EVALUATING AEOLIAN SAND TRANSPORT VECTORS IN DUNE BLOWOUTS

An Undergraduate Research Scholars Thesis

by

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Submitted to Honors and Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

Approved by
Research Advisor: Dr. Chris Houser

May 2013

Major: Geography
Specialization in GIS

TABLE OF CONTENTS

ABSTRACT

Evaluating Aeolian Sand Transport Vectors in Dune Blowouts. (May 2013)

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Grain size distribution is the reflection of the feedback between sediment transport system and morphologic change of beach systems. In this respect, early models suggest that grain size can be used to determine the transport vectors. However, recent evidence suggests this model is inaccurate in coastal systems, because the sediment supply on a beach tends to be limited. Accurate transport models can provide valuable information to predict accretion, erosion, and sediment movement. This study examines whether spatial variation in grain size distributions varies with respect to\ the underlying morphology, and can therefore be used to determine the transport vectors as suggested by the earlier models. Specifically, grain size statistics were spatially sampled across a dune blowout system at Padre Island National Seashore in Texas. Sediment samples were taken in five transects across a dune blowout system to analyze the sediment variability in this coastal system. Sieved samples were processed through GRADISTAT to determine grain size distribution, sorting, and skewness. Results suggest transport vectors do not relate to the underlying morphology and therefore grain size distribution cannot be used to determine transport vectors.

ACKNOWLEDGEMENTS

I would like to thank Dr. Chris Houser for all his guidance and support, all the random meetings and answered questions as I navigated my way through my first major research project. Thank you for opening the door to let me see so many incredible opportunities and a future in a field I may not have dreamed of.

Thank you also to all of Dr. Houser's graduate students for teaching me and answering all my questions while still respecting and including me. Thank you especially to Christy Swann for the personal help ranging from title names to showing me the proper sieve methodology, and to Mallorie Jewell for inviting me on the Padre Island National Seashore trip to help with graduate work where all my research became possible. Thank you very much I could not have completed this thesis without all of your help.

CHAPTER 1

INTRODUCTION

Beaches constantly change morphologically in response to complex transport mechanisms, primarily aeolian and wave transport, and the knowledge of these morphological processes is limited at best. Studies are necessary to understand the sediment change across beaches, as well as the change of sediment distribution during active sediment transport (Bauer 1991). Sediment analysis is important in classifying coastal environments, characterizing the transporting agents, identifying properties of the material and its resource potential, and understanding its morphologic behavior.

The movement of sediment grains is very complex balance of the relationship between wind and wave transport as a primary force in the beach environment (Bagnold and Barndorff-Nielsen 1980). The previously conducted research has been based on individual processes such as mean size or sorting. However, it is difficult to evaluate individual sediment transport processes in different beach systems due to the interconnected nature of the fluid and wind transport pathways (Le Roux 1994). The convoluted nature of the two distinctively different systems, aeolian and wave transport, contributes to the limited understanding as well as the difficulty of quantitatively assessing these systems efficiently.

Grain size variability can reveal changes in the morphology over time and space, providing more knowledge of sediment transport over time. Grain size demonstrates the competence of a system, which is the ability of the system to move a certain size of sediment. For example, a small grain size does not need a high competence because the granule does not require as much energy to move. Simply put, grain size demonstrates the strength of the fluid or transport mechanism.

Grain sorting properties can reveal energy variations or the primary type of fluid that is transporting sediments. Most aeolian dune sands are well sorted because aeolian wind whittles at the finer particles and thus creates a well-sorted environment. Grain skewness quantifies the deposits that exceed the competence of the most common events in the system. A common instance of skewness occurs when larger particles are left behind because they exceed the competence of even the fastest winds in the system.

The study site is a dune blowout system located in Padre Island National Seashore, Texas (Figure 1). Blowouts are typically defined as a trough-shaped depression formed by wind erosion on a sand deposit (Hesp and Hyde 1996). The system's preexisting morphology can impact the morphology of the blowout over time. Factors such as dune height, wind magnitude, and vegetation cover can all impact the development of the blowout over time. It is important to note that blowouts do not occur initially from erosional processes. Rather, they may contain the morphologic features, like limited vegetation, preceding the blowout formation (Hesp and Hyde 1996).

