RAINWATER KILLIFISH IN NEARSHORE EPIFAUNAL COMMUNITIES OF SOUTHERN BISCAYNE BAY: INDICATOR OF ECOSYSTEM CHANGE FOR SOUTH FLORIDA RESTORATION ASSESSMENTS

G.A. Liehr*¹, J.A. Browder, S. Bellmund, D. Lirmann, J. Serafy, T. L. Jackson

*¹ corresponding author: ph.: +1 -850 -245 -8779, @: Gladys.Liehr@dep.state.fl.us
Biscayne Bay will be affected by structural and operational changes in the water management system planned under the Comprehensive Everglades Restoration Plan (CERP).

As part of CERP RECOVER, the Integrated Biscayne Bay Ecosystem Assessment and Monitoring (IBBEAM) Team is monitoring and assessing nearshore flora and fauna in relation to salinity.

Results are being used to help prepare ecological indicators and performance measures to assess effects of water management changes as they are implemented.
Rainwater killifish – *Lucania parva*

- Most numerically-dominant fish species in nearshore Biscayne Bay.
- Stress specialist: Highly tolerant of hypoxia, high temperature, high salinity and rapid salinity changes.
- Important prey to economically valuable species such as spotted seatrout and gray snapper.
- Potential indicator species?
Objective

- Examine rainwater killifish abundance and condition in relation to salinity indices.

**Biota**
- Density
- Condition factor

**Salinity**
- Mesohaline Index
- Hypersaline Index

Temporal and Spatial Pattern
Changes with Halohabitat
Captured with Quantile Regression
IBBEAM Material & Methods

- Samples dry and wet season, Dry 2008–Dry 2015 at 44 sites.
- Salinity, temperature, DO, pH, and depth recorded.
- Fish collected with 1 m² throw-trap, thrown 3-times per site, 4 sweeps.
- Samples identified, measured, and weighed.
- Salinity data recorded at 15-min intervals 365 days/yr, 24/7, at 17 nearby sites.
<table>
<thead>
<tr>
<th>Area</th>
<th>Site ID</th>
<th>WQ</th>
<th>Wet</th>
<th>Faunal Sampling (3m2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Site ID</td>
<td>Dry</td>
<td>Wet</td>
<td>Site ID</td>
</tr>
<tr>
<td>1</td>
<td>D6</td>
<td>86976</td>
<td>70651</td>
<td>1-2</td>
</tr>
<tr>
<td>2</td>
<td>D2</td>
<td>86975</td>
<td>70656</td>
<td>3-4</td>
</tr>
<tr>
<td>3</td>
<td>62</td>
<td>86247</td>
<td>70547</td>
<td>5-6</td>
</tr>
<tr>
<td>4</td>
<td>C8</td>
<td>70930</td>
<td>70655</td>
<td>7-8</td>
</tr>
<tr>
<td>5</td>
<td>C6</td>
<td>70944</td>
<td>70501</td>
<td>9-10</td>
</tr>
<tr>
<td>6</td>
<td>56</td>
<td>70648</td>
<td>70656</td>
<td>11-12</td>
</tr>
<tr>
<td>7</td>
<td>C4</td>
<td>70944</td>
<td>70654</td>
<td>13-14</td>
</tr>
<tr>
<td>8</td>
<td>C2</td>
<td>70944</td>
<td>66342</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>B8</td>
<td>87263</td>
<td>69885</td>
<td>16-17</td>
</tr>
<tr>
<td>10</td>
<td>B6</td>
<td>87264</td>
<td>70656</td>
<td>18-19</td>
</tr>
<tr>
<td>11</td>
<td>B4</td>
<td>86352</td>
<td>70656</td>
<td>20-26</td>
</tr>
<tr>
<td>12</td>
<td>40</td>
<td>86976</td>
<td>66022</td>
<td>27-29</td>
</tr>
<tr>
<td>13</td>
<td>28</td>
<td>86976</td>
<td>70656</td>
<td>30</td>
</tr>
<tr>
<td>14</td>
<td>22</td>
<td>84463</td>
<td>70656</td>
<td>31-32</td>
</tr>
<tr>
<td>15</td>
<td>A8</td>
<td>87262</td>
<td>68097</td>
<td>33-37</td>
</tr>
<tr>
<td>16</td>
<td>14</td>
<td>76256</td>
<td>67379</td>
<td>38-39</td>
</tr>
<tr>
<td>17</td>
<td>A6</td>
<td>85961</td>
<td>70656</td>
<td>40-44</td>
</tr>
</tbody>
</table>
Comparison of Salinities Measured

