Manatee telemetry, spatial modeling, and a camera-based sampling system are used to characterize seagrass beds in the Ten Thousand Islands, Florida, USA

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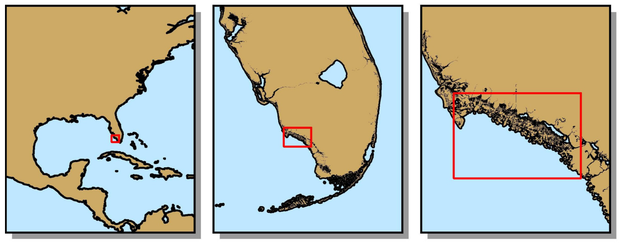
Summary

The Florida manatee (*Trichechus manatus latirostris*) is an endangered species that inhabits most coastal waters of the state. This species is an excellent indicator and sentinel of estuarine health, and is being used as a gauge of Comprehensive Everglades Restoration Plan (CERP) success. One of the habitat needs of manatees is seagrasses or other aquatic vegetation for forage. The Ten Thousand Islands (TTI) is recognized as an important region for manatees, as well as fish, sea turtles, and other wildlife that depend on seagrasses, but knowledge of the spatial distribution and characterization of seagrasses are incomplete. Waters are generally turbid in the TTI, and attempts to map available seagrass beds from aerial imagery have been largely unsuccessful.

We analyzed GPS telemetry records from radio-tagged manatees tracked in the TTI region and created zones of high, medium, and low density use. We then performed stratified field-sampling to correlate the manatee use areas with the occurrence of seagrass or macroalgae during either April (spring) or October (fall). Sampling points were visually scored using a low-light, high resolution camera mounted to a rotating frame.

The most abundant seagrasses found were *Halodule wrightii* and *Thalassia testudinum*. At least one of these species was found in more than 3/4 of the High density sampling points, more than 2/3 of the Medium density cells, and almost 1/2 of the Low density cells, but generally not in the buffers. *Halodule wrightii* was found mostly at <1.5m depth at mean tide, and *T. testudinum* was found in <2.5m depth, but generally >1m depth. Macroalgae was common across all manatee density classes, including the buffers. We also found *Halophila engelmannii*, *Halophila decipiens* and *Syringodium filiforme* in low numbers. Our results indicate that the manatee locations were a good fit to seagrass beds, supporting the initial assumption that manatee use patterns in shallow water reflects foraging efforts targeted at seagrasses.

Study Location



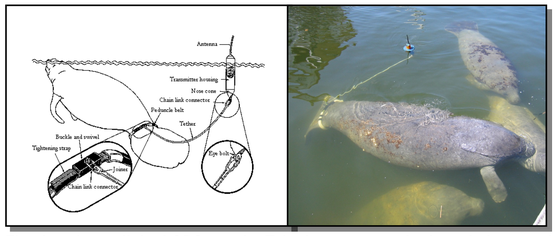
Southwest Florida, U.S. Ten Thousand Islands area, including the northwest portion of Everglades National Park.

Mapping Difficulties

Mangrove tannins cause murky water conditions in the Ten Thousand Islands and poor viewing for seagrass surveys.

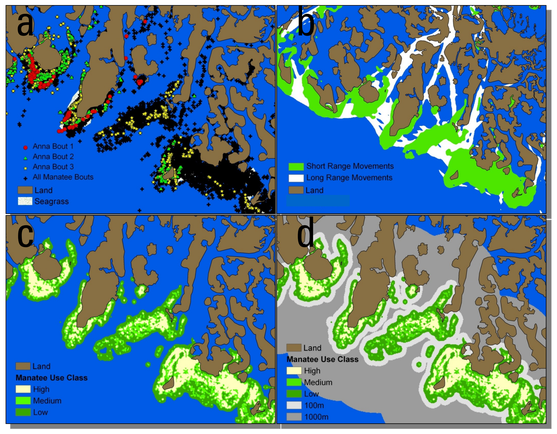
Manatees sometimes prefer sparse seagrass beds, which are difficult to detect from the air.

