ANNUAL MONITORING REPORT (2 OF 3)

2017

SAVE CRYSTAL RIVER PILOT PLANTING REPORT

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1. INTRODUCTION

The city of Crystal River is located northwest of the center of Citrus County (28.900670, -82.593699) on the northeast side of Kings Bay and the Crystal River, an inlet of the Gulf of Mexico. U.S. Routes 19 and 98 pass through the center of the city, leading south 7 miles (11 km) to Homosassa Springs and north 46 miles (74 km) to Chief land. State Road 44 leads east from Crystal River 17 miles (27 km) to Inverness, the Citrus County seat. Crystal River is at the heart of the Nature Coast of Florida. A cluster of 50 springs designated as a first-magnitude system feeds Kings Bay. A first-magnitude system discharges 100 cubic feet or more of water per second, which equals about 64 million gallons of water per day. Because of this discharge amount, the Crystal River Springs group is the second largest springs group in Florida, the first being Spring Creek Springs in Wakulla County near Tallahassee. Kings Bay is routinely home to over 500 manatees during the winter when the water temperature in the Gulf of Mexico cools. Crystal River was designated as an Outstanding Florida Water under Chapter 62-302.700 F.A.C, which affords the waters special protection due under Florida State law. Crystal River is unique in that the headwaters are freshwater springs, which transition into a tidally influenced river system that spans 6 miles and over 600 acres. The springs offer many recreation activities, and provide the majority of tourism revenues to Crystal River and Citrus County. The springs attract worldwide visitors and is listed in Frommers Travel Guide. This first of a kind Pilot project took place in 3.4 acres of upland canals as outlined in Figure 1 for 12 months from September 2015 to September 2016.

Recently, the Crystal River system has suffered from declining of water quality, attributed to increased nutrient loads and invasive plant and algal species. Non-native invasion and nutrient loading are linked, with the combination of increased nutrients and lack of natural controls allowing the invasive species to flourish. It was the intent of the project to restore Submerged Aquatic Vegetation (SAV), in particular *Vallisneria Americana* (tape grass) to the upland canal systems in the Kings Bay water way. Under the right conditions Tape grass will (1) outcompete noxious macroalgae and invasive plants, (2) absorb excess nutrients and (3) bolster dissolved oxygen levels.

Prior to the commencement of the Save Crystal River Pilot restoration project, Sea and Shoreline assessed benthic conditions. Benthic conditions were surveyed for soft-sediment depth and organic composition. The substrate on average was a mixture of organic material and sand. The thickness of the soft-sediment layer averaged between 1.5 to 4 feet from the sediment surface to the rocky foundation. Prior to planting, detrital material, muck, and algae mats were selectively vacuumed from the benthos. Post dredging conditions left sand and organic sediments throughout the project site.

Based on stakeholder input it was decided that there needed to be anchorage areas to allow tour boat access to the newly restored areas. The canals were marked in gridlines with three “lanes” of GrowSAV Herbivory Exclusion Devices. The lanes provided room for vessel and manatee traffic to occur without impacting navigation and movement through the canals. The GrowSAV Devices were placed roughly on 15-ft centers. In areas experience heavy anchorage from vessels, the distances between the GrowSAV Devices were expanded to compensate for the increased vessel intensity. There were three areas, one in each canal, that were left without GrowSAV Devices to allow for anchorage. The GrowSAV Devices were loaded onto a 20-ft fiberglass barge by hand from shore. The GrowSAV Devices were then placed into the water in the predetermined areas marked by buoys and a gridline. The gridline was based on equal distance from the necessary depth contour line to ensure that the GrowSAV device will have at least two feet of water above the planting site based on mean low waterline. When the GrowSAV Devices were properly weighted and placed on the bottom the gridline and buoy system were removed.

Once all 360 GrowSAV devices were placed on the canal bottom, the planting began. Nursery grown *Vallisneria americana* (tape grass) peat pot units were loaded into enclosed trailers and delivered from Sea and Shorelines based aquaculture facility (Ruskin, Florida). Peat pot units were transported in trays to reduce disturbance, and were acclimated to the system overnight. The trays were then loaded onto the fiberglass barge and delivered to the planting site. Planting took place in November 2015 by certified divers experienced in submerged aquatic planting. Each of the 360 GrowSAV Devices were planted with 5 peat pot units each.

As part of the permit requirements the Save Crystal River Pilot was monitored at regularly spaced monitoring campaigns (4 weekly, 2 bi-weekly, 9 monthly and 3 annual), each resulting in a report on the ecological health and survivorship of planted tape grass for a total of 18 reports by 2018. During each monitoring campaign, Sea and Shoreline will evaluate benthic vegetation in planted and adjacent areas. **This report is the second of three annual monitoring events.**

2. METHODS

2.1. Sampling Design for Monitoring and Site Description

The transplanting site is situated in the upland canal systems located in the Kings Bay basin. Accessibility to the site was made available by the presence of canals (Figure 1). Sediment inspection revealed that it was muddy-sand to sandy-mud, reflecting the protected nature of the canal system (i.e., reduced fetch). Central water depths were 0.8-2.5 m. Additionally, prior to planting, there was no tape grass or other beneficial submerged aquatic vegetation observed in the restoration area, only filamentous green algae. However, limited populations of *V. Americana* were recorded in adjacent canals.

The transplanting/restoration sites (1, 2 and 3) were nearly rectangular polygons, oriented parallel to the canals (Figure 1). Cages were spaced approximately 3.0 m apart in rows oriented parallel to the shoreline. Between November 9 and 16, 2015 (7 working days) Sea and Shoreline Team transplanted more than 1,800 PUs, into 360 GrowSAV cages (nominally 5 PUs per cage). Once planting was completed, Sea and Shoreline delineated the perimeter of the transplant area using a handheld DGPS unit with sub-meter accuracy (Trimble GeoExplorer 6000). Each cage was physically tagged for future identification, and 10% of the 360 units were haphazardly selected for monitoring. As a reference, randomly located positions were selected no less than 2 m from each monitoring point. All monitoring and reference locations were permanently tagged. A small waterproof label was securely attached to the looped end onto the cage. Planting and reference points (72 total points) were monitored during each sampling campaign. WGS coordinates of the 36 sampling points are presented in Table 1 while that of the 36 reference points are presented in Table 2.

Assessment of the survival, health and growth of the planting units at the planted site, and a comprehensive suite of biological attributes were quantified and compared to the reference sites. These include benthic community composition, assessments of planting unit survival, *V. americana* shoot density, areal coverage (frequency, abundance, and density), canopy height, epiphyte cover, macroalgal cover and general notes on site condition. Physicochemical water and seabed properties were also measured at each site to provide environmental context for any observed changes in benthic cover or PU performance. The monitoring event was performed within the seagrass monitoring season within the month of September 2017.

2.2 Biological Parameters

Benthic community composition was monitored using 0.25-m² quadrats by Sea and Shoreline biologists using SCUBA and/or snorkel. Supplementary photo-quadrats of the seafloor were collected at each of the monitored planting and reference locations. All imagery was reviewed in the laboratory to verify SAV species composition and will serve as archival evidence of project performance.

2.2.1. Survival of Planting Units

Survival of planting units were assessed by noting the presence or absence of healthy *V. Americana*. Survival was defined as the presence of a single shoot, as even a single shoot indicates association with a growing rhizome (Fonseca et al., 1998).

2.2.2. *V. americana* Shoot Densities

V. Americana shoot density was estimated at each of the 72 individual permanent sampling points by placing a 10 x 10 cm quadrat in the center of each Braun-Blanquet monitoring quadrat and manually counting all of the shoots present (Figure 2). Shoot count data was then multiplied by 100 to obtain shoot densities in the number of shoots per square meter (shoots m^{-2}). Total grass shoot density is reported the sum of all species counted in a quadrat (shoots/m^2). The data are reported as mean densities per treatment: planted (N =36) and reference (N = 36).

