Sebastian Inlet Seagrass Monitoring Program

2021 Annual Seagrass Monitoring Report

Sebastian Inlet District

14 March 2022

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1. Introduction

In August 2007 the Sebastian Inlet District (SID) completed the construction of a navigation channel connecting Sebastian Inlet from Channel Markers No.18 and 19 westward to the Intracoastal Waterway (ICW). The purpose of this 3,120-ft long, 10.7-acre (5:1 side slope; -9 ft NGVD) channel extension was to provide the growing maritime community with a safe, clearly designated passage to/from the Atlantic Ocean as a matter of public safety and for the future protection of associated aquatic resources. To offset impacts to 3.08 acres of seagrass habitat and 7.62 acres of non-vegetated soft bottom, and pursuant with the U.S. Army Corps of Engineers (USACE) and the Florida Department of Environmental Protection (FDEP) permits SAJ-2002-7868 (IP-TSD) and 05-264486-001, issued March of 2007, the permittee, the SID, provided the following over the course of a five-year (2008-2012) seagrass mitigation and monitoring program:

1) The recovery of 459 seagrass planting units (179 *Halodule wrightii*; 279 *Syringodium filiforme*; 1 *Halophila johnsonii*) from the proposed channel alignment and subsequent planting of 41 propeller scars (hereafter, “prop scars”), filling an estimated 366.95 m of linear damage.

2) The balance of financial support needed to install the Indian River County Main Relief Canal Pollution Control Structure, estimated at $750,000.00. The structure came online in July 2008.

3) The establishment and/or monitoring of the St. Johns River Water Management District (SJRWMD) fixed seagrass transect No. 51, plus 9 additional transects in the vicinity of the Main Relief Canal Outfall (Vero Beach, Florida). The monitoring protocol and periodicity followed those previously established and utilized by the SJRWMD. Three baseline monitoring events and eight post-activation monitoring events occurred from May 2007- August 2012.

4) The placement of “*Caution, Shallow Water, Seagrass Area*” signs clearly delineating 145 acres of the flood tidal shoal as seagrass habitat, protecting an initially estimated 110.26 acres (2007) of mixed meadow seagrasses. Current (2021) estimates place this area of live seagrass habitat at 123.05 acres.

5) The quantification of seagrass coverage within the six designated protected areas (“A” thru “F”) using low-level, high resolution, digital orthophotography.

6) A complete inventory and tracking of annual changes to anthropogenic damage within the protected areas.

7) The successful deployment of 2,031 Sediment Tubes® into 32 previously identified propeller-related scars, including 22 significant “blow-out” features. Work was conducted in partnership with Seagrass Recovery, Inc.

The five-year monitoring program associated with the Sebastian Inlet navigation channel was completed in 2012. However, the SID completed the Sebastian Inlet channel realignment project (FDEP Permit No. 05-264486-005-EM) from May 2012 to July 2012, which corrected the severe angle of the channel west of the shoal by widening the turn. The widening resulted in additional seagrass impacts which were included in the available mitigation from the original channel construction project. The widening project resulted in the continuation of an abbreviated version of the seagrass monitoring program. As part of this abbreviated monitoring program, the SID continued to quantify seagrass coverage (#5 above) and inventory and tracked anthropogenic damage (#6 above) within the protected areas on the flood tidal shoal over a period of three years (terminating in 2015). The SID contracted Atkins to continue the abbreviated seagrass monitoring program in 2016, 2017, 2018, 2019, 2020, and 2021 with a focus on the quantification of seagrass coverage within the protected areas of the flood tidal shoal.

2. Aerial Image Analysis

2.1. Objectives

To assess changes in the submerged aquatic resources within the protected areas or mitigation zone, a Geographic Information System (GIS)-based approach using low-level, digital aerial photography was implemented in June 2007 and has continued annually thereafter. The 2021 aerial image analysis had five primary objectives:

1) To quantify the aerial extent of existing seagrasses within the mitigation zone (*see Section 2.3.1*),
2) To assess changes to the spatial distribution and aerial extent of seagrass (*see Section 2.3.2*),
3) To identify visible anthropogenic impacts (i.e., prop scarring) within the mitigation zone (*see Section 3.2*), and
4) To field verify (hereafter referred to as "groundtruthing") the validity of observations made remotely (i.e., by analyzing the aerials) (*see Section 3.2*).

2.2. Methods

GPI Geospatial, Inc. (previously Aerial Cartographics of America, Inc.) was selected to supply low-altitude, high-resolution, color imagery for the 500-acre region of the shoal. Aerial imagery was captured on August 5, 2021 during an incoming tide. The resultant digital imagery was georectified and had an effective ground pixel resolution of 0.25 feet (Figure 2-1).

To estimate seagrass coverage within the mitigation zone, the 2021 aerial photographs were assessed for the presence or absence of perceived seagrasses (i.e., features that appeared to be seagrasses) using the Environmental Systems Research Institute (ESRI) ArcGIS software, ArcMap 10.7.1 and recorded manually as a polygonal feature class. All GIS analyses were conducted using source data projected in the State Plane system for East Florida:

Projected Coordinate System: NAD_1983_HARN_StatePlane_Florida_East_FIPS_0901_Feet
Projection: Transverse_Mercator
False_Easting: 656166.66666667
False_Northing: 0.00000000
Central_Meridian: -81.00000000
Scale_Factor: 0.99994118
Latitude_Of_Origin: 24.33333333
Linear Unit: Foot_US

Geographic Coordinate System: GCS_North_American_1983_HARN
Datum: D_North_American_1983_HARN
Prime Meridian: Greenwich
Angular Unit: Degree

Generally, the distinction between seagrass and the surrounding habitat was made while viewing the photography at an absolute resolution of 1:400 to 1:500. In most cases, water depth and clarity provided a seemingly clear view of the benthos (bottom flora), with little ambiguity regarding bed boundaries. However, during systematic sweeps of the image, several locations were unidentifiable or visually skewed by wave activity, turbidity, color, density (salinity) discontinuity layers, and/or artifacts of image manipulation made during production. These locations, and all positions of uncertainty, were recorded on a separate point feature class (N=99) or polyline feature class (N=66) and visited during the field verification or "groundtruthing" exercise (*see Section 3 Groundtruthing below*).

