# Seagrasses Along the Texas Coast:

## Using GIS to Examine Differences from 2011-2012

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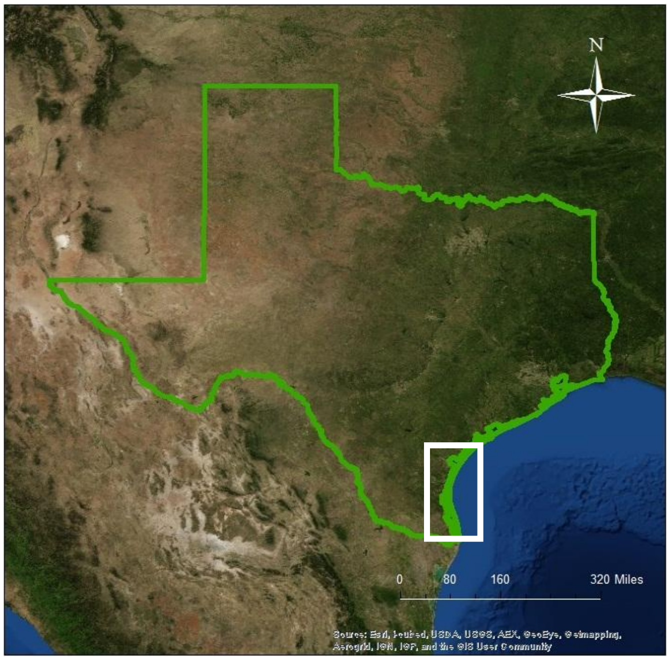
# Part I - Introduction

Texas coastal waters are home to extensive seagrass beds (approximately 235,000 total acres in 1994) that provide a variety of ecosystem services (TWPD 1999). Over 90% of the total acreage of seagrasses occurs within the Nueces/Corpus Christi/Redfish Bays, Baffin Bay, and the Laguna Madre (TPWD 1999) along the Southeast coast of Texas. For this reason, a monitoring plan for these areas was proposed within the Seagrass Conservation Plan published by Texas Parks and Wildlife in 1999. Under the supervision of Dr. Ken Dunton at the University of Texas Marine Science Institute , a three-tier monitoring approach began in the summer of 2011 and continued through 2012.



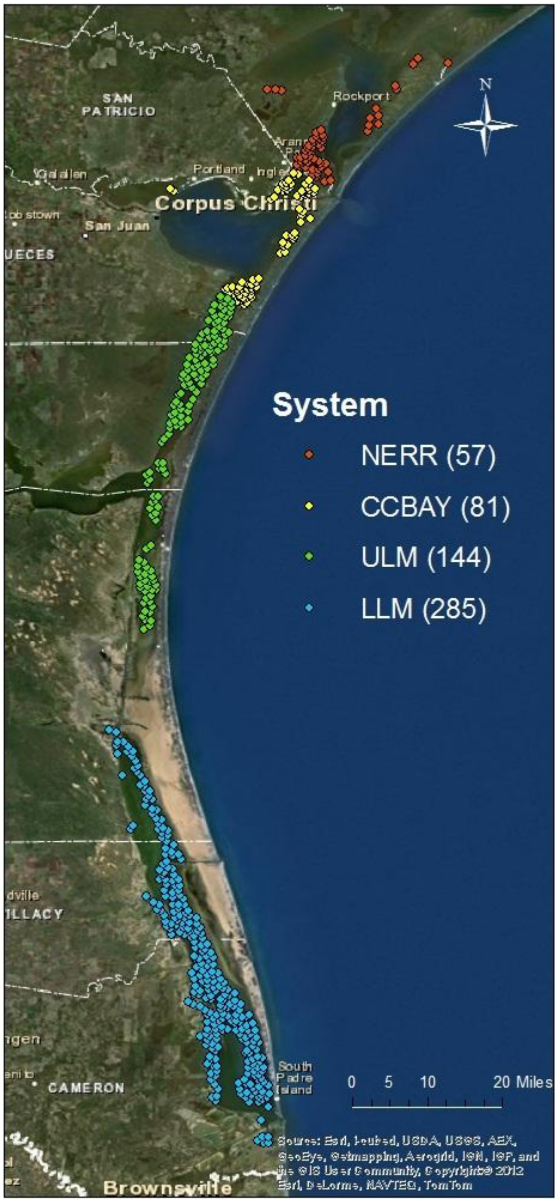




**Figure 1: Sampling Station Locations.**

This monitoring program examined both biotic and abiotic parameters at 567 sampling stations within 4 systems- the Mission-Aransas National Estuarine Research Reserve (MANERR), Corpus Christi Bay (CCBAY), and the Upper (ULM) and Lower (LLM) portions of the Laguna Madre (Figure 1). In this report, the MANERR and CCBAY stations are considered together.

Biotic parameters that this monitoring program evaluated *in situ* were seagrass percent cover (%), species composition, and canopy height (cm) (four measurements per sampling station, one from each corner of the boat). Abiotic parameters measured *in situ* included salinity (ppt), temperature (°C), percent surface irradiance (% SI), light attenuation ($K_d$), pH, chlorophyll a (µg/L), and dissolved oxygen (mg/L). In the laboratory, water samples were analyzed to find total suspended solids (mg/L). Additionally, stable isotope analysis for $\delta^{13}C$ (‰) and $\delta^{15}N$ (‰) was done for seagrass samples.

The purpose of this project was to use geographic information systems (GIS) in order to visually assess changes in seagrass percent cover in Texas between 2011 and 2012 for each species as well as the total percent cover. Additionally, differences from 2011 to 2012 for light attenuation, salinity, pH, and dissolved oxygen were graphed, and compared to the differences observed in seagrass percent cover. Each section includes a discussion of how the designated parameter may influence seagrass growth. As a result of this project, predictions can be made for seagrass coverage in 2013, and any areas of concern where seagrass percent cover has declined from 2011-2012 will become obvious.

All of the interpolations in this report were prepared using Inverse-Distance Weight (IDW) interpolation techniques, with the ‘IDW (Spatial Analyst)’ tool in ArcGIS 10.1. Performing an IDW interpolation was ideal since these monitoring efforts involved relatively dense sampling over the four study sites (ArcGIS Resource Center). By using a shapefile from the National Oceanic and Atmospheric Administration that showed extent of the seagrasses (obtained through aerial photography), and the ‘Extract by Mask (Spatial Analyst)’ tool in ArcGIS, all the interpolations were extracted so that their extent only covered that of the seagrass beds. Interpolations were created for both 2011 and 2012, then the 2011 interpolation was subtracted from the 2012 interpolation using the ‘Minus (Spatial Analyst)’ tool, in order to create the ‘difference’ rasters. Positive values in these rasters are indicative of an increase in seagrass percent cover, while negative values indicate a decrease.

# Part II – Differences in Seagrass Percent Cover

Evaluating seagrass percent coverage is one of the most time- and cost-efficient ways to monitor both seagrass extent and health. Assessing station-specific differences in percent cover each year may be a good way to determine which stations are experiencing changes. However, it should be noted that certain parameters such as currents or winds can affect the exact position and orientation of the boat *in situ*, which in turn affects exactly where percent cover estimates are taken. For these reasons, large discrepancies between 2011 and 2012 data sometimes occur, and it is difficult to assess whether this is due to subpar positioning of the boat, or due to actual changes in seagrass extent. Similarly, some beds contain large bare areas (e.g. areas with propeller scars), so a 0% cover assessment of that area may not accurately reflect the surrounding percent cover. It is for precisely these reasons that we assess percent cover four times per station, and over so many locations. For this report, the average percent cover from the four assessments at each station was used for interpolations.

Five species of seagrasses can be found in Texas: *Halophila engelmanii*, *Ruppia maritima*, *Syringodium filiforme*, *Thalassia testudinum*, and *Halodule wrightii*. The dominant species is *H. wrightii*, with some areas showing moderate amounts of *S. filiforme* or *T. testudinum*, and relatively few stations with *R. maritima* or *H. engelmanii*. Figure 2 shows the relative percent cover of each species across the three systems (average of 2011 and 2012 data).