2.2.3. Visual Assessment of Braun-Blanquet Frequency, Abundance, and Density

The coverage (frequency, abundance and density) of each SAV species, total SAV community, macroalgae and total macroalgal community in the planting and reference sites were evaluated using the Braun-Blanquet visual assessment method in 0.25-m^2 quadrats (Table 3; Braun-Blanquet 1965, Kenworthy et al. 1992, Fourqurean et al. 2001). In each quadrat, all observed benthic plant and algal species, total SAV and total macroalgae were visually scored and recorded inside the quadrat by Sea and Shoreline biologists using SCUBA or snorkel. Braun-Blanquet scores corresponded to coverage ranges reported in Table 5. Three variables (frequency, abundance, and density) were then calculated from the scores according to the following formulas:

Frequency = *number of occupied quadrats ÷ total number of quadrats* (1)

Abundance = *sum of B-B score values ÷ number of occupied quadrats* (2)

Density = *sum of B-B score values ÷ total number of quadrats* (3)

2.2.4. Benthic Plant Community Canopy Height

In the same 10 x 10 cm quadrats used for shoot counts, the canopy height of the benthic plant community (SAV and/or macroalgae) was measured *in situ* by the observer using a metric ruler. All values were rounded to the nearest 0.5 cm. For sites with *V. americana* these data represent blade length, for those without, algal thickness. Data are reported as a mean value per treatment: planted (N =36) and reference (N = 36).

2.2.5. *V. americana* Epiphyte Cover

The cover of epiphytes on *V. americana* leaves in the relocated and reference grasses was assessed inside each Braun-Blanquet quadrat (1-m^2). Observers used a visual estimation technique based on a scale ranging from 0 (clean) to 3 (heavy; Table 4). The data are reported as mean epiphyte cover per treatment: planted (N =36) and reference (N = 36).

2.3. Physical Parameters

2.3.1. Water Quality

Water temperature, pH, salinity, dissolved oxygen (DO) and turbidity (NTU) were measured at the surface and bottom at four (4) stations once during each monitoring event (two stations per treatment) using a calibrated YSI 6600 V2 sonde or a YSI Professional Plus multi-parameter water quality logger (Figure 3). The water quality values for each individual parameter at each depth are reported as mean values for the two stations at the planted and reference sites, respectively. Water quality measurements were further evaluated for compliance with DEP/EPA Standards for environmental protection.

2.4. Permanent Archive

Video recordings of the seafloor along longitudinal/diagonal transect and/or photographs of the "tagged" sods/quadrats in the monitoring and reference sites were collected during each monitoring period. These recordings were electronically archived and will serve as a permanent record of project performance.

3. RESULTS

3.1 Biological Parameters

3.1.1. Survival of Planting Units

During this 2nd monitoring campaign (22 months post-planting) the planting unit survival was 92%. This was slightly lower than Campaign 1 which had a 97.2% survival. The reference sites were also surveyed for survival even though no plants were planted or present during the Time Zero monitoring at the beginning of the project. The survival for the reference site during Campaign 2 was 67% compared to 47% in Campaign 1(Figure 4).

As planting units continue to spread into the barren reference sites, we will continue to see an increase in plant density within these sites.

3.1.2. Mean *V. americana* Shoot Densities

V. americana was observed in both the planted and reference sites (Figure 5). Shoot densities within the planted zone were highly variable. During Campaign 2, the average shoot count was higher when compared to the previous campaign (994 shoots m^{-2}; 839 shoots m^{-2} respectively). Reference densities continue to increase as well when compared to the pervious campaign at a considerably higher rate from 31 shoots m^{-2} in Campaign 1 to 361 shoots m^{-2} during Campaign 2.

3.1.3. Braun-Blanquet Frequency

In Campaign 2, the frequency of total SAV was higher at the reference site (0.97, planted; 1.0, reference) and total macroalgae lower (in the reference versus the planted sites 1.0, planted; 0.10, reference) (Figure 6). *Lyngbia* was more frequent in the planting area than adjacent reference locations (1.00, planted; 0.07, reference), while the transplanted species, *V. americana* was more frequent (0.92, planted; 0.05, reference). Interestingly, now that the cages have been removed *Hydrilla* is more abundant in the planted sites than at the reference sties (0.94 and 0.04, respectively). *Najas* was practically absent at both reference and planted sites.

3.1.4. Braun-Blanquet Abundance

In the quadrats occupied by *V. americana* in Campaign 2, abundance values were higher in the relocation sites (3.42) than in the reference sites (0.05; Figure 7). Total SAV abundance was also higher in the relocation (4.77) than the reference sites (4.32), and the same was observed for total macroalgae (3.11 and 0.10, respectively). Within the macroalgae community, *Spirogyra* was less abundant (1.05 vs. 0.01). Najas species was practically absent. Overall, however, frequency and abundance patterns were similar.

3.1.5. Braun-Blanquet Density

During Campaign 2, Braun-Blanquet densities for total SAV were 1.07 times higher within the planted cages (4.64) than in adjacent reference stations (4.32; Figure 8). SAV density was 1.33 times higher in Campaign 2 than in Campaign 1. This was driven almost entirely by *V. americana* (3.14) As with other Braun-Blanquet derived metrics, total macroalgal densities were much higher outside of the planted cages than within (3.71 and 3.11, respectively), with *Lyngbia* driving much of that pattern (2.60, reference; 2.06 planted).

3.1.6. Mean Coverage of Total SAV in the Relocation Site.

The coverage of total SAV in the relocation sites ranged from 0 to 5 with a mean Braun-Blanquet score of 4.64 (Figure 9). This was similar in reference locations, which ranged from 0 to only 5 with a mean coverage of 4.32. Mean SAV cover during Campaign 2 was slightly higher than Campaign 1 (4.64- 3.46, respectively) at the relocation site. The reference site was 3.04 times higher than Campaign 1 (4.32; 1.67, respectively).

3.1.7. Benthic Plant Community Canopy Height

Canopy heights ranged from 10 to 20 cm at the relocation sites (GrowSAV cages removed) and 0 to 15 cm in adjacent references (Figure 10). Mean values were 13.14 and 7.78 cm, respectively.

During Campaign 1 there was a canopy disparity between the reference and the planted sites due to the much larger leaf lengths of *V. americana* at the planted site compared to the reference sites. Campaign 2 exhibited a much lower mean canopy height compared to Campaign 1 (13.14; 35.4 respectively) at the relocation site, while the reference site exhibited a small increase (4.36; 7.78 respectively). This may indicate that at the planting site grazing maintains shorter canopy heights due to the absence of cages.

3.1.8. Mean Epiphyte Cover

During Campaign 2, the epiphyte cover was similar between the planted cages and adjacent reference sites with mean values of 1.42 and 0.94, respectively and similar to Campaign 1 (1.69; 0.42, respectively) (Figure 11). Based on the epiphyte scale values, (Table 3) both treatments had clean to heavy coverage with mean values approximating light epiphytic loading. This is consistent with the idea that the primary epiphyte grazers (most likely small invertebrates) were smaller than the GrowSAV mesh aperture, leading to equivalent grazing pressures between treatments.

3.3. Physical Parameters

3.3.1. Discrete Water Quality Data

The discrete water quality data for each individual station are presented in Table 6. Water temperatures at all 4 sites (2 references, 2 planted) were 70° F. Turbidity readings were similar between stations ranging from 10 to 12 NTU. Dissolved oxygen (DO) varied slightly with mean values of 7.07 mg/L. Repeated depth profiles of salinity, temperature and dissolved oxygen were conducted during Campaign 2. Based on these readings, it was determined that there was no evidence for vertical stratification in the water column, therefore only the surface readings are presented here.

Turbidity values were almost 10 times higher than in Campaign 1 due to hurricane IRMA (1.6 NTU Campaign 1; 11 NTU Campaign 2).

4. DISCUSSION & SUMMARY OF RESULTS

The results of the second monitoring campaign indicated that nearly the entire PU deployment survived the transplanting process (92% survival) and that biological response of the transplanted *V. americana* indicates a healthy and viable population. This survival rate is better than the average global success rate for transplanting seagrasses considered to be ≤50% (Fonseca et al. 1998). The initial biological response of transplanted *V. americana* indicates that the relocation methods were successful in alleviating undue stress and, at year two, the survival rate of relocated plants exceeds the target rate of 80%.