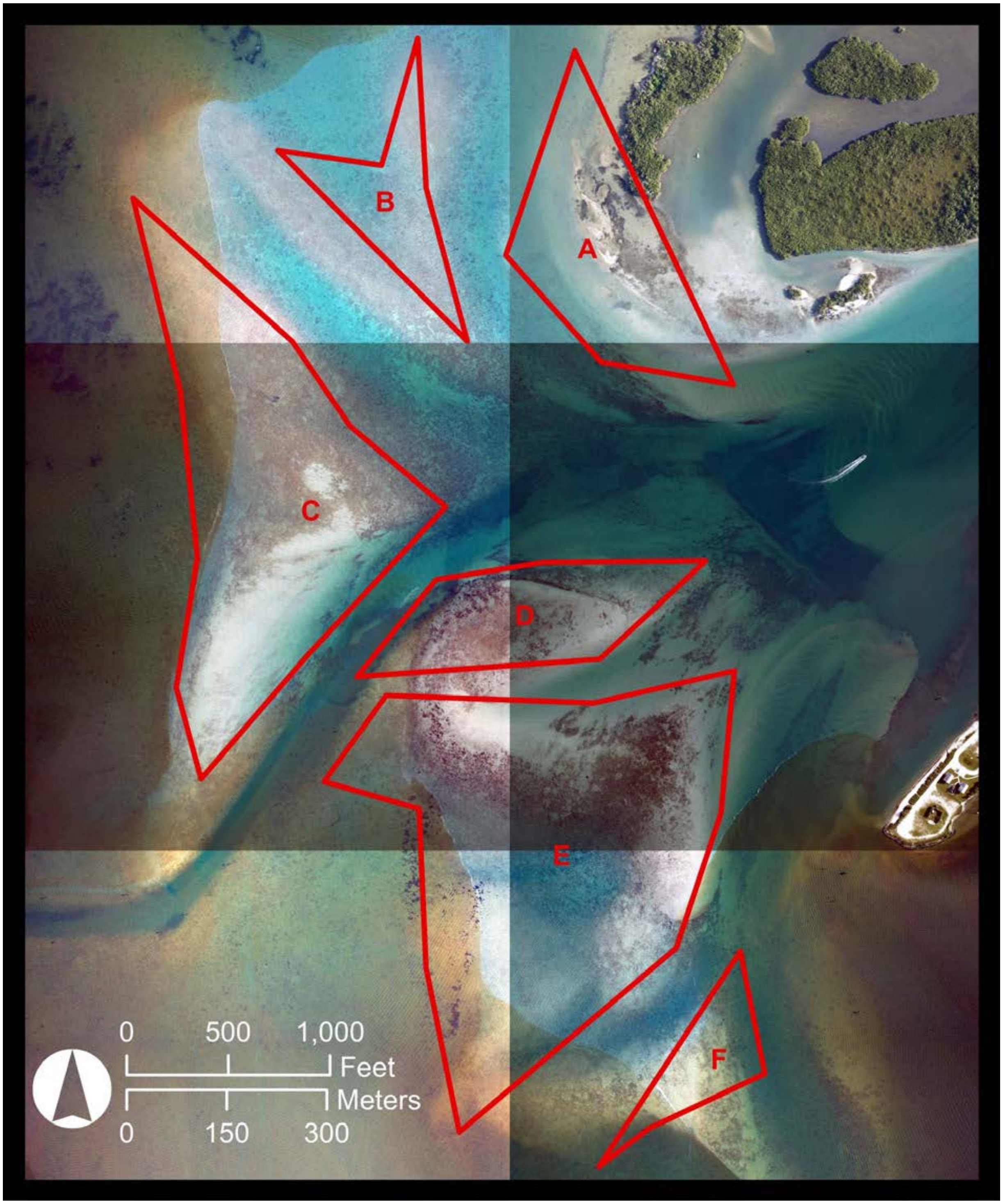

Figure 2-1 **Aerial imagery of Sebastian Inlet flood tidal shoal (Florida). The image was taken on August 5, 2021 by GPI Geospatial, Inc. for the Sebastian Inlet District.**

2.3. Results

2.3.1. 2021 Seagrass Coverage

The finalized seagrass coverage feature class (post-groundtruthing) yielded ~123.05 acres of seagrass in 2021, equivalent to 84.86% of the mitigation zone (Figure 2-2). Zone-specific seagrass acreage estimates ranged from 5.79 acres (Zone F) to 53.31 acres (Zone E) with percent cover values (i.e., the percentage of the zone area covered by seagrass) from 40.93% (Zone A) to 100% (Zones B and F). A complete listing of 2021 zone values can be found in the inset table of Figure 2-2.

Zone	SAV Acreage	Zone Acreage	% SAV
Total	123.05	145.01	84.86%
A	7.65	18.7	40.93%
B	8.13	8.13	100.00%
C	37.14	41	90.59%
D	11.03	13.66	80.74%
E	53.31	57.73	92.34%
F	5.79	5.79	100.00%

Figure 2-2. ESRI feature class depicting the estimated extent of seagrass within the mitigation zone in 2021. The associated table summarizes area and percent coverage of seagrass by zone. Aerial image taken August 5, 2021.

2.3.2. Change Analysis

To estimate changes in the distribution of seagrass within the flood tidal shoal, finalized seagrass coverage feature classes were compared between 2020 and 2021 for regions of “Gain” and “Loss.” ESRI ArcGIS Pro was used to cut the areas of non-overlap from alternating comparisons of the two datasets, leaving a remaining portion as a static region of “No Change.” A visual depiction of these changes can be seen in Figure 2-3.

Figure 2-3 Spatial distribution of inter-year change in seagrass coverage within the mitigation boundaries. Gains are depicted as - green, losses - red, and areas consistent between years - gray. Analysis included 2020 and 2021 data.

From 2020 to 2021, there was an increase in seagrass shoal-wide of ~8.08 acres. All zones exhibited net increases in seagrass coverage ranging from 0.08 acres (Zone B) to 2.29 acres (Zone C) (Figure 2-4). Zones E and F respectively had the highest and lowest total acreage of seagrass in both 2020 and 2021; however, this is unsurprising as these are respectively the largest and smallest shoals. In terms of percent coverage of the zone occupied by seagrass, Zone B had the highest coverage in both 2020 and 2021 (equalled by Zone F in 2021), while Zone A had the lowest coverage in both years. Zone A has experienced erosion of sediment along the western edge since 2012 preventing seagrass reestablishment in the deeper, eroded areas; however, since 2020 grass appears to be filling in gaps in the main grass bed and expanding in the northwestern portion of the shoal.

