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Movements of Juvenile Green Turtles (*Chelonia mydas*) in Nearshore Waters of the Northwestern Gulf of Mexico

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Green turtles utilize Texas waters primarily as juvenile foraging habitat.

Increasing number of greens stranding in TX during cold stunning events (Shaver et al. 2017); Overwintering
STUDY OBJECTIVES

 Track movements of juvenile green turtles in Texas waters

 Utilize Hierarchical Switching State-Space Model (hSSM) to determine track behavioral status - Resident vs. Migratory

 Utilize Kernel Density Estimation (KDE) to determine core use (50%) and home range (95%) areas

 Perform Space-Time Hot Spot Analyses to identify trends in habitat use

 Examine influence of biotic and abiotic factors on habitat use
MATERIALS AND METHODS

Study Areas

Entanglement Nets:
91.4 m long; 2.9-3.6 m deep
17.8 cm bar mesh
2-4 nets deployed

Seney and Landry (2008)
MATERIALS AND METHODS

- Track data filtered and processed similarly to Seney and Landry (2011) in STAT (Coyne & Godley, 2005)
- Hierarchical Switching State-Space Model (hSSM)
  - Applied methods described by Dawson et al. 2017 and Jonsen 2017
  - RStudio package ‘bsam’
- KDE Core Area and Home range
  - Excluded hSSM b values < 1.6 (Dawson et al. 2017)
  - Utilized KDE tool in ArcGIS 10.3 in conjunction with ‘ks’ library in Rstudio
- Space-Time Hot Spot Analyses of habitat use
  - Getis-Ord (Gi*) statistic returned for each feature is a z-score (Getis and Ord, 1992); the larger the z-score, the more intense the clustering of high values (e.g. “hot-spots”)
  - Mann-Kendall trend test is performed on every location with data as an independent bin time-series test
MATERIALS AND METHODS

- Influence of biotic and abiotic factors on habitat use:
  - Seagrass data (Texas Only)
  - NOAA Marine Cadastral Dataset (https://marinecadastre.gov/data/)
  - Overlapped seagrass habitat with 50% and 95% KDE contours

- Water Temperature - Laguna Madre Only
  - PTT-derived temperature data paired with raw track latitude (Argos) to determine temperature exposure during track
  - National Buoy Data Center (NBDC) data paired with hSSM-derived latitude; Non-linear regression to determine temperature at which turtles initiated migration
Green Turtle Satellite Tracking (2006-2011)

- **AB**: 3 wild; 1 rehab
- **LM**: 8 wild; 1 rehab
- **MB**: 1 wild; 1 rehab

Rehab turtles provided by:
- NMFS Galveston Lab/Moody Gardens Aquarium
- Animal (Amos) Rehabilitation Keep
- Sea Turtle, Inc.
# RESULTS - TRACK STATS