## *Halophila engelmanii*

The presence of the seagrass *Halophila engelmanii* was reported at only 3% of sampling stations in both 2011 and 2012 (n=18). In 2011 *H. engelmanii* was observed at 2 MANERR

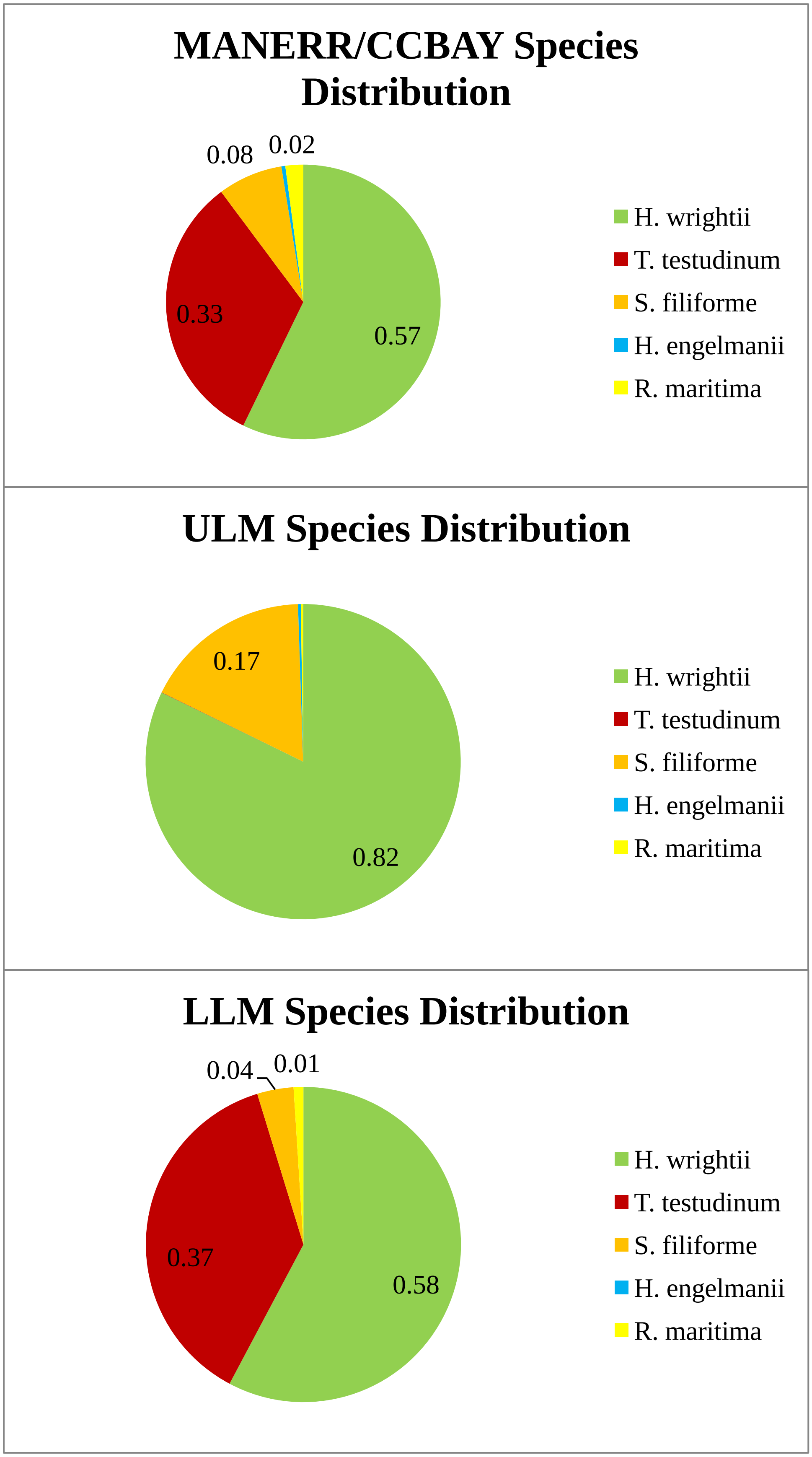



**Figure 2: Species Distribution of Seagrass in the MANERR/CCBAY, ULM, and LLM. Reported values were averaged from 2011 and 2012.**

stations, 2 CCBAY stations, and 14 ULM stations. During 2012, a slightly different pattern was seen, with *H. engelmanii* observed at 1 MANERR station, 10 CCBAY stations and 7 ULM stations. Due to the small extent of *H. engelmanii* throughout Texas coastal waters, the interpolations are not included in this report. However, it should be noted that percent cover of *H. engelmanii* in these areas is most likely underestimated. Growing only a few centimeters in height, *H. engelmanii* may be difficult to observe amongst mixed beds with other grasses, whose taller canopies effectively hide the short *H. engelmanii* from view(Wilson, personal observation). However, if shading of this *H. engelmanii* is occurring, the other seagrasses that are present would be present in such high amounts that any further contribution to total percent cover the *H. engelmanii* would make is negligible.

## *Ruppia maritima*

The presence of *Ruppia maritima* was observed at only 7% of sampling stations in 2011 (n=41),and at only 4% of stations in 2012 (n=25). During 2011, *R. maritima* was observed at 11 MANERR stations, 6 CCBAY stations, 6 ULM stations, and 18 LLM stations. During 2012, *R. maritima* was observed at 8 MANERR stations, 6 CCBAY stations, 2 ULM stations, and 9 LLM stations. Because of the small extent of *R. maritima*, the interpolations of percent coverage are not included in this report. It is likely that percent cover of *R. maritima* is underestimated as well, though for a different reason than *H. engelmanii*. The blades of *R. maritima*, when young (short), are very similar in appearance to those of young *Halodule wrightii*, the dominant seagrass along the Texas coast (Wilson, pers. obs.). A novice field assistant may mistakenly identify *R. maritima* as *H. wrightii*. While a sincere effort is made to send seasoned field assistants to collect the data, this is not always possible due to time constraints of the sampling season, and for other reasons outside of our control. Hence, it should suffice to say that any *R. maritima* being mistaken for *H. wrightii* will at least be contributing to the assessment of overall seagrass percent cover.

## *Syringodium filiforme*

### Mission-Aransas National Estuarine Research Reserve and Corpus Christi Bay

The seagrass *Syringodium filiforme* was observed at 14% of sampling stations in both 2011 and 2012 (n=81 and n=80). Figure 3 shows *S. filiforme* coverage in the MANERR and CCBAY sampling stations (n=18 and n=22). Most of the area show slight increases in *S. filiforme* percent cover, with the exception of a patch around Aransas Pass that shows decline. Some scattered areas did not show any change in *S. filiforme* percent cover, such as the west coast of San Jose Island and areas to the northwest of Port Aransas.