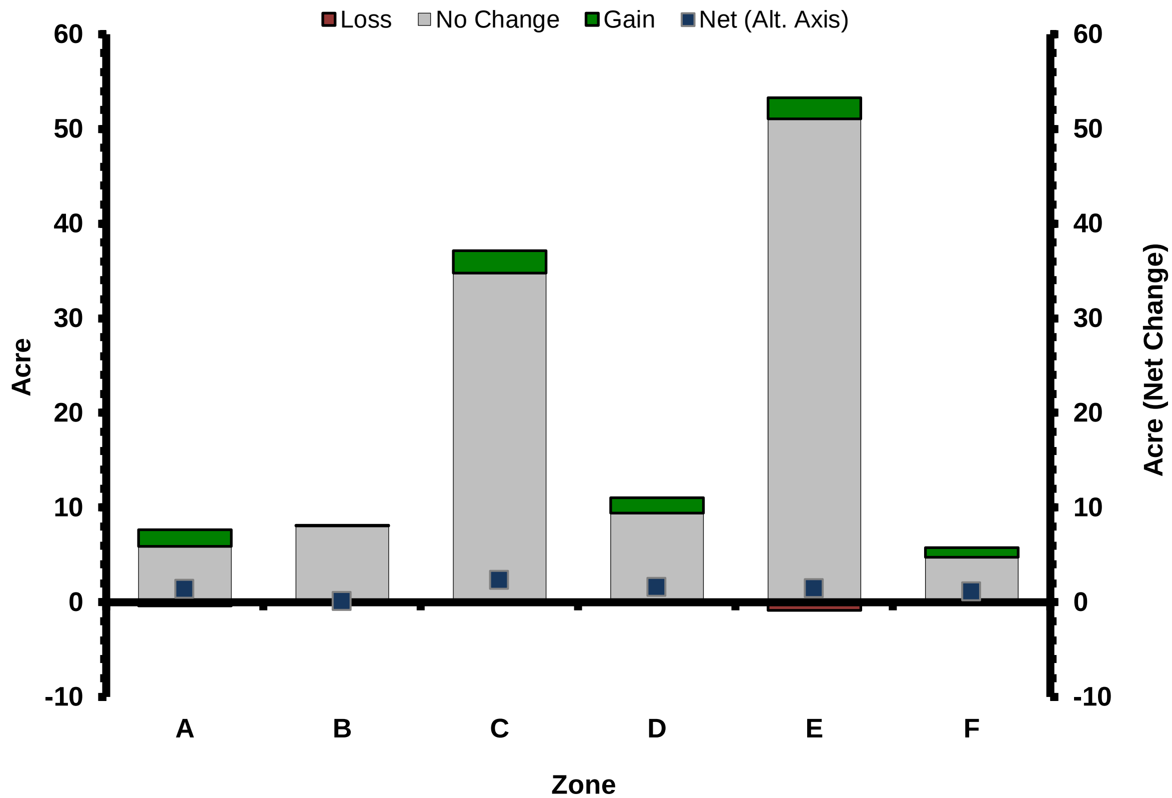

Figure 2-4 **Zone-specific changes in seagrass cover (acres) between 2020 and 2021. Net change in total acreage depicted on alternate axis.**

3. Groundtruthing/Field Verification

3.1. Objectives

Any attempt to characterize benthic composition from high-resolution aerial imagery presents a suite of technical challenges, including changing optical properties of water with depth and water density, variations in water constituents across the spatial extent of an image (e.g., tannins), reflections caused by an imperfect water surface, and shadows from taller features. These issues were exacerbated at the Inlet by the confluence of two distinctly different water bodies (i.e., sometimes lower salinity, tannin-rich lagoon water and more saline, comparatively clearer, but at times sand/silt containing, nearshore Atlantic Ocean water), creating a heterogeneous mixture of optical properties over a range of depths.

Methodological errors are confounded by lag time between the aerial flight and actual physical groundtruthing (time needed to produce and review the aerials before fieldwork can be performed). During the 2021 monitoring event, official groundtruthing efforts commenced September 21, 2021, which was 47 days post-flight (aerial imagery collected August 5, 2021). The sampling of the shoal was successfully accomplished using the results of the aerial image analyses and guided by a Trimble R1 handheld DGPS unit, interfacing with a Samsung Galaxy S3 handheld tablet running ESRI Collector (hereafter referred to as ESRI Collector).

The objectives of the 2021 groundtruthing event were to:

1) Confirm potential anthropogenic damage (e.g. prop scarring) to the shoal,

2) Field-verify points or lines (i.e., groundtruthing points or transects) of uncertainty encountered during the aerial image analyses,

3) Refine the original seagrass coverage GIS dataset using *in situ* mapping and field annotation, and

4) Obtain adjacent seagrass species data for each position visited.

3.2. Methods and Results

To estimate the quantity of anthropogenic impact within the mitigation zone in 2021, biologists systematically examined the 2021 aerial photography at an absolute resolution of 1:400 to 1:500 for the presence of linear and otherwise un-natural features on the shoal (i.e., prop scars). The potential prop scars digitized from the aerial imagery were uploaded to ESRI Collector which was used for data collection and navigation purposes during the groundtruthing effort (Figure 3-1).

During the September 21-23, 2021 groundtruthing effort, biologists used ESRI Collector to visit the 10 potential prop scar locations identified in the August 5, 2021 aerial image, assessing them for validity. No prop scars were field verified from the aerial imagery; aside from 2019 (when 34 prop scars were field verified) the number of validated scars has typically been low in recent annual surveys.

Points of uncertainty (N=99) were also identified during the 2021 aerial image analysis and generally consisted of darkened (or lightened) areas inconsistent with the color signal of adjacent seagrasses, or other spectral anomalies potentially related to changes in seagrass density within contiguous beds, discontinuous epiphytic or drift algal loads, or differences in underlying substrata (Figure 3-1). Similar to the potential prop scar locations, these points of uncertainty were uploaded to ESRI Collector, which was used for data collection and navigation purposes. Physical confirmation of seagrass presence or absence at each of these sites consisted of a haphazard swim, resulting in a broad assessment of bottom type, as well as seagrass species identification (where applicable). The point feature class was then appended on site and used for later refinement of the bed boundaries within the seagrass coverage GIS dataset.

A total of 66 groundtruthing transects were also identified during the aerial image analysis (Figure 3-1). These groundtruthing transects were uploaded to ESRI Collector. Biologists performed a broad assessment of the bottom type along these transects including seagrass species identification (where applicable). The polyline feature class was then appended on site. In certain instances, point data were also collected along the transects to signal a change in benthic composition (e.g., seagrass presence/absence or seagrass species observed).

Additional field annotation regarding seagrass presence/absence was recorded in transit between uncertain points/groundtruthing transects. Using ESRI Collector, biologists were able to confirm in real-time the accuracy of the seagrass coverage data and/or collect new seagrass data that were not observed during the aerial image analysis. In these instances, using ESRI Collector, biologists collected data around the boundaries of seagrass patches. Point, line, and polygon data were used for refinement of the seagrass bed boundaries within the seagrass coverage GIS dataset. The finalized 2021 seagrass

GIS dataset can be seen in Figure 2-2 and was used in all acreage calculations reported within this document.

