

**ANALYSIS OF BENEFITS OF *SARGASSUM* ON GALVESTON ISLAND AND
INDICATIONS FOR BEACH MANAGEMENT POLICY**

A Thesis

by

AMY M. WILLIAMS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2007

Major Subject: Forestry

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Approved by:

Chair of Committee, Russell A. Feagin

Committee Members, Urs P. Kreuter

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ABSTRACT

Analysis of Benefits of *Sargassum* on Galveston Island and Indications for Beach Management Policy. (August 2007)

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Chair of Advisory Committee: Dr. Russell A. Feagin

Sargassum fluitans and *natans*, types of brown algae, wash up on Galveston Island, Texas annually from May to August. *Sargassum* smells bad, hurts tourism and impairs sea turtle hatchings. Coastal managers are confronted with the difficult choice of cleaning *Sargassum* off the beach or leaving it alone. The current beach management practice is to rake the algae with tractors and deposit it at the base of the dunes. The environmental impacts of raking and ecological benefits of *Sargassum* are unknown.

The Galveston Island Park Board of Trustees (GIPBT) used to rake all beaches under their management before Hurricane Alicia in 1983. Then, citizens started to complain that raking was causing erosion. Now, there are people who argue for both raking and leaving the beach alone.

Environmental policies require complex decisions that take into consideration social, economical, ecological, and cultural values. The GIPBT initiated the *Sargassum* Policy Committee to gain knowledge of different stakeholder values and scientific research to develop beach management.

The first study analyzed elevation changes over a year period on raked and unraked beaches on both the West and East end of Galveston Island. The Analysis of

Variance results indicated that there is not a difference in elevation changes between the raked and unraked beaches over a year.

The second study analyzed the effects of *Sargassum* on the dune plant *Panicum amarum*. Plants were asexually grown in a greenhouse in sand without (control) and with *Sargassum*. The effects of small versus large amounts, top versus mixed with sand and washed versus unwashed *Sargassum* were tested. The results indicated that the addition of *Sargassum* increased plant growth. The treatments with large amounts of *Sargassum* and unwashed treatments showed significant growth changes at the 95% confidence level.

The last component analyzed the collaborative potential of the *Sargassum* Policy Committee through observations of meetings and surveys of the members. Daniel and Walker's Progressive Triangle was used to assess the relationship, procedural and substance dimensions of collaborative learning. Then, suggestions were made for increasing collaboration.

The combination of scientific research and stakeholder values has resulted in the creation of sound beach management.

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I would like to thanks Dr. Tarla Peterson and Dr. Urs Kreuter for their participation on my committee and their comments on the thesis.

I would like to thank the members of the *Sargassum* Policy Committee for letting me participate in the committee.

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I send out a huge thanks to my friends and family who have always supported me in too many ways to mention. Thanks for always encouraging me and believing in me.

NOMENCLATURE

GIPBT	Galveston Island Park Board of Trustees
GISP	Galveston Island State Park
SPC	<i>Sargassum</i> Policy Committee
Texas GLO	Texas General Land Office
TOBA	Texas Open Beaches Act

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INTRODUCTION

What Is *Sargassum*?

Sargassum fluitans and *natans*, types of brown alga commonly known as gulfweed (Figure 1), grow in dense intertwined mats in the Sargasso Sea (GOWER *et al.*, 2006). Masses of *Sargassum* as large as football fields are deposited by currents and wind on different coastlines around the world (TANAKA and FOSCA, 2003). *Sargassum* collects near the high tide line and piles up along the beach (GHESKIERE *et al.*, 2006) on Galveston Island, Texas each year from May to August (Figure 2).

The large piles of *Sargassum* restrict access to the beach and water. The *Sargassum* traps other material such as seeds, animals, decaying matter and anthropogenic litter from the water column, which are also deposited on the beach (COLOMBINI and CHELAZZI, 2003). The trapped anthropogenic litter, such as plastics, paper and medical wastes, is hazardous to human health since people have to push through the piles to get to the water. The *Sargassum* smells bad. Tourists complain about the presence of *Sargassum*.

This thesis follows the style of *Journal of Coastal Research*.



Figure 1. Specimen of *Sargassum* spp. Picture taken by Dr. Rusty Feagin in April 2006

Erosion of the beach causes loss of nesting sea turtles (GARCIA *et al.*, 2003), but the *Sargassum* may cause problems by interfering with the choice of nesting location. Kemp's Ridley sea turtles (*Lepidochelys kempi*), an endangered species, typically lay their eggs in the dunes. They may be incapable of getting over the accumulated *Sargassum* and instead end up laying their eggs in the *Sargassum*. The eggs then may be washed out to sea prior to hatching.



Figure 2. Deposition of *Sargassum* spp. On Galveston Island, Texas. Picture taken by Dr. Rusty Feagin, April 2007.

Since the deposition of *Sargassum* occurs in the middle of the high tourism season, coastal managers are confronted with the difficult choice of cleaning *Sargassum* off the beach or leaving it alone. One method of dealing with the problem of *Sargassum* is to use mechanical equipment to rake the material and deposit it at the base of the dunes (CONAWAY and WELLS, 2005; DUGAN *et al.*, 2003; GHESKIERE *et al.*, 2006; NORDSTROM *et al.*, 2006). Leaving the *Sargassum* could have adverse economic effects, but removing it could have adverse environmental effects.

Galveston is a 27 mile long barrier island off the coast of Texas approximately 50 miles south of Houston (Figure 3). The West end of the island is eroding while the