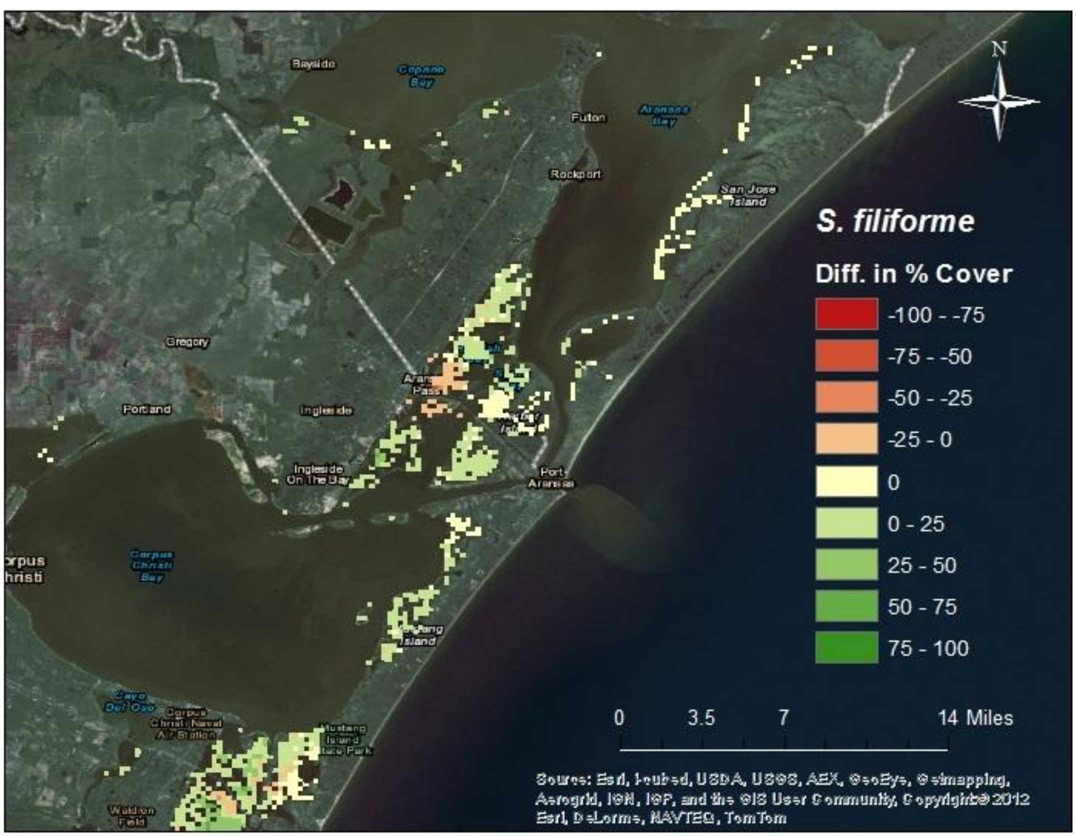



**Figure 3: MANERR and CCBAY Differences in *S. filiforme* Percent Cover from 2011-2012.**

**Upper Laguna Madre**

Figure 4 shows *S. filiforme* coverage in the ULM sampling stations (n=47 and n=41). The southern region of this site shows no changes in *S. filiforme* percent cover. This is to be expected, due to the fact that *S. filiforme* has not occurred in these areas in 2011 or 2012 (Wilson, unpub. data). The rest of the ULM shows variation between slight to moderate increases and slight to moderate decreases.

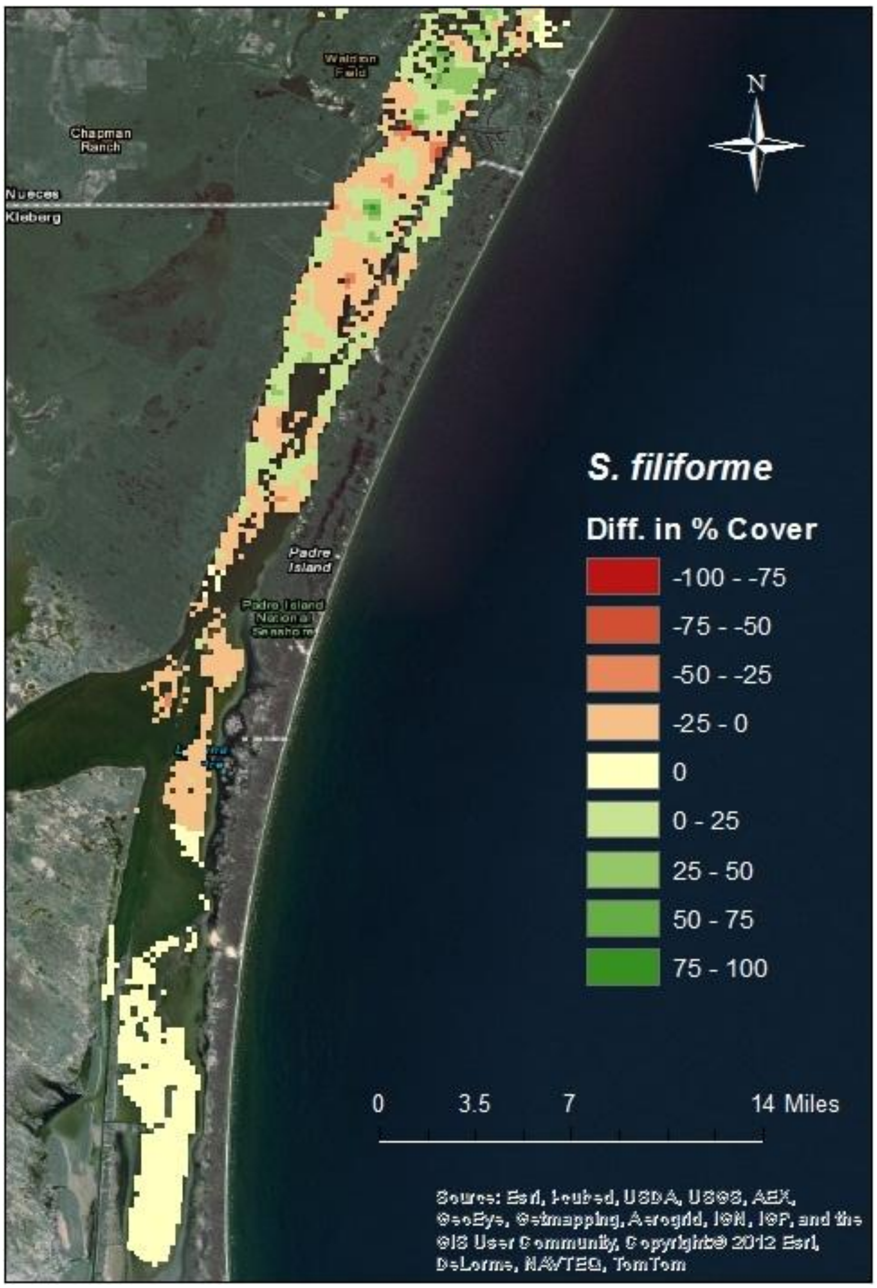



**Figure 4: ULM Differences in *S. filiforme* Percent Cover from 2011-2012.**

**Lower Laguna Madre**

Figure 5 shows *S. filiforme* coverage in the LLM sampling stations (n=16 and n=17). The great majority of LLM showed no change in *S. filiforme* percent cover, which is again due to the fact that *S. filiforme* has not grown in these areas from 2011-2012 (Wilson, unpub. data). The southern regions of the LLM generally show slight increases in percent cover.

