vides et al 2007

Kendall tau b correlation between Halimeda and TN and TP
• Morphometrics of *Halimeda* can be good indicator of the conditions under which they are found
  — Yñiguez et al 2010

• Larger and more upright forms tend to be in lower-light, higher-nutrient, and calmer environments
  — Beach et al. 2003, Vroom et al. 2003

• Linear correlation between CaCO3 and biomass, a ratio that can be used as indicator of calcification status. Loss of CaCO3 is expected as pH decreases.
  — Borowitzka 1984, Andersson et al 2009, many others
Recent shifts in *Halimeda* trends in Sprigger Bank

\[ y = 0.3358x^2 - 21.507x + 487.87 \]
\[ R^2 = 0.3031 \]
Calcareous Green Algae abundance

CO2 ↔ CaCO3

Photosynthesis and Calcification rate

Seagrass increase

Nutrient enrichment N and P

Increase in nutrients might affect CGH growth and morphology

Thalassia testudinum compete with Halimeda for nutrients.

Semesi et al. 2009
Davis & Fourqurean 2001
Campbell & Fourqurean 2010

Waycott et al. 2009
Duarte et al. 2008

Beer & Larkum 2001
Demes et al. 2010

Borowitzka 1984...

Beach et al. 2003, Vroom et al. 2003, Yñiguez et al. 2010
Conclusions

• Our data set is a base-line that will allow us detect potential changes in CaCO3 expected to happen under change of CO2 and pH scenarios.

• Changes in *Halimeda* will be the result of a set of complex processes in which nutrients and competition will play an important role in the final output, as well as CO2 and pH changes.

• We suggest that *Halimeda* should be included in long term monitoring programs as indicators of productivity and acidification at large scales in the FKNMS.
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• FCE- LTER

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