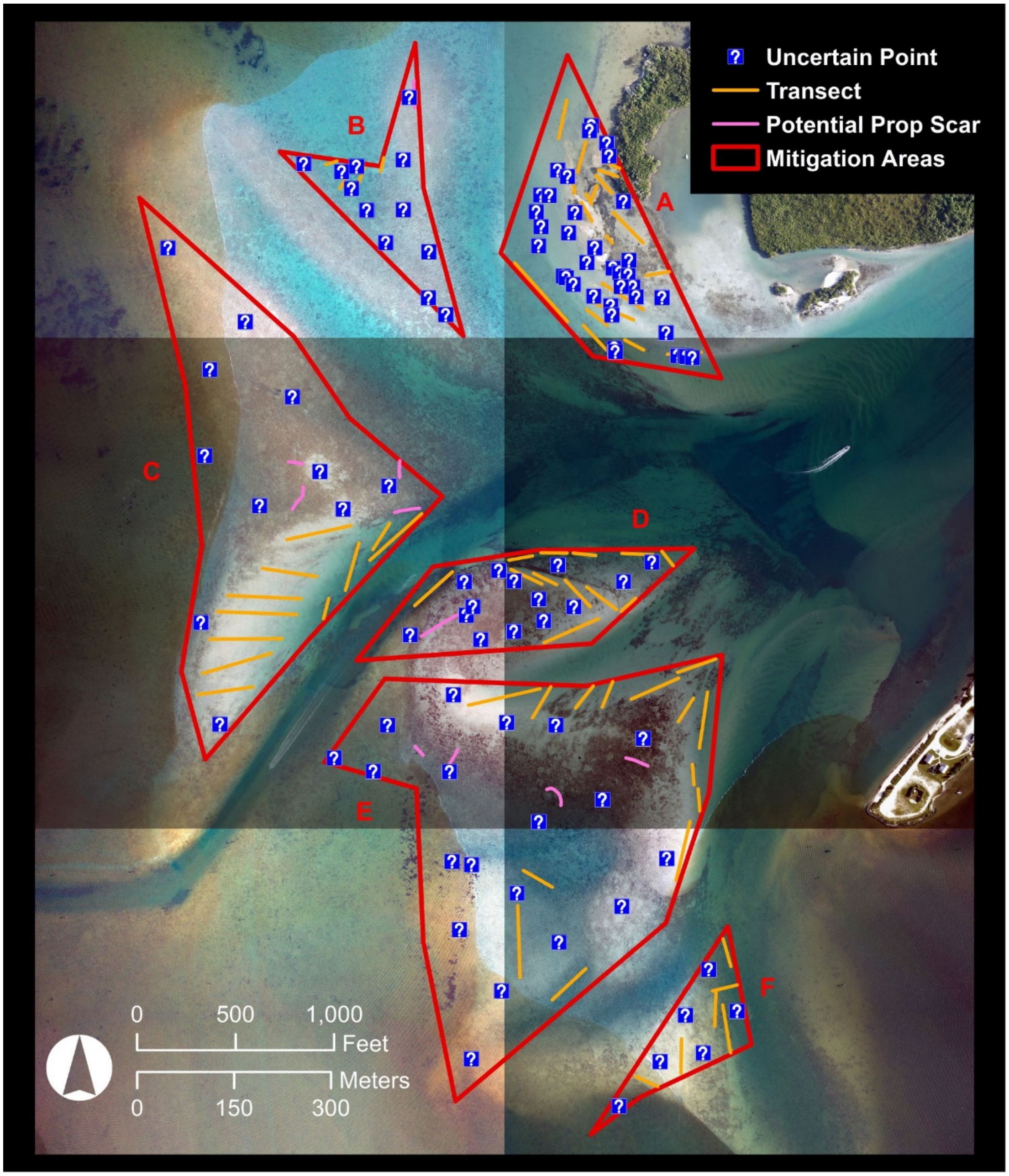

Figure 3-1 **Location of potential prop scars, points of uncertainty, and groundtruthing transects established for the 2021 groundtruthing event. Aerial image taken August 5, 2021.**

Due to weather, tide, and schedule constraints, not all pre-designated points, transects, and scars were field-verified; in particular Zone E was undersampled. All positions identified during the image analysis and verified in the field (46 points, 22 transects, and 1 potential prop scar), as well as additional seagrass data collected during the groundtruthing event (263 points), were sampled for benthic composition (N=332 positions)[1]. Over 99% of these positions (N=330) contained seagrass species (Figure 3-2). The remaining <1% consisted of turf algae over sand; other features observed during general reconnaissance included shell material (Figure 3-3), cyanobacteria, sand, worm tubes, detritus/drift algae mats (most notably at the channel edge in Zone D), and macroalgae (*Caulerpa* sp., see photo in Figure 3-3). Figure 3-2 depicts the locations of seagrass species/species combinations observed on the shoal in 2021. Species-specific data revealed that ~76% of the sites that contained seagrass were monospecific patches of seagrass, including *Halodule wrightii* (30%), *Halophila johnsonii* (45%), and *Syringodium filiforme* (<1%). The remaining ~24% consisted of species combinations, including *H. wrightii/H. johnsonii* (the predominant species combination at 19%), *S. filiforme/H. wrightii* (1%), *S. filiforme/H. wrightii/H. johnsonii* (1%), *S. filiforme/H. wrightii/H. decipiens/H. johnsonii* (1%), and *S. filiforme/H. johnsonii* (1%) (see Figure 3-4 photographs of seagrass species observed).

Differences have been observed when comparing predominant seagrass species/species combinations on the flood tidal shoal over time. In the past (2008-2011), the flood tidal shoal was predominately *Halodule wrightii, Syringodium filiforme,* and combinations of the two species (Figure 3-5). *Halophila johnsonii* was only observed at a small percentage of locations. In 2012 and 2013 (beginning of seagrass recovery after region-wide seagrass loss), the dominant seagrass species on the flood tidal shoal were *H. johnsonii, H. wrightii,* and combinations of the two species (Figure 3-5). In 2014-2021, *H. wrightii* and *H. johnsonii* continue to be the predominant seagrass species; *S. filiforme* is present in deeper areas such as the v-notch in the north side of Zone B, the west side of Zone C, the channel side of Zone D, the west side of Zone E, and the east and west ends of Zone F (Figure 3-2).

According to the Endangered Species Act (ESA), *Halophila johnsonii* is listed as a threatened species (listed on September 14, 1998) throughout the range of the species from central Biscayne Bay to Sebastian Inlet. The ESA requires the federal government to designate “critical habitat” for any listed species. The designation provides explicit notice to federal agencies and the public that these areas are vital to the conservation of the species. Critical habitat for *H. johnsonii* was established on April 5, 2000 and includes ten locations between Sebastian Inlet and Biscayne Bay. Because areas located north and south of the Sebastian Inlet channel are considered *H. johnsonii* critical habitat, a separate figure was created, clearly showing the distribution of *H. johnsonii* within the mitigation zone in 2021 and the designated critical habitat areas (Figure 3-6). *H. johnsonii* (or a species combination including *H. johnsonii*) was present at ~67% of all sites that contained seagrass in 2021, which is comparable to the 2020 survey (~64% of all sites). It should be noted that as of December 23, 2021 the National Marine Fisheries Service (NMFS) has proposed delisting *H. johnsonii* from the ESA based on published genetic and morphological studies concluding the species found in Florida is actually an introduced population of the Indo-Pacific seagrass *Halophila ovalis* (Waycott et al. 2021). Regardless of its future taxonomic and regulatory status, *H. johnsonii* has been significant in the recovery of seagrasses on the flood tidal shoal and the stability of the shoal as seagrasses recolonize.

It should be noted that the Florida Fish and Wildlife Conservation Commission and the U.S. Fish and Wildlife Service have declared an Unusual Mortality Event (UME) for the Florida manatee for 2020 and 2021, with 637 recorded statewide deaths in 2020 and 1,100 in 2021 (FFWCC 2021). Brevard County had the highest number of recorded manatee deaths in both years, accounting for 173 in 2020 and 358 in 2021. The driving factor for this UME is believed to be starvation due to seagrass losses, particularly in the Indian River Lagoon. Manatees and signs of grazing were observed during the 2020 and 2021 aerial imaging (visible in Zone C and just outside Zones A and F in 2021; see Figure 3-7) and groundtruthing events. While the continued increase in seagrass coverage on the inlet shoals is a promising development, the seagrass density and species composition have not as yet returned to the pre-2011 condition; overall seagrass biomass in the area is still likely reduced.