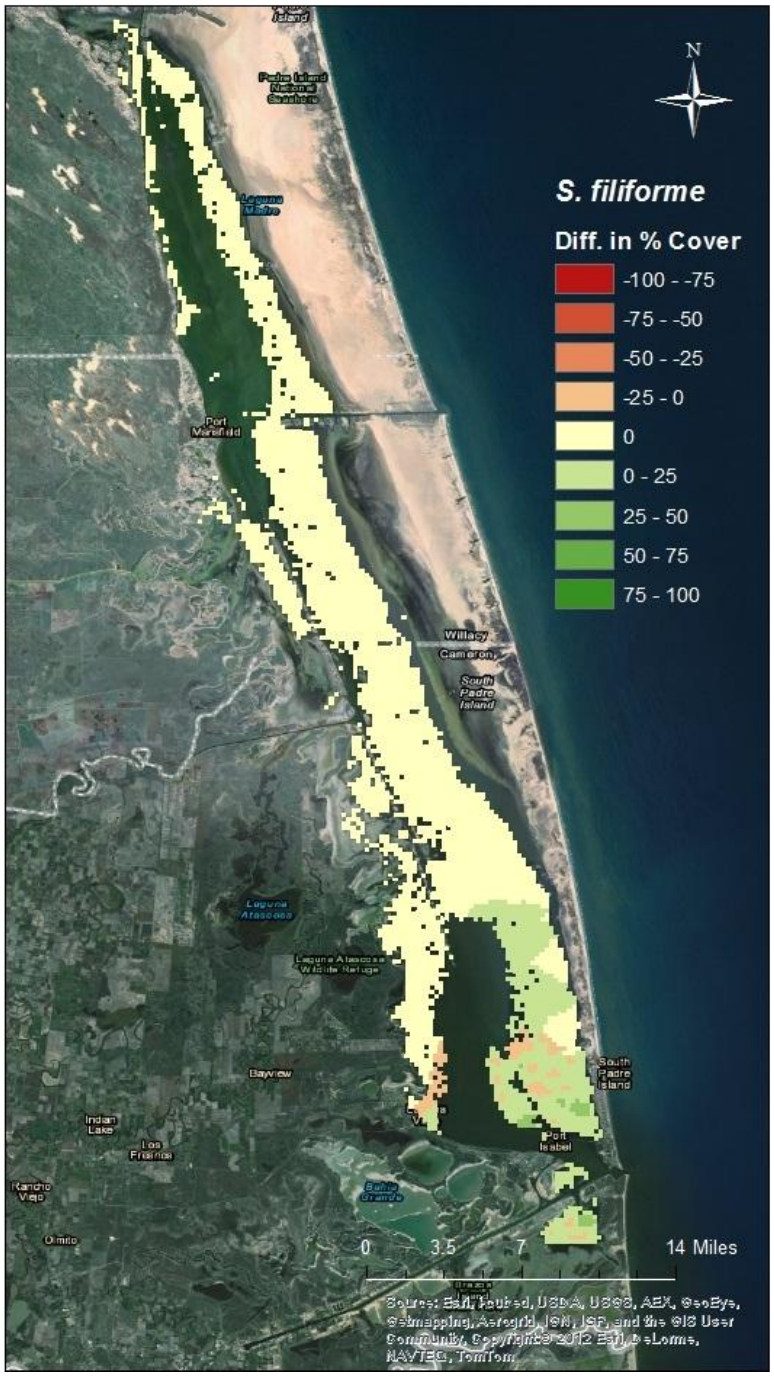



**Figure 5: LLM Differences in *S. filiforme* Percent Cover from 2011-2012.**

## *Thalassia testudinum*

### Mission-Aransas National Estuarine Research Reserve and Corpus Christi Bay

The seagrass *Thalassia testudinum* was observed at 27% of sampling stations in 2011 (n=157) and at 26% of stations in 2012 (n=148). Figure 6 shows *T. testudinum* coverage in the MANERR and CCBAY sampling stations (n=59 and n=58). This map is quite varied, showing a few areas to the south with no changes in percent cover, and slight to moderate increase or decrease in the rest of the region.

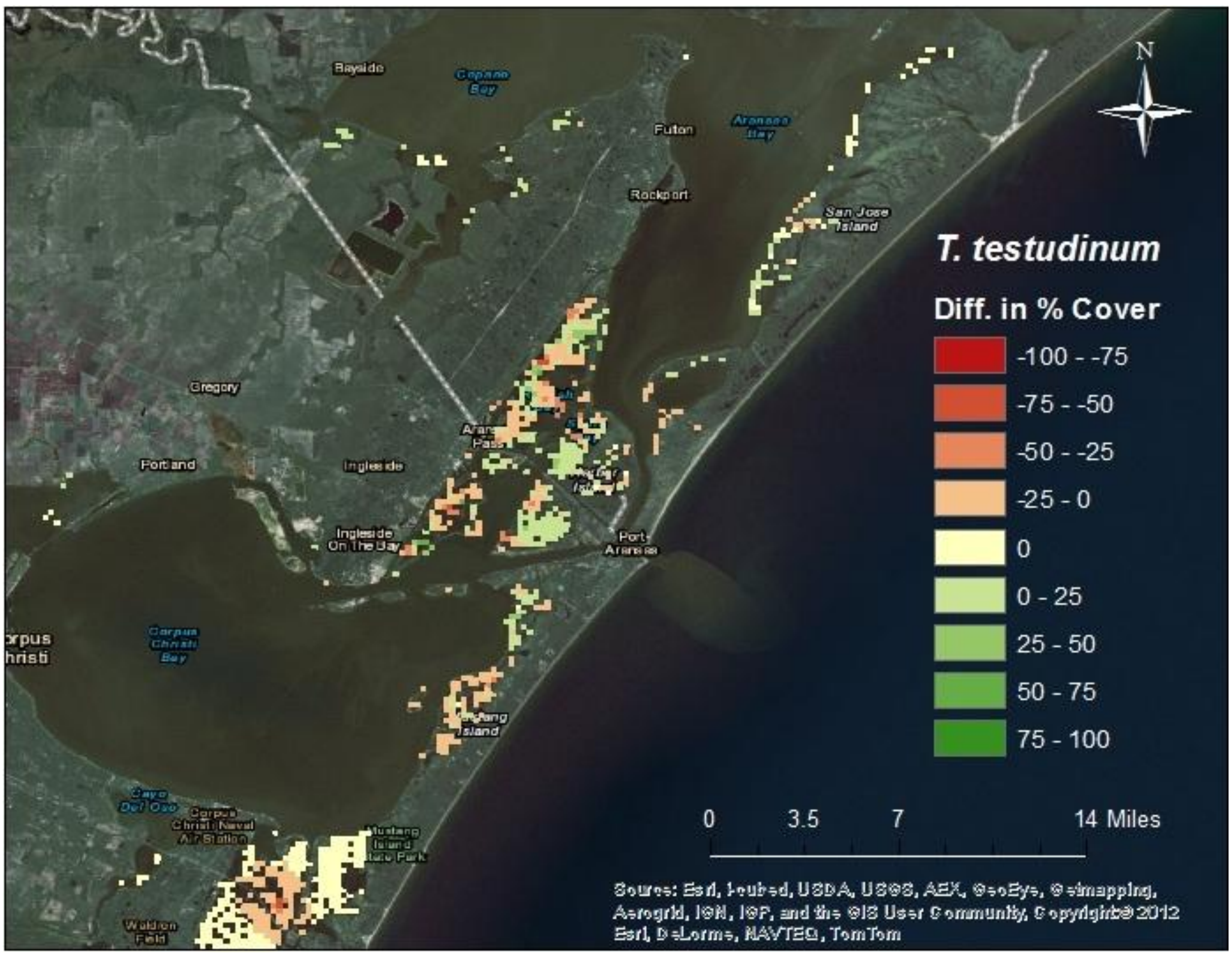



**Figure 6: MANERR and CCBAY Differences in *T. testudinum* Percent Cover from 2011-2012.**

**Upper Laguna Madre**

Figure 7 shows *T. testudinum* coverage in the ULM sampling stations (n=1 and n=0). The very northernmost decreases in the map are actually part of the MANERR/CCBAY map shown in Figure 6, and are simply present in this map for spatial context. Hence, only the one station that had *T. testudinum* in 2011 (seen near the Nueces and Kluberg county line) showed decrease in 2012, while the rest of the area showed no change due to the fact that no *T. testudinum* was present here in 2011 or 2012 (Wilson, unpub. data).

