IMPROVING SEAGRASS MAPS OF FLORIDA'S SPRINGS COAST THROUGH DIGITAL IMAGERY

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ABSTRACT

Digital imagery (1 ft resolution) was collected for Florida Springs Coast (70 mile stretch of coastline north of Tampa Bay) in April 2007 for the purpose of mapping the extensive seagrass beds of this region. This was the first time digital imagery was used in this region. The new imagery provided improvements in positional accuracy, image resolution and clarity, and enhanced detail of seagrass density. This paper compares the mapping results of the 2007 digital imagery to previous mapping efforts that used film imagery in 1985 and 1999 (Continental Shelf Associates 1985, and SWFWMD 2001). The seagrass coverage completed in 1985 was mapped through a combination of low resolution film imagery (scale 1:40,000) and underwater diver transect data. The seagrass coverage produced in 1999 used true color film imagery (1:24,000) with a scanned digital resolution of 1 meter. The use of digital imagery in 2007 resulted in a higher intensity of line work and delineation of seagrass polygons when compared to the 1985 and 1999 maps. The total area of dense seagrass was similar between the 2007 and 1985 coverages, but was substantially different between the 2007 and 1999 coverages. The total area of sparse seagrass and area of patchy seagrass calculated in 2007 were substantially different from the areas calculated for these classifications in 1985 and 1999. The 2007 digital imagery also revealed new information on other important benthic habitats of the Springs Coast and showed promising results for mapping hardbottom habitat and for distinguishing between areas dominated by seagrass and those dominated by macroalgae. A future phase of this project is currently under planning to map hardbottom habitat of the Springs Coast.

INTRODUCTION

Previous seagrass mapping efforts of the Big Bend Region of Florida have estimated inshore seagrass beds at nearly 800,000 acres and the offshore seagrass coverage at 1,000,000 acres. These combined regions of inshore and offshore seagrass place them among the largest seagrass communities in the world (Dawes et al, 2004). Seagrass of this region is intricately linked to the sustainability of coastal fisheries, shellfish, mammals, and macro invertebrates. Detailed information on seagrass is needed for the management and protection of these marine resources. This project focused on the southern half of Florida’s Big Bend Region, known as the Springs Coast Region and completed the first seagrass maps of both inshore and offshore waters (525,000 acres) using high resolution digital imagery collected in April 2007. This region of Florida has had much less research attention than other more urban regions to the south, and it is critical to establish a detailed inventory of seagrass in this region so that changes and impacts to this valuable can be detected. The project serves to monitor the long term health of seagrass beds and to promote informed management decisions of this complex system of estuaries, bays, and marine waters.
METHODS

Approximately 1000 digital images were collected in April 2007. Ten flight lines oriented parallel to the coast were flown over a roughly 70 mile stretch of the coast line with the outside line extending 15 miles offshore. The imagery was collected using an Intergraph Digital Mapping Camera (DMC) and Applanix Inertial Measurement unit (IMU) utilizing airborne GPS procedures. Image resolution was 1 ft. A comparison of the 2007 digital imagery to the 1999 film imagery is shown in Figure 1a and 1b, showing the improved resolution of 2007 imagery. Imagery was acquired when flight conditions were met on the absence of cloud cover, low wind, low wave height, high water clarity, and low tide. Conditions were measured in the field prior to flights to determine if conditions were suitable. Data on seagrass density, water clarity, and depth was collected at 60 stations during the month of April. The stations were equally spaced at four mile intervals across the 525,000 acre project area. The data was used as background for field verification and final mapping accuracy.

Photo interpretation and mapping was completed by Avineon Inc. Roughly 96 stations were visited during ground truthing exercises to verify seagrass density. Seagrass density was classified using the Florida Land Use and Cover Classification System (FLUCCS). Seagrass categories included dense (FLUCCS 9112), sparse to medium (9111), and patchy (9113). Unvegetated areas were classified as bays and estuaries (5400), tidal flats (6510), or oyster bars (6540). Land was classified as either spoil islands (7430) or unclassified land. The mapping unit for all categories was 0.5 acres. An accuracy assessment was completed by field verification of 130 randomly generated polygons.