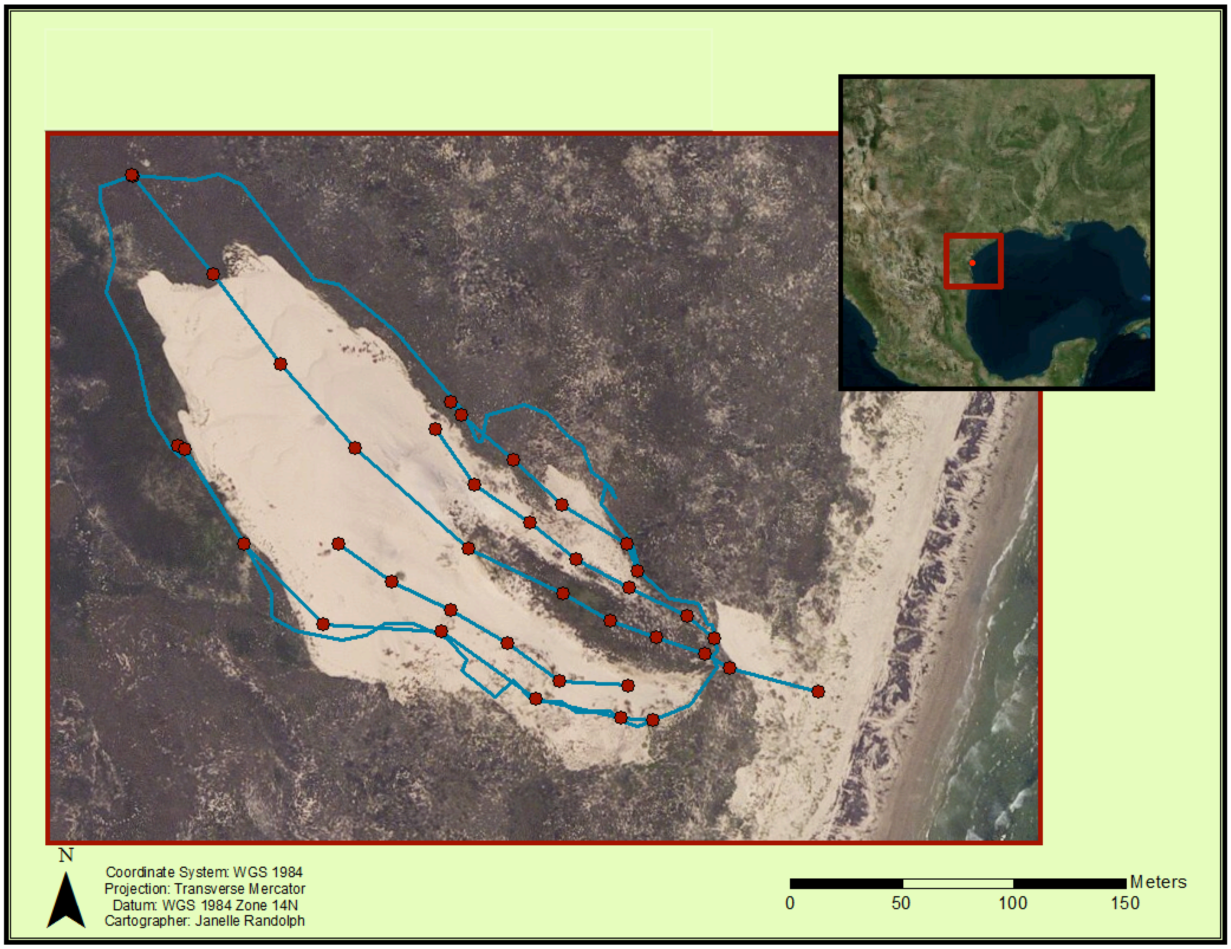

Figure 1: Blowout of interest located in Padre Island National Seashore

The dune blowout system specific to this study is a trough-shaped blowout, which Cooper (1958) described as one of the two major categories of blowout types. The trough blowout is more elongated than the saucer blowout and has longer, steeper ridge slopes and a greater depression across the middle (Hesp and Hyde 1996). The topographic shape of the system magnifies wind effects, almost acting like a tunnel. Wind speeds accelerate greatly through the trough of the system, causing high sediment transportation especially in areas with low or no vegetation that can be seen in sand ripples present on the ridge of the dune, mid-ridge of the dune, and basin of the blowout.

Blowouts occur frequently in areas of erosion and high wind or wave environments (Hesp and Hyde 1996). Wind direction and blowout formation largely impact the evolution of dune blowout systems and the migration of blowouts across barrier islands (Bauer et al 2012). Winds blow through a trough shape blowout up the center and slow dramatically once past the dune ridges. The grain size distribution should be similar to the profile of the transport fluid, wind. Understanding the relationship between wind movement and sediment transport is essential to creating an accurate assessment of what this study should reveal.

Previous research of wind vectors in trough-shaped blowouts is very limited. Prior to Hesp and Hyde (1996), no studies had been conducted in relatively deep and narrow trough-shaped blowouts. However, extensive research of saucer-shaped blowouts has identified characteristics of wind movement and transport. Gares and Nordstrom (1987) found wind speeds were lowest in a small saucer-shaped blowout base and highest on the upwind foredune crest and along the southern rim with the greatest transport at a seaward foredune crest (Hesp and Hyde 1996).

Many blowouts evolve form parabolic dunes. Previous research characterizing transport vectors within parabolic dunes can provide insight of trough vectors. A study by Finnigan et al (1989) observed regions of symmetrical flow separation forms over the depositional lobe of the dune. Another study by Robertson-Rintoul (1990) found closed windward and leeward eddies formed from upwind and downward flow separation along the dune ridge (Hesp and Hyde 1996). All of these previous saucer-shaped blowout transport characteristics built a foundation for trough-shaped profiles.

Hesp and Hyde (1996) were the first to study trough-shaped blowouts. They found jet flows are common due to the flow compression resulting from the narrow morphologic structure in the throat of the blowout, and a resultant corkscrew pattern can sometimes form through the centerline. Winds accelerate up the basin and small roller vortices form over the wall crests. Figure 2 is the morphologic diagram by Hesp and Hyde (1996) illustrating wind flow in a trough blowout. Resulting transport is dependent on the flow dynamics of the system. Transport is maximized down the centerline and decreases radially from the centerline while sand transport is at a maximum on some parts of the erosional walls, primarily the slopes with no vegetation. The small roller vortices transport sand from the upper part of the walls over the crest, depositing sediment immediately over the crest. Past the narrow throat of the blowout where it expands and opens, wind speeds decelerate and jet flows are less pronounced. Flow expansion causes the most rapid deceleration at the margin, causing very low transport in this region resulting in deposition (Hesp and Hyde 1996).

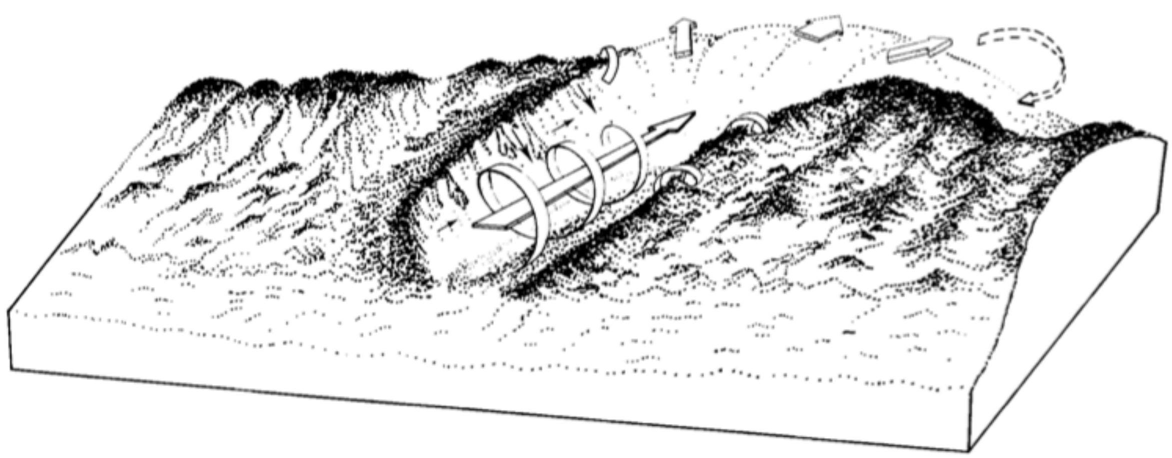

Figure 2: Transport vectors in a trough-shaped blowout according to Hesp and Hyde (1996).