Qualitatively, the PU's appear to be in very good condition. In the relocation sites, mean SAV density is probably higher than when first transplanted, as vegetative runners were observed beyond cage boundaries, a clear indication that transplanted individuals have acclimated to their new location. In general, the mean total grass shoot densities in the relocation sites were comparable to densities of natural meadows reported for the Crystal River area (Shepard et al. 1992; Kenworthy et al. 1993; Erftemeijer and Shuail 2012). Over the entire relocation site, SAV cover was generally between 50 to 75 %. Typically, during the initial period following grass transplanting there is a stress response as the relocated grasses adjust to the physical disturbance of relocation and acclimation to a new environment. However, the results of the biological survey data from Campaign 2 shows that coalescence has been archived to the extent that the *V. americana* vegetiative growth (rhyzomes) have spread into the reference area. As indicated above, shoot densities were normal and coverage values were acceptable. Additionally, the leaf epiphyte cover values were low overall and similar to adjacent *V. americana*; at present epiphytic cover is below thresholds established in the marine literature for inhibiting establishment of SAV (Hemminga and Duarte 2000).

The initial success of relocation may be partially attributable to the dredging and the use of the GrowSAV Herbivory Exclusion Devices that provides protection from herbivory while mitigating some of the hydrodynamic influences of the site. Even though the GrowSAV Herbivory Exclusion Devices were removed 10 months prior to this monitoring Campaign 2, (removed on 11/10/2016) the relocation success is very high and can be partially attributable to initial protection provided by the cages and to the rapid growth nature of *V. americana*.

As reported in the baseline survey, sediments at the relocation and reference sites consisted mostly of fine, medium and coarse sands with silty mud. The sediment conditions at both sites were typical of conditions known to support the growth of grasses in Crystal River. During this Campaign 2 we observed very little change in the measured environmental parameters compared to the baseline survey. The pH conditions were normal for spring fresh water and temperatures were 70° F. Turbidity (NTU) in the water column was similar between the relocation and reference sites but much higher than the previous campaign. The last hurricane that Florida endured, Hurricane Irma, left behind much debris in the water, including particles from surrounding land making the water in some areas turbid and brown in color. We hope that this brown water dissipates in the near future before it may have a negative impact in the newly transplanted *V. americana*. With respect to water depth, all of the measured water quality parameters indicated that the water column was well mixed with no indication of vertical stratification or bottom-water anoxia that could inhibit SAV development. Should the environmental conditions we observed during this monitoring campaign continue to improve, we expect that the PUs will continue to propagate vegetatively and ultimately expand to cover a significant portion of the project site.

In summary, the biological assessments of survival, density and abundance of SAV during this second monitoring campaign indicated that transplanted *Vallisneria americana* were healthy and thriving. There was limited evidence of plant mortality; therefore the amount of SAV present in the relocation or planting site is currently meeting project requirements. Presently, all of the physical parameters measured at the relocation site were similar to the conditions in Crystal River were *Vallisneria americana* has been shown to thrive. Unless there are significant changes in these parameters, we do not expect to observe any negative effects on survival and growth.

5. BIBLIOGRAPHY

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6. TABLES

Table 1: Real time coordinates of tagged grass planting units (PU) cages for monitoring

Latitude	Longitude	Point_ID
28.892502950	-82.590531883	1
28.892555200	-82.590524147	2
28.892776858	-82.590543423	3
28.893062196	-82.590458280	4
28.893338166	-82.590076064	5
28.893400581	-82.589967110	6
28.893482639	-82.589843256	7
28.893606153	-82.589674322	8
28.893660283	-82.589551950	9
28.893849625	-82.589258693	10
28.893804401	-82.589403657	11
28.893949503	-82.589110507	12
28.893643942	-82.589646866	13
28.893808685	-82.589441222	14
28.893899611	-82.589292980	15
28.894017165	-82.589180425	16
28.893829972	-82.589510418	17
28.894043300	-82.589300498	18
28.893772291	-82.589085731	19
28.893597179	-82.588957463	20
28.893397637	-82.588880960	21
28.893167109	-82.588679265	22
28.893204555	-82.588698470	23
28.893280672	-82.588731238	24
28.892700445	-82.588506284	25
28.892612355	-82.588465588	26
28.892509625	-82.588412240	27
28.892354862	-82.588337215	28
28.892596090	-82.588672779	29
28.892588468	-82.588824789	30
28.892611637	-82.588896264	31
28.892589289	-82.589006155	32
28.893146216	-82.590349790	33
28.893397066	-82.589992206	34
28.893623148	-82.589660493	35
28.893698006	-82.589565070	36

Table 2: Real time coordinates of tagged reference grass quadrats for monitoring.

Not available.

Table 4: Braun – Blanquet (BB) score values and corresponding grass cover.

Braun Blanquet Score	Cover Value
0	Absent
0.1	Solitary specimen
0.5	Few, with small cover
1	Numerous, but less than 5% cover
2	5% - 25%
3	25% - 50%
4	50% - 75%
5	75% - 100%

Table 3: Epiphyte cover scale with corresponding qualitative descriptions.

Scale	Epiphytic Coverage Description
0	Clean
1	Light
2	Moderate
3	Heavy

Table 5. Temperature, salinity, dissolved oxygen, pH and turbidity in the bottom waters at each of the two stations in the relocation and reference sites.

Temperature (°C)	Bottom
Monitoring Site 1	70
Monitoring Site 2	70
Reference A	70
Reference B	70
Salinity (ppt)	
Monitoring Site 1	0
Monitoring Site 2	0
Reference A	0
Reference B	0
Dissolved Oxygen (mg/L)	
Monitoring Site 1	7.03
Monitoring Site 2	7.04
Reference A	7.06
Reference B	7.1
pH	
Monitoring Site 1	ND
Monitoring Site 2	ND
Reference A	ND
Reference B	ND
Turbidity (NTU)	
Monitoring Site 1	11
Monitoring Site 2	11
Reference A	12
Reference B	10

7. FIGURES

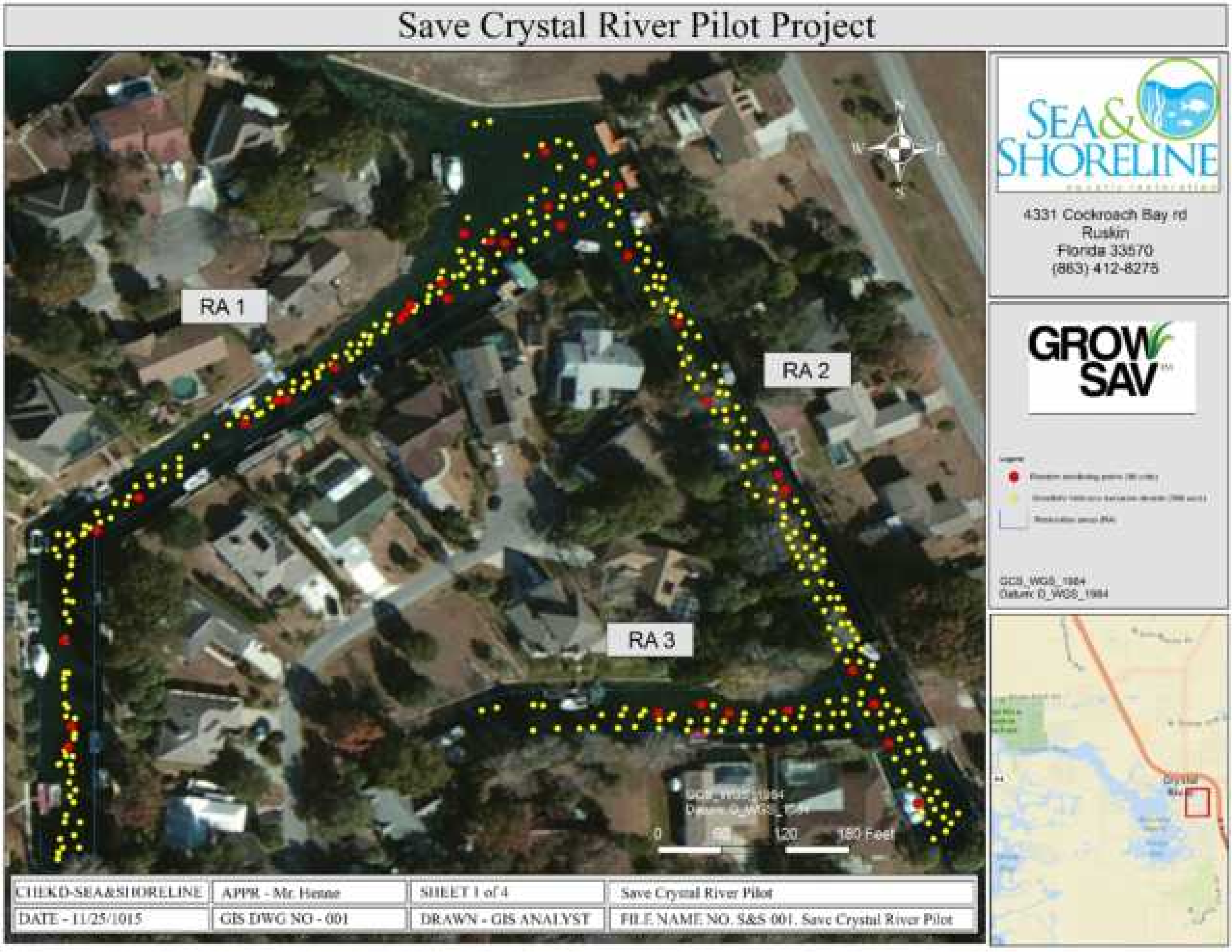


Figure 1. Map showing the location of the grass relocation site (blue polygons), exclusion cages and planting units location (Yellow dots), locations of the permanent sampling sites (red dots).