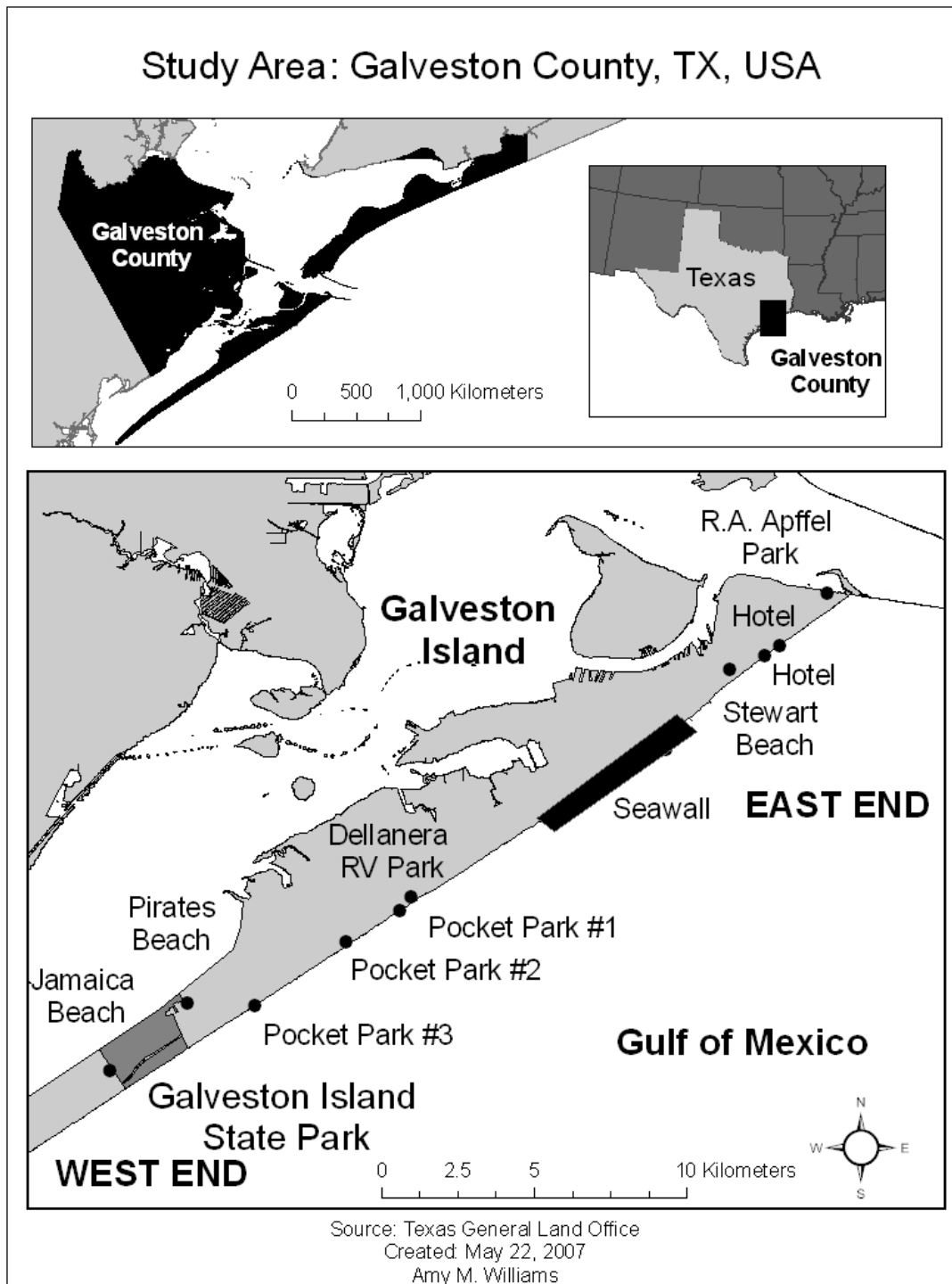


Figure 3. Study Site of Galveston Island. Data obtained by the Texas General Land Office website (May 15, 2007)

East end is accreting (GIBEAUT *et al.*, 2000). Attempts to slow erosion have already been implemented on Galveston Island but are failing. Along the middle of the island, a 10 mile long seawall was established after the Galveston Hurricane of 1900. The seawall was created to protect development landward but may be impacting land elsewhere along the shoreline (PHILLIPS and JONES, 2006). Other past attempts to stabilize the beaches include bails of hay brought in from off the beach, dune planting and geo-tubes of synthetic material filled with sand being placed at the dunes.

Current Beach Management Issues of *Sargassum* on Galveston Island

The Galveston Island Park Board of Trustees (GIPBT) is in charge of beach management on the island. GIPBT used to rake all beaches under their management before Hurricane Alicia in 1983. Then, citizens started to complain to the GIPBT that raking was causing erosion. Now, there are people who argue for both raking and for leaving the beach alone.

Currently, *Sargassum* management varies on different parts of the island. The GIPBT rakes the areas in front of the seawall, the Pocket Parks on the West end of the island, and in front of 2 condominiums on the East end (“raked beaches”) during the summer months. The tractor deposits the *Sargassum*-sand mixture haphazardly into piles along the current dunes. Trash and other natural debris are hand-picked every week by employees of the Park Board. The GIPBT leaves *Sargassum* in place on the beach at other, usually undeveloped, areas (“unraked beaches”).

Areas not managed by the GIPBT have their own beach cleaning procedures. Galveston Island State Park on the West end is a natural area where no raking occurs.

Private communities decide individually how to clean their beaches. Some hire an outside contractor to rake the beaches, for which a permit from the Texas General Land Office (GLO) is required, while others hand-pick the trash from the *Sargassum* themselves and others leave it alone.

Though the deposition of the *Sargassum* at the base of the dunes may provide material to help establish another dune system (CONAWAY and WELLS, 2005), *Sargassum* may be beneficial on the beach front. *Sargassum* provides a home for many animals while it floats in the water, but also provides shelter and food for organisms once on the beach (GHESKIERE *et al.*, 2006; ORR *et al.*, 2005; ROBERTS and POORE, 2005; RYLAND, 1974; TANAKA and FOSCA, 2003). *Sargassum* acts like a sponge during daily events and hurricanes by absorbing wave energy. This protects the sand from wave erosion. Also, the tangled, wet webs of *Sargassum* trap sand from wind erosion. The accumulation of sand around patches of *Sargassum* helps build small embryonic dunes that stabilize the beach (GHESKIERE *et al.*, 2006).

Further, it is thought that *Sargassum* may enhance dune stability through plant growth (ANTHONY *et al.*, 2006; MOUNTNEY and RUSSELL, 2006; TSOAR, 2005). *Sargassum* contains nutrients in the algal matter and the bryophytes and small fish that accompany it (NOAA 1998). *Sargassum* has been found to enhance plant germination through the form of liquid fertilizer (SIVASANKARI *et al.*, 2006; TRONO JR., 1999). Dune plants retain sand on the dunes through their roots and above-ground biomass (KURIYAMA *et al.*, 2005; LABUZ and GRUNEWALD, 2007; STALLINS, 2005).

Studies indicate beach raking increases the loss of sand from wave-induced erosion, hurricane forces and wind erosion by removing the initial barrier that accumulates sand (CONAWAY and WELLS, 2005). Since erosion can cause destruction of houses on the coast (BUSH *et al.*, 2004; PHILLIPS and JONES, 2006), removal of *Sargassum* could have adverse economical impacts also.

ELEVATION CHANGES ON RAKED AND UNRAKED BEACHES OF GALVESTON ISLAND, TX

Introduction

The current management practice of beach raking may be affecting the elevation levels of the beach. Erosion can cause environmental issues for the species that depend on the beach. Erosion can cause economic loss through the loss of tourism due to a lack of beach and destruction of property. Additionally in Texas, the Texas Open Beaches Act makes erosion a political issue.

The state of Texas owns the coast from mean high tide to 10.3 nautical miles out to sea. Property landward of the mean high tide can be privately owned, however, the state has an easement on that land from the mean high tide to the vegetation line. The easement provides free and unrestricted right to the beaches (GUNTER *et al.*, 1987). No individual can obstruct beach access through any type of objects, from fences to houses. The Texas Open Beach Act requires houses that are seaward of the vegetation line to be removed at the owner's expense. Since the vegetation line is associated with the dunes, stability of dunes is critical.

This study will compare the changes in elevation at raked and unraked beaches on Galveston Island in order to ascertain whether *Sargassum* helps build elevation through sand trapping and accretion. Study sites will be located on the East and West ends of the island to control for any natural longshore drift factors.

Methods

Galveston Island is split into the East end and West end by a seawall that runs along the shoreline in the middle of the island. The island is accreting on the East while eroding on the West end (GIBEAUT *et al.*, 2000). The sample sites on the West end correspond with core sample sites of current research by Texas A&M Galveston.

In order to test the effect of raking the *Sargassum* upon elevation, there were two treatments: raked versus unraked. To account for the known variation between the East End (accreting) and West End (eroding) beaches, a blocking factor was established with two levels: East End versus West End.

Two sites were randomly chosen within the possible locations for each treatment x block combination. On the East End, the two raked sites were in front of hotels, while the unraked sites were located in front of undeveloped land. On the West End, the raked beaches were in front of developed public parks, while the unraked sites were in front of undeveloped land (Figure 4).

Within each replicate site, three transects were established relative to a permanent benchmark. Each transect was randomly located within the 50 meter wide site. Elevation was measured every three months from April 2006-April 2007 using survey equipment (CST Berger PAL 26 level and tripod). Elevation was recorded at 5 meter intervals along the transect, from the dunes to the water line. A consistent benchmark was used to reference the change in elevation from each sampling date. The length of each transect varied from one sampling period to the next, as based on the width of the beach relative to the tide level. Elevation changes over the entire length of

the study period were calculated as the difference between April 2006 and April 2007. Data was truncated by the sampling date with the least about of beach width. This occurred due to differences in tides on the sampling dates.

