New and Innovative Techniques for Seagrass Restoration

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ABSTRACT

Reports of seagrass decline worldwide have been occurring for many years. The decline has been attributed to dredge and fill, pollution, and propeller scarring. Past techniques to restore seagrass beds have not always been successful with many transplanting projects having only a 20% survival rate. New techniques for seagrass recovery are presented that include: a seagrass formula for re-growth into prop scars, an injecting boat that can inject nutrients into prop scars, and a planting boat that can plant short shoots of *Halodule wrightii* in bare root or in peat pots. The planting boat can also plant seedlings of *Thalassia testudinum* grown from seeds.

INTRODUCTION

Seagrass communities are composed of flowering plants that form underwater "meadows" in the shallows of marine environments. Worldwide there are only 58 species of seagrasses, which are the only submerged angiosperms. These are not true grasses, and are taxonomically placed in the suborder Liliopsidae. Seagrasses form dense carpets of grass that may have as many as 4,000 blades per square meter in optimal conditions.

Seagrasses are unusual for flowering plants because of where they live. Seagrasses must live totally submerged in salt water and have strong anchoring systems to hold them in place as currents flow past them. They also have to have a unique reproductive system different from land plants. They create flowers, yet they must rely on currents for pollination rather than insects as the land plants do. In addition they must compete with one another and with the algae for space, nutrients and available light.

Seagrass beds are strongly influenced by environmental conditions. Currents, waves, sediments, turbidity, salinity, temperature, desiccation and boat propellers affect them. In some locations where the currents and waves are too strong the seagrasses cannot hold on to the substrate. Where sediments are too fine or contain inappropriate nutrients, seagrasses will not grow. If turbidity is too high, then the plants cannot thrive due to a lack of sunlight. In some parts of the world the salinity is too low to support seagrasses. For example, during the rainy summer month's freshwater runoff into bays can be extensive. This dilutes the saltwater to such an extent that seagrasses can be stressed. A typical seagrass needs at least 20 parts per thousand of salt dissolved in the water (typical ocean water is 33 parts of salt per thousand parts of water). Sometimes the salinities will drop to as low as 10 parts per thousand stressing the grasses to the point that they may not survive.

Temperatures in shallow waters can be quite extreme. During the winter months if the temperature drops below 22 degrees C, and a tide is moving out, many seagrasses will be exposed to a temperature that is potentially lethal. In addition, when the tides are at their extremes, seagrasses may be exposed to the air long enough for them to dry out. These extremes may kill large quantities of seagrasses. Boat propellers are another source of damage to seagrasses. The propellers can cut through the grasses at such a depth they destroy not only the visible blades, but also the subterranean parts of the plants and the microbes that help to support the plants (Dawes et al, 1997). Boat damage has the potential of destroying extensive beds of grass before they can recover. Damaged seagrasses may take as long as 5 years to recover.

Damage to seagrasses has been occurring in Tampa Bay for many years resulting in a loss of about 80% of the seagrasses that were present over 50 years ago (Lewis and Estevez, 1988). In the past 5 years there has been some natural recovery of seagrasses due to water quality improvements, but not enough to offset the losses that have occurred.

The value of seagrasses

Available scientific literature gives several reasons for the importance of seagrasses. Among the reasons are the following:

1. Seagrasses tend to have very high growth rates and production rates. They tend to add to the overall productivity of a region because of their growth rates.

2. The leaves of seagrasses tend to support large numbers of epiphytic organisms with biological mass approaching that of the seagrasses themselves.

3. Seagrasses, and the organisms on them, produce large amounts of detritus, which become food for other organisms.

4. Seagrasses have extensive root systems and lateral rhizome structures that tend to hold sediments together and prevent erosion.

5. Seagrasses act as nutrient sinks and sources.

6. Seagrass beds become the home to many forms of juvenile organisms as well as adult organisms. In areas where seagrasses have been destroyed, the populations of shrimp, snook, and many other species, tend to decline dramatically.

7. Seagrasses are used as a food source for Manatees, which have been seen in and around Tampa Bay.

Seagrass Loss in Florida

Seagrass loss in Florida has occurred for many years and has been extensive. The primary reasons for seagrass loss have been dredge and fill, changes in water quality and propeller damage. Examples of seagrass loss in Florida as reported by Sargent et al was as follows:

- Florida has lost about 2 million acres of seagrasses.
- Indian River Lagoon has lost 30%.
- Charlotte Harbor has lost 29%.
- Tampa Bay has lost 80%.
- Ponce Deleon Inlet has lost 100%.
- St. Andrews Bay has lost 30%.
- Florida Bay has lost 60,000 acres since 1987.