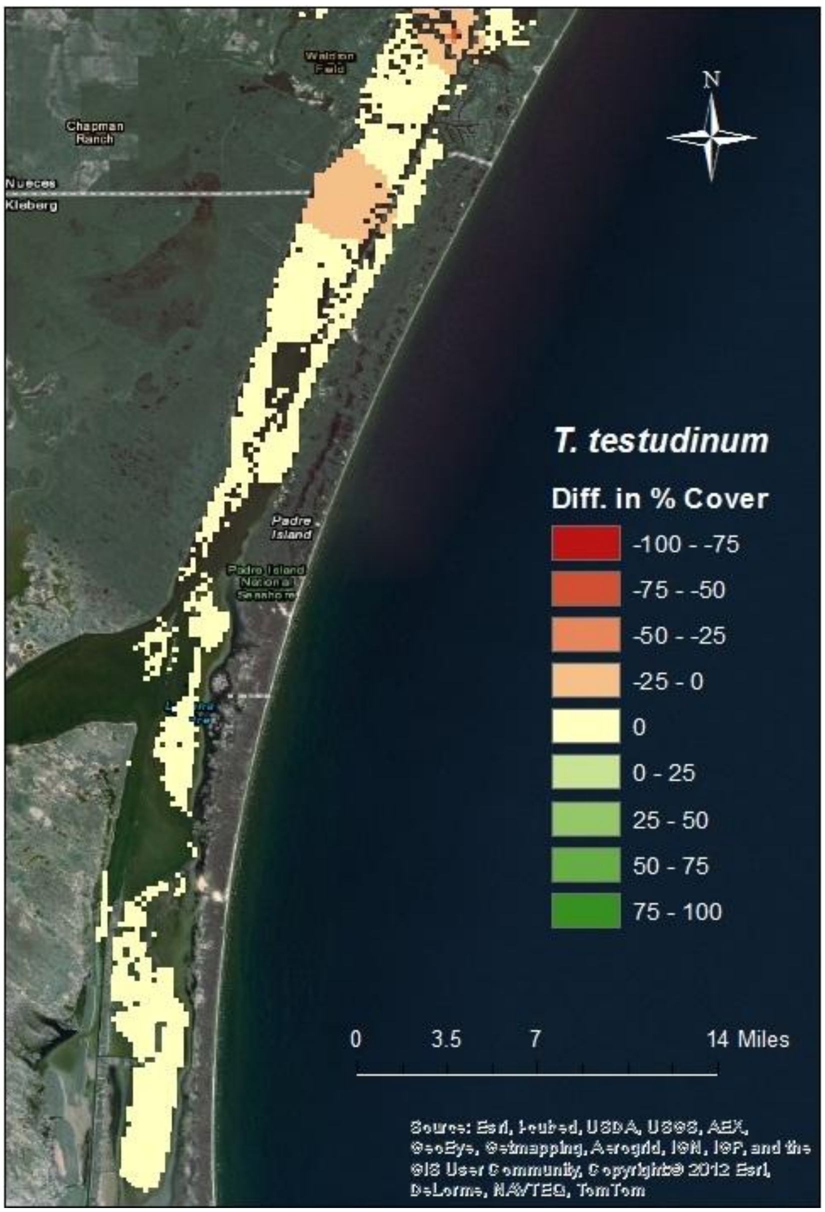



**Figure 7: ULM Differences in *T. testudinum* Percent Cover from 2011-2012.**

**Lower Laguna Madre**

Figure 8 shows *T. testudinum* coverage in the LLM sampling stations (n=97 and n=90). The upper third of the LLM region shows slight increase in seagrass percent cover, and the lower third shows areas of both slight to moderate increase or decrease in seagrass percent cover. The central third of this region showed no change in *T. testudinum* percent cover, which is due to the fact that no *T. testudinum* grew in this area from 2011 to 2012 (Wilson, unpub. data).

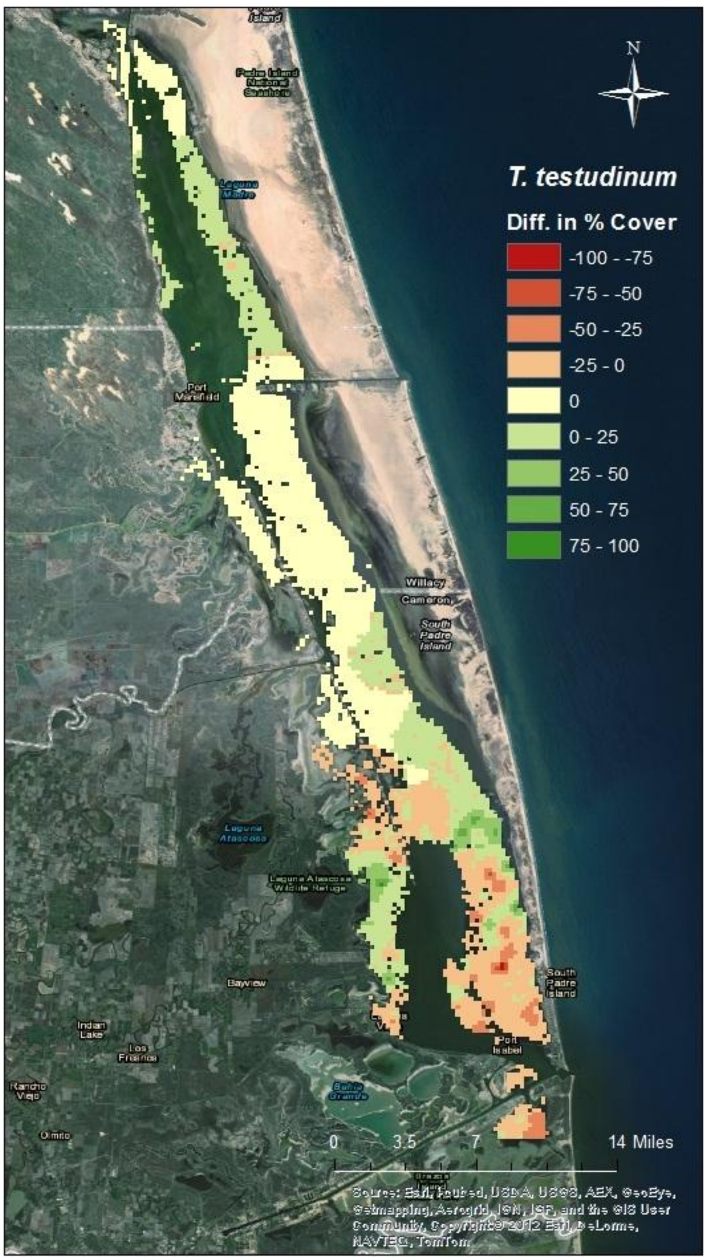



**Figure 8: LLM Differences in *T. testudinum* Percent Cover from 2011-2012.**

# *Halodule wrightii*

## Mission-Aransas National Estuarine Research Reserve and Corpus Christi Bay

The seagrass *Halodule wrightii* was observed at 67% of sampling stations in both 2011 and 2012 (n=380 and 385). Figure 9 shows *H. wrightii* coverage in the MANERR and CCBAY sampling stations (n=101 and n=95). Some increases are seen along the west coast of San Jose Island, and a large decrease can be seen at one station on the west coast of Mustang Island. All other areas showed small increases or decreases in *H. wrightii* percent cover.