[1] Locations not visited in the field (n=106) have been excluded from this total.

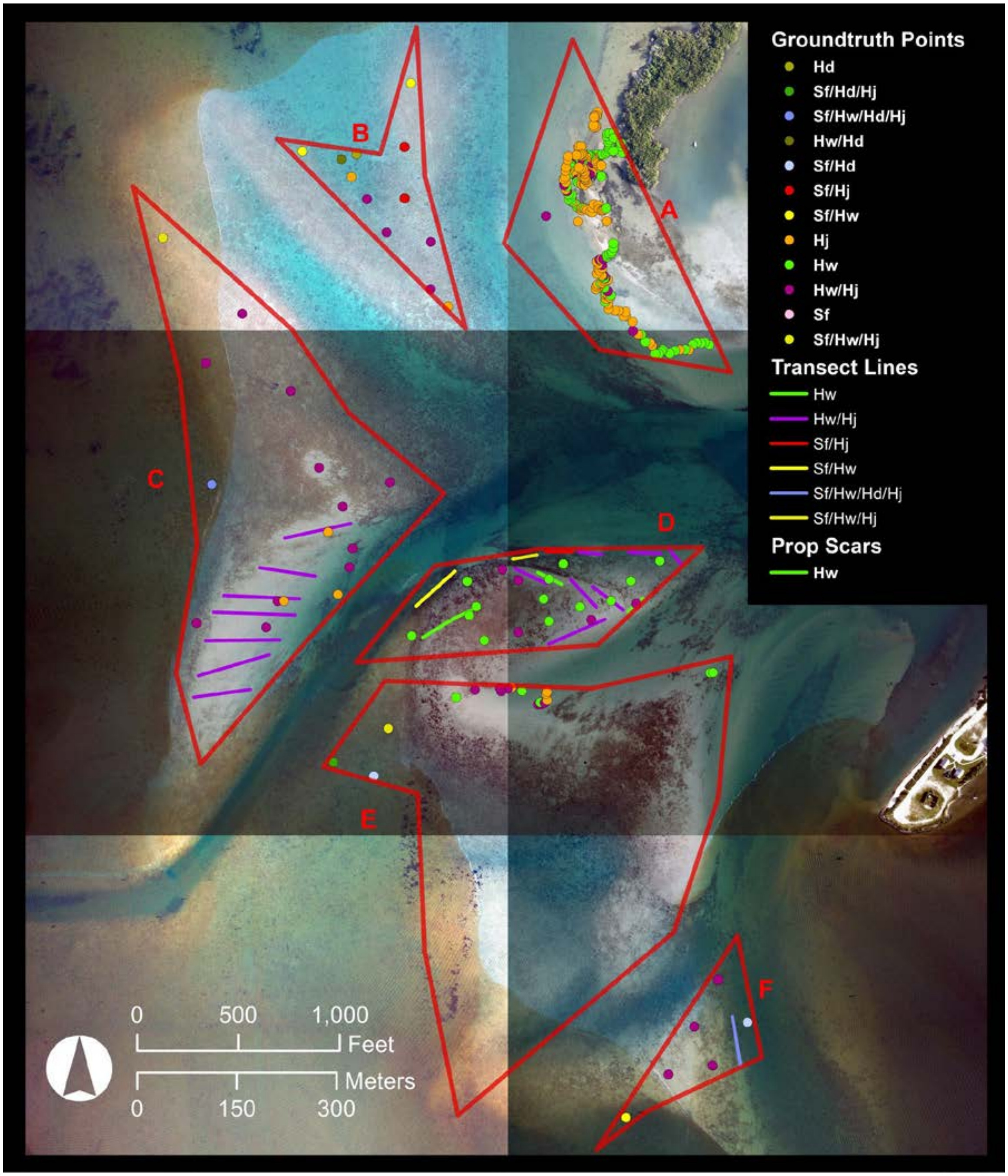

Figure 3-2. **Locations of seagrass species and species combinations observed during the 2021 groundtruthing event. Abbreviations Hj = *Halophila johnsonii*, Hw = *Halodule wrightii*, Hd = *Halophila decipiens*, Sf = *Syringodium filiforme*.**

Figure 3-3. Other features observed during 2021 groundtruthing effort – mix of worm tubes and bottom detritus (upper left, Zone F); drift algae atop *Halodule wrightii* (upper right, Zone A); bottom covered with oyster shell (lower left, Zone A); and tannic water at low tide (lower right, background, Zone A).