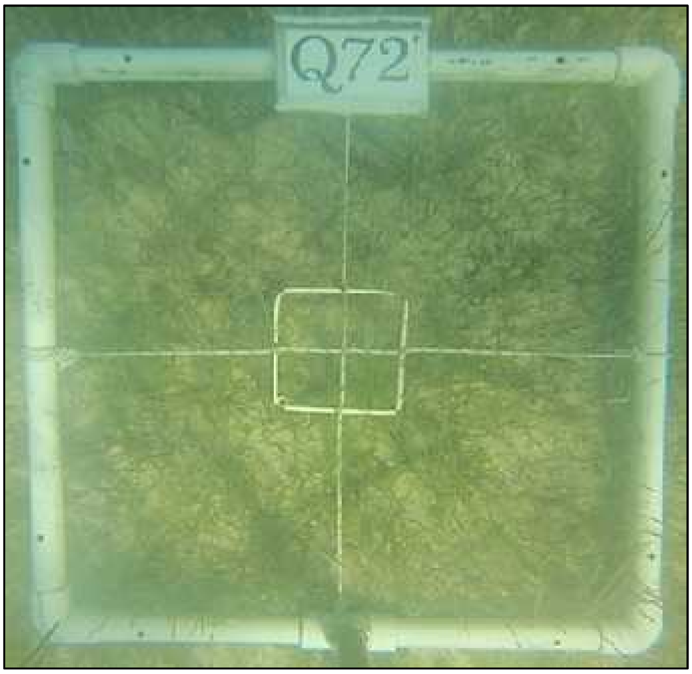


Figure 2. Underwater photograph showing the shoot count quadrat (10 cm x 10 cm) placed inside the center of the larger Braun Blanquet quadrat (100 cm x 100 cm, not to scale).

Figure 3. YSI Professional Plus multi-parameter water quality logger. Inset – YSI 6600 V2 Sonde

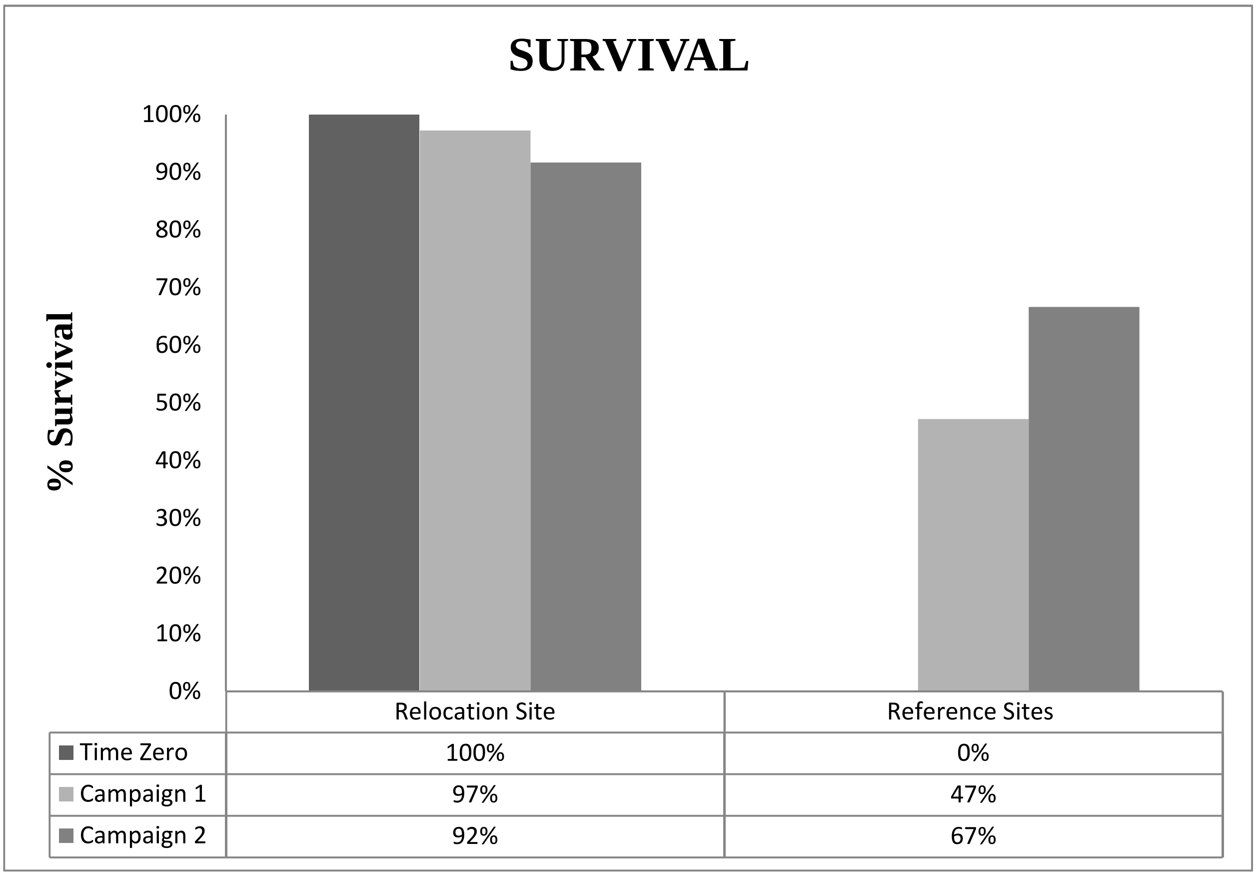
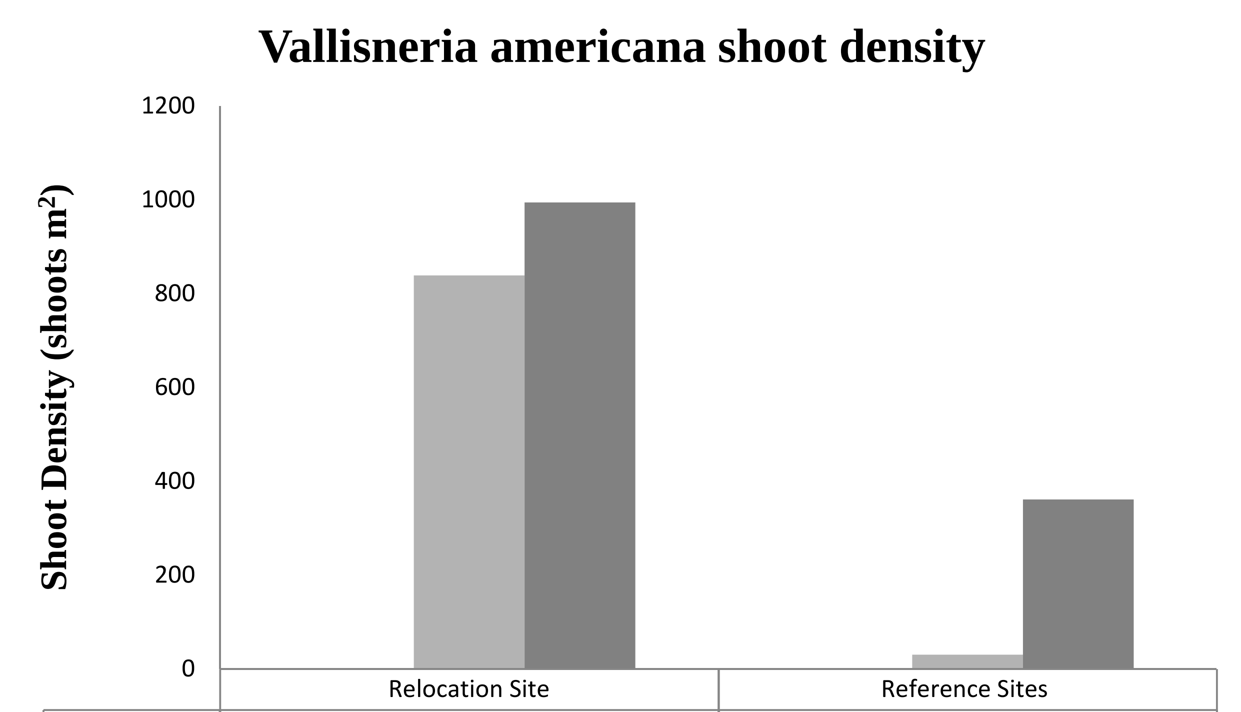
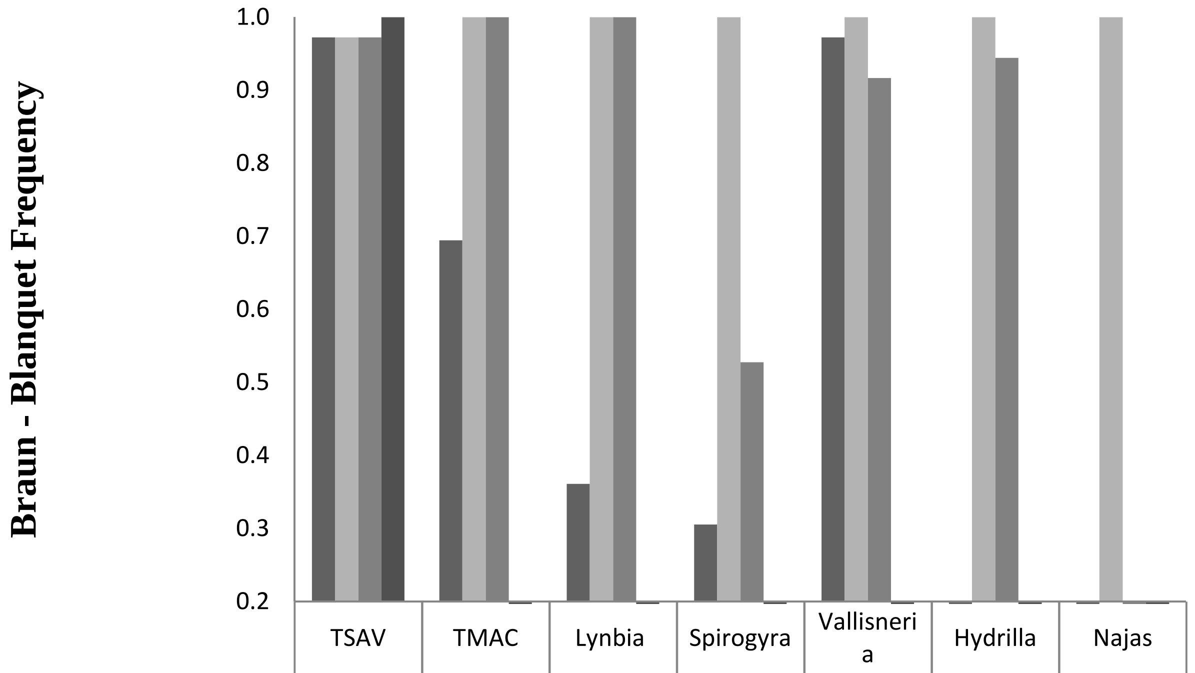