DISCUSSION

Little data or imagery has been collected of the seagrass and other benthic communities of the offshore waters (beyond 6 miles) of the Springs Coast. Prior to this project, the most recent imagery for offshore areas was collected in 1985 (Continental Shelf Associates 1985). The broad shallow coastal shelf along the Springs Coast permits the development of an extensive seagrass area and is geologically characterized as drowned karst with limestone at or near the surface (Mattson 1995, Wolfe 1990). Seagrass density is low or absent where limestone is at the surface. Areas that contain clay sediment generally support thick or dense seagrass.

The 2007 imagery provided the first detailed images of offshore waters of the Springs Coast. The imagery revealed a more complex assemblage of seagrass than interpreted from the 1985 imagery. Most of the offshore waters from 6 miles to 14 miles offshore were classified as a monotypic stand of dense seagrass. The 2007 imagery shows this region to contain a mix of dense, sparse, patchy seagrass and unvegetated areas that intertwine in complex patterns and are intermixed with hardbottom habitats. An example of these complex variations in seagrass density is shown in Figure 2. Field data collected during the project suggests that these complex variations in density are associated with differences in sediment substrates and thickness. The darker strands in Figure 2 were dense seagrass growing in deeper clay or muddy sediment. The lighter colored areas depicted sparse or patchy seagrass growing in a thin veneer of sediment on top of limerock.

Unique large isolated strands of dense seagrass beds were revealed in the northern offshore portion of the project area, 12 miles west of Crystal River (Figure 3). These dense strands of Syringodium contained predominantly soft clay sediment 6 to 8 inches in depth. Areas adjacent to these meandering river-like strands were predominantly hardbottom with containing macroalgae and sparse seagrass. Other unique features observed throughout the offshore imagery were large circular areas of dense seagrass. These circular dense beds are likely solution basin depositional areas that occur within this karst region (Wolfe 1990). Some of these features are large comprising 50 to 200 acres.

The new imagery of the offshore waters provided new information on damage from boating activities. Scarring was evident within an offshore shoal (10 to 12 miles offshore) found to contain numerous large scars traversing this roughly 2000 acre area. Field examination of the scars found evidence that the impacts were recent occurrences with some occurring over the last two years. The scars range from 10 to 15 feet wide and hundreds of feet long. Several scars have lengths close to one mile. The large size of the scars suggests they were caused by large vessels with more than one propeller. Due to the severity of the damage to this shoal area, the scars were digitized at the request of state and federal marine resource regulatory agencies. The re-establishment of seagrass within the scars will likely be a slow process due to wave action and strong currents across the shoal.

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Figure 1 a. 1999 imagery showing circular area of dense seagrass bed.

Figure 1 b. 2007 imagery showing same dense bed, note boat and linear hardbottom features.

Figure 2. Alternating dense and sparse seagrass 8 miles offshore Hernando County, depth 10 to 12 ft.

Figure 3. River-like strand of dense Syringodium 12 miles offshore Citrus County, depth 12 to 14 ft.
RESULTS

A comparison of the total acreages calculated for each seagrass class is shown in Table 1. Dense seagrass comprised roughly 288,000 acres or 67 percent of the 2007 project area. Sparse seagrass comprised the second largest area at 73,000 acres or 17 percent, followed by non-vegetated bottom (49,000 acres, 11.5 percent). Patchy seagrass comprised the smallest area (19,000 acres, 4.5 percent).