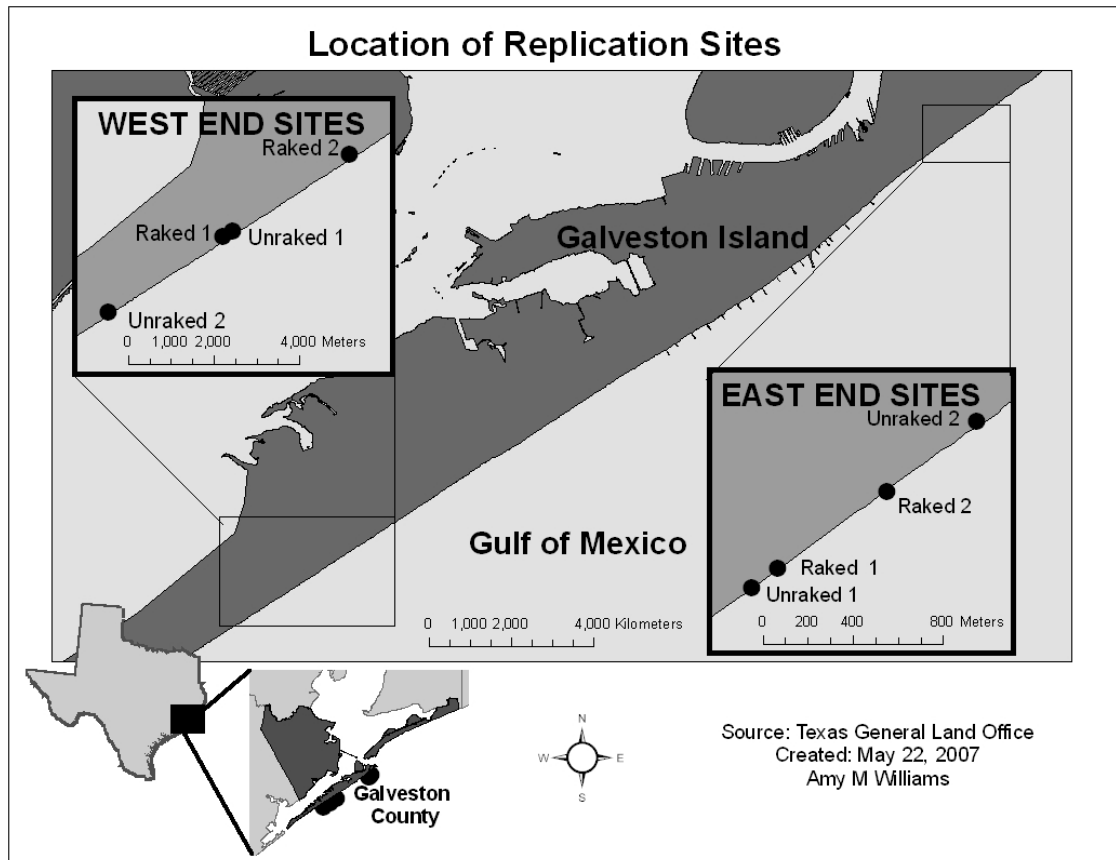


Figure 4. Study Site of East and West Replicates on Galveston Island.

Using Analysis of Variance (ANOVA), we tested the elevation changes in the transects in three ways: the overall average of the transect, the average of twenty meters from the waterline, and the average of twenty meters from the dunes. The three

categories were assigned to capture the spatial heterogeneity of the beach from the water to the dunes. SPSS 14.0 for Windows (Release 14.0.1 18 Nov 2005) was used.

This experimental design allowed us to test the difference between the raked versus unraked treatments, while balancing out the blocking factor variance. It also allowed us to capture the variation of each experimental unit, i.e. the replicate sites, as well as the variation within each site, i.e. where transects are sub-samples of the site variation.

Results

The results of the ANOVA are presented in Table 1. There was no significant difference between raked versus unraked samples for overall, waterline and dune average (p-value = 0.4899, 0.3381 and 0.8777, respectively). Blocks (i.e. the difference between the East end and West end) were insignificant for the overall and dune average (p-value = 0.1089 and 0.2338). Blocks were significantly different for the waterline average (p-value = 0.0460). For overall, waterline and dune averages, the interaction between the treatment factor and the block factor were insignificant (p-value = 0.2133, 0.4074 and 0.0459). This means that the blocking did not confound the results. Additional measures of blocking efficiency showed that using blocks was 1.40, 2.31, and 0.92 times more efficient than not using them, respectively, for the overall transect waterline and dune line.

Sites were significantly different for all three ANOVA tests: overall (p-values = 0.0042), waterline (p-value = 0.0010) and dune (p-value = 0.0459). This indicates that

the sampling method was sensitive enough to capture the difference between replicates sites.

Table 1. ANOVA.

	Overall Average				
Source	Sum of Squares	DF	Mean Square	F-value	p-value
Raked vs Unraked	0.0134	1	0.0134	0.5767	0.4899
Block	0.0986	1	0.0986	4.2282	0.1089
Raked vs Unraked * Block	0.0067	1	0.0067	1.6802	0.2133
Site(Raked vs Unraked * Block)	0.0932	4	0.0233	5.8750	0.0042
Error	0.0635	16	0.0040		
Total	0.6035	24			
Corrected Total	0.2754	23			
	Waterline Average				
Raked vs Unraked	0.0318	1	0.0318	1.1820	0.3381
Block	0.2200	1	0.2200	8.1715	0.0460
Raked vs Unraked * Block	0.0024	1	0.0024	0.7240	0.4074
Site(Raked vs Unraked * Block)	0.1077	4	0.0269	7.9889	0.0010
Error	0.0539	16	0.0034		
Total	1.2725	24			
Corrected Total	0.4159	23			
	Dune Average				
Raked vs Unraked	0.0008	1	0.0008	0.0269	0.8777
Block	0.0596	1	0.0596	1.9633	0.2338
Raked vs Unraked * Block	0.0030	1	0.0030	0.3050	0.5884
Site(Raked vs Unraked * Block)	0.1214	4	0.0304	3.0940	0.0459
Error	0.1570	16	0.0098		
Total	0.4811	24			
Corrected Total	0.3418	23			

Discussion

During a one year time period, there was not a significant change in elevation between the raked and unraked beaches on Galveston Island. The sampling method was able to detect a difference in elevation on the East and West ends of the island at the waterline. The difference was expected in our results, which is why both sides of the

island were sampled. The difference between the waterline averages is probably based on daily changes caused by long-shore drift, waves and tides. The changes in elevation near the dunes are from less frequent processes.

The sampling method was able to capture differences that exist between replicate sites. The lack of significance between raked and unraked sites is not due to a Type II error since the experimental design is sensitive enough to pick up replicate site variation. The transects within a site are all relatively similar, yet the sites are different, while the difference in sites are mixed without regard to the treatment factor, i.e. raking versus not raking.

Raking does not appear to have an effect on beach elevation in the time period of one year. However, future studies for longer periods of time may be able to see some effects on elevation. This study only takes into account the vertical accretion of the beach, not the horizontal seaward expansion. The movement of sand may be in a different direction that is not captured by this study. Analysis of the slope of the beach may be able to detect changes that are not dependent upon elevation alone.

THE EFFECTS OF *SARGASSUM SPP.*, A BROWN ALGAE, ON DUNE PLANT GROWTH OF SPECIES *PANICUM AMARUM*

Introduction

Sargassum may be a natural source of fertilizer for dune plants which help to stabilize the dune system from erosion (ANTHONY *et al.*, 2006; TSOAR, 2005).

Vegetation can stabilize dunes by trapping particles above and below ground (KURIYAMA *et al.*, 2005; MOUNTNEY and RUSSELL, 2006; STALLINS, 2005). Vegetation increases the roughness of the landscape which increases the wind velocity threshold needed to move sand (BRESSOLIER and THOMAS, 1977; LANCASTER and BAAS, 1998). Vegetation can be observed growing on top of the large piles of *Sargassum* that is mixed with the excess sand from the raking process.