Figure 4. Survival of *V. americana* PUs during Campaign 1 and 2.



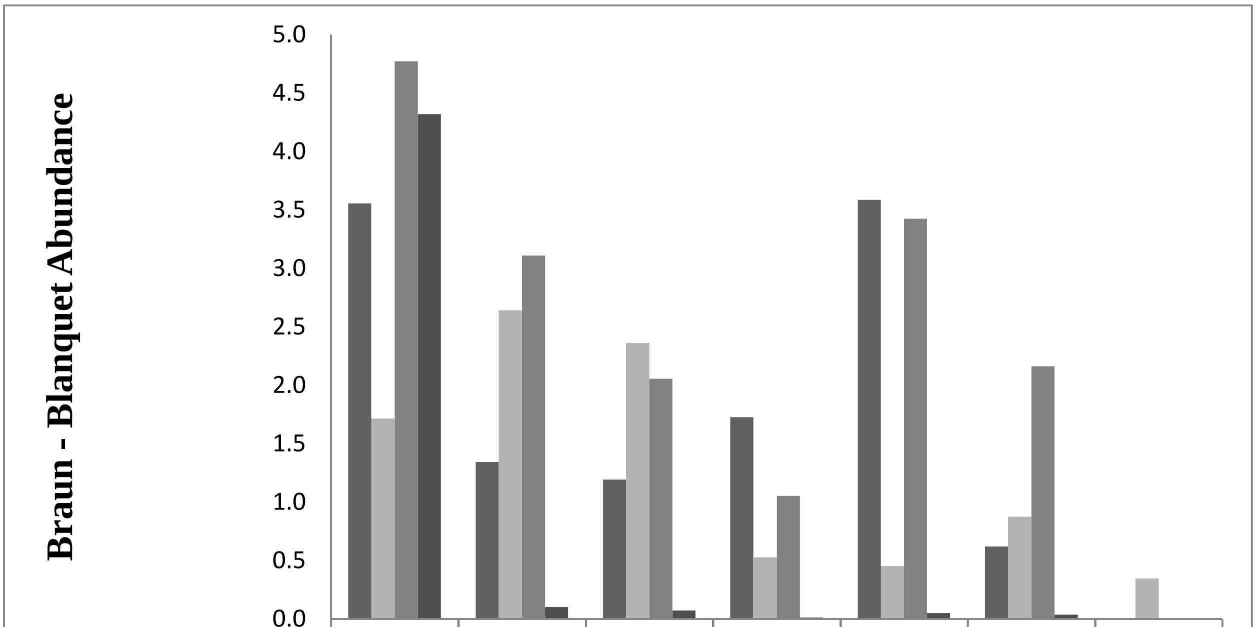
	Relocation Site	Reference Sites
Time Zero	0	0
Campaign 1	839	31
Campaign 2	994	361

Figure 5. Vallisneria americana shoot density (shoots/m2) at the reference and relocation sites during Campaign 1 and 2.



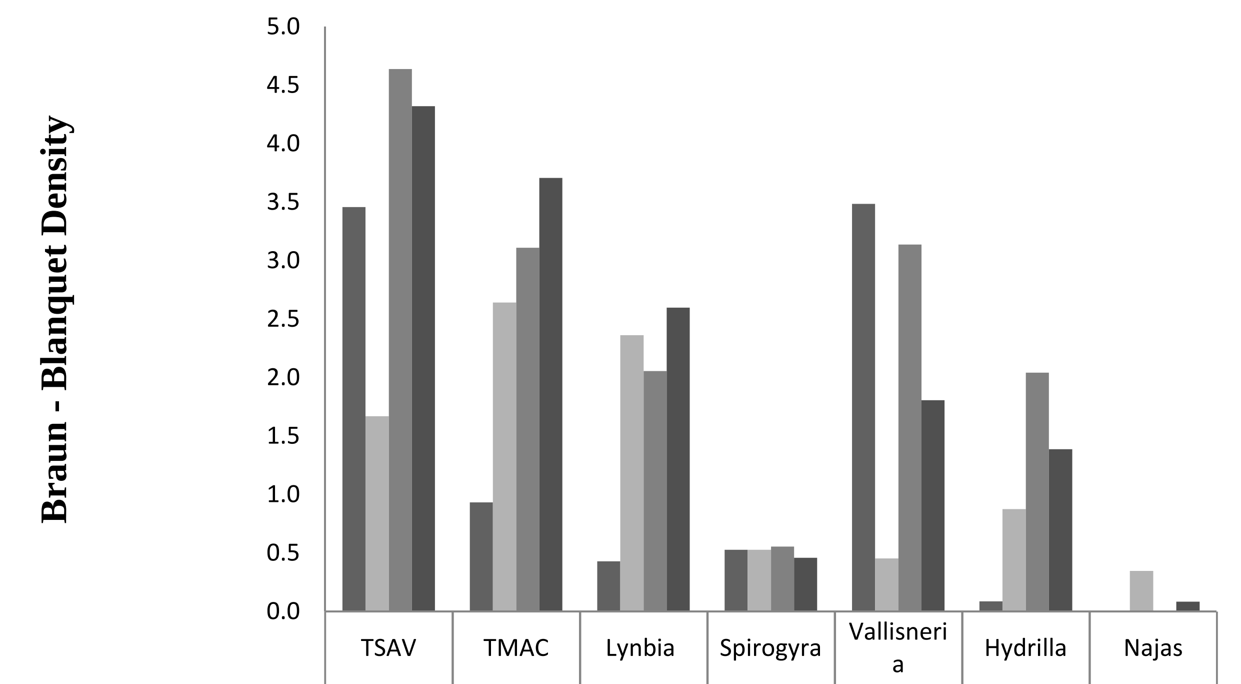
	TSAV	TMAC	Lynbia	Spirogyra	Vallisneria	Hydrilla	Najas
Campaign 1 planted	0.97	0.69	0.36	0.31	0.97	0.14	0.00
Campaign 1 reference	0.97	1.00	1.00	1.00	1.00	1.00	1.00
Campaign 2 planted	0.97	1.00	1.00	0.53	0.92	0.94	0.00
Campaign 2 reference	1.00	0.10	0.07	0.01	0.05	0.04	0.00