Manatee Tagging



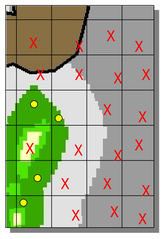
Floating, Argos-linked GPS tags by Telonics were attached to a belt around the manatee peduncle. The GPS receiver in the floating tags generally produced a location accuracy of <5m. Locations were logged every 20 or 30min whenever the tag was floating at the surface, which would have been when travel speeds were low and the animal depth was less than 2m. In the waters around the Ten Thousand Islands, seagrass grows only in shallow water, so feeding bouts were particularly well represented, compared to high-speed traveling movements.

GIS Analysis of GPS Data



<a> GPS points from manatees showed locations for individual animals (Such as Anna in this example) and the overall group, showing clear preferences for distinct areas. A bout is all locations from a single animal, from tag deployment until the tag came off of the animal.
<b> Kernel density analysis of short-range local use and longer-range travelling movements allowed us to isolate potential feeding areas.
<c> Further analysis of the short-range movements maps the potential feeding areas into density classes (high, medium low use). Pixel size is ~10x10m
<d> Two buffer zones, one at 100m to capture potential mismatch in the GPS tracks vs seagrass beds, and one at 1000m to complete the sampling universe, were added to create a total of five strata.

Sampling Plan



Yellow circle = selected sampling cell

Red X = rejected sampling cell

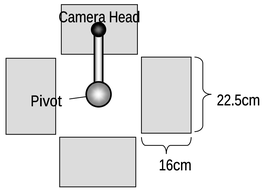
Stratified sampling – complete inference for all strata

Spatial – Randomized grid sampling
- Determine desired sample size per stratum
- Create grid based on sample size and stratum area
- Randomly choose 1 grid cell per grid area
- If random cell is desired stratum, then select, otherwise reject (example on left is for dark green stratum).
- Repeat process for other strata

Seasonal – Spring and Fall
Repeated – Each season was repeated twice

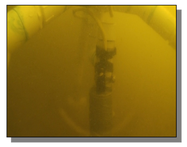
The selected cells for all five strata were uploaded into a GIS and overlaid onto aerial photos to use for field maps. The points were also uploaded into a WAAS-enabled marine GPS for navigation.

The "Quad-Cam"
Low-visibility benthic quadrat sampler



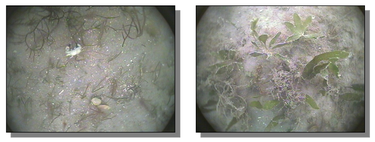
Video Camera:

Very low light, ultra-wide angle 2.9mm planar lens. 13cm distance to substrate. 720x480 resolution for a pixel size of 0.3x0.3 mm.



<Left> Secchi-disk readings were often <0.5m, causing poor visibility for regular video cameras.

<Below> The wide angle and high sensitivity of the Quad-Cam allowed for a clear view of the substrate and seagrass. The camera was dropped eight times and rotated to the four views at each sampled cell, for a total of 32 subsamples.



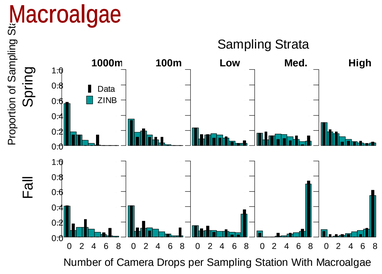
Data Analysis

- Zero-inflated negative binomial spatial model (ZINB)
- Censored sampling data at 8 camera drops
- Programmed in [R] with Bayesian parameters fitted using BRugs library link to OpenBUGS

The ZINB model was used to estimate the probability of finding each species of seagrass at a station in each strata, and the number of camera drops where it would be visible.

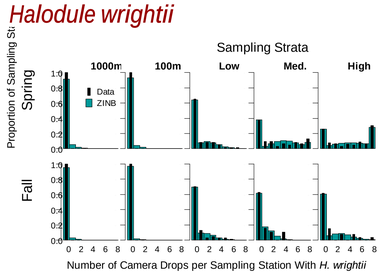
Results

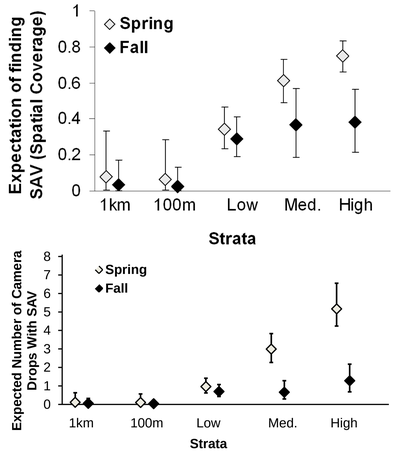
Macroalgae



Various types of macroalgae (not differentiated for this study) were abundant in all manatee use strata, including the two outer buffers, indicating that the manatees were not basing their movements on macroalgae distribution.