The presence of prop scars in seagrass meadows has been a concern for a number of years. Sargent, et al reported that statewide there are about 63,989 acres of seagrass that have moderate to severe propeller damage. The most heavily scarred areas are in Monroe, Lee, Dade, Pinellas, and Charlotte counties. Monroe County leads the list with over 15,000 acres of moderate to severe damage.

Recovery of seagrasses into prop scars can take many years. Zieman (1976) stated that *Thalassia testudinum* (Turtle-grass) might require at least two years to begin to re-colonize a prop scar. Durako et al. (1992) stated that recovery to normal density would take from 3.6 to 6.4 years. Others have stated that complete seagrass recovery may take as long as ten years (Lewis and Estevez, 1988).

One of the reasons postulated for the slow re-growth of *Thalassia testudinum* into prop scars is the slow appearance of a new apical meristem on the rhizome (Dawes et al, 1997). Formation of a new apical meristem may take as long as 10 months. However, this only partially explains the slow re-growth. Ehringer in 1993 speculated that the loss of the anaerobic bacteria in the sediment due to the stirring effect of the prop was part of the problem. Perhaps the bacteria were a source of nutrients to the roots and rhizomes. It may take a period of time to re-grow the bacteria colonies and the resulting nutrient load in the sediment.

Seagrass planting programs have not been very successful. Fonseca, Kenworthy and Thayer reported in 1987 results of an extensive comparison of seagrass transplanting techniques. In one of their planting projects all manatee grass was gone and only 30 per cent of the shoal grass had survived. In another planting project in Tampa Bay, Florida by Fonseca, Kenworthy and Courtney 14 plots of seagrasses were planted with 6 losing 95 to 100 per cent of their plants. Another 5 sites were lost later. Fonseca, Kenworthy, Courtney and Hall reported in 1994 on another transplanting project in which 40 per cent of transplants of *Syringodium filiforme* survived. All of their transplants of *Halodule wrightii* failed to survive. Techniques have been tried using peat pots, bare root, staples, and a variety of other methods. Yet the survival of the transplants remains low.

Injection of prop scars

Experiments have been conducted by Ehringer in Tampa Bay since 1993 working with fertilizers and plant growth regulators in an attempt to re-grow seagrasses into prop scars. Experiments were conducted in Cockroach Bay, a small bay attached to Tampa Bay, and at the Fort Desoto Aquatic Preserve from 1993 through 1999. Injection of prop scars in Tampa Bay following numerous replications resulted in the average re-growth of *Thalassia testudinum* into a prop scar at 56% of complete recovery in one season. In this same series of experiments *Halodule wrightii* re-grew into prop scars at 76% of complete recovery in one season. The results of further experiments are listed below. The means of injection was an injector boat built by James Anderson of Ruskin, Florida.

James Anderson built a special boat and injection system in the winter of 1997. The boat was designed to inject a nutrient formula into the seagrass sediments. The machine has a series of small injectors that push about 10 ml. of formula into the sediment. The injectors are set in a circular pattern around a wheel. As the wheel rolls along the bottom, the nutrients are injected into the sediment with a force of about 20 pounds per square inch. There are two wheels that roll along the sediment parallel to each other injecting at the same time. There are two other wheels that roll behind the injector wheels that push sediment over the injector holes to seal the nutrient formula into the sediment. The boat contains a 100-gallon tank for mixing of the formula. The formula is pumped from the tank through a series of tubes down to the injectors.

A mixture of 100 pounds of prilled nitrogen 44% plus 2 ounces of synthetic cytokinin and 2 ounces of a synthetic gibberellin was mixed in 100 gallons of seawater. The seawater was pulled from the bay at the site of the injections. Injections were placed into the sediment about every 20 centimeters along designated prop scars. Injections were made at Fort Desoto beginning in May of 1997 and extended for 5 injections approximately every 7 to 14 days. An additional injection was made in May of 1998. Injections were also made in Cockroach Bay and in the Lignumvitae preserve in the Florida Keys.