Models of beach change typically do not take into account variations in grain size despite impacts on the transport processes and model accuracy. The assumption of a constant grain size is a major limiting factor in these models, and understanding the variations in grain size could contribute to a more accurate modeling of nearshore morphologic change. Sediment sorting occurs at all stages of transport and sorting generally improves in the direction of transport. Masselink et al (2008) used this principle to retrospectively attempt to derive transport vectors from spatial variation based on previous models, which had been applied to beach environments to derive transport pathways from grain analysis. Masselink et al (2008) found differences in the derived transport vectors and the observed sediment pathways. Not only was there no agreement in the observed and derived sediment pathways, but also significant differences were observed among the derived sediment pathways. Even the distribution of the vectors seemed to be random.

Sediment trend analysis and transport direction “rules” require a major premise and minor premise is true. The major premise is a universal truth of the relationship between transport direction and sorting, and the minor premise asserts a connection between transport direction and either size or skewness. The McLaren and Bowles (1985) model is based on deductive reasoning requiring the premises be true. It is well established that sediment sorting improves in the direction of sediment transport due to selective sorting, but there is no agreement of a relationship between size and skewness (Masselink et al 2008). Net sediment transport pathways are not the only factor involved in creating spatial patterns in sediment characteristics and may be of less importance when compared to other factors in nearshore environments (Masselink et al 2008).

On the basis of deductive reasoning, McLaren and Bowles (1985) developed a sediment transport model that found two dominant trends: sediments become better sorted, finer and more negatively skewed in the direction of transport, and sediments also become better sorted, coarser and more positively skewed (Le Roux 1994). The McLaren model is based on theoretical principles and studies have since been conducted under this same assumption. Gao and Collins (1992) and Le Roux (1994) founded on the model of McLaren and Bowles (1985) and expanding on their model. These three models are based on the premise that because sorting generally improves in the direction of sediment transport, spatial patterns from sorting processes can ultimately derive sediment pathways based on these patterns in grain characteristics (Masselink et al 2008). The model by McLaren and Bowles (1985) asserts a person can take any grain size across a beach profile and that grain could derive the transport vector, and is the model that is centrally analyzed in this study.

The purpose of this study is to analyze grain size across a dune blowout to see if there are any indications of an energy gradient as proposed by McLaren and Bowels (1985). An accurate transport model is essential to the understanding of sediment transport movement in barrier island migration and aiding in barrier island protection, accretion, and erosion. Using sediment variability to derive transport vectors would be a much better alternative to traditional methods that use expensive instruments and complicated numeric modeling. However, it is essential that these models be applied accurately to ensure accurate estimates of accretion, erosion, and sediment movement. Based on previous applications and known transport patterns in blowouts, it is anticipated that the principles of McLaren and Bowles (1985) cannot accurately depict transport in this dune blowout. Sediment variation cannot accurately derive transport vectors in this dune blowout environment in Padre Island National Seashore.

CHAPTER II

METHODOLOGY

On Sunday October 14 of 2012, 39 samples were obtained across a blowout system in the Padre Island National Seashore (Figure 3). Samples of the blowout are taken in a grid formation in order to maintain consistency. The five parallel transects are situated along the western dune ridge, eastern dune ridge, western mid-ridge, eastern mid-ridge, and center of the blowout system. Within the grid, the sediments were labeled as transect number, ranging from the western ridge as two, western mid-ridge as three, center as four, eastern mid-ridge as five and eastern ridge as six, and also soil sample number as either alphabetic starting with 'A' if the sediment was sampled from inland to the beach or the sample was marked numerically beginning with the number ‘1’ if sampled from the beach and inland. The samples with even numbered transects, two, four and six, were measured at fifty feet intervals, whereas odd numbered transects located across the mid-ridge were measured in thirty feet intervals. The mid-ridge intervals are smaller than the other transect intervals because the mid-ridge feature had a smaller overall area to measure when compared to the center transect that runs the entire distance of the blowout including the sand table and back to the beginning of the foredune. Samples were roughly three inches deep into the ground and placed in airtight bags until sediment could be taken to the lab to process.