<table>
<thead>
<tr>
<th>Season/Year</th>
<th>D11</th>
<th>W11</th>
<th>D12</th>
<th>W12</th>
<th>D13</th>
<th>W13</th>
<th>D14</th>
<th>W14</th>
<th>D15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinity (psu)</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>30</td>
<td>32</td>
<td>34</td>
</tr>
</tbody>
</table>

Salinities at Epifaunal Sampling Event

Salinities from 15min BNP data

\[ y = 1.177x - 3.6858 \]

\[ R^2 = 0.85 \]
## Rainwater killifish density per season/year

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry season</strong></td>
<td>Average log(Density (3m²) +1)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>Wet season</strong></td>
<td>Average log(Density (3m²) +1)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

![Bar chart showing the average log of rainwater killifish density per season/year from 2010 to 2016.](image-url)

- **Dry season**
  - 2010: 0
  - 2011: 1
  - 2012: 2
  - 2013: 3
  - 2014: 4
  - 2015: 3
  - 2016: 3

- **Wet season**
  - 2010: 3
  - 2011: 3
  - 2012: 3
  - 2013: 3
  - 2014: 3
  - 2015: 3
  - 2016: 3

The chart indicates a generally increasing trend in density from 2010 to 2016, with a peak in 2013 for both seasons. The dry season typically shows higher densities compared to the wet season.
Rainwater killifish density and salinity of selected season/years:
Rainwater killifish Length-Weight relationship:

Relative Condition

\[ Kn = \frac{W}{W'} \quad \rightarrow \quad W' = a \cdot L^b \]

Growth of the fish

\[ b = \frac{\log(W) - \log(a)}{\log(L)} \]

***theoretical ideal growth results in \( b = 3 \)***
Rainwater Killifish Condition vs Halohabitat:

- **Normality Test (Kolmogorov-Smirnov)**
  - Failed  \((P < 0.050)\)

- **Kruskal-Wallis One Way Analysis of Variance on Ranks**
  - \(p = 0.047\)

- **Normality Test (Shapiro-Wilk)**
  - Passed  \((P = 0.332)\)

- **Equal Variance Test:**
  - Passed  \((P = 0.906)\)

- **One Way Analysis of Variance**
  - \(P < 0.001\)
Quantile Regression

Density vs. Mesohaline Salinity Index Condition

<table>
<thead>
<tr>
<th>Quantile</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>0.8</td>
<td>0.0006</td>
</tr>
<tr>
<td>0.9</td>
<td>0.0082</td>
</tr>
</tbody>
</table>

Mesohaline Index: Proportion of time with salinity in range 5 - 18.
Quantile Regression

Density vs. Hyperhaline Salinity Index Condition:

<table>
<thead>
<tr>
<th>Quantile</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>0.00551</td>
</tr>
<tr>
<td>0.8</td>
<td>0.09363</td>
</tr>
<tr>
<td>0.9</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Hyperhaline Index: $1 - \text{Proportion of time when salinity was greater than 38 ppt.}$
Conclusions

- Abundance and condition factor, a function of weight to length that reflects fish health, is influenced by salinity in the rainwater killifish.

- Quantile regression is an appropriate method to estimate functional relationships for all parts of a probability distribution.

- Rainwater killifish is a potential indicator of salinity change in Biscayne Bay.
Acknowledgment – *Special Thanks*

Robin Casioli
Crawford Drury
G. Harris
M. Harangody
C. Hermann
Rolando Santos
St. Schopmeyer
B. Teare
C. Vilmar
Ian Zink