A counting method was established to determine the number of new shoots that would potentially grow into the prop scars after the injections. A one-meter square PVC frame was made to place over PVC stakes placed in a square pattern over a prop scar. The center portion of the frame had a one-meter by 22-centimeter frame inside the larger frame that fit over the prop scar lengthwise. This frame was set over the stakes at each counting period so that the seagrass shoots could be counted each time in the same manner. Six sites were established for counting in injected prop scars. Sites were set up as controls. The results from the injection sites was as follows:

- In Cockroach Bay experiments were conducted over a three-year period. Using the planting boat in this series of experiments *Thalassia testudinum* re-grew into prop scars at a rate estimated at 40 to 60% during the period. Each count was performed within 6 months of the injections. There were 30 replications of the experiment. Controls showed re-growth of less than 10%.

- In Fort Desoto at the start of this experiment 9.25 shoots were found in the prop scars (13.2%). The prop scars were injected with the injector boat. After 15 months the average number of shoots was 47.3, or 68% of complete recovery. Therefore, prop scar recovery had grown to the point of 68% of a normal seagrass bed in 15 months at Fort Desoto as a result of the injections.

- In the Florida Keys at the Lignumvitae Preserve experiments were conducted in the spring and summer of 1998. Two formulations of the seagrass formula were used. The first formula contained the same nutrients as listed above. The second formula added phosphorus. The results were averaged for each formula (average number of short shoots of *Thalassia testudinum* per unit of 22 cm by 1 meter) as follows:

	May 1998	October 1998
Formula #1	7.75	31.50
Formula #2	8.75	34.80
Control	4.00	4.00

The data show an increase in short shoots of *Thalassia testudinum* in the prop scars from the period of May 1998 to October 1998 that is not apparent in the controls. No new shoots were found in the controls. One of the injected sites did not have any shoots of *Halodule wrightii* in the counting area in May of 1998 but had 135 short shoots in the October count. The data for *Halodule wrightii* is not counted in the above data.

In the summer of 1999 two sets of injected scars were found and one set of controls. The data was as follows:

	May 1998	June 1999
Formula #2	4.50	28.50
Control	4.00	6.00

A complete recovery of a prop scar 22 cm by 1 meter would have about 70 short shoots of *Thalassia testudinum*. Under normal circumstances a complete recovery would take years. From the above October data formula #1 gained 45% and formula #2 grew 49.7% of complete recovery during the five months from May to October.

The planting boat

In early 1998 James Anderson of Ruskin, Florida designed, built and patented a seagrass planting boat. The pontoon boat floats over the seagrass beds while two workers on board "feed" the seagrasses into a planting wheel. The wheel pushes the seagrasses into the sediment at a precise depth. Depending upon the number of seagrasses to be planted per acre, the boat has the potential to plant an acre in a day or two.

This technique requires fewer workers, is faster than traditional methods, and is less expensive. In addition, since the planter floats over the seagrasses beds, there is no damage to the planted seagrasses by workers walking through the beds to plants new seagrasses. The planter has been used on a limited basis in Cockroach Bay, in Fort Desoto and in Laguna Madre waterway at Corpus Christi, Texas. The system plants *Halodule wrightii* in peat pots or in bare root. In 1998 and in 1999 thousands of short shoots of *Halodule wrightii* have been planted using the boat. At the time of this writing no final counts have been made of the seagrass beds where the planter was used. Earlier indications are that the planting system was very successful.

A seagrass nursery

A seagrass nursery was established in the field using plants removed from Fred Howard Park. The seagrasses were removed as part of a mitigation plan to widen the beach at the park. Approximately 1,000 square feet of seagrasses were planted at Mangrove Point, near Simmons Park in Tampa Bay. The site was chosen for the following reasons:

1. The site was privately owned. It does not have boat traffic through it.
2. The site had a few seagrasses growing in it along an opposite bank; therefore, the water quality could have been conducive to seagrass planting.
3. The salinity regime was within a normal range for seagrasses.
4. The site has an easy access for boats and the site is shallow.

Beginning on June 18, 1998 and several dates thereafter, seagrasses were planted at the site by hand. Plants were soaked in the seagrass formula prior to planting. Twenty-two boxes were planted on June 18, 1998. About 400 shoots were planted with the planting machine. In August about 15 more boxes of bare root plants were planted at the site by hand. As of June of 1999 over 60% of the plants had survived.