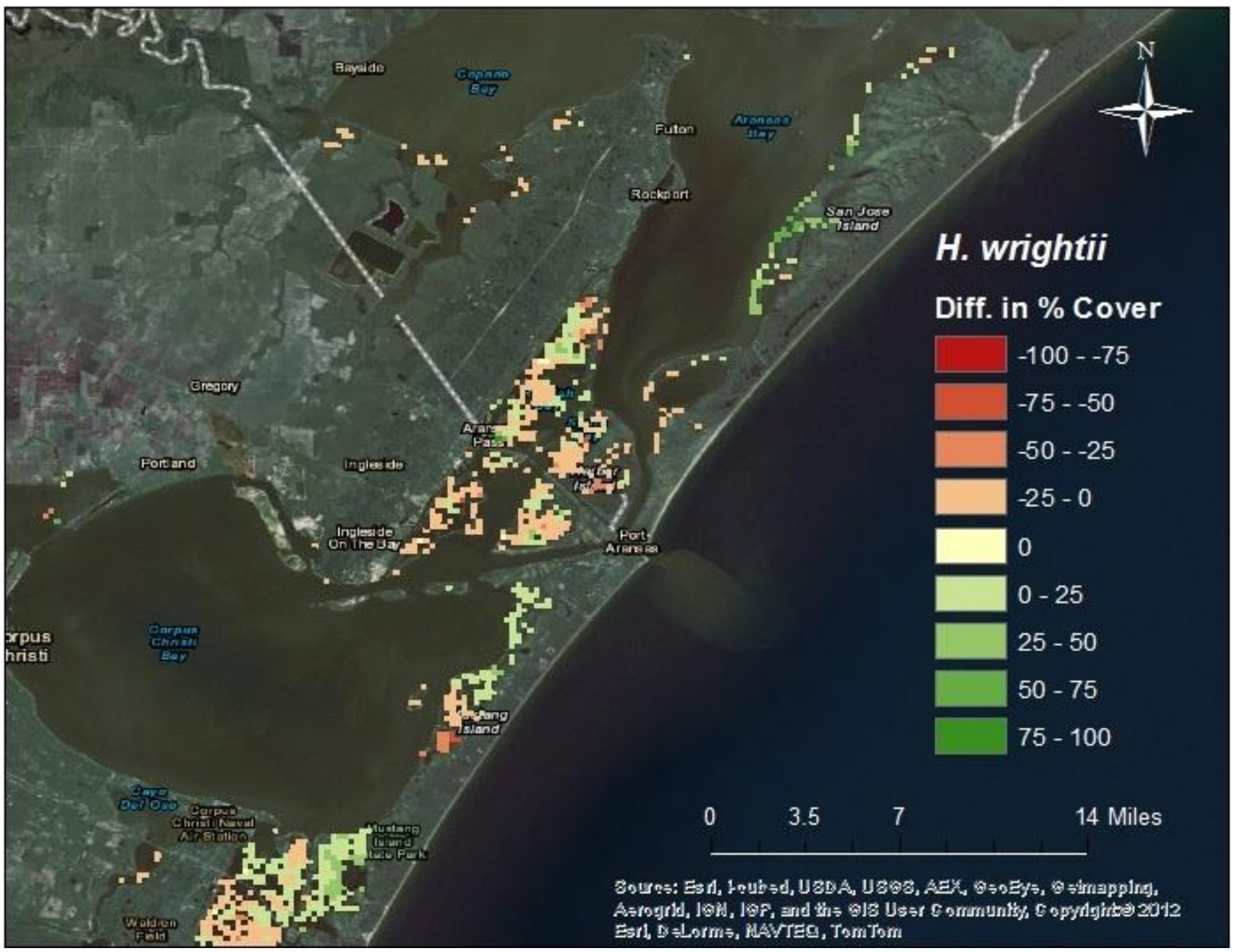



**Figure 9: MANERR and CCBAY Differences in *H. wrightii* Percent Cover from 2011-2012.**

**Upper Laguna Madre**

Figure 10 shows *H. wrightii* coverage in the ULM sampling stations (n=127 and n=126). The majority of stations experienced an increase in *H. wrightii* cover, with only a few decreases, generally towards the North.

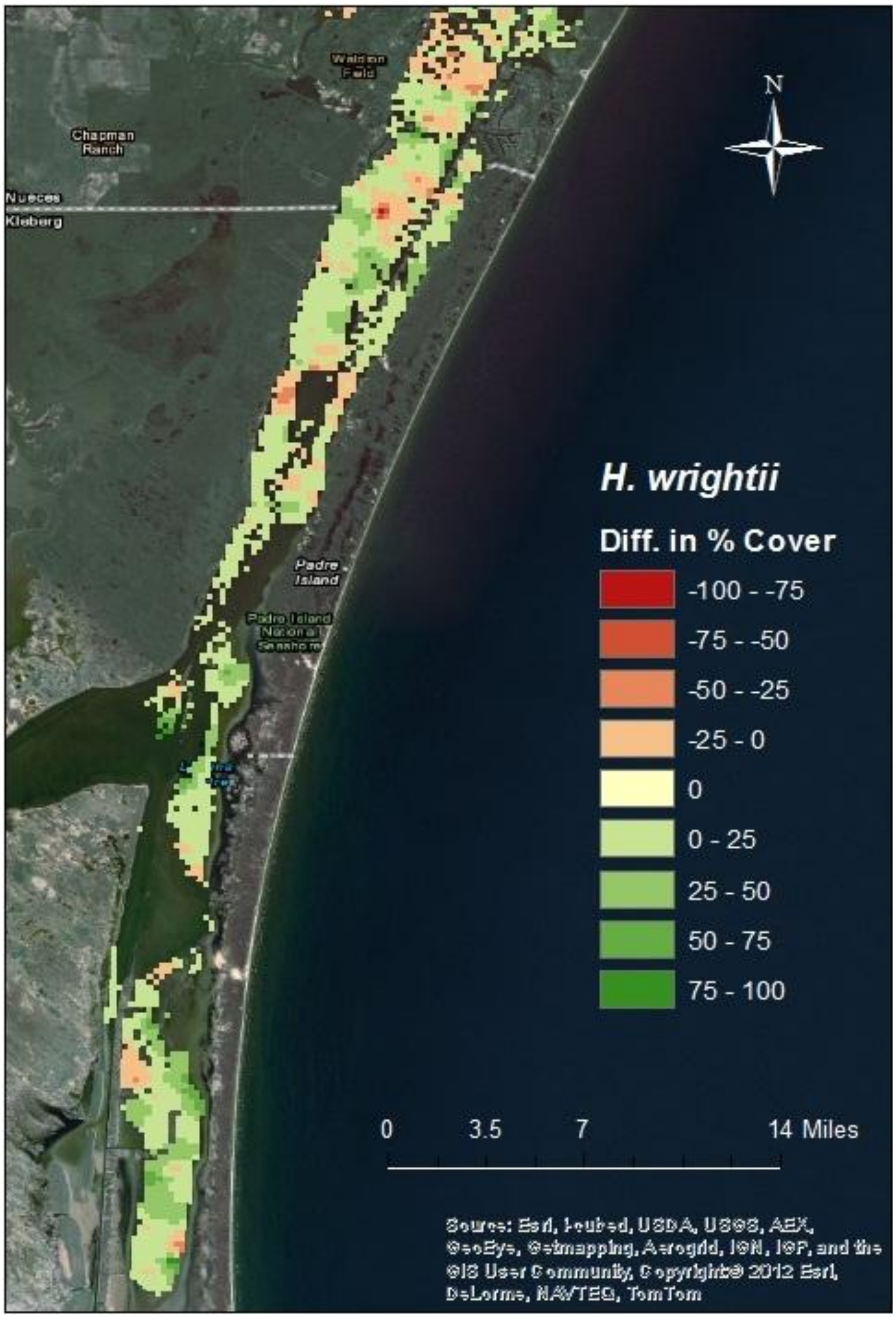



**Figure 10: ULM Differences in *H. wrightii* Percent Cover from 2011-2012.**

**Lower Laguna Madre**

Figure 11 shows *H. wrightii* coverage in the LLM sampling stations (n=152 and n=164). There are a few areas of very substantial decreases, mostly right along the eastern shore of the mainland, which should be watched carefully in the future. The central third of the LLM shows light to moderate declines in percent cover, with most of the rest of the area showing light to moderate increases. The areas near the bottom of the map showing no change in percent cover indicate areas where no *H. wrightii* is present (Wilson, unpub. data).