Dense seagrass mapped in 1985 was estimated to cover 313,000 acres (73.6 percent) and was similar to total area of dense seagrass (288,000 acres) mapped in 2007 (Table 1). The total acreages estimated for the remaining seagrass classes were substantially different (Table 1). Patchy seagrass comprised the second largest area in 1985 (73,000 acres or 17.2 percent), and non-vegetated bottom and sparse seagrass covered similar areas (21,000 and 18,500 acres, respectively). Although the total area calculated for dense seagrass was similar between the 1985 and 2007 maps, there were large differences in detail of line work and number of polygons interpreted. The 1985 map classified the majority of the offshore region of the Springs Coast as dense seagrass with only two large polygons representing 288,000 acres. In contrast, dense seagrass was represented by roughly 1900 polygons in the 2007 map. The large region of the coast depicted as dense seagrass in 1985 was found to contain a more diverse assemblage of seagrass, containing a mix of dense and sparse seagrass, and bare bottom.

Table 1. Total area calculated for each seagrass class in 1985 and 2007.

<table>
<thead>
<tr>
<th>Classification</th>
<th>1985</th>
<th>1985 percent</th>
<th>2007</th>
<th>2007 percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense</td>
<td>313,000</td>
<td>73.6</td>
<td>288,000</td>
<td>67.0</td>
</tr>
<tr>
<td>Sparse</td>
<td>18,500</td>
<td>4.2</td>
<td>73,000</td>
<td>17.0</td>
</tr>
<tr>
<td>Patchy</td>
<td>73,000</td>
<td>17.2</td>
<td>19,000</td>
<td>4.5</td>
</tr>
<tr>
<td>Non-vegetated</td>
<td>21,000</td>
<td>5.0</td>
<td>49,000</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Another difference between the 2007 and 1985 coverage was the delineation of the offshore edge of dense continuous seagrass. This offshore edge begins near 4 miles offshore in the southern region of the project (near Anclote Island, Pinellas County) and gradually extends further offshore in the northern region where the coastal shelf widens. The edge of the dense continuous seagrass was found to extend further offshore in the southern project area (Pasco and Pinellas Counties) than previously mapped in 1985 (Figure 4). The difference ranged between 0.5 miles and 1 mile. It is unclear whether this increase was related to the natural expansion of seagrass or to differences between resolution of the old and new imagery and ability to view seagrass. The dense edge was found to extend beyond the outside flight line of 2007 imagery (15 miles) in the central portion of the project (offshore of Hernando County) where the coastal shelf extends further offshore. The shallow depth (< 18 ft), good water clarity, and adequate light penetration support dense growth in these offshore waters (Zieman and Zienman 1989).

The 2007 flight acquisition area was nearly two times larger than the 1999 area. The 1999 map primarily mapped nearshore regions (no further then 6 miles offshore). In order to compare acreages of seagrass classes between the 1999 and 2007 coverages, the smaller 1999 project area was used to clip the 2007 coverage so

Figure 4. Comparison of the offshore edge of dense, continuous seagrass mapped in 1985 and later in 2007, location 7 miles offshore Pasco County.
that only a common would be compared between the two data sets. A different seagrass classification was used in 1999 than during 1985 and 2007. The 1999 classification added an extra class for medium density seagrass. In addition, the patchy and non-vegetated classes were not used in 1999. The most similar class between the 1999 and 2007 maps was the dense seagrass, with both years defining dense as bottom with greater than 75% percent continuous seagrass cover.

There were substantial differences between the 1999 and 2007 seagrass coverages. Dense seagrass comprised the largest area in the 2007 map (155,000 acres) and was roughly twice the size of area mapped as dense seagrass in 1999 (71,000 acres). Sparse seagrass comprised the largest area in 1999 (112,000 acres); where as, sparse seagrass comprised a much smaller area in the 2007 coverage (58,000 acres). It is unclear whether the differences were due to the dissimilar mapping techniques or simply the differences between resolutions of the imagery. Due to these differences additional work will be completed to examine areas showing the greatest difference between the 2007 and 1999 maps (e.g. dense versus sparse). A change analysis between the 1999 and 2007 coverages will be completed in the future to identify areas that showed the most difference in seagrass density. Although the 1999 coverage used a different classification system, common classes (dense and sparse) can still be compared. This may identify areas that may need improvement in the existing 2007 coverage.