Figure 6. Braun-Blanquet frequencies for SAV and algal species at the planted and reference sites



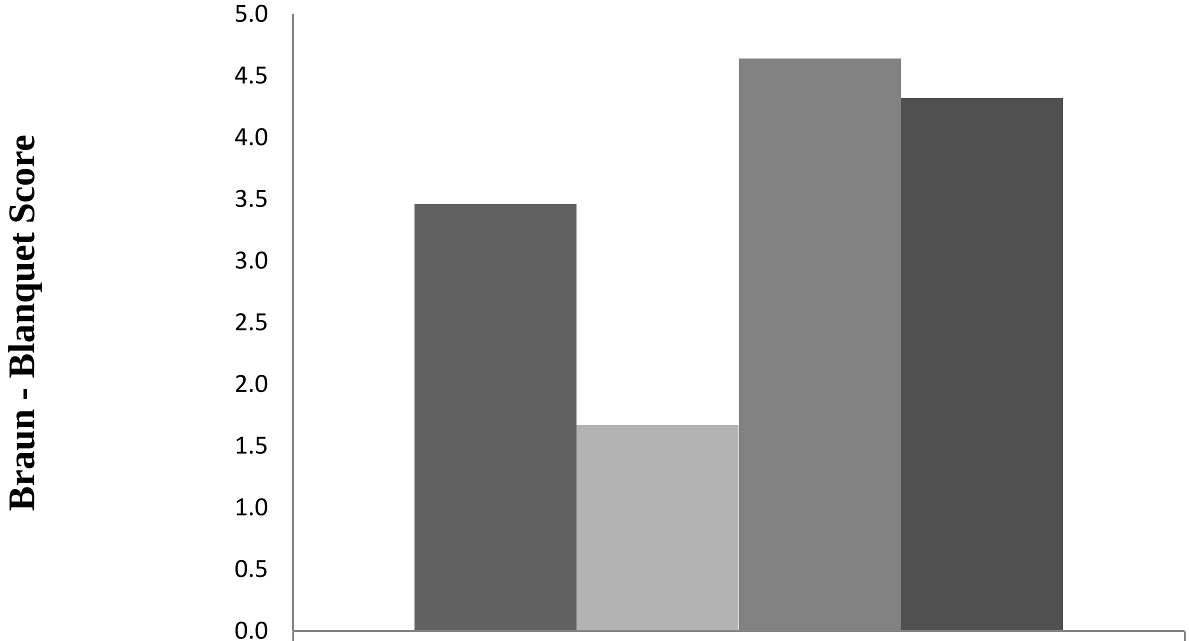
	TSAV	TMAC	Lynbia	Spirogyra	Vallisneria	Hydrilla	Najas
Campaign 1 planted	3.56	1.34	1.19	1.73	3.59	0.62	0.00
Campaign 1 reference	1.72	2.64	2.36	0.53	0.45	0.88	0.35
Campaign 2 planted	4.77	3.11	2.06	1.05	3.42	2.16	0.00
Campaign 2 reference	4.32	0.10	0.07	0.01	0.05	0.04	0.00

Figure 7. Braun-Blanquet abundances for SAV and algal species at the planted and reference sites during campaign 1 and 2.



	TSAV	TMAC	Lynbia	Spirogyra	Vallisneria	Hydrilla	Najas
Campaign 1 planted	3.46	0.93	0.43	0.53	3.49	0.09	0.00
Campaign 1 reference	1.67	2.64	2.36	0.53	0.45	0.88	0.35
Campaign 2 planted	4.64	3.11	2.06	0.56	3.14	2.04	0.00
Campaign 2 reference	4.32	3.71	2.60	0.46	1.81	1.39	0.08

Figure 8. Braun-Blanquet densities for SAV and algal species at the planted and reference sites during campaign 1 and 2.



	TSAV
Campaign 1 planted	3.46
Campaign 1 reference	1.67
Campaign 2 planted	4.64
Campaign 2 reference	4.32

Figure 9. Braun-Blanquet scores for Total SAV recorded in the planted cages and reference areas during Campaign 1 and 2.

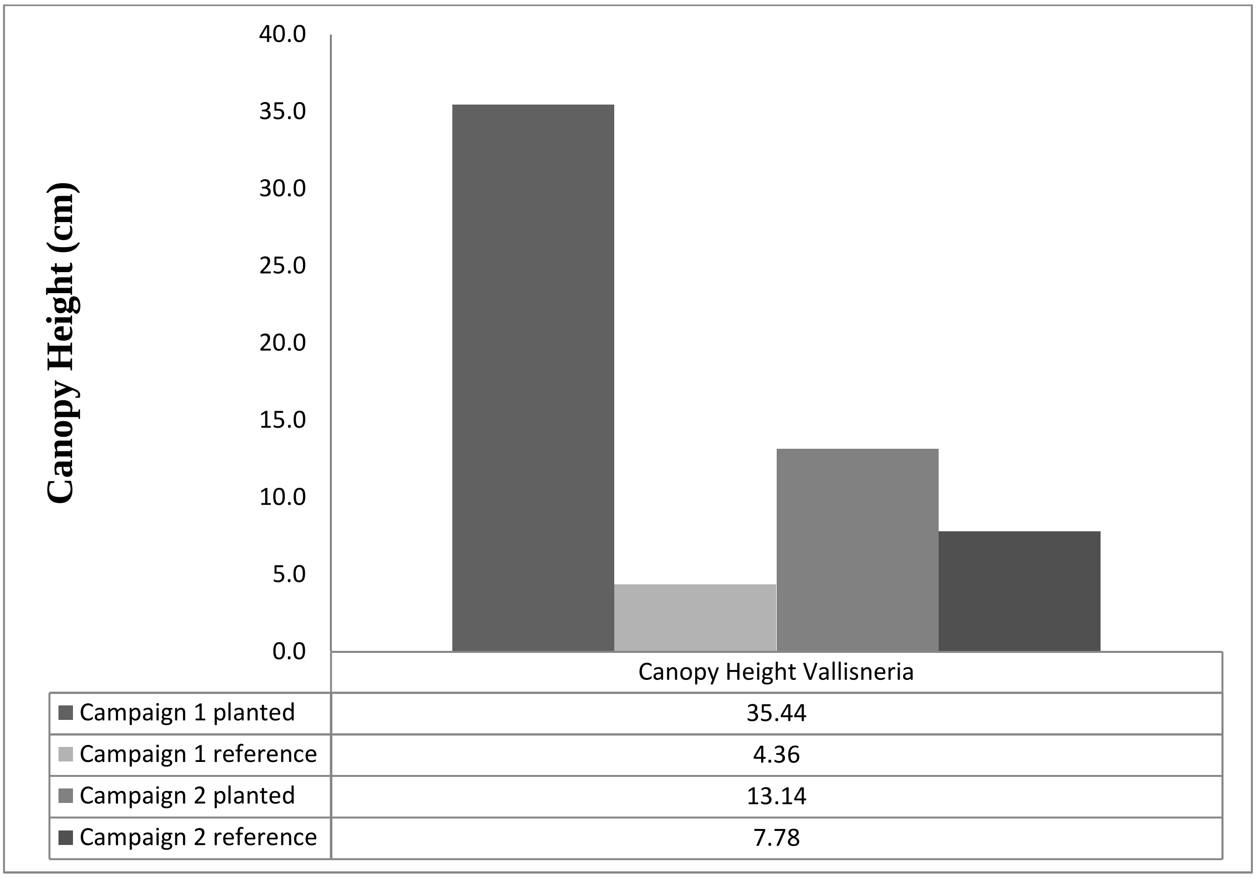


Figure 10. Canopy height (cm) for benthic plant communities at the relocation and reference sites during campaign 1 and 2.