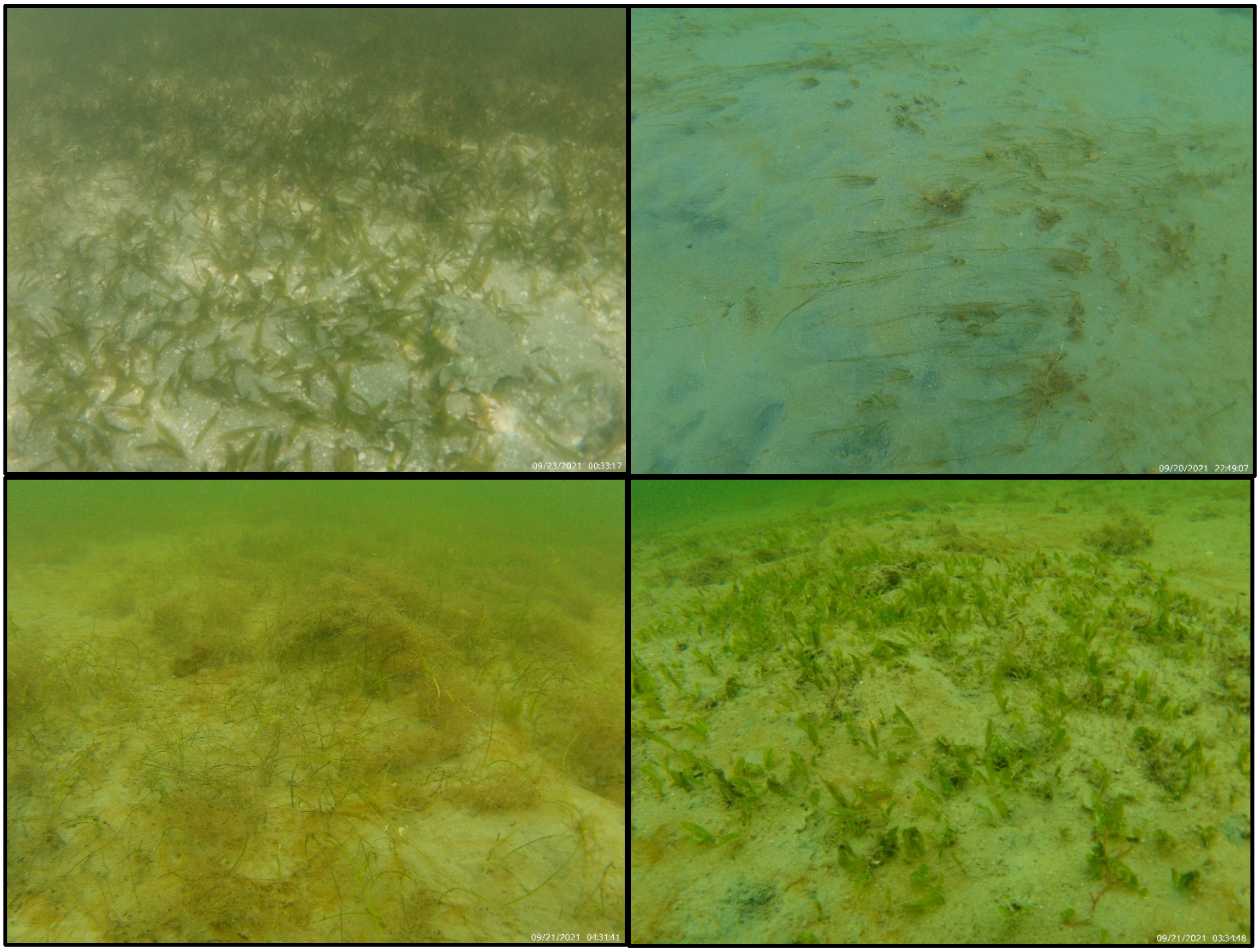

Figure 3-4. The seagrass species found on the shoal in 2021 – *Halophila johnsonii* (upper left, Zone A); *Halodule wrightii* (upper right, Zone C), *Syringodium filiforme* (lower left, Zone F); and *Halophila decipiens* (lower right, Zone F).

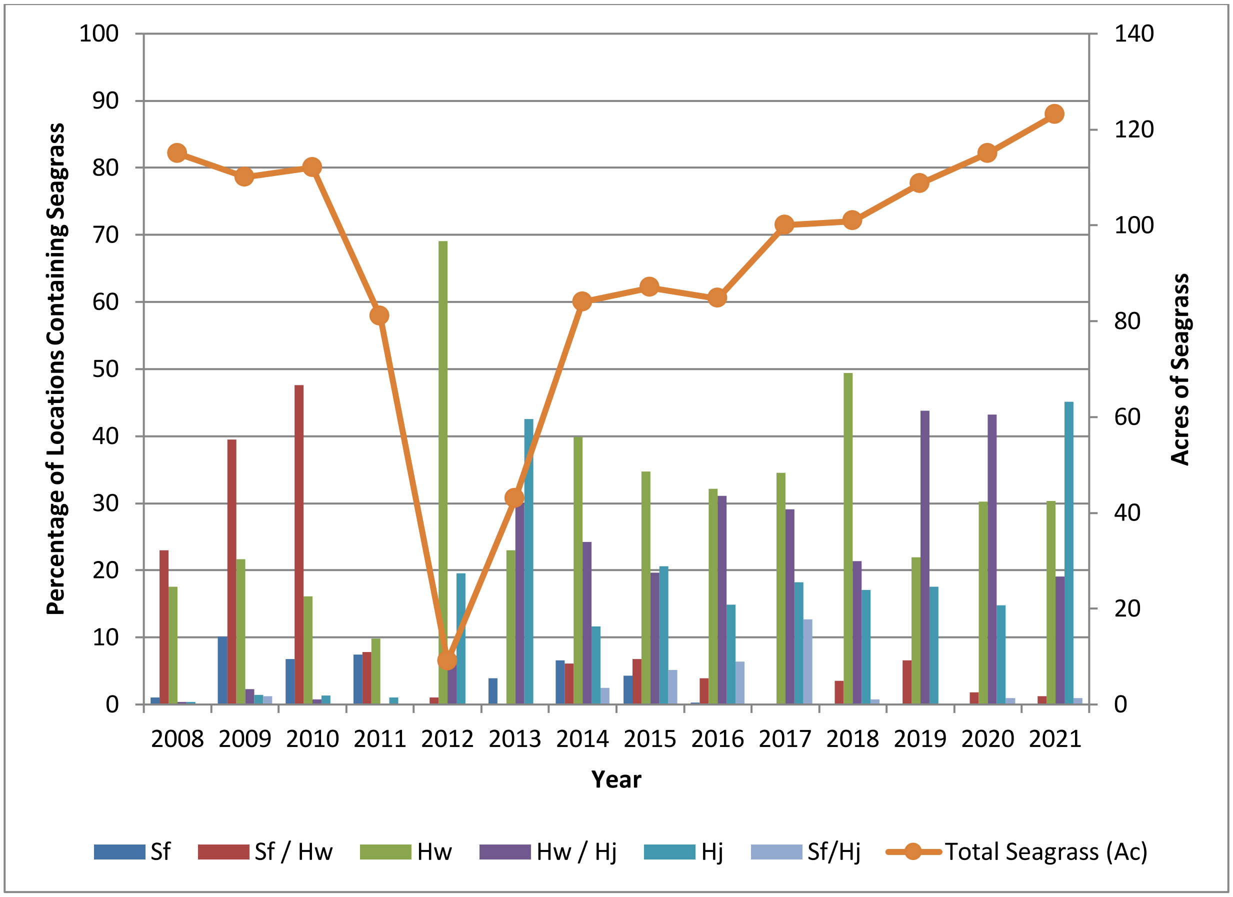

Figure 3-5. **Predominant seagrass species/species combinations observed from 2008 to 2021 showing the effects of and recovery after the region-wide seagrass loss. Abbreviations: Sf = *Syringodium filiforme*, Sf/Hw = *S. filiforme/Halodule wrightii*, Hw = *H. wrightii*, Hw/Hj = *H. wrightii/Halophila johnsonii,* Hj = *H. johnsonii,* and Sf/Hj = *S. filiforme/H. johnsonii*. Total seagrass acreage within the mitigation zone displayed on the secondary y-axis.**

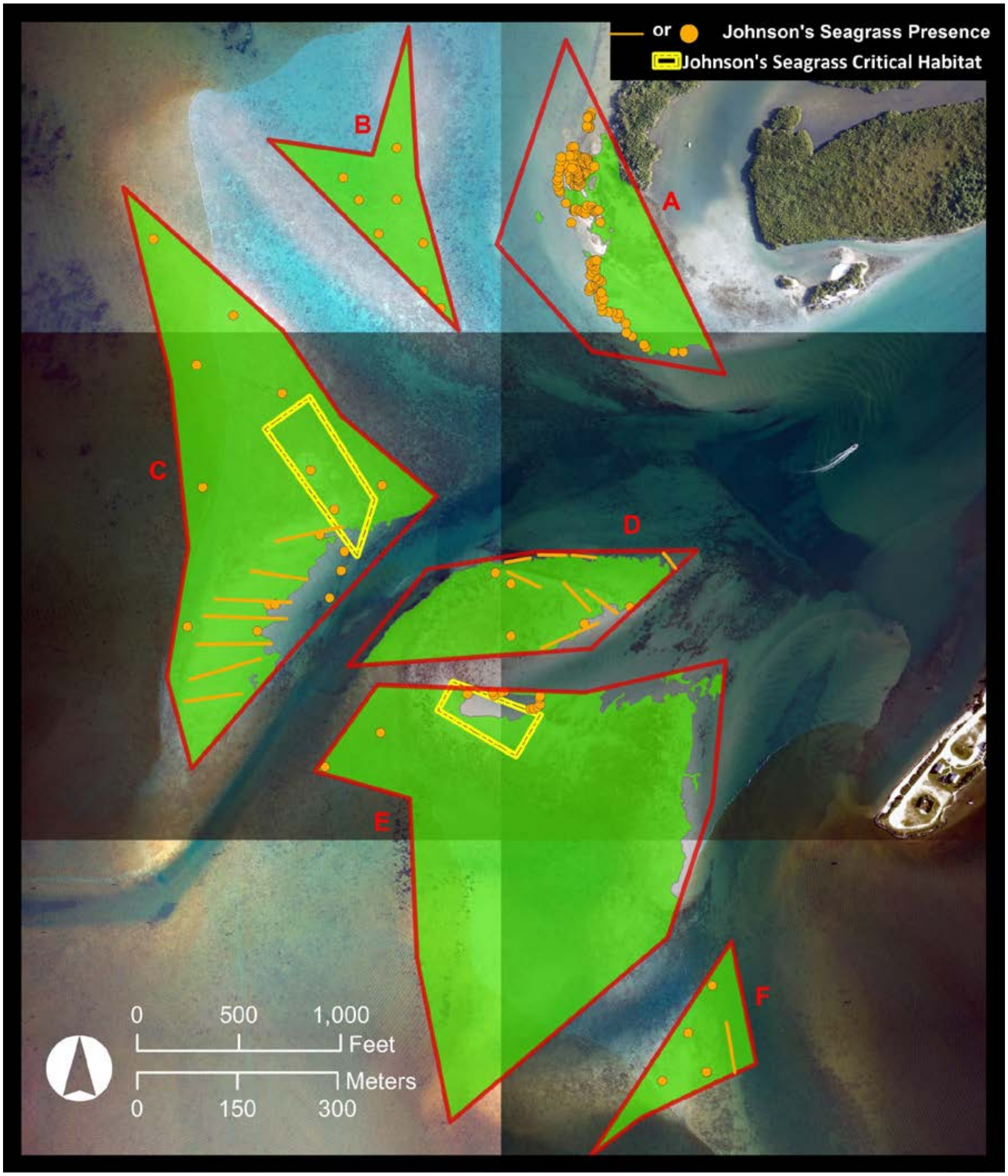

Figure 3-6. Locations with *Halophila johnsonii* observed during the 2021 groundtruthing event.

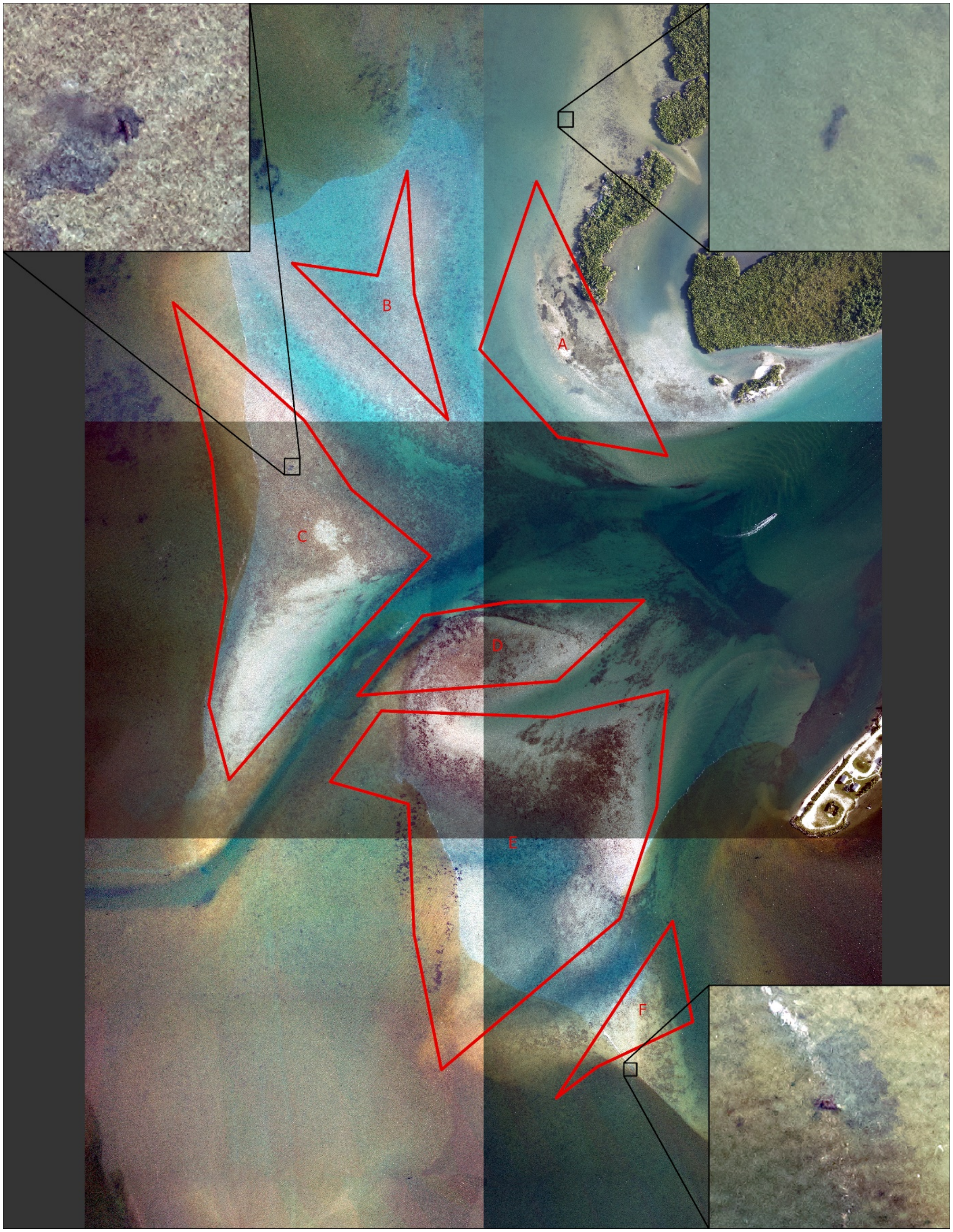

Figure 3-7. **Expanded August 5, 2021 aerial image with enlarged insets showing a total of three manatees engaged in feeding behavior on the shoals.**

4. Conclusions

The SID contracted Atkins to continue the abbreviated seagrass monitoring on the Sebastian Inlet flood tidal shoal in 2021 with the focus on the identification of species and quantification of seagrass coverage within the designated protected areas on the shoals. This was accomplished using a GIS-based approach using low-altitude, high-resolution digital aerial photography followed by a groundtruthing/field verification exercise to validate the observations made remotely. The following is a summary of the 2021 results within the protected areas on the flood tidal shoal including a change analysis from 2020-2021.

- 2021 Results
    - The finalized seagrass coverage feature class (post-groundtruthing) yielded ~123.05 acres of seagrass in 2021, equivalent to 84.86% of the mitigation zone. Zone A had the least coverage of seagrass (40.93% of the zone occupied by seagrass) while Zones B and F had the greatest (100% of both zones occupied by seagrass).
    - Species-specific data revealed that ~76% of the sites that contained seagrass were monospecific patches of seagrass, including *Halodule wrightii* (30%), *Halophila johnsonii* (45%), and *Syringodium filiforme* (1%). The remaining ~24% consisted of species combinations, including *H. wrightii, H. johnsonii, H. decipiens,* and *S. filiforme. H. wrightii/H. johnsonii* was the predominant species combination at 19%.
    - No prop scars were field validated in 2021.

- 2020-2021 Results
    - From 2020 to 2021, there was an increase in seagrass shoal-wide of ~8.08 acres. All zones exhibited net increases in seagrass coverage ranging from 0.08 acres (Zone B) to 2.29 acres (Zone C).
    - Zones E and F respectively had the highest and lowest total acreage of seagrass in both 2020 and 2021; however, this is unsurprising as these are respectively the largest and smallest shoals. In terms of percent coverage of the zone occupied by seagrass, Zone A remained the lowest while Zones B and F both attained 100% coverage in 2021.
    - The total acreage of seagrass present in 2021 exceeds the acreage present in 2008 (115 ac), 2009 (110 ac), and 2010 (112 ac) – the three years prior to the region-wide seagrass loss in 2011 and 2012. However, while total acreage of seagrass is now above pre-loss coverage, the species composition and density has undergone a drastic shift. In the past (2008-2011), the flood tidal shoal was predominately a mix of *Halodule wrightii* and *Syringodium filiforme*. In 2012 and 2013 (beginning of seagrass recovery after region-wide seagrass loss), the dominant seagrass species on the flood tidal shoal were *H. johnsonii, H. wrightii,* and combinations of the two species. In 2014-2021, *H. wrightii* and *H. johnsonii* continue to be the predominant seagrass species; *S. filiforme* is present in deeper areas such as the v-notch in the north side of Zone B, the west side of Zone C, the channel side of Zone D, the west side of Zone E, and the east and west ends of Zone F.
    - *H. johnsonii* (or a species combination containing *H. johnsonii*) was present at ~67% of all sites that contained seagrass in 2021, which is comparable to the 2020 survey (~64% of all sites). While its ESA listing status is under revision, *H. johnsonii* has been significant in the seagrass recovery on the flood tidal shoal and the stability of the shoal as seagrasses recolonize.

5. Future Recommendations

2022 will mark 10 years since the initial extension of the monitoring plan and the 2012 seagrass die-off event, during which the Sebastian Inlet flood tidal shoals have experienced drastic changes in seagrass area, density, and species composition. The upcoming 2022 monitoring event should be taken as an opportunity to create a more in-depth review of those changes, as well as assessing new objectives for data collection and potential improvements to the flood tidal shoals.

5.1. Aerial Analysis

The efficiency of the monitoring program depends in large part on the quality and timing of the aerial images. With clear water over the shoals, denser areas of seagrass at least can be delineated in GIS with high confidence and only spot checks may be required for groundtruthing. If seagrass patches are indistinct or obscured, additional field effort is required to delineate them. While some confounding factors such as sparse areas, macroalgae, and oyster hash are continuously present, tannic or turbid water can be mitigated for by scheduling overflights during periods of low rainfall. While this is not a factor that can be totally controlled, obtaining images as early in the season as possible (late May or June) would be preferable. This would also assist with fieldwork conditions; once the aerials are flown there are typically several weeks of lag time required in order to evaluate the images for suitability, georectification, preliminary analysis, and field effort organization. The earlier in the summer the field effort can occur, the better the chances of being able to work full field days without interruption from thunderstorms.

5.2. Prop Scar Analysis

As originally mandated by the USACE and FDEP permits for the establishment and later realignment of the Sebastian Inlet channel, the scope of monitoring efforts has included the assessment of prop scars by both aerial delineation and field verification. However, as the monitoring efforts tied to these permits ended in 2015, this scope item has been of limited importance to the continued long-term monitoring effort. Additionally, with the seagrass die-off and the nature of the recovery (prevalence of sparse areas of quickly-regrowing seagrasses), field verification of prop scars has typically yielded a low number of confirmed scars. As such, it may be best to revise this scope item to better suit the overall purpose of the long-term monitoring event by shifting from delineating and verifying individual scars to identifying scarring hotspots. If concentrations of prop scars are observed during the preliminary aerial analysis for a given year, these can be visited in the field and mitigation measures discussed (e.g. scar repair, improved signage, increased enforcement efforts, etc.). If no concentration of scarring is observed, this scope item may be removed entirely from that year's monitoring event.

5.3. Biological Monitoring

As previously noted, while overall acreage has recovered to or in fact exceeded what was present prior to the 2012 seagrass die-off event, seagrass density, species composition, and biomass have likely not recovered to the levels present prior to 2012. While the past 10 monitoring events have attempted to collect species presence and distribution data, these numbers do have to be treated with some caution as they have historically been mostly compiled from sampling in areas of disturbed and/or indistinct seagrass presence (prop scars and other areas which appear unvegetated or thinly vegetated). This may partially skew the results towards species such as *Halophila johnsonii* and *Halodule wrightii*, which may be difficult to delineate from aerial images in low densities. Based on observations throughout the area these two species are likely still dominant on the shoals by large margins; however, undersampling of denser areas of seagrass may mask changes over time in more visible species such as *Syringodium filiforme*.

One potential solution going forward, which was partially implemented in the 2020 and 2021 monitoring events, is to add randomly selected sampling points to each shoal; however, these tend to be "drowned out" by the volume of points collected in the field to delineate areas of uncertainty. For future monitoring events, it may be best to collect a distinct "sampling points" feature class specifically for species analysis (seagrass species can still be collected when delineating features, which can be used to visually show species distribution). The sampling points feature class could also include seagrass coverage data (either as direct percent cover or Braun-Blanquet scoring).

5.4. Shoal Alterations

In addition to the changes in seagrass coverage, the physical features of the shoals themselves have been altered over time. While the main channel between Zones C, D, and E is maintained by regular dredging events, the remainder of the flood tidal shoals have been subject to natural accumulation and erosion. The period after the 2011/2012 seagrass die-off likely diminished the integrity of the shoals by removing rhizomes from the sediment. While some of these changes may have resulted in no net loss of seagrass habitat (e.g., the effective merger of Zones D and E via partial filling of the gap between them, Zone F losing material at the northeast end but spreading out to the southeast and west), Zone A appears to have experienced a large net loss of material on its western side since 2011. Based on discussions with SID and review of aerial images over the past decade, the general direction of sediment transport seems to be south-southeast towards the inlet sand trap. This likely contributes to Zone A still showing a net loss of seagrass coverage from prior to 2012.

Based on discussions with SID, Atkins biologists have initiated a discussion with Atkins coastal engineers regarding options to arrest erosion along Zone A. While these discussions are at a preliminary stage at present, one suggestion would be to create an oyster break extending west from the southwest end of the present shoal to trap and accumulate sand, as well as potentially assist with water quality.

6. Literature Cited

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