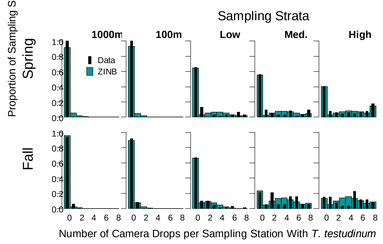
Halodule wrightii

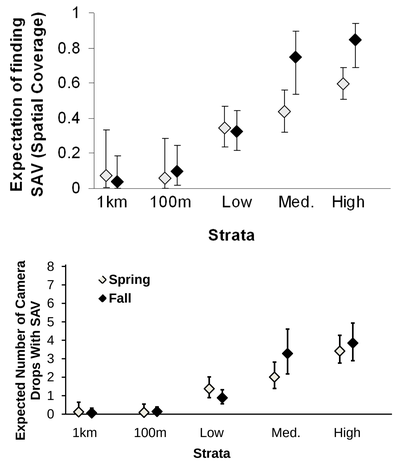




In stark comparison to macroalgae, *H. wrightii* was found only in the manatee use areas, especially the high use strata, and never in the buffers. This species was more widespread and denser in the spring. Note that the model predicts some seagrass in the buffers as a result of model uncertainty.

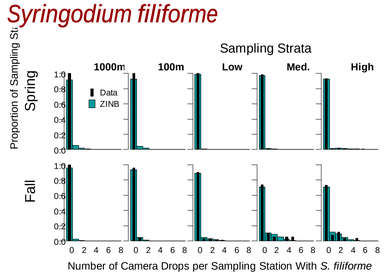
Thalassia testudinum



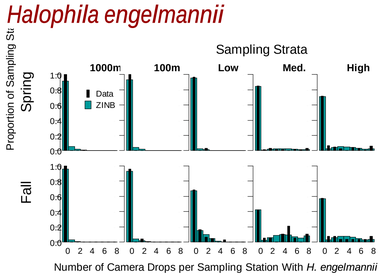


Similarly, *T. testudinum* was found more in the higher manatee use areas, but was seen twice in the buffers. This species was more widespread in the Fall.

Syringodium filiforme

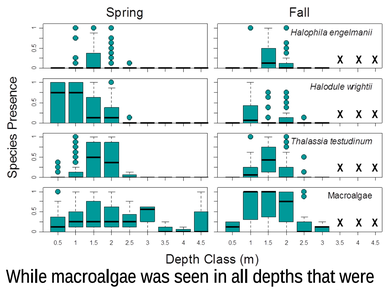


Halophila engelmannii



Other seagrass species that were occasionally found were *S. filiforme* and *H. engelmannii*. These species were only found (with two exceptions) in the manatee use areas, and generally in the fall. *Halodule decipiens* was also seen very rarely.

Depth by Species



While macroalgae was seen in all depths that were sampled, no seagrass species was seen much below 2m (mean sea level). The low Secchi readings consistently seen in the area indicate that seagrasses are light-limited.

Ongoing & Future Work

Current efforts for this modeling and mapping project are to:

1. Create and validate a physical model for spatial prediction that eliminates the need for manatee GPS data, using:
   - Bathymetry
   - Wave Energy
   - Channel Influence
   - Visible Features on Aerial Photos
2. Analyze biomass samples associated with the camera samples to determine quantity of seagrass in the region to:
   - Associate biomass with manatee use and physical covariates
   - Estimate total forage availability

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Ten Thousand Islands NWR

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Port of the Islands Hotel & Resort

[1]U.S. Geological Survey, Southeast Ecological Science Center, Gainesville, FL, USA
[2]Center for Coastal Fisheries and Habitat Research, NOAA, Beaufort, NC, USA.

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