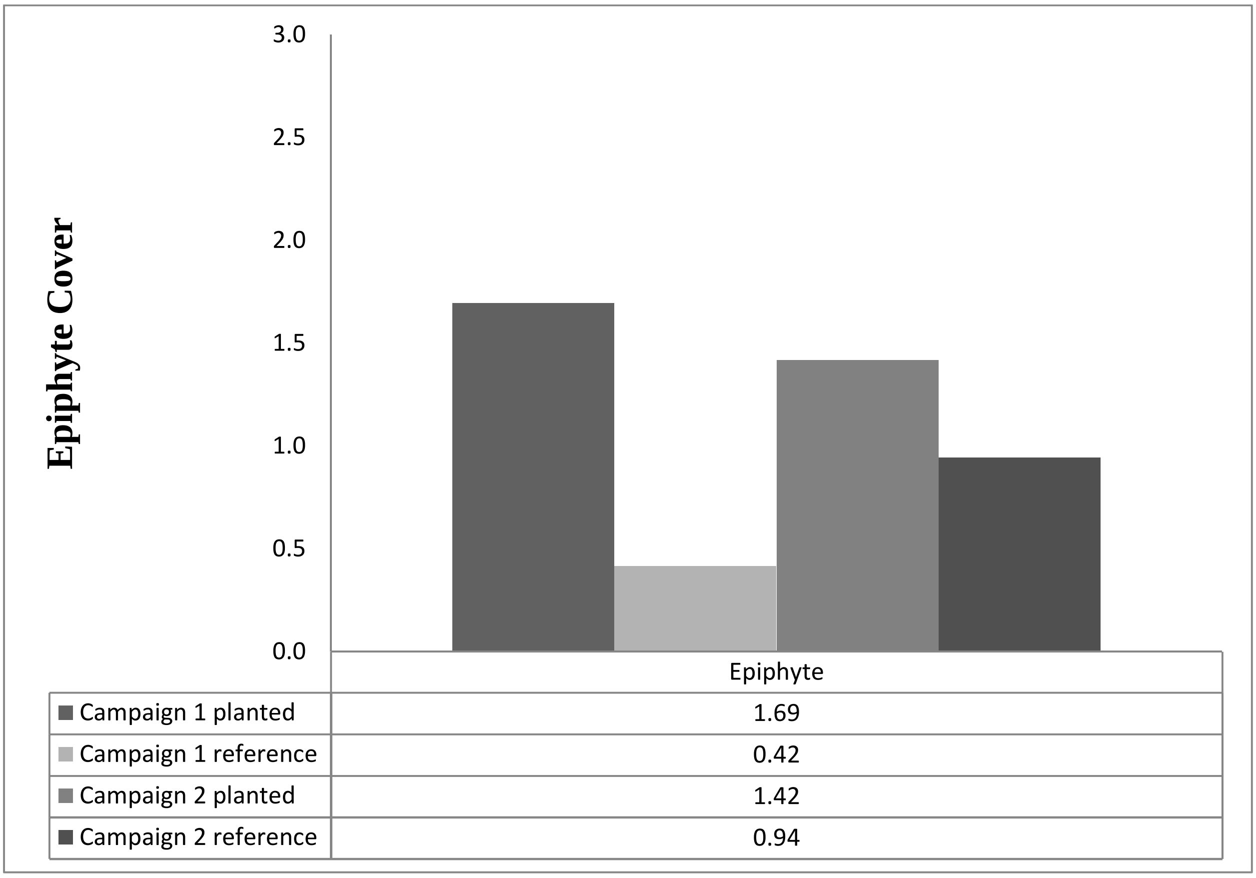


Figure 11. Epiphytic cover on Vallisneria americana at the relocation and reference sites during Campaign 1 and 2.

8. APPENDICES

8.1 Field Data Sheets

Year	ID	Treatment	Epiphyte	Blade_Length	TSAV	TMAC	LW	SG	VA	HV	NG	VA_SSCount	survival	Va_shoots M2
2016	1	Planted	2	53	4	2	2	0	4	0.5	0	9	1	900
2016	2	Planted	2	56	4	1	1	0	4	0	0	8	1	800
2016	3	Planted	3	60	5	1	1	0	5	0.1	0	14	1	1400
2016	4	Planted	1	45	3	0	0	0	3	0	0	8	1	800
2016	5	Planted	1	15	3	0	0	0	4	0	0	0	1	0
2016	6	Planted	3	65	4	0.1	0	0	1	0.5	0	13	1	1300
2016	7	Planted	2	13	1	1	1	0	4	0	0	2	1	200
2016	8	Planted	3	43	4	1	1	0	2	1	0	11	1	1100
2016	9	Planted	1	26	2	1	1	0	3	0	0	3	1	300
2016	10	Planted	1	38	3	0.5	0.5	0	2	0	0	9	1	900
2016	11	Planted	2	31	2	3	3	0	3	0	0	4	1	400
2016	12	Planted	1	2	3	1	1	0	3	0	0	7	1	700
2016	13	Planted	3	50	3	3	0	3	5	0	0	12	1	1200
2016	14	Planted	2	65	5	1	0	1	2	0	0	16	1	1600
2016	15	Planted	1	12	2	2	0	2	4	0	0	3	1	300
2016	16	Planted	1	45	4	0	0	0	5	0	0	4	1	400
2016	17	Planted	1	54	5	0	0	0	4	0	0	18	1	1800
2016	18	Planted	1	11	4	2	0	0	4	0	0	7	1	700
2016	19	Planted	1	25	4	0	0	0	5	0	0	6	1	600
2016	20	Planted	1	0	5	0	0	0	3	0	0	13	1	1300
2016	21	Planted	2	23	3	3	0	3	5	0	0	3	1	300
2016	22	Planted	3	54	5	1	0	1	5	0	0	14	1	1400
2016	23	Planted	1	58	5	1	0	1	5	0	0	13	1	1300
2016	24	Planted	3	29	4	1	0	1	3	1	0	7	1	700
2016	25	Planted	2	31	2	2	0	2	2	0	0	4	1	400
2016	26	Planted	1	68	5	0	0	0	5	0	0	20	1	2000
2016	27	Planted	2	35	3	1	0	1	3	0	0	7	1	700
2016	28	Planted	2	30	4	1	0	1	4	0	0	11	1	1100
2016	29	Planted	3	21	3	1	1	0	3	0	0	5	1	500
2016	30	Planted	3	57	5	0	0	0	5	0	0	16	1	1600
2016	31	Planted	0	0	0	0	0	0	0	0	0	0	0	0
2016	32	Planted	1	10	0.5	1	1	0	0.5	0	0	0	1	0
2016	33	Planted	1	27	4	1	1	0	4	0	0	7	1	700
2016	34	Planted	1	59	5	0	0	0	5	0	0	13	1	1300
2016	35	Planted	2	50	3	1	1	3	3	0	0	7	1	700
2016	36	Planted	1	15	3	0	0	0	3	0	0	8	1	800
2016	1	Reference	0	5	0.5	1	1	0	0	0.5	0	0	0	0
2016	2	Reference	0	5	0	2	2	0	0	0	0	0	0	0
2016	3	Reference	0	4	2	5	5	0	0	2	0	2	0	200