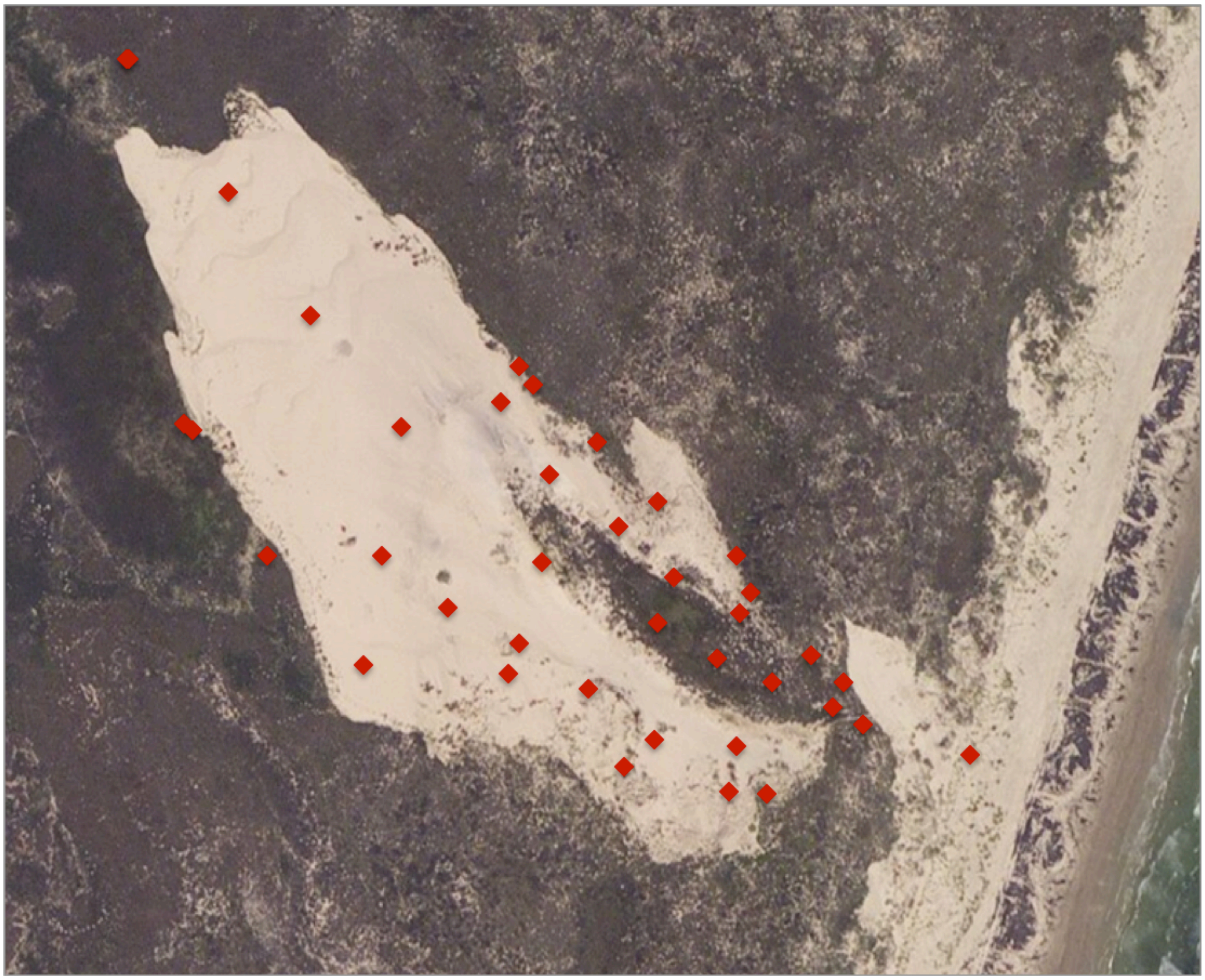

Figure 3: Location of samples obtained across the study site

Once in the lab, sediment was dried and weighed to obtain the proper weight of the sediment by removing the moisture content. The samples were placed into vessels then placed in an oven for twenty-four hours to remove moisture. After the twenty-four hours, samples were weighed and recorded again then placed back into airtight containers so the sediment grains could be separated and examined without compromising moisture content. Sediment weight was determined by removing the weight of the vessel from the post oven sediment sample weight. The process of drying samples is important because it allows for a proper examination of the variability of grain size within each sample.

Nine sieves with varying mesh sizes ranging from 0.062 millimeters to 2.00 millimeters were obtained to place in a sieve, model number R3005. Each individual sieve was cleaned with a wire brush prior to beginning the process in order to remove all remaining sediment that could compromise results. Each one was then stacked on top of each other in descending mesh size beginning with the largest mesh size of 2.00 millimeters at the top and gradually decreasing mesh size to 0.062 millimeters at the bottom then the pan was placed underneath to catch all remaining sediment smaller than 0.062 millimeters. Each dried sample was individually weighed and poured into the sieve so that each layer entrained a designated grain diameter and smaller grain sizes fall to the lower sieve layer until all sediment within the sample has been ordered by grain size diameter in millimeters.

Weighted sediment samples were placed in the R30050 sieve and shaken for five minutes to order the sediment by grain size. After the sieve completed the sediment ordering, the amount of sediment in each layer was weighed and placed in a vessel. A wire brush was used to lift any entrained sand to ensure samples were complete assessments of the weight of the grains within the individual layers of the sieve without affecting the mesh size of the sieve. After all the sediment layers were individually weighed, the total sample was weighed again to assess the amount of sediment lost in the sieve process. The individual sample was then placed back in its designated airtight container and sieves were reordered by mesh size in the same fashion with the largest mesh size at the top of the stack and the smallest at the bottom next to the pan. The next sample was then weighed, placed in the sieve to shake for five minutes, weighed individually and collectively, returned to its back and the sieves are reordered. The process continued until each sample has been ordered, weighed and returned to its bag.

Once all samples had been ordered by sediment size and weighed with a final combined weight at the end, GRADISTAT was used to analyze the results of the variability of the grains size across the beach profile. The program is written in Microsoft Visual Basic and integrated into a Microsoft Excel spreadsheet to allow for graphical output. A percentage of sediment present was input for each sample at each sieve value. Sediment percentage was calculated by dividing the weight of sediment present at each mesh size interval by the total sample weight.

To quantitatively assess grain size variation across the beach profile, GRADISTAT will be employed to compare all the sediment samples. GRADISTAT is widely used in geomorphology and sedimentology. It calculates various grain size statistics of many samples rapidly at a rate of roughly 50 samples per hour using the methods by Folk and Ward (1957) and moments methods (Blott and Pye 2001). GRADISTAT will calculate mean, mode, sorting or standard deviation, skewness, kurtosis, and a range of cumulative percentile values or the grain size at which a specified percentage of the grains are coarser than the others (Blott and Pye 2001). After sorting grain size by using a sieve, GRADISTAT will be most beneficial to the study if there is less than five per cent of the sample remaining in the pan after sieving. Method of moments is the most susceptible to errors from remaining sediment, and errors in Fold and Ward parameters are only significant when there is more than five per cent left in the pan (Blott and Pye 2001).

Sample locations were measured using a total station then converted to geographic coordinates with respect to the total station. Grain size statistics were joined with the geographic location for each sample and placed in a Geographic Information System (GIS). Inverse Distance Weighted (IDW) interpolations were then calculated using standard parameters for the following variables: sorting, skewness, and mean grain size. The IDW interpolation maps provide a continuous assessment of the sorting, skewness, and mean grain size across the dune blowout using a nearest neighbor calculation that weights samples located closest in proximity at a higher value than samples further apart in proximity. A t-test was employed to assess whether or not the difference in skewness, mean grain size, and sorting is considered a significant difference. A t-test will provide an accurate way to compare data and understand whether or not the IDW interpolations are significant and should be considered important in the analysis.

TABLE 1

Graphic Mean Values	
Φ units	
< -1	Gravel
-1 to +0	Very coarse sand
+0 to +1	Coarse Sand
+1 to +2	Medium Sand
+2 to +3	Fine Sand
+3 to +4	Very Fine Sand
+4 to +8	Silt
+8 <	Clay

Table 1: Graphic Mean Categorization in phi units

TABLE 2

Graphic Standard Deviation	
Φ units	
0.00 to 0.35	Very well sorted
0.35 to 0.50	Well sorted
0.50 to 0.71	Moderately well sorted
0.71 to 1.00	Moderately sorted
1.00 to 2.00	Poorly sorted
2.00 to 4.00	Very poorly sorted
4.00 <	Extremely poorly sorted

Table 2: Graphic Standard Deviation Categorization in phi units

TABLE 3

Graphic Skewness		
Φ units	Mathematically	Graphically
+1.00 to +0.30	Strongly positively skewed	Very negative phi values; course
+0.30 to +0.10	Positive skewed	Negative phi values
+0.10 to - 0.10	Near symmetrical	Symmetrical
- 0.10 to - 0.30	Negative skewed	Positive phi values
- 0.30 to - 1.00	Strongly negative skewed	Very positive phi values; fine

Table 3: Graphic Skewness Categorization in phi units

Tables 1 through 3 are grain size values by Folk and Ward (1957) that are used to categorize and interpret grain statistics including mean grain size, sorting, and skewness. It is important to note these tables are categorizations for all sediments possible and have a much wider range of values. The sediment of interest in this study yielded much smaller ranges in values due to the nature of sediment present in a low energy coastal system.