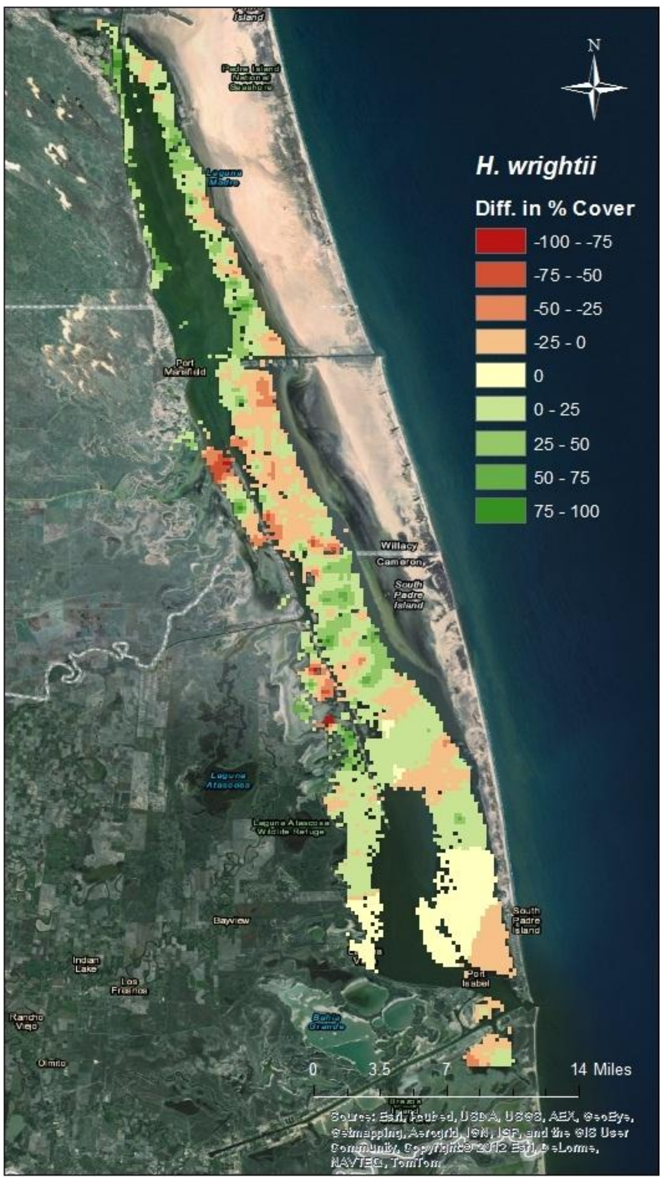



**Figure 11: LLM Differences in *H. wrightii* Percent Cover from 2011-2012.**

# All seagrass

### Mission-Aransas National Estuarine Research Reserve and Corpus Christi Bay

Seagrass (all species included) was observed at 89% of sampling stations in 2011 (n=506) and at 90% of sampling stations in 2012 (n=511). Figure 12 shows seagrass coverage in the MANERR and CCBAY sampling stations (n=134). Increases and decreases in these areas are very station-specific. Increases are seen in the northern sites along the West Coast of San Jose Island as well as most of the southern part of this area. Stations with both increase and decrease in percent cover are scattered throughout the central stations in this area.

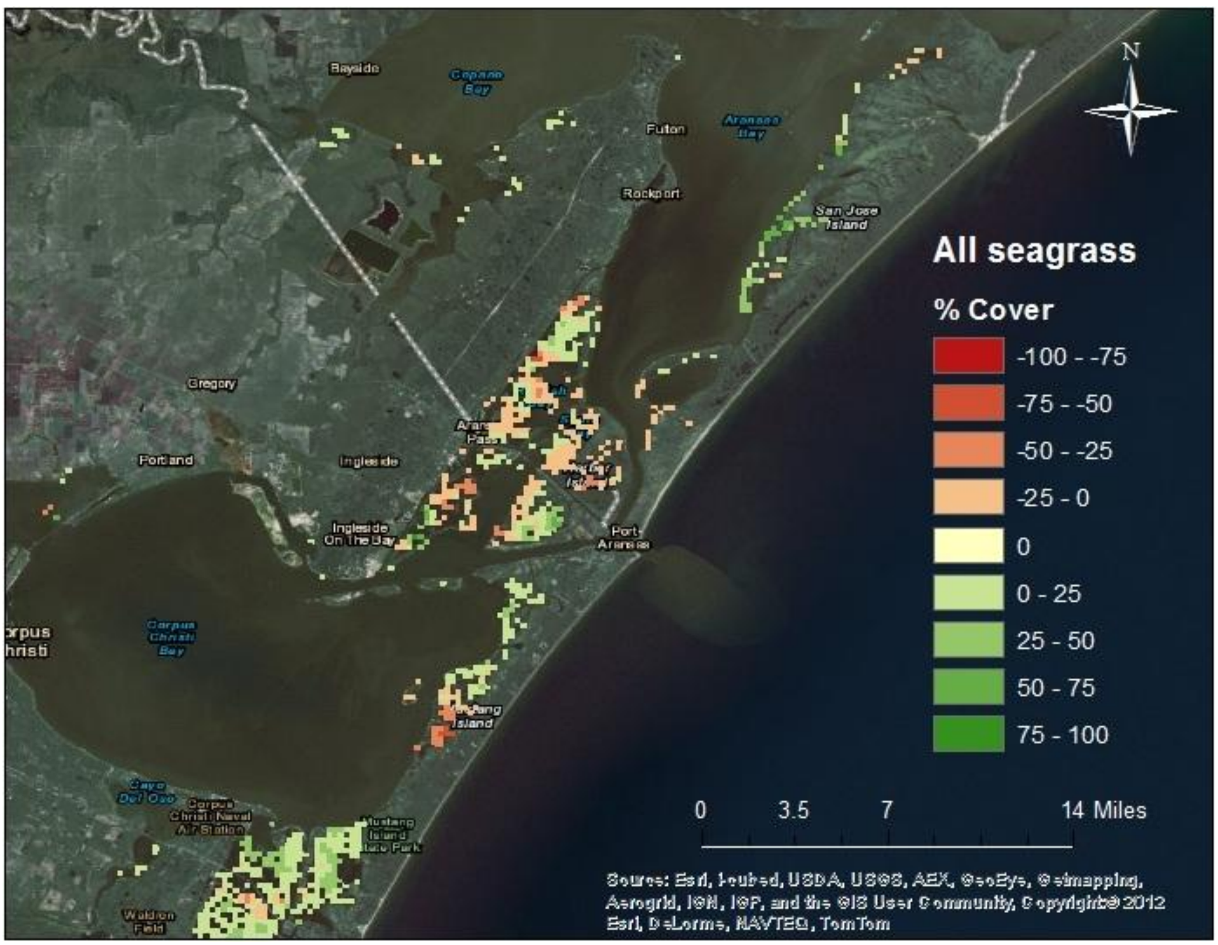



**Figure 12: MANERR and CCBAY Differences in Total Seagrass Percent Cover from 2011-2012.**

**Upper Laguna Madre**

Figure 13 shows seagrass coverage in the ULM sampling stations (n=137 and n=136). Almost all stations seemed to experience small increases in percent coverage. These beds are likely healthy and probably growing to fill in their more sparse areas with new shoots.