Planting seeds

Seeds of *Thalassia testudinum* typically float inshore in very large amounts in the months of August and September in Monroe and Dade Counties, Florida. About 3,000 seeds were collected in September of 1998. The seeds were placed in small peat pots and stored in saltwater tanks in upland tanks at a seagrass nursery in Ruskin, Florida. The seeds were kept at the nursery for about 6 weeks allowing them time to grow into small seedlings. The planting units were transported to the Florida Keys and planted at a site selected by personnel from the Department of Environmental Protection (DEP). The seedlings were planted using the planting boat. The use of peat pots proved to be a good choice because the units were set into the sediment in a manner that could not be dislodged by currents. By May of 1999 most of the seedlings have survived, but a final count has not yet been made.

DISCUSSION

Two often-repeated standards were: "you cannot grow seagrasses into an area where seagrasses have not previously grown," and "seagrasses cannot be stimulated to re-grow." The foundation for the statements was that a seagrass nutrient formula had not been successfully tested, nor was a plant growth regulator available to stimulate rhizome growth in *Thalassia testudinum*. Recent experiments have shown that both are available. In addition, with the use of a planting boat, seagrass restoration can occur on a larger scale with less expense. The following steps illustrate the technique for a future mitigation project:

1. **The donor site:** remove the seagrasses in a 10-inch swath for any length necessary. A length of 50 feet will result in the removal of enough plants for an acre of planting.

2. **Recovering the donor site:** use the injector boat to inject nutrients and plant growth regulators into seagrass beds for rapid recovery of the seagrasses in the 10-inch swath. For the example above, inject the site where the seagrasses have been removed. Experiments with *Halodule wrightii* have shown that a section 10 inches wide by 50 feet in length can recover in one season to one year. For mitigation purposes, this concept results in no net loss of seagrasses as a result of a transplanting program (in fact, there is a gain of seagrasses at the transplant site).

3. **Preparing seagrasses:** Most seagrasses, when removed from the sediment will lose their roots. The loss of roots slows down the growth process after they have been transplanted, and even causes some loss of the seagrasses. To prevent this the seagrasses from the donor site can be soaked in nutrients and plant growth regulators to increase the probability of growing new apical meristems on the cut rhizomes. With new apical meristems on the rhizomes, the plants can colonize the new site more rapidly. The plants may also be placed in peat pots in order to anchor the transplants into the sediment.

4. **Planting of seagrasses:** plant an acre of seagrasses per day using the seagrass planting boat. The seagrasses are taken from the aquaculture tanks in their peat pots or in bare root, and planted with the machine. The peat pots hold the plant in place. The peat pots will dissolve in less than one year, releasing a nutrient formula to the plant that keeps the plant alive and accelerates growth.

5. **Follow-up injections:** two months after planting, inject the seagrasses with the formula of nutrients and plant growth regulators. This process accelerates the spreading of the seagrasses by inducing apical meristem growth and providing appropriate nutrients for rapid growth. The above experiments have shown that it is possible to use this technique even in locations where seagrasses have not previously grown.

6. **Follow-up planting:** if some of the plants do not survive the transplanting process, the planting boat can easily go back into the bay and plant new seagrasses. This assures a complete recovery at the site.

This seagrass mitigation concept may now be a reality with the advent of a seagrass planter, a seagrass injector and a formula to grow seagrasses. A full test is now needed.

SUMMARY

Since 1991 a series of experiments has been conducted to attempt to re-grow seagrasses into propeller scarred beds. Analyses were made of the sediments of healthy seagrass beds and compared to that of a prop scar. From this series of experiments a formula was derived that replaced the loss nutrient in a prop scar. Following this, another series of experiments was conducted in order to find a formula for a plant growth regulator that would grow an apical meristem on a cut rhizome of *Thalassia testudinum*. The combination of nutrients and plant growth regulators was tested in prop scars in Cockroach Bay, Fort Desoto and in the Florida Keys. The result showed that about 56% of complete re-growth was possible in one season. The formula was injected into the sediment using an injector boat built by James Anderson. Mr. Anderson also built a seagrass planting boat that was capable of planting up to an acre of seagrasses in one day.

The boat has been tested in Tampa Bay, the Florida Keys and in Texas. The planting boat has been used to plant short shoots of *Halodule wrightii* in peat pots and bare root. It has also been used to plant seedlings of *Thalassia testudinum* grown from seeds in the Florida Keys. These new techniques, taken together, offer a wide range of mitigation possibilities for recovery of seagrasses.

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