CHAPTER III

RESULTS

Sieve data was run through GRADISTAT individually. Sample statistics yielded from GRADISTAT showed all samples were considered to be "very well sorted, fine sand" as seen in Table 4. Interpolations of mean grain size, sorting, and skewness revealed a relatively small range of values. The data had more skewness categorizations than sorting and mean grain size categorizations ranging from near symmetrical to strongly negatively skewed. Slight variations do exist within each individual variable as seen in Figures 3 through 5.

TABLE 4

TRANSECT	SAMPLE	EASTING	NORTHING	ELEV	SORTING	SKEWNESS	MEAN	KURTOSIS
T2	SSA	666915	3031711	-26.801	COMPROMISED SAMPLE			
T2	SSB	666918	3031709	-28.796	0.245	0.000	2.874	0.738
T2	SSC	666945	3031667	-26.247	0.245	0.000	2.865	0.738
T2	SSD	666980	3031631	-16.814	0.245	0.000	2.872	0.738
T2	SSE	667033	3031628	-5.194	0.242	0.000	2.869	0.738
T2	SSF	667075	3031597	-6.408	0.247	0.000	2.877	0.738
T2	SSG	667113	3031589	-6.932	0.291	0.130	2.885	0.998
T2	SSH	667127	3031588	-14.993	0.294	0.136	2.886	1.013
T3	SS1	667116	3031604	-19.764	0.245	0.000	2.874	0.738
T3	SS2	667086	3031606	-22.329	0.240	0.000	2.865	0.738
T3	SS3	667062	3031623	-24.439	0.244	0.000	2.872	0.738
T3	SS4	667037	3031638	-21.686	0.243	0.000	2.870	0.738
T3	SS5	667011	3031650	-22.201	0.250	0.000	2.877	0.738
T3	SS6	666987	3031667	-23.304	0.245	0.000	2.865	0.738
T4	SS1	667201	3031601	-32.467	0.318	0.170	2.897	1.116
T4	SS2	667162	3031611	-25.571	0.315	0.166	2.895	1.106
T4	SS3	667151	3031617	-25.653	0.250	0.000	2.870	0.738
T4	SS4	667129	3031625	-29.108	0.246	0.000	2.871	0.738
T4	SS5	667109	3031633	-26.043	0.257	0.000	2.869	0.738
T4	SS6	667087	3031645	-24.160	0.304	0.147	2.885	1.044
T4	SS7	667045	3031665	-26.319	0.292	0.121	2.878	0.974
T4	SS8	666994	3031710	-31.565	0.251	0.000	2.867	0.738
T4	SS9	666961	3031747	-32.365	0.238	0.000	2.863	0.738

T4	SS11	666931	3031788	-31.470	0.296	0.137	2.885	1.017
T4	SS12	666894	3031832	-30.610	0.244	0.000	2.866	0.738
T4	SS13	666895	3031832	-26.650	0.330	0.179	2.905	1.150
T5	SSA	667030	3031718	-19.311	0.305	0.153	2.890	1.063
T5	SSB	667048	3031694	-22.717	0.336	0.182	2.911	1.161
T5	SSC	667073	3031677	-31.056	0.304	0.151	2.889	1.058
T5	SSD	667093	3031660	-20.177	0.247	0.000	2.878	0.738
T5	SSE	667117	3031648	-22.936	0.247	0.000	2.872	0.738
T5	SSF	667143	3031634	-18.177	0.240	0.000	2.866	0.738
T5	SSG	667155	3031625	-16.100	0.248	0.000	2.879	0.738
T6	SS1	667121	3031655	-9.616	0.286	0.120	2.884	0.970
T6	SS2	667116	3031667	-21.496	0.250	0.000	2.881	0.738
T6	SS4	667087	3031685	-21.001	0.323	0.174	2.900	1.132
T6	SS5	667065	3031705	-23.743	0.247	0.000	2.877	0.738
T6	SS6	667042	3031724	-25.030	COMPROMISED SAMPLE			
T6	SS7	667037	3031730	-24.354	0.308	0.158	2.891	1.077

Table 4: GRADISTAT Statistical Analysis Results

The IDW mean grain size interpolation of the study location (Figure 4) shows the lowest mean grain size value across the site is 2.8630 phi units. The highest mean grain size is 2.9109. This results in a range of only 0.0479, with an average mean grain size of 2.88695 phi units. The Folk and Ward (1957) categorization of the average mean grain size across this site is “fine sand”. The highest mean grain size values occur in an isolated area at the eastern mid-ridge, the beginning of the blowout and the end. The lowest mean grain size values occur on the western mid-ridge and throughout the rest of the dune.