Extractions of *Sargassum* have been used in the form of liquid fertilizers to increase germination of seeds of dune plants (TRONO JR., 1999). Other research has shown that tannins from *Sargassum* increase the growth of seeds (SIVASANKARI *et al.*, 2006), however no studies have investigated whether *Sargassum* actually enhances the growth of dune plants.

In this study, I will analyze the effects of *Sargassum* on the growth of the dune plant *Panicum amarum*, the plant most commonly used to bind sediment and restore dunes in Texas. I hypothesize that the addition of *Sargassum* to the soil will cause an increase in above ground length of the plants and that the greater quantity of *Sargassum*

added will result in greater growth. Additionally, I hypothesize that there will be a greater increase in growth of plants that were treated with *Sargassum* in its natural state rather than *Sargassum* that has been rinsed off by tap water.

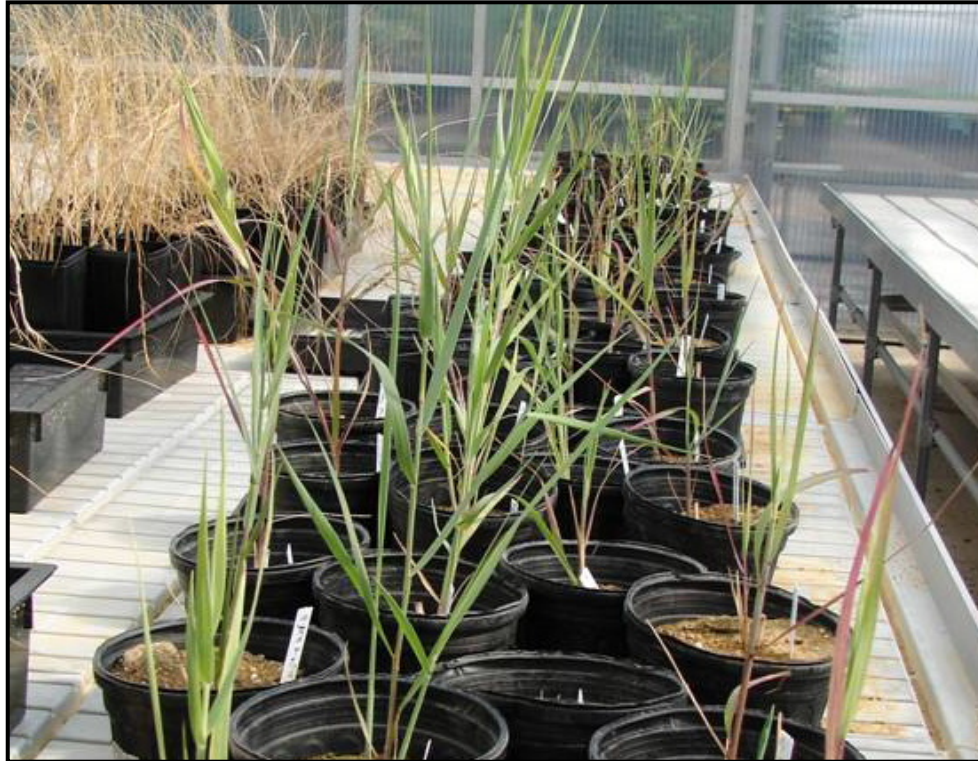


Figure 5. *Panicum amarum*. Plants grown in a greenhouse at Texas A&M University with and without *Sargassum*. Picture taken by Amy Williams in November 2007.

Methods

In July 2006, field samples of *Panicum amarum* were collected from Galveston Island, Texas and the plants were asexually cloned through propagation of individual nodes. *Panicum amarum*, or bitter panicum, is native to Texas and is one of the commonly most used plants for dune stabilization projects (HESTER *et al.*, 1994;

PALMER, 1975). Clones were grown in nutrient poor sand from an inland sand pit. Since the field samples came from the same area, therefore genetic differences are assumed to be minimal. Of the 144 specimens that were cloned, the most robust 72 of those plants were used in the experiment (Figure 5). Plants were grown for 15 weeks and above ground lengths were measured every five weeks for the growing tip height and leaf length as described in Feagin and Wu (2005) to derive a measurement of the total vegetation length of each plant.

There were nine treatments:

1. No *Sargassum* – control
2. Small amount (0.0222 kg \pm 0.004 S.D) of unwashed *Sargassum* on top (STUW) – represents natural deposits of *Sargassum* onto dunes
3. Small amount of washed *Sargassum* on top (STW) – nutrient/sand deprived *Sargassum* placed on top
4. Small amount of unwashed *Sargassum* mixed in (SMUW) – represents raked deposits of *Sargassum* on the dunes
5. Small Amount of washed *Sargassum* mixed in (SMW) – represents nutrients/sand deprived *Sargassum* mixed in
6. Large amount (0.0420 kg \pm 0.005 S.D.) of unwashed *Sargassum* on top (LTUW) – represents double of #2
7. Large amount of washed *Sargassum* on top (LTW) – represents double of #3
8. Large amount of unwashed *Sargassum* mixed in (LMUW) – represents double of #4
9. Large Amount of washed *Sargassum* mixed in (LMW) – represents double of #5

The affect of the amount of *Sargassum* was analyzed by the treatments that have small amounts of *Sargassum* (2,3,4,5) versus large amount of *Sargassum* (6,7,8,9).

These treatments will determine if the amount of *Sargassum* matters in affecting the growth of the plants. If too little is used, will the *Sargassum* not help increase plant growth? If too much is used, will the *Sargassum* stunt growth?

The location of *Sargassum* was analyzed by the treatments with *Sargassum* on top of the sand (2,3,6,7) versus the treatments with *Sargassum* mixed in the sand (4,5,8,9) .

These treatments represent what happens during natural deposition versus raked deposition. If the *Sargassum* is deposited onto the dunes naturally from a big storm or a high tide, the *Sargassum* would be placed on top of the sand. If the *Sargassum* is raked and relocated to the dunes, it is mixed in with the sand. This will test if either is more beneficial.

The affect of washing the *Sargassum* was analyzed by the washed treatments (3,5,7,9) versus the unwashed treatments (2,4,6,8). The unwashed treatments represent *Sargassum* directly from the sea in the naturally occurring condition, while the washed treatments have been rinsed with tap water. Unwashed *Sargassum* may either enhance the growth of the plants through the addition of nutrients, or inhibit the growth due to over-application of the nutrients, or may have no effect on the plants as compared to the washed *Sargassum*. The elements that are removed from washing the *Sargassum* may be detrimental to the growth of plants. Washed treatments represent an option of management if *Sargassum* was used as a fertilizer. .

Total above-ground length change was calculated by subtracting the initial lengths from July from the final lengths in November. Statistical differences between treatments in terms of the overall length changes were compared with Analysis of Variance (ANOVA) in SPSS 14.0 for Windows (Release 14.0.1 18 Nov 2005). A Three-Way ANOVA was used to determine the effect of the interactions between the different treatment variables. Then, a Post-hoc ANOVA Dunnett's T was performed to test the treatments for significant changes as compared to the control.

Results

There was a significant difference between the small and large amount treatments ($F = 20.667$, $p\text{-value} = < 0.001$) and the washed versus unwashed treatments ($F = 8.335$, $p\text{-value} = 0.006$). There was no significant difference between top versus mixed treatments ($F = 0.158$, $p\text{-value} = 0.693$). The washed versus unwashed and small versus large amount interaction was marginally significant ($F = 1.956$, $p\text{-value} = 0.080$). When these two variables are interacting, there is a difference between treatments that are washed and unwashed with large amounts of *Sargassum*, but there is not a significant difference at the 95% confidence level in the difference between treatments that are washed and unwashed with a small amount of *Sargassum*. There were no other interactions or significant differences (Table 2).

Table 2. 3-Way ANOVA.

Source	Type III Sum of Squares	DF	Mean Squares	F	Sig.
Small vs Large amount	1197412.0	1	1197412.0	20.667	<.001
Top vs Mixed	912.8	1	912.8	0.158	0.693
Washed vs Unwashed	48295.6	1	48295.6	8.335	0.006
Small vs Large * Top vs Mixed	126.3	1	126.3	0.022	0.883
Top vs Mixed * Washed vs Unwashed	11334.3	1	11334.3	3.181	0.167
Small vs Large * Washed vs Unwashed	18431.5	1	18431.5	1.956	0.080
Small vs Large * Top vs Mixed * Washed vs Unwashed	12490.9	1	12490.9	2.156	0.148
Error	324463.8	56	5794.0		
Total	1006101.5	64			
Corrected Total	535797.0	63			

The One-Way ANOVA was used to determine if the addition of *Sargassum* increased the plant growth by comparing each treatment total with the control treatment (Figure 6). There was a significant increase in the Large Top Unwashed (p-value < 0.001), Large Mixed Unwashed (p-value = 0.001) and the Large Mixed Washed (p-value = 0.013) treatments over the control treatment. None of the treatments with a small amount of *Sargassum* were significantly different from the control of no *Sargassum* (p-values ≥ 0.299). Also, the Large Top Washed treatment did not show significant growth (p-value = 0.345). This shows that the small versus large amounts and washing or not washing *Sargassum* may cause a difference in growth, however the top versus mixed location of the *Sargassum* does not seem to make a difference. \

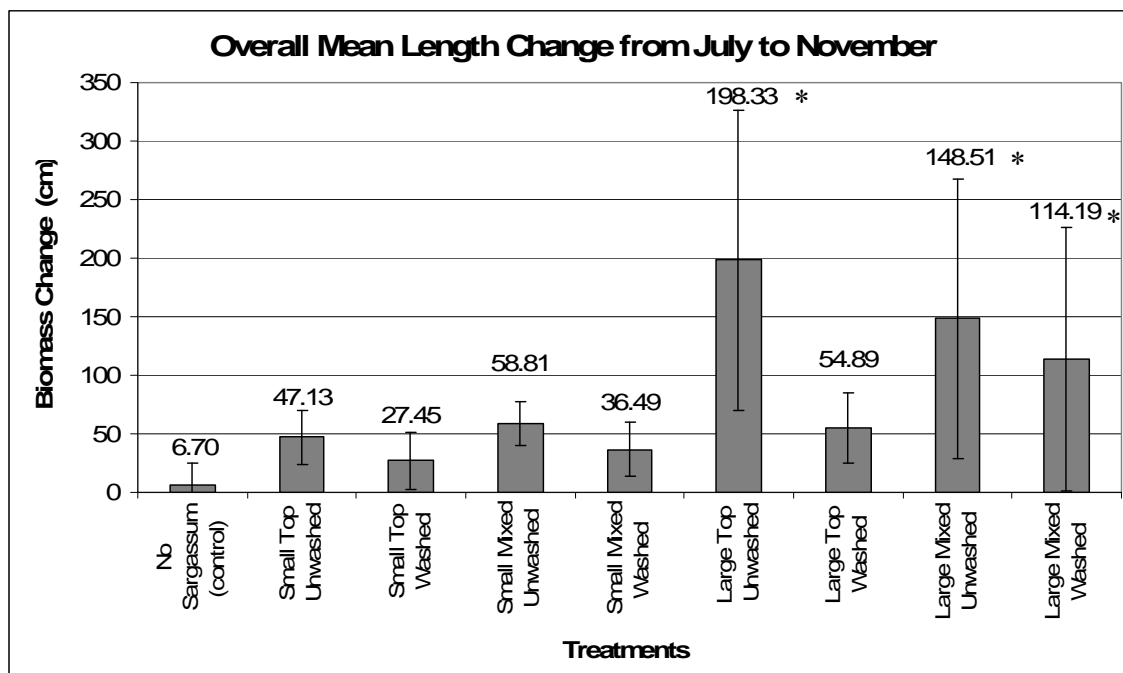


Figure 6. Total Vegetation Length Changes. This graph shows the overall mean biomass change (+/- standard deviation) in cm from July to November for each of the nine treatments of plants. * Indicates significant different between treatment and control.

Discussion

The significant change of length between the treatments with large amounts and small amounts of *Sargassum* indicates that the more *Sargassum* that is placed on the vegetation, the more growth will occur. As this experiment is only performed for two amounts of *Sargassum*, a linear relationship can not be confirmed. Further research would determine if there is a point where the plants either plateau in the amount of growth or are inhibited by too much *Sargassum*. However, initially this research indicates that there would not be harm to *Panicum amarum* by adding more *Sargassum* to the dunes.

Since the top versus mixed location of the *Sargassum* does not significantly increase growth, it indicates that it does not matter whether the *Sargassum* is deposited naturally on top of the soil or mixed in by raking. This indicates that raking the *Sargassum* and placing it at the dunes while mixed with the sand would not prevent the *Sargassum* from increasing plant growth of *Panicum amarum*.

The significant change of length between the washed and unwashed treatments of the *Sargassum* indicates that *Sargassum* in its natural state from the ocean would be appropriate to increase plant growth. Dune plants naturally grow in an environment where they encounter sea-spray and may be adapted to the natural condition of the *Sargassum*.

Overall, *Sargassum* increases the above-ground growth of the dune plant *Panicum amarum* when it is placed in large amounts directly from the sea in an unwashed state. It does not matter whether the *Sargassum* is placed on top of the soil or

mixed in. This indicates that beach raking of *Sargassum* and placing the *Sargassum* on the dunes could beneficially increase vegetation growth of *Panicum amaraum*.

The increased plant growth of *Panicum amarum* indicates that *Sargassum* has beneficial aspects on the beach. Beach management policies should be altered to capitalize on this benefit. *Sargassum* could still be raked daily to the base of the dunes in one pile, but some method to spread the *Sargassum* more evenly along the pre-existing dunes should be implemented. The *Sargassum* would not have to be spread daily, but could be done monthly or seasonally. In this way, beach management would remove the nuisance *Sargassum* from the beach front and help to stabilize the dunes at the same time. The public would benefit from the more recreationally-pleasing beach and enhanced dune protection for the landward ecosystems and development.

Plants are typically limited by nitrogen, potassium and phosphorous that is available in the soil (HESTER and MENDELSSOHN, 1990; VAN DEN BERG *et al.*, 2005). Future research to analyze the nutritional components of the washed and unwashed *Sargassum* would determine what nutrients the plants are attaining from the *Sargassum*. Since the unwashed treatments grew better, the comparison of the nutrients found in the washed and unwashed *Sargassum* could indicate what nutrients are critical in increasing plant growth.

Additionally, it may be possible to capitalize on the benefits of *Sargassum* by selling it as a fertilizer. *Sargassum* has economic value in other parts of the world for food products, pharmaceuticals, cosmetics, alginate production and extracts for medical uses (INA *et al.*, 2007; MARINHO-SORIANO *et al.*, 2006; TRONO JR., 1999), but currently

there is not a market for it in Texas. Further research would need to be done to see if *Sargassum* helps the growth of other types of plants besides *Panicum amaraum*. There may be a difference in the nutrients needed in garden varieties of plants from dune plants.

**ANALYSIS OF THE COLLABORATIVE POTENTIAL OF THE SARGASSUM
POLICY COMMITTEE TO DEVELOP BEACH CLEANING POLICES ON
GALVESTON ISLAND, TX**

Introduction

Coastlines are constantly affected by both human management and nature's forces. Beach management plans focus on short-term goals that sustain tourism. These practices often subsequently destroy the natural, dynamic processes that create the beach (BUSH *et al.*, 2004; PHILLIPS and JONES, 2006).

The economy of Galveston Island, Texas depends on tourism. Natural processes such as erosion, hurricanes, and influx of natural and cultural litter threatens tourism and drives beach cleaning policy (BUSH *et al.*, 2004; MCGLASHAN and WILLIAMS, 2003). Environmental policies require complex decisions that take into consideration many different values.

Integrated coastal zone management is a technique of solving issues through deliberation with multiple stakeholders by taking into account social, economic, cultural, political, institutional, biophysical and legal constraints (PHILLIPS and JONES, 2006; ROCKLOFF and LOCKIE, 2004). One technique to identify these competing values and work towards effective management decisions is collaborative learning (DANIELS and WALKER, 2001; INNES and BOOHER, 2004).

On Galveston Island (Figure 3), people both support the method of mechanical beach raking and argue for leaving the beach along. Raking the beaches provides beach and water access for short-term goals, but may impede stability for long-term use. *Sargassum* may help plants grow; therefore, it may be beneficial when it is placed at the base of the dunes. Some stakeholders believe that raking is destroying an important resource that protects the beach from erosion. However, there is a significant lack of scientific data to support or deny the cost/benefits of beach raking and *Sargassum* on the beaches.

The inconsistency of raking on the island is a problem. The GIPBT has a policy to rake every day and hand-pick every week but it is not being implemented equally throughout the island due to a lack of funding and time. Private communities lack guidelines and often do not attain a permit from the Texas GLO.

Overall, there is a struggle between social, ecological and economical aims. It had become apparent to the GIPBT that this is a complex environmental issue which can not adequately be solved by just one party. The *Sargassum* Policy Committee (SPC) was formed to collaboratively improve the situation.

In this paper, I will assess the collaborative potential of the *Sargassum* Policy Committee established on Galveston Island, Texas. I will then provide suggestions for increasing collaboration within the committee.

Collaborative Potential Theory

Environmental issues concern many different stakeholders' values and goals (INNES and BOOHER, 2004; MCGLASHAN and WILLIAMS, 2003; PARKINS and MITCHELL,

2005; ROCKLOFF and LOCKIE, 2004). Collaborative learning is used to generate improvements in a situation of mutual concern through stakeholder participation (DANIELS and WALKER, 2001). Authentic dialogue, networks and institutional capacity make collaborative learning an improved alternative from traditional participation practices (INNES and BOOHER, 2004).

Daniels and Walker (DANIELS and WALKER, 2001) introduced the Progressive Triangle as a method to assess three dimensions of collaborative learning: relationship, procedural and substance. The Relationship Dimension focuses on the interactions and connections between the stakeholders involved in the conflict. Inclusion of all stakeholders, trust, respect and past personal issues are critical aspects of this dimension (HAMILTON, 2004; INNES and BOOHER, 2004). The Procedural Dimension focuses on the aspects of management that are necessary for the implementation of the decisions, such as legal, jurisdictional and funding constraints (PARKINS and MITCHELL, 2005). The Substance Dimension focuses on the complexity of the issues in regards to the need for mutual gains, the technicality of information, the timescale, the symbolism of ideas, the existing tensions, and the link between process and outcome (PARKINS and MITCHELL, 2005; WALKER, 2004). Figure 7 is the survey used to assess the *Sargassum* Policy Committee based on the guidelines created by Daniels and Walker (DANIELS and WALKER, 2001).

Five phases of collaborative learning exist (DANIELS and WALKER, 2001): assessment, training, design, implementation/facilitation and evaluation. In this

research, the first phase, assessment, will be used to analyze the collaboration potential of the *Sargassum* Policy Committee (SPC).

To the members of the *Sargassum* Policy Committee
March 28th, 2006

My name is Amy Williams. I am a graduate student at Texas A&M in College Station. I am playing two roles at this meeting today. First, I am taking a public participation class in which I am writing a paper on the potential collaboration of the *Sargassum* Policy Committee. I am using a method of assessment from Steven E. Daniels and Gregg B. Walker's book *Working Through Environmental Conflict: The Collaborative Learning Approach* (2001). However, I am also involved in the committee as a graduate research student whose research project is to analyze the impact of beach raking on sedimentation on the Galveston beaches. As a researcher, I am interested in finding what is best for our coasts in terms of sedimentation and erosion. The results of my research will be available to this committee and any others interested.

Now that I have told you a little about myself, for my public participation paper, I need to learn more about the rest of the group. Commonly, a diverse group of people, interests and values are affected by coastal management and policy. Please answer the following questions as completely and honestly as possible. Thank you very much for your time. Feel free to use additional paper to answer questions. I also have a Word document version that I can email to you if you email me at maddie71@neo.tamu.edu. **Please return to me at next meeting, mail to Amy Williams, [REDACTED], or email to [REDACTED]**

1. What is your name and/or what group do you represent (personal names can be kept confidential, but it is important for me to have a group name to refer to in my paper)?
2. What aspects of the *Sargassum* Policy interest you/your group the most?
3. Why are you/your group involved in the *Sargassum* Policy Committee? (for example, are you/your group trying to gain more information, do you/your group have a strong opinion you'd like to share, are you/your group interested in coming to a compromise, etc)
4. Besides working on the committee, what other alternatives do you/your group have?
5. Have you/your group had any past experiences with other groups involved?
6. Are you (as an individual or group representative) likely to attend all meetings or will someone be attending at other times in your place?
7. Do you feel you/your group have adequate knowledge of the situation? If not, what can be done to increase your/your group's knowledge?
8. Please indicate if there is anyone that you/your group thinks should be involved but is not present. What do you/your group think is the reason for their absence?

Figure 7. Survey for the Members of the *Sargassum* Policy Committee.

Collaborative Potential of *Sargassum* Policy Committee

Overall Process and Goals of the SPC

The *Sargassum* Policy Committee met from March 16, 2006 to July 26, 2006 on a weekly or biweekly basis for a total of fourteen meetings. The committee met in a conference room at the park board office in Galveston. The members sat around tables facing each other which facilitated participation. The meetings were run by a chairperson, whom was picked by the chairperson of the GIPBT based on her knowledge of beach management and social ability to run the meetings. Members contributed to meetings by identifying themselves, asking questions or emailing suggestions for presentation.

The members of the committee were personally invited by the chairperson of the GIPBT. Members representing public opinion or professional resources included individuals from the hotel businesses, beach concessionaires, rental agencies, involved citizens from certain community groups along the island, researchers currently working on *Sargassum* projects, representatives of the GIPBT and a representative of the GIPBT beach cleaning operations.

The committee learned about the beach cleaning budget, schedule and methodologies, current scientific research, current beach management practices in other communities on the Gulf Coast through phone interviews, legal requirements through a conference call with the Texas GLO, other beach cleaning equipment possibilities

through internet searches, and the aesthetics of the beach through observations. The goals of the committee were as follows:

1. To promote short-term and long-term solutions benefits to the shoreline and the dune systems through sound beach management and practices
2. To recommend policies attainable within the GIPBT budget and to identify other funding sources;
3. To take into account the economic impact of *Sargassum* on Galveston Island.

The committee developed specific objectives for these goals. The objectives were split into three topics: education, operation and funding. Within the three topics, the committee identified objectives that were immediate, short-term and long-term. The recommendations were presented at the GIPBT Board Meeting on August 8, 2006. Most notable was the recommendation for a “Beach Advisory Committee” that would be appointed by the Park Board. This new permanent committee would be in charge of recommending sound beach management practices, reviewing the annual beach cleaning budget and recommending additional funding sources. The members of the GIPBT unanimously agreed to implement the Beach Advisory Committee.

The Relationship Dimension

The major stakeholder groups were established from observations and surveys. The stakeholders present can be separated into institutional members (research or political professions) and local members (concerned citizens) (MCGLASHAN and WILLIAMS, 2003). From observations of the meetings, institutional members of the

group include members of the GIPBT, researchers and beach operation employees.

Local members include hotel industry members, beach concessionaire, rental associations, and concerned citizens. Six institutional members and seven local member that participated in the meetings. Nine members returned the survey (Table 3).

Respondent 1 believed in developing research data that will help in the decision-making process. His/her (his or he will be used for brevity) goals were to use education to better “weigh scientific data with public opinion” for policy creation. He related to the “beauty and health of our beaches and had fond memories of the beach from childhood”. He has actively participated in beach management at the city, state and national level. His current position allows him to influence policy. He personally invited the other members of the group based on his past relationships with them. He attempted to find people that he thought would get along and be able to have open discussions.

Respondents 2 and 3 both primarily valued the environmental aspects of the beach and were concerned with attaining scientific data that would determine the effects of beach raking and *Sargassum* on erosion. Respondent 2 hoped that current research would help to develop protocol to be used in determining the effects of *Sargassum* in beach erosion.

Respondents 4 and 5 felt that beach clean up in front of the seawall was a major concern. Respondent 4 was also concerned with the funding and erosion policies. Though Respondent 4 was relaying information between the committee and his employer, he was personally concerned about the issue and even went to the beach to see

the *Sargassum* for himself. Respondent 4 believed that there are other organizations on the island besides the SPC that he could work with to influence policy.

Respondent 5 stated that conservation along with clean up was important to him. He was interested in supporting an improved method of cleaning the beaches, developing funding and gaining knowledge of the problem of *Sargassum*. He felt there was no other alternative besides this committee to influence policy. He indicated that he has interacted in the past with others members on the committee.

Respondent 6 was directly impacted by the *Sargassum* on the beach due to his business. If his beach littered with *Sargassum* and trash, tourists will go to a cleaner beach and he will lose money. He has been upset by the GIPBT's inconsistent approach to cleaning the island. His beach has a scarp about one meter which creates an unrakable beach as the tractor can not work in that area. Also, he believed that raked areas are more aesthetically pleasing due to the clean beach as well as accumulation of vegetation into the areas where the *Sargassum* has been raked. He wanted to provide local knowledge to the group from his 25 years of experience working on the beach. Besides this committee, he believed he has no other alternative but to "just sit back and watch what happened". He did not have previous experience with others on the committee.

Respondent 7 wanted the policy of beach cleaning to be consistent across the entire island as opposed to the current situation where policies are managed for each individuals' "own piece of beach". He would like the GIPBT to adapt a "conservationally-oriented, equitable and clear" policy. His other alternatives to influencing policy were to complain directly to the GIPBT or other organizations. Still,

he preferred to work collaboratively as a group with the GIPBT through the SPC. He has worked with other people in the committee before.

Respondent 8 called himself an environmentalist that was a “daily beach walker and nature lover”. He was concerned with the management of *Sargassum* and was interested in learning more about *Sargassum*. He was concerned mainly with the environment, not the tourism aspect. He considered the SPC as the priority now over any other possible options.

Respondent 9 was hoping that the results of current research would be useful in creating a policy that was best for the beaches. His community has legal obligations to work on beach restoration and his SPC work was contributing to that. His other alternatives to influence policy were to work with community groups on the island. He had previous experience with three other members of the committee.

Seven of the responders felt that they had adequate knowledge of information about the issue, had received it within the first couple of meetings or would be receiving it from the current studies that were occurring. Respondent 7 thought that people did not have a good overview of the problem but instead were too concentrated on their own part of the beach and needed more education about the whole situation. There was a general consensus that the committee members lacked information on current beach policy. Additionally, there was a lack of knowledge about the governing parties over beach management and what influence the SPC could have over those parties.

Four of the respondents thought that the group had a good representation of stakeholders, but most were not opposed to including any new members. Other

suggested members included the Galveston beach patrol, non-profit organizations such as the Sierra Club, Texas General Land Office, other communities and organizations on the island, other citizens, someone with knowledge of funding, and someone with knowledge of the raking machinery involved. The stakeholders that are presently involved seem to be the primary stakeholders, while some of the suggested stakeholders may have secondary interests. Also, the members of the committee were invited personally, not through a general forum; therefore, there may be members of the public that are excluded from the process. Conference calls with the GLO and guest presentations were used to include other technical information. Though the group is not very well publicized, media interest was apparent when a press conference was held.

During observations of the meetings, joint-fact finding was an obvious goal of the members. Conversation between stakeholders and inclusions of educational presentations from other entities were used to meet this goal. For example, the representative of the beach cleaning operations attended some meetings and provided knowledge to the committee about the mechanical aspects of beach raking. Also, one member took some of the committee members on a ride along the beach to show geomorphic difference in the beaches along the seawall.

In the meetings, most stakeholders were interested in finding alternatives to the current system of raking on the beaches. These alternatives include bailing the *Sargassum* and placing it to establish a new dune line or creating cuts through the existing *Sargassum* mats to provide access to the water for recreation. Educational presentations on these topics were also included in the meetings.

A variety of personalities are represented at the meetings. Some of the stakeholders were passive and mainly observe. Other members are very active and outspoken during the meetings. During the meetings, usually the chair and two other stakeholders dominant the conversation. The chair does encourage participation by everyone and keeps the meetings on track. Though some members have not strongly expressed their thoughts, all seem eager to learn more about the topic.

The Procedural Dimension

There are legal boundaries and jurisdictions over policies which constrain the actions of the committee. The GIPBT has created the policy for beach cleaning for land under their management, which includes R.A. Apffel Park, Stuart Beach Park, 10th-61st street, Pocket Parks and Dellanera R.V Park. The Pocket Parks are actually owned by the county, but they are under the management of the GIPBT. In the past, they would rake private subdivisions if it was requested, but recently they do not have the funds to meet those requests. One of the legal constraints to beach management by the GIPBT regulations is that sand can not be removed from the beach.

Areas not under the management GIPBT are the Galveston Island State Park, Jamaica Beach, and Pirates Beach. The State Park does not rake as it is a natural area. The other areas are required to get a permit from the Texas GLO if they want to rake their beaches. In the past, some communities have failed to attain a permit, but the violations have not been punished.

The SPC was required to present their recommendations to the GIPBT. It was critical that the committee works within the requirements of GIPBT regulations. Since

there were three members of the GIPBT on the SPC, it was likely that the key supervisors of the GIPBT would be supportive in the recommendations made by the committee.

Past policies of beach cleaning have involved a variety of different mechanical equipment to move the *Sargassum*. One year, the *Sargassum* was “hay bailed” and the bails were placed near the dunes. The bails have stayed in place and are now creating dunes. This process was costly and required specialized machinery. One of the researchers is working on getting an outside contractor to do an experiment on the benefits of bailing at the expense of one of the private communities.

Mutual learning seemed to be desired by the members of the group. Funding was a major issue. Identification of options for funding as one of the goals. Another procedural option was educating the public.

The chair of the SPC was picked when the committee was formed by the chairperson of the GIPBT and thus she may not have been seen by all as procedurally unbiased. Not all members verbally contribute equally at the meetings. Also, though all members introduced themselves at the first meeting, other members might not have a clear idea of the values and goals of all the other members. Values and goals are often complex and not easily describe in a thirty second introduction.

The Substance Dimension

The issues present in the *Sargassum* Policy Committee were both tangible and symbolic. How to clean the beaches was a tangible issue with relevance to the issue of human health and the mechanical processes of cleaning a beach. However, the reason

people may want the beaches cleaned were symbolic to the individual stakeholder. A clean beach is a cultural value of society that has been created through media which promotes what a beach should look like (CANTRILL, 2004). The media has created an image that is rarely found in nature.

There were multiple sources of tension over the issue at hand. First, the lack of scientific data on the effects of beach raking left less strength to the arguments against raking. Conversely, stakeholders that were biasing their arguments towards the tourism benefits competently state that leaving the *Sargassum* deters tourism. The lack of data results in strong voices for raking and a silencing of voices for leaving *Sargassum*.

Similarly, there was tension between the values of “what is best for the beach” versus “what is best for the individual”. Those who believed that the *Sargassum* should be left on the beach primarily valued nature, while those who want the beach to be raked were valuing their income, health or recreation possibilities. This caused problems for a holistic approach to beach management.

Some of the aspects discussed by the SPC have been technical and others have not. The process of beach raking is not very technical, though some knowledge of machinery is necessary. Beach cleaning employees and guest speakers with knowledge on the topics had briefed the group. The processes of beach geomorphology, wave actions and erosion are technical and demand a holistic management approach that takes many factors into account (BUSH *et al.*, 2004; VAN DEN BELT, 2004). Complex interacting issues about beach processes were not discussed and there was a lack of

scientific information in the SPC members, although some learning opportunities were available during the meetings.

There were some topics of conversation that may have different meanings to different stakeholders. A hotel manager may have a different view of a “nice beach” than an environmentalist. The definition of “improving” the beach may be very different for different stakeholders. The aspects concerned with the economics of a beach may be different for different stakeholders. Some individuals may include environmental services within economics while other might only consider fiscal aspects of economics. “Trigger” words that have ambiguous meanings were avoided during the creation of the goals. Certain words were defined by the committee for clearer interpretations.

Mutual gains were a complex issue for the SPC. Many of the values competed with each other. One aspect that may have been seen as a mutual gain by many, but not all, was an increase in tourism through well-managed beaches. This would increase the economy which is better for both the tourism industry and the resident’s housing values (PHILLIPS and JONES, 2006). While everyone involved wanted the beach available for recreation, some stakeholders were looking at short-term goals while others were focused on long-term goals.

Suggestions for Improvements of the *Sargassum* Policy Committee

The *Sargassum* Policy Committee was a good attempt to tackle the environmental, economic and social issue of beach cleaning through deliberation at the outset of the issue. The governing party, the GIPBT, recognized that the issue was too complex for them to make a decision on their own. The committee is well developed with

compatible representatives of the major stakeholder groups. The members have a strong commitment to participation during the meetings. The inclusion of institutional and local stakeholders make for a strong committee (PARKINS and MITCHELL, 2005) that produced positive outcomes. The physical aspects of the meetings, such as the frequency and seating arrangement, encouraged conflict resolution through participation (HAMILTON, 2004; ROCKLOFF and LOCKIE, 2004; SENECAH, 2004). Also, many members saw no alternative to participation in the committee, therefore much effort was be put into the committee.

However, some improvements would have been possible. External and internal exclusion may have been detrimental to the implementation process (PARKINS and MITCHELL, 2005; ROCKLOFF and LOCKIE, 2004). The committee was not inclusive of all possible stakeholders since membership was by invitation only. To increase the committee's legitimacy, a more comprehensive representative of stakeholders could have been achieved through an open announcement to the general public (INNES and BOOHER, 2004; MCGLASHAN and WILLIAMS, 2003; PARKINS and MITCHELL, 2005). Internal exclusion, though not intentional, stemmed from the lack of scientific information about what is "best" for the beach. Effects of beach raking on tourism are well established, while the environmental impacts are generally unknown. Stakeholders that were concerned with the environmental impacts need more scientific knowledge in order to take a stronger stance. Since the chair was not an unbiased member, the committee would have benefit from a facilitator who is an impartial individual who would guide the meetings (DANIELS and WALKER, 2001).

Implementing a consistent and equitable beach cleaning process along the island may be a hard goal to accomplish. Political and environmental boundaries do not coincide (MCGLASHAN and WILLIAMS, 2003). The GIPBT only manages parts of the island, while private communities and the state of Texas own other areas. These groups were not all represented in the committee. In order to develop a holistic approach throughout the island, the committee would need to go beyond the GIPBT for implementation.

Funding was a major constraint to the committee in terms of continuing the raking. Also, the time pressure to develop a management plan within one year made it difficult for the committee to research new strategies, identify more funding and gain scientific knowledge. The committee had to do the best they could to develop a plan. The creation of the Beach Advisory Committee will provide a solution for future plans.

Though the stakeholders have collaborated, it was not apparent if individuals understand the views of other stakeholders on the committee. Stakeholder analysis and social mapping are two participatory tools that could be used to help the members to discover the values of participating stakeholders in a visible way (ROCKLOFF and LOCKIE, 2004).

A long-term vision may have been compromised by the short-term goals (CANTRILL, 2004; PHILLIPS and JONES, 2006). Perhaps, mediated modeling (VAN DEN BELT, 2004) could be used to improve the effectiveness of the committee's decision making by including socio-economics, environmental, ecological and cultural aspects to determine long-term effects of decisions.

Overall, the *Sargassum* Policy Committee was a novel attempt in Galveston Island at improving beach cleaning. It is an accomplishment that the governing party, the Galveston Island Park Board of Trustees, realized the issue was too complex to handle alone. Collaboration of multiple stakeholders was needed at the outset of policy creation. However, external and internal exclusion of stakeholders, lack of an impartial facilitator, administrative boundaries, lack of funding, and time constraints may have impaired the development and implementation of possible policies. Greater elaboration on the different values of the stakeholders along with consideration of the long-term effects would have enhanced the collaboration. The acceptance of the Beach Advisory Committee to continue the tasks of the SPC on the permanent basis is a great achievement that will help to implement short-term goals along with the long term goals. Hopefully, the new committee will be able to continue the collaboration that the ad hoc *Sargassum* Policy Committee accomplished.

CONCLUSION

The overlapping values of social, ecological and economic goals of Galveston Island caused complications in creating beach management policies. The combination of scientific research and stakeholder collaboration was a proactive approach to managing the complex community.

The issue of managing the beach first had to address the scientific advantages and disadvantages of beach raking and *Sargassum*. The first study indicated that beach raking did not significantly change the elevation of raked of raked beach as compared to unraked beaches for a one year time period. The second study indicated that *Sargassum* does provide benefits to the dune plant *Panicum amarum*. The addition of large amounts of *Sargassum* directly from the sea, either mixed in or on top of the sand, increased the above-ground growth of *Panicum amarum*, the most commonly used plant for dune stabilization. This indicates that beach raking of *Sargassum* and deposition of the *Sargassum* at the dunes could increase vegetation growth of *Panicum amaraum*.

The second issue of managing the beach was dealing with the people of the community. The last component of the research, the analysis of the collaborative potential of the *Sargassum* Policy Committee, provided insight into a public committee. The realization by the Galveston Island Park Board of Trustees that input from stakeholder was needed to develop improved beach management policy was crucial for the productive development of new policy. Though improvements could have been made, overall the committee was a success. The development and the acceptance of the

Beach Advisory Committee to continue the tasks of the SPC on the permanent basis is a great achievement that will help to implement short-term goals along with the long term goals.

Continuation of collaboration with affected stakeholders is critical for continued success of policy decisions. Future research of the nutrients that are being contributed to the soil from the unwashed *Sargassum* should be done to understand the mechanisms that are increasing plant growth. It may be possible to capitalize on the benefits of *Sargassum* by selling it as a fertilizer. Further research would need to be done to see if *Sargassum* helps the growth of other types of plants besides *Panicum amaraum*. There may be a difference in the nutrients needed in garden varieties of plants from dune plants.

Balancing the social, environmental and economical needs of the coastal community is important in management decisions. Beach management policies should take into consideration these studies when developing beach management decisions. Alterations of current management could greatly enhance the beach for tourists and the environment. *Sargassum* could still be raked daily to the base of the dunes in one pile, but some method to spread the *Sargassum* more evenly along the pre-existing dunes should be implemented. In this way, beach management would remove the nuisance *Sargassum* from the beach front and help to stabilize the dunes at the same time. The public would benefit from the more aesthetically-pleasing beach and enhanced dune protection for the landward ecosystems and development.

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