<table>
<thead>
<tr>
<th>Turtle Name</th>
<th>SCL (cm)</th>
<th>Study Area</th>
<th>Release Date</th>
<th>Days at Large</th>
<th># Accepted Locations (N)</th>
<th>Mean Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprout*</td>
<td>48.1</td>
<td>MB</td>
<td>8/1/2006</td>
<td>147</td>
<td>90</td>
<td>-2.424 ± 0.454</td>
</tr>
<tr>
<td>Billy</td>
<td>61.3</td>
<td>MB</td>
<td>6/15/2007</td>
<td>56</td>
<td>127</td>
<td>-1.676 ± 0.136</td>
</tr>
<tr>
<td>Heddy*</td>
<td>48.2</td>
<td>AB</td>
<td>7/24/2006</td>
<td>73</td>
<td>36</td>
<td>-2.407 ± 0.843</td>
</tr>
<tr>
<td>Stickney</td>
<td>43.5</td>
<td>AB</td>
<td>8/7/2006</td>
<td>141</td>
<td>91</td>
<td>-2.031 ± 0.374</td>
</tr>
<tr>
<td>Stretch</td>
<td>45.4</td>
<td>AB</td>
<td>5/21/2007</td>
<td>75</td>
<td>34</td>
<td>-4.981 ± 1.473</td>
</tr>
<tr>
<td>Jeffy</td>
<td>57.5</td>
<td>LM</td>
<td>7/27/2007</td>
<td>43</td>
<td>37</td>
<td>-2.074 ± 0.489</td>
</tr>
<tr>
<td>Coastie</td>
<td>68.6</td>
<td>LM</td>
<td>6/20/2006</td>
<td>41</td>
<td>127</td>
<td>-1.872 ± 0.522</td>
</tr>
<tr>
<td>Ralphie</td>
<td>55.0</td>
<td>LM</td>
<td>5/17/2007</td>
<td>128</td>
<td>117</td>
<td>-4.612 ± 0.833</td>
</tr>
<tr>
<td>Katie</td>
<td>43.4</td>
<td>LM</td>
<td>6/26/2007</td>
<td>43</td>
<td>58</td>
<td>-1.492 ± 0.204</td>
</tr>
<tr>
<td>Andy T</td>
<td>52.5</td>
<td>LM</td>
<td>8/13/2009</td>
<td>16</td>
<td>42</td>
<td>-1.699 ± 0.221</td>
</tr>
<tr>
<td>Sea Aggie</td>
<td>47.1</td>
<td>LM</td>
<td>8/3/2006</td>
<td>207</td>
<td>82</td>
<td>-5.220 ± 1.241</td>
</tr>
<tr>
<td>Laguna</td>
<td>69.2</td>
<td>LM</td>
<td>8/10/2009</td>
<td>263</td>
<td>514</td>
<td>-2.203 ± 0.126</td>
</tr>
<tr>
<td>Whitley</td>
<td>52.5</td>
<td>LM</td>
<td>11/8/2009</td>
<td>193</td>
<td>169</td>
<td>-3.739 ± 0.619</td>
</tr>
<tr>
<td>Papi*</td>
<td>64.8</td>
<td>LM</td>
<td>10/2/2010</td>
<td>181</td>
<td>320</td>
<td>-7.372 ± 0.642</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>53.1 ± 2.4</td>
<td></td>
<td></td>
<td>136. ± 27.6</td>
<td>133.9 ± 33.2</td>
<td>-5.5 ± 1.3</td>
</tr>
</tbody>
</table>

* = Rehabilitated
Fall (red) and summer (orange) locations were restricted to inland waters within Texas bays and estuaries.

Winter (yellow) locations showed longest migrations into the Laguna Madre in Mexico.
RESULTS – KDE & SEAGRASS OVERLAP

- No difference between seasons for core area
- Winter home range sig. larger than summer

- TX core area = 1345 km²; ~25% seagrass cover
- TX home range = 4558 km²; ~17% seagrass cover

- Of available seagrass habitat in Texas, 88% within summer home range
Results - Space-Time Hot Spot

- Consecutive and sporadic hot spot trends detected in the lower reaches of LM near Port Isabel.
- New hot-spot trend detected in the upper reaches of LM near Port Mansfield.
- Hotspots in Mexican Laguna in earlier months (Jan-Mar).
- Hotspots in Matagorda/Aransas Bays later in the year (Apr-Dec).
All migratory turtles remained within waters > 15°C regardless of latitude.

Non-linear relationship in which turtles initiated migration to lower latitudes as water temperatures declined below ~19°C in LM.
SUMMARY & CONCLUSIONS

- Strong fidelity to Texas sea grass beds, especially in Fall and Summer

- Utilizing majority of available seagrass habitat throughout the Texas coast

- Laguna Madre represents area of highest activity, especially later in year, according space-time hotspot analysis

- Although cold stunning events suggest a high degree of overwintering in Texas, green turtles are capable of seasonal migration
  - Migration south to Mexico in Dec.-Jan. and return to Texas Mar.-Apr.
  - Migration initiated at temperatures between 15°C-19°C
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  - Carole Allen (HEART-STRP)
  - US Army Corps of Engineers
Questons


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