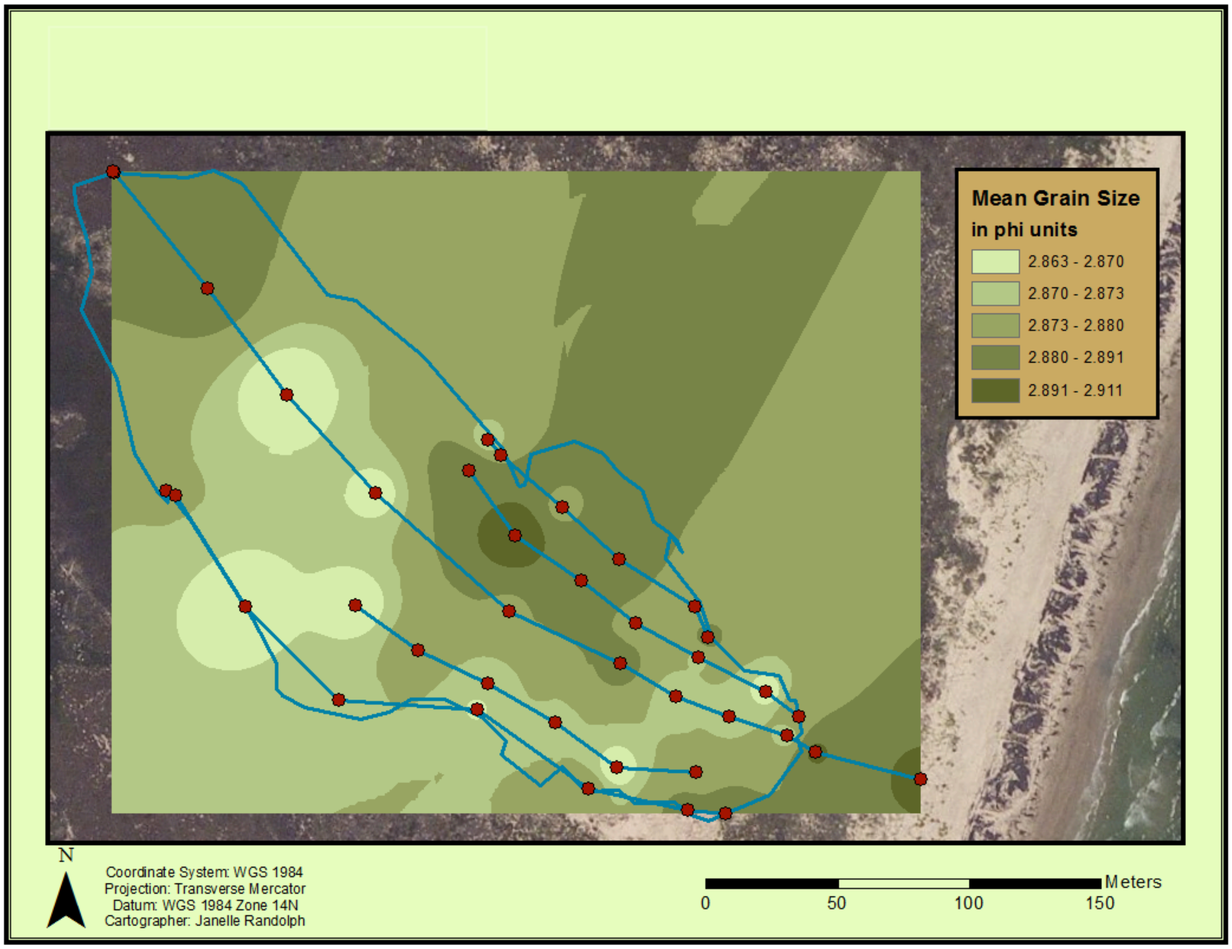

Figure 4: Mean Grain Size Inverse Distance Weighted (IDW) interpolation values across the study site.

According to the Folk and Ward (1957) categorization values, any sorting value from 0.00 to 0.35 phi units is considered "very well sorted". All of the values within the interpolation chart lie within that range, so the entire area of the dune blowout is considered "very well sorted". The area that is best sorted has a value of 0.238 phi units and the area that has the least amount of sorting is 0.336 phi units. These values are consistent with "very well sorted" values according to this categorization. Sorting across the study site, Figure 5, resembles the mean grain size value IDW interpolation. The least sorted areas are located on the eastern mid-ridge, beginning of the dune and at the far end of the blowout. Areas of more sorting are across the western ridge as well as the dune throat and towards the mid-back area of the dune.

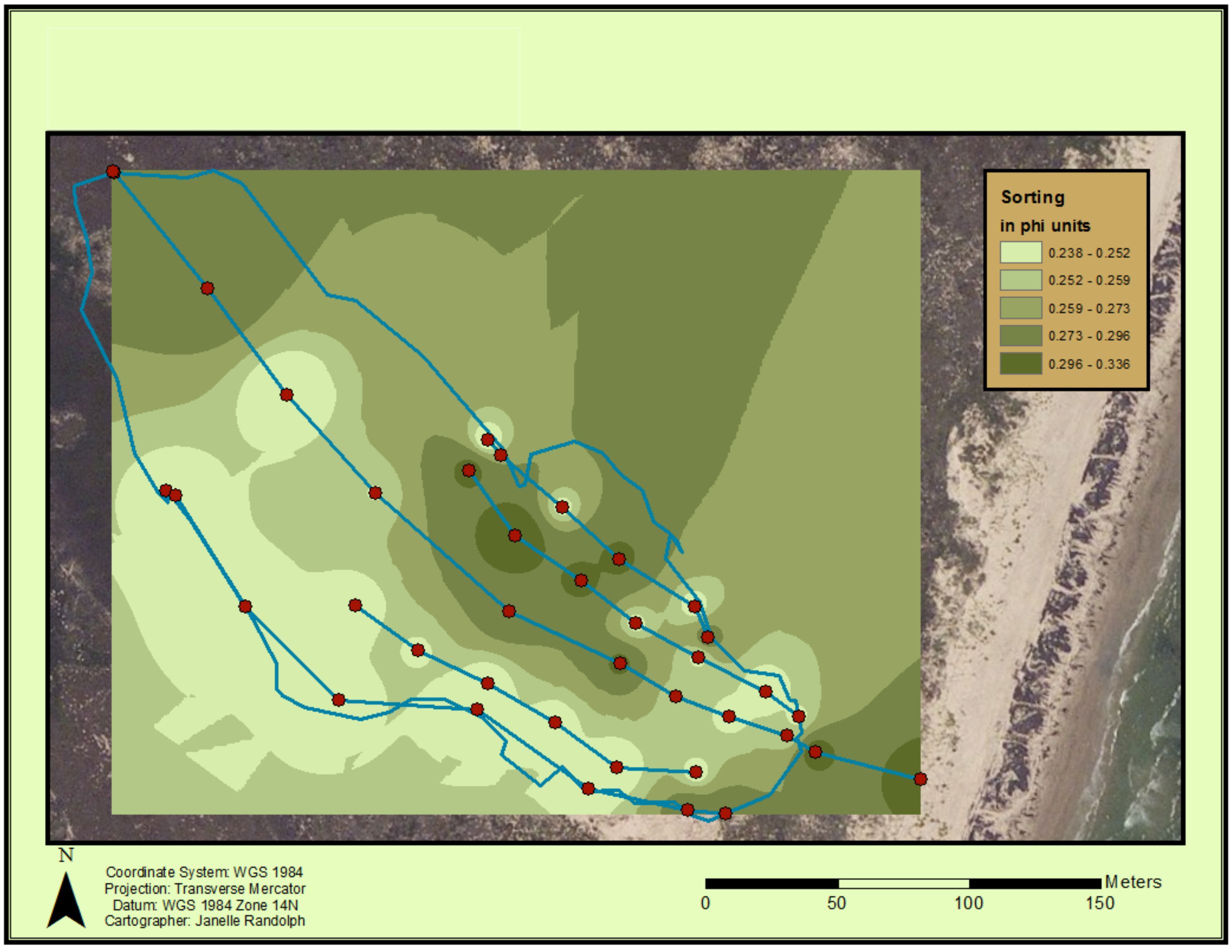

Figure 5: Sorting Inverse Distance Weighted (IDW) interpolation values across the study site.