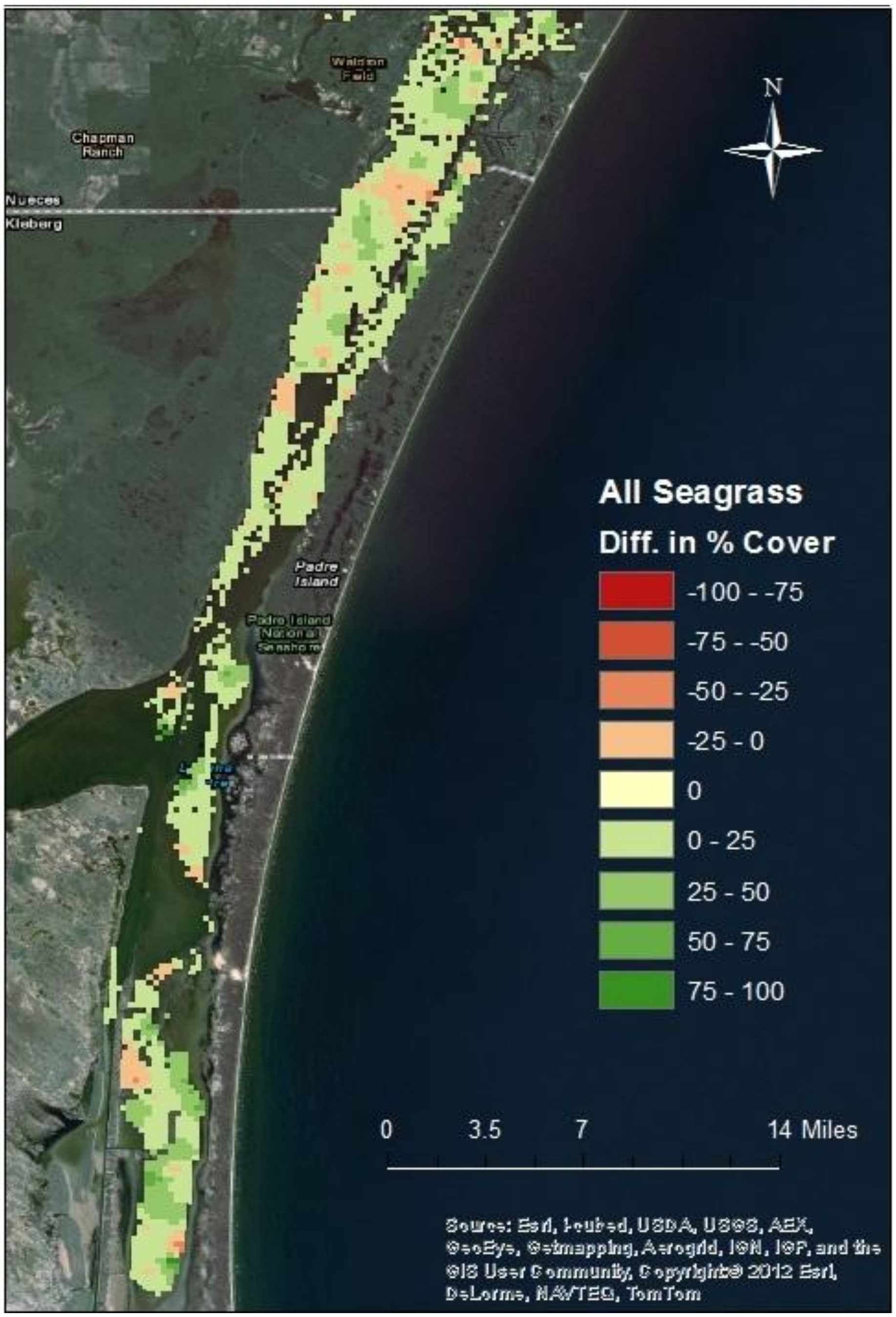



**Figure 13: ULM Differences in Total Seagrass Percent Cover from 2011-2012.**

**Lower Laguna Madre**

Figure 14 shows seagrass coverage in the LLM sampling stations (n=235 and n=241). Predictably, the same area that showed declines in both *T. testudinum* and *H. wrightii* has experienced decreases in total seagrass percent cover. There are several locations showing substantial declines, but also areas showing substantial increases. Changes in percent cover in this region seem to be quite variable by station.

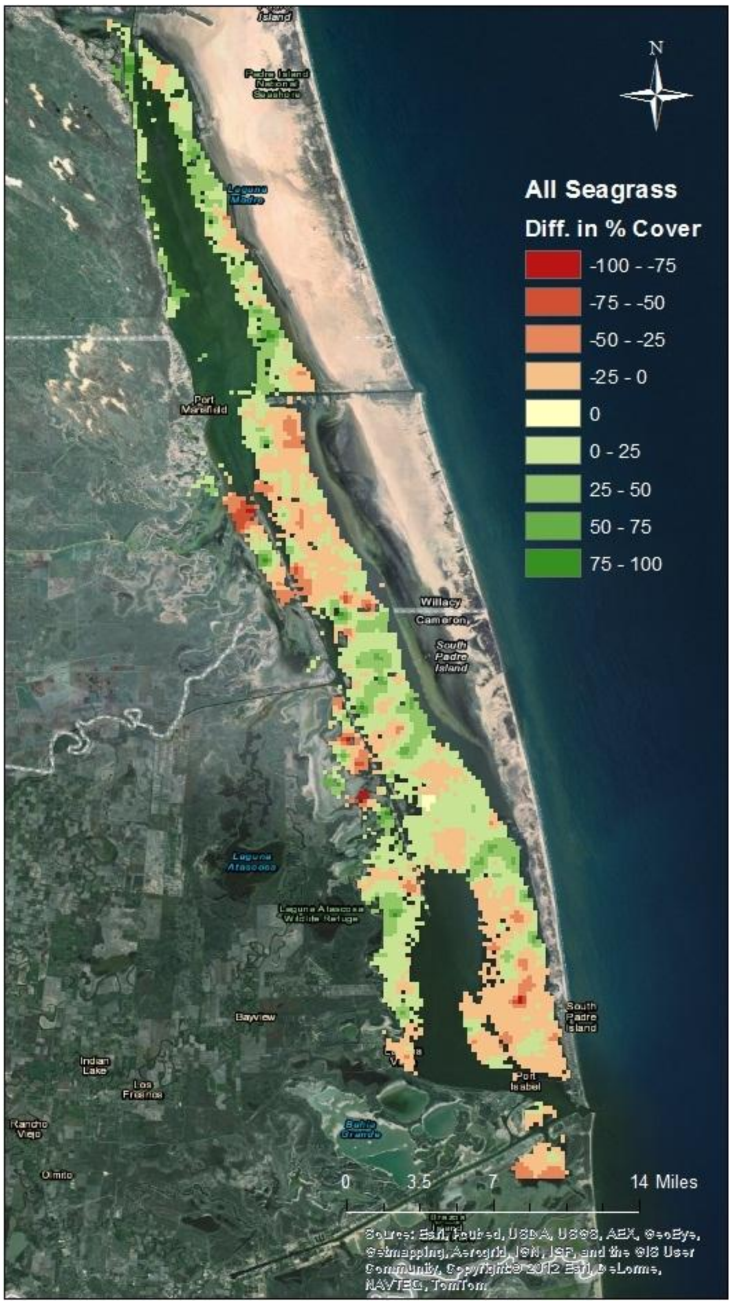



**Figure 14: LLM Differences in Total Seagrass Percent Cover from 2011-2012.**

# Part III – Differences in the Light Attenuation Coefficient $K_d$ and Comparisons to Seagrass Percent Cover

Light attenuation in water refers to the intensity of light that is lost as the light penetrates through the water column. Seagrasses need high light levels to reach them so that they can photosynthesize and grow, so minimal attenuation of light is optimal. Generally, areas where the light attenuation coefficient $K_d$ has a value below 0.69 are best for seagrasses (Dunton *et. al* 2005). Attenuation varies by station and also over time, since tides and currents are constantly circulating suspended materials in the water. Due to these variations, five light measurements were taken at each site, both at the surface and at depth if a site was > 70 cm (measurements could not be taken at sites with water depths < 30 cm due to instrument limitations). The five measurements of light (µmol photons $m^{-2}$ $s^{-1}$) were averaged to determine a surface light value and a depth light value. From here, $K_d$ was determined using the following equation:

$$K_d = - \ln(I_z/I_0) / d$$

$I_z$ refers to the light at depth and $I_0$ refers to light at the surface, and d refers to depth in meters (always 0.3 for our calculations since the two sensors were fixed exactly 30cm apart). All measurements were taken using an LI-190SA quantum sensor.

Decreases in $K_d$ reflect less light being attenuated, and hence more light available to reach the seagrasses. For this reason, the legends in Figures 15-17 depict decreases in $K_d$ in shades of green, which may correspond to increases in total seagrass percent cover that are also noted in shades of green (Figures 12-14).

**Mission-Aransas National Estuarine Research Reserve and Corpus Christi Bay**

The area along the central western coast of Mustang Island shows a large increase in light attenuation (Figure 15), and parts of this area also showed a substantial decrease in total seagrass percent cover (Figure 12). However, some areas near Port Aransas and Aransas Pass that showed decreases in seagrass percent cover (Figure 12) showed only slight increases in attenuation (Figure 15). Areas with substantial decreases in light attenuation, such as Copano Bay and to the West of Port Aransas (Figure 15) did not experience substantial increases in seagrass percent cover (Figure 12).