Table 2. Total area calculated for each seagrass class in 1999 and 2007

<table>
<thead>
<tr>
<th>Seagrass Class</th>
<th>1999</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
<td>percent</td>
</tr>
<tr>
<td>Dense</td>
<td>71,000</td>
<td>35.0</td>
</tr>
<tr>
<td>Sparse</td>
<td>112,000</td>
<td>42.0</td>
</tr>
<tr>
<td>Medium</td>
<td>44,000</td>
<td>21.0</td>
</tr>
<tr>
<td>Patchy</td>
<td>Not used *</td>
<td></td>
</tr>
<tr>
<td>Non-vegetated</td>
<td>Not used *</td>
<td></td>
</tr>
</tbody>
</table>

* Patchy and non-vegetated classes were not used in the 1999. The medium density class was only used in 1999

**FUTURE WORK**

During the seagrass mapping project the digital imagery was reviewed for its potential to map hardbottom habitat which is the second most abundant benthic habitat along the Springs Coast. Hardbottom is characterized as mixed communities of macroalgae, sponges, octocorals, and stony corals. Areas containing dense stands of sponge, coral, and rock outcroppings can provide habitat to hundred of species of invertebrates.

Previous efforts to map hardbottom using conventional film imagery were unsuccessful and in the past hardbottom and seagrass have been lumped together under seagrass classifications. The 2007 digital imagery revealed numerous hardbottom features and showed high potential for distinguishing between areas dominated by hardbottom vegetation and those dominated by seagrass. Figure 5 shows an example of hardbottom features identified through color balancing of the digital imagery. The red areas depict hardbottom, where a thin over lying veneer of sand on exposed limerock supports predominantly macroalgae growth.

New information was also provided on dense hardbottom habitat, such as rock outcroppings, patch reefs, and shoal reefs. These habitats of the Springs Coast have received little attention by the research community, partly due to their remote and obscure locations. An initial scan of the imagery suggests that a larger number of patch reefs and rock outcroppings may occur in this region than previously estimated. The next phase of this project will use the digital imagery to map hardbottom habitat including dense hardbottom. The completed map will be combined with the 2007 seagrass coverage to represent the first comprehensive benthic habitat map of the Springs Coast.
SUMMARY

In summary, the higher resolution digital imagery has revealed a complex assemblage of seagrass beds within the offshore region of the Springs Coast and identified unique offshore seagrass features. Dense meandering river-like strands were found throughout the offshore imagery along with circular shaped patches that lie in solution basin depositional areas. The detailed imagery provided an opportunity to map variations in seagrass density at a higher level detail than previous efforts that used lower resolution film imagery. The completed 2007 seagrass coverage provided a more accurate representation of the complexity of the seagrass beds in this region and will provide a solid baseline to monitor future changes and potential impacts to this valuable system.

The total acreages determined for each of seagrass classes in 2007 were substantially different than those of the 1985 and 1999 coverages, with the exception of dense seagrass between the 1985 and 2007 estimates. Due to these large differences a change analysis between the 1999 and 2007 coverages will be completed in the future to identify areas that showed the most difference in seagrass density. The change analysis will help explain if these differences were associated with natural changes in seagrass density or associated with differences in the mapping methods. Additionally, areas needing improvement in the 2007 coverage may be identified during this process.

The 2007 imagery also provided updated information on boating impacts (scarring) to seagrass beds, such as those identified within a large offshore shoal (2200 acre area) containing dense beds. Although seagrass was the...
focus of the project, the imagery provided spatial data on the vast hardbottom habitats of the Springs Coast. The imagery showed promising results for mapping hardbottom habitat and for distinguishing these different habitats and associated fauna from seagrass beds. A future phase of this project is currently under planning to map hardbottom habitat of the Springs Coast including dense hardbottom (rock outcroppings, reefs, and sponge beds)

ACKNOWLEDGMENTS

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REFERENCES