Skewness across the site exhibits a different pattern than sorting and grain size (Figure 6). The areas of high skewness are located in the same areas; however, the lowest values of skewness are much more isolated. Areas of higher skewness do not form in an island like the previous two IDW interpolations. The lowest values of skewness, or the least skewed regions, occur on the western ridge and at a few sites on the eastern ridge. The skewness values have a wider range than the other two variables with the lowest at 0.000 and highest value at 0.182 phi units. According to Folk and Ward (1957) the skewness values range from near symmetrical to negatively skewed.

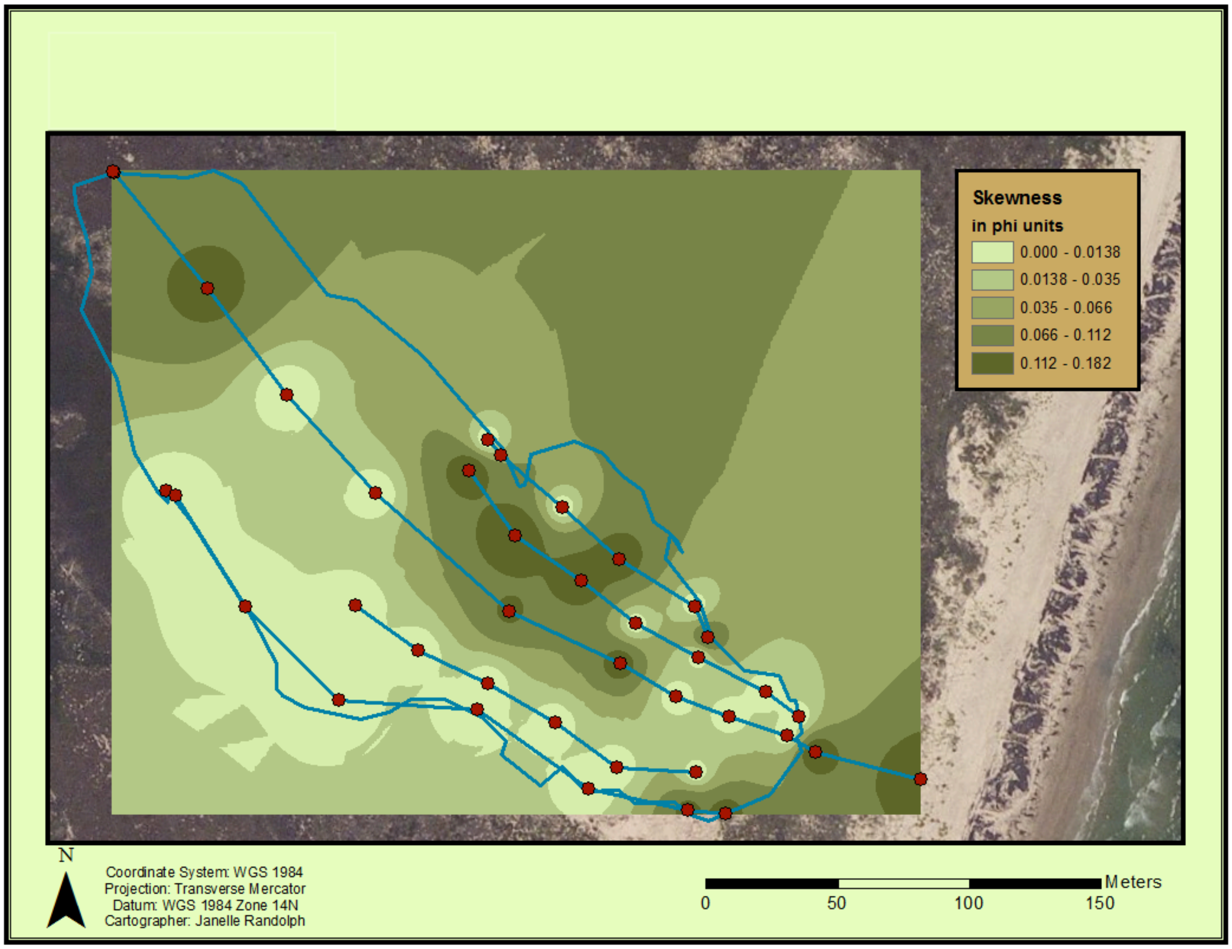

Figure 6: Skewness Inverse Distance Weighted (IDW) interpolation values across the study site.

All three of the interpolation figures resulted in a difference of values between the east and rest ridges. The east ridge of the blowout consistently contained some of the highest values, and the west ridge had the lowest values of the site. The higher values continued through the mid-ridge and somewhat into the center of the blowout at the base of the ridge. This pattern of values is different from the anticipated pattern seen in Figure 6. Further discussion of the polarization of the ridges is located in the results section

The relatively small range in resultant interpolation values required further processing of the data to determine the statistical significance of the relationship between the three variables and transport vectors. A t-test was employed to assess the significance of the interpolations. Table 5 shows the results of the t-test. The t-test proved there is no statistical significance for any of these interpolations of mean grain size, sorting, and skewness. As a result, the previous three maps are insignificant and cannot be used to assess sediment variability.

TABLE 5

	SORTING	SKEWNESS	MEANSIZE
Minimum	0.238	0	2.863
Maximum	0.336	0.182	2.911
Average	0.269135135	0.057405405	2.878918919
Standard Deviation	0.031710638	0.075637461	0.012058603
Sample Size	37	37	37
Degrees of Freedom	36	36	36
Correlation Coefficient	-0.031298408	-0.024675159	-0.014157676
Standard Error	0.166585014	0.16661592	0.166551117
T	0.187882495	0.148096045	0.223538538
Significance	0.852023795	0.883093381	0.824380078
t-test Result	0.315877487	0.06500491	3.492222818

Table 5: Results from t-test analysis.

CHAPTER IV

DISCUSSION

The basic principle of wind acceleration and sediment transport movement within a dune blowout discussed by Hesp and Hyde (1996) provides a comparison to validate calculated statistical values. Studies previous to Hesp and Hyde (1996) were isolated to only saucer-shaped blowouts and parabolic dunes. Blowouts are frequently formed from parabolic dunes and can provide information of transport patterns when assessed along with results from Hesp and Hyde (1996) who pioneered the study of trough-shaped blowouts.

Hesp and Hyde (1996) characterized transport vectors within trough-shaped blowouts. Wind enters the blowout and accelerates in the throat due to flow compression resulting in frequent formation of jet flows. This center flow pattern maximizes the transport up the centerline. Transport decreases radially away from the centerline, and causes relatively symmetrical ridge flow patterns in relatively uniform parabolic depositional lobes. Sediment is deposited immediately over the crests due to small roller vortices that flow from the upper region of the walls over the crest. After passing through the narrow throat of the blowout, wind speeds and velocity decelerate and lessen jet flows. The most rapid deceleration occurs after the throat of the blowout when the blowout opens due to flow expansion.

The anticipated result was low sorting, high mean grain size, and no skewness in the center of the blow out. The center of the blowout should be a low energy zone with very low transport. The wind accelerates from the center of the blowout and over the ridges with the highest amounts of transport at the ridge, mid-ridge, and end of the blowout. Sediment samples should show no energy away from the center of the blowout and significantly higher energy in the centerline and the ridges of the blowout. If the results of the test were consistent with the theory of McLaren and Bowels (1985) then the result would show a variation in mean grain size, sorting, and skewness that would increase when rising over the dune ridge and at the end of the blowout. From this sediment variability, transport vectors would then be easily and accurately derived.

The model of McLaren and Bowles (1985) is theoretical, meaning it relied on the validity of the major and minor premise of sediment trend analysis. The major premise states a universal truth of the relationship between transport direction and sorting, and the minor premise asserts a connection between transport direction and either size or skewness (Masselink et al 2008). Masselink et al (2008) found differences in observed and derived sediment pathways as well as significant differences among the derived sediment pathways when applying the model of McLaren and Bowles (1985) to a beach environment. Even the distribution of the vectors in the system seemed to be random. Masselink et al (2008) stated net sediment transport patterns are not the only factor involved in creating spatial patterns in sediment characteristics and may be less important in nearshore environments. While sorting is known to improve in the direction of sediment transport, there is no clear relationship for size and skewness (Masselink et al 2008). The discrepancies seen in the study of Masselink et al (2008) proves flaws in the minor premise, resulting in a model that will not be accurate in all environments.

In each of the three maps there is no variation in sediment samples reflecting the known transport vectors and sediment characteristics. Sorting improves in the direction of transport due to selective sorting (Masselink et al 2008). The results of the interpolation, Figure 3.2, are not congruent with this widely accepted characteristic of sorting. Size and skewness changes do not have as much consensus of the characteristic changes in the direction of transport. Sediment has been observed as finer and coarser in the direction of transport (Masselink et al 2008). In this study there was no significant relationship between sediment size and transport (Figure 3.1). Skewness has previously been used to discriminate between depositional environments such as the difference between river and dune deposits (Masselink et al 2008). Figure 3.3 has no statistical significance as well. Although it should show that it is a dune deposit environment, the skewness shows no significant relationship.

The three interpolations show some variation in grain size across the dune blow out. In order to appropriately interpret this data, statistical significance must be understood. A t-test provides a way to interpret the data accurately and empirically assess significance. The t-test computes a t-value, and the larger the t-value, the more likely the difference is significant. Ultimately, if the t-value is greater than or equal to the critical t-value then there is a significant difference in the data. All sample sets had t-values much less than the critical t-value. Simply, the three IDW interpolations across the dune blowout do not have a significant relationship.

The difference in variation between the east and west ridge is not congruent with the morphologic model from Hesp and Hyde (1996), which states that transport vectors in a trough-shaped blowout should be relatively symmetrical. The inconsistency means there must be a difference in the transport fluid, or a difference in the friction at the site. There is an area of vegetation located towards the eastern ridge, which could cause entrainment of grain sediments due to a higher friction. The lowest mean grain size values located along the western ridge and throughout the middle of the blowout are likely a result of normal aeolian forces. There is no vegetation across the base of the western ridge to entrain the larger grains. This could be the normal result that could be seen if there were no vegetation present in the system, and could indicate the normal aeolian forces characteristic of a dune blowout. The area of vegetation located at the base of the eastern ridge impacts the sorting as well because wind transport cannot work powerfully enough to overcome the friction from the vegetation present. More research is necessary to accurately explain the differences in grains between the east and west ridge.

Two issues arose while examining sediment samples individually. T2 SS1 was compromised while drying and weighing the sample. T6 SS6 was compromised while sieving the sample. Both samples were removed from the results to prevent any skewing of data from compromised samples. Removing two samples from consideration would not significantly impact the results of this study. The two samples that were compromised were located at the ends of the ridges where there was enough sample data to comparatively assess the sediment variability across the system. The result of the t-test would not have been impacted significantly by the additional two variables, so it can still be confidently stated that variability cannot derive transport vectors.

Future research should compare the results of this study in other blowout systems. While this study proved the previous models cannot accurately depict transport vectors, it cannot generalize that grain size cannot accurately provide information about transport vectors in all blowouts. Different systems have varying primary transport mechanisms, sediment composition, and other factors that could impact the primary morphologic structure and eventual morphologic change.

This study suggests previous models do not accurately depict transport in all cases. At this dune blowout in Padre Island National Seashore, the t-test proves that grain variability cannot derive transport vectors. Ultimately, more research should be conducted to improve these models. Accurate transport models are essential to predict morphologic change such as erosion, accretion, and sediment transport. The model by McLaren and Bowles (1985) cannot be considered an accurate model for a dune blowout system in this case. The original hypothesis stated grain size variability would not resemble transport vectors, so grain variability cannot derive transport vectors. This hypothesis has been proven accurate and accepted after the results of this study. Grain size variability in this system cannot be used to derive transport vectors because variability did not accurately represent or resemble in any form the transport vectors occurring across this system.

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