2016	4	Reference	0	1	0	1	1	0	0	0	0	0	0	0
2016	5	Reference	0	3	0	3	3	0	0	0	0	0	0	0
2016	6	Reference	0	5	3	4	4	0	0	3	0	0	0	0
2016	7	Reference	2	4	2	5	5	0	1	1	0	0	1	0
2016	8	Reference	0	8	4	5	5	0	0	0	0	0	0	0
2016	9	Reference	0	4	0	4	4	0	0	0	0	0	0	0
2016	10	Reference	0	2	0	3	3	0	0	0	0	0	0	0
2016	11	Reference	0	13	3	2	2	0	0	2	1	0	0	0
2016	12	Reference	0	5	1	4	4	0	0	1	0	0	0	0
2016	13	Reference	0	3	2	2	0	2	0.1	0	2	0	1	0
2016	14	Reference	1	4	1	2	1	2	1	0	0	0	1	0
2016	15	Reference	1	4	2	2	0	5	0.5	2	0	0	1	0
2016	16	Reference	1	8	1	5	4	0	1	0	0	1	1	100
2016	17	Reference	2	2	2	4	5	0	2	0	0	2	1	200
2016	18	Reference	0	9	0	5	5	0	0	0	0	0	0	0
2016	19	Reference	0	3	4	5	1	0	0	4	0	0	0	0
2016	20	Reference	0	3	4	1	4	0	0	2	2	0	0	0
2016	21	Reference	0	8	3	4	1	0	0.1	0	3	0	1	0
2016	22	Reference	1	4	0.5	1	3	0	0.5	0	0	0	1	0
2016	23	Reference	1	7	2	3	0.1	0	2	0	0	1	1	100
2016	24	Reference	0	0	0.1	0.1	0	0	0.1	0	0	0	1	0
2016	25	Reference	0	0	0	0	1	4	0	0	0	0	0	0
2016	26	Reference	0	8	1	5	4	1	1	0	0	0	1	0
2016	27	Reference	0	2	1	1	1	0	1	0	0	1	1	100
2016	28	Reference	0	0	1	0	0	0	1	0	0.5	0	1	0
2016	29	Reference	0	3	3	1	1	0	1	0	3	1	1	100
2016	30	Reference	0	6	4	1	1	0	0	4	0	0	0	0
2016	31	Reference	0	3	4	2	2	0	0	4	0	0	0	0
2016	32	Reference	0	4	0	4	4	0	0	0	0	0	0	0
2016	33	Reference	3	2	2	2	2	0	0	2	0	0	0	0
2016	34	Reference	1	9	2	3	3	0	2	0	0	2	1	200
2016	35	Reference	1	3	1	1	1	1	1	0	0	1	1	100
2016	36	Reference	1	3	4	2	2	4	1	4	1	0	1	0
2017	1	planted	3	20	4	2	2	0	[illegible]	0.5	0	10	1	1000
2017	2	planted	2	20	4	2	2	0	3	0	0	7	1	700
2017	3	planted	2	20	4	2	1	0	4	2	0	14	1	1400
2017	4	planted	1	30	4	2	1	0	3	1	0	7	1	700
2017	5	planted	1	20	4	3	2	0	[illegible]	1	0	5	1	500
2017	6	planted	2	15	4	2	2	0	4	0.5	0	12	1	1200
2017	7	planted	2	15	4	4	2	0	4	0	0	5	1	500
2017	8	planted	1	15	4	3	3	0	[illegible]	0.5	0	12	1	1200

2017	9	planted	1	15	4	2	2	0	4	0.5	0	10	1	1000
2017	10	planted	2	13	4	2	2	0	[illegible]	2	0	13	1	1300
2017	11	planted	2	10	4	1	1	0	4	1	0	12	1	1200
2017	12	planted	2	15	4	3	3	0	3	2	0	9	1	900
2017	13	planted	1	10	5	5	4	0	[illegible]	3	0	7	1	700
2017	14	planted	1	10	5	5	4	1	2	1	0	5	1	500
2017	15	planted	2	15	5	4	4	1	3	1	0	3	1	300
2017	16	planted	1	15	5	4	2	2	4	2	0	4	1	400
2017	17	planted	1	15	5	4	2	0.5	4	2	0	15	1	1500
2017	18	planted	1	10	5	2	0.5	0	5	2	0	15	1	1500
2017	19	planted	1	10	5	2	1	2	4	1	0	13	1	1300
2017	20	planted	2	15	5	3	2	0.5	4	1	0	14	1	1400
2017	21	planted	1	10	5	3	2	0.5	4	2	0	8	1	800
2017	22	planted	1	10	5	3	0.5	0.5	5	3	0	15	1	1500
2017	23	planted	1	10	5	4	3	0.5	4	3	0	16	1	1600
2017	24	planted	2	10	5	5	2	0	2	4	0	8	1	800
2017	25	planted	2	10	4	4	2	1	[illegible]	2	0	0	1	0
2017	26	planted	1	10	5	5	2	0	2	5	0	2	1	200
2017	27	planted	2	10	5	5	3	0.5	4	2	0	10	1	1000
2017	28	planted	1	10	5	5	3	0.5	[illegible]	0.5	0	12	1	1200
2017	29	planted	1	10	5	2	1	0.5	4	3	0	8	1	800
2017	30	planted	1	10	5	5	2	0	[illegible]	3	0	16	1	1600
2017	31	planted	1	15	5	4	2	1	4	1	0	13	1	1300
2017	32	planted	1	10	5	2	1	1	0	3	0	8	0	800
2017	33	planted	2	10	5	1	1	1	0	5	0	13	0	1300
2017	34	planted	1	10	5	2	2	2	0	5	0	14	0	1400
2017	35	planted	1	10	5	3	3	3	0.5	4	0	10	1	1000
2017	36	planted	1	10	5	2	2	1	0.5	4	0	13	1	1300
2017	1	Reference	2	10	4	3	1	0	2	0.5	0	3	1	300
2017	2	Reference	0	0	4	4	4	0	0	2	0	0	0	0
2017	3	Reference	0	0	4	4	1	0	0	4	0	0	0	0
2017	4	Reference	0	0	3	3	2	0	0	2	0	0	0	0
2017	5	Reference	0	15	3	3	2	0	1	1	0	0	1	0
2017	6	Reference	2	10	4	4	4	0	2	1	0	3	1	300
2017	7	Reference	2	10	5	5	3	0	2	2	0	1	1	100
2017	8	Reference	1	10	4	4	2	0	2	3	2	0	1	0
2017	9	Reference	0	0	1	1	1	0	0	0	0	0	0	0
2017	10	Reference	0	0	0.5	0.5	0.5	0	0	0	0	0	0	0
2017	11	Reference	2	15	5	1	1	0	5	0	0	14	1	1400
2017	12	Reference	2	15	4	4	4	0	2	0	0	10	1	1000
2017	13	Reference	1	10	4	4	4	0	0.5	0	1	0	1	0

2017	14	Reference	1	15	4	4	4	0	1	0.5	0	3	1	300
2017	15	Reference	1	10	5	5	0.5	5	2	2	0	0	1	0
2017	16	Reference	1	10	5	1	0.5	0.5	5	0	0	13	1	1300
2017	17	Reference	2	15	5	5	0.5	0.5	2	0	0	2	1	200
2017	18	Reference	2	15	5	3	2	2	5	0	0	14	1	1400
2017	19	Reference	2	10	5	3	0.5	2	5	0.5	0	13	1	1300
2017	20	Reference	1	10	5	5	5	0	0.5	0	0	0	1	0
2017	21	Reference	0	0	5	5	5	1	0	1	0	0	0	0
2017	22	Reference	2	10	4	4	2	0	3	2	0	10	1	1000
2017	23	Reference	2	10	5	4	3	0	3	3	0	8	1	800
2017	24	Reference	0	0	5	5	3	0	0	5	0	0	0	0
2017	25	Reference	0	0	5	5	2	3	0	5	0	0	0	0
2017	26	Reference	0	0	5	5	5	0.5	0	0.5	0	0	0	0
2017	27	Reference	1	10	2	2	2	0	2	0	0	0	1	0
2017	28	Reference	1	10	5	4	3	0	3	3	0	5	1	500
2017	29	Reference	1	10	5	2	2	0	4	1	0	6	1	600
2017	30	Reference	0	0	5	5	4	2	0	2	0	0	0	0
2017	31	Reference	0	0	5	5	3	0	0	3	0	0	0	0
2017	32	Reference	1	10	5	5	3	0	2	3	0	3	1	300
2017	33	Reference	1	10	5	5	4	0	3	1	0	9	1	900
2017	34	Reference	1	10	5	4	3	0	3	2	0	6	1	600
2017	35	Reference	1	10	5	4	4	0	2	0	0	3	1	300
2017	36	Reference	1	10	5	3	3	0	3	0	0	4	0	400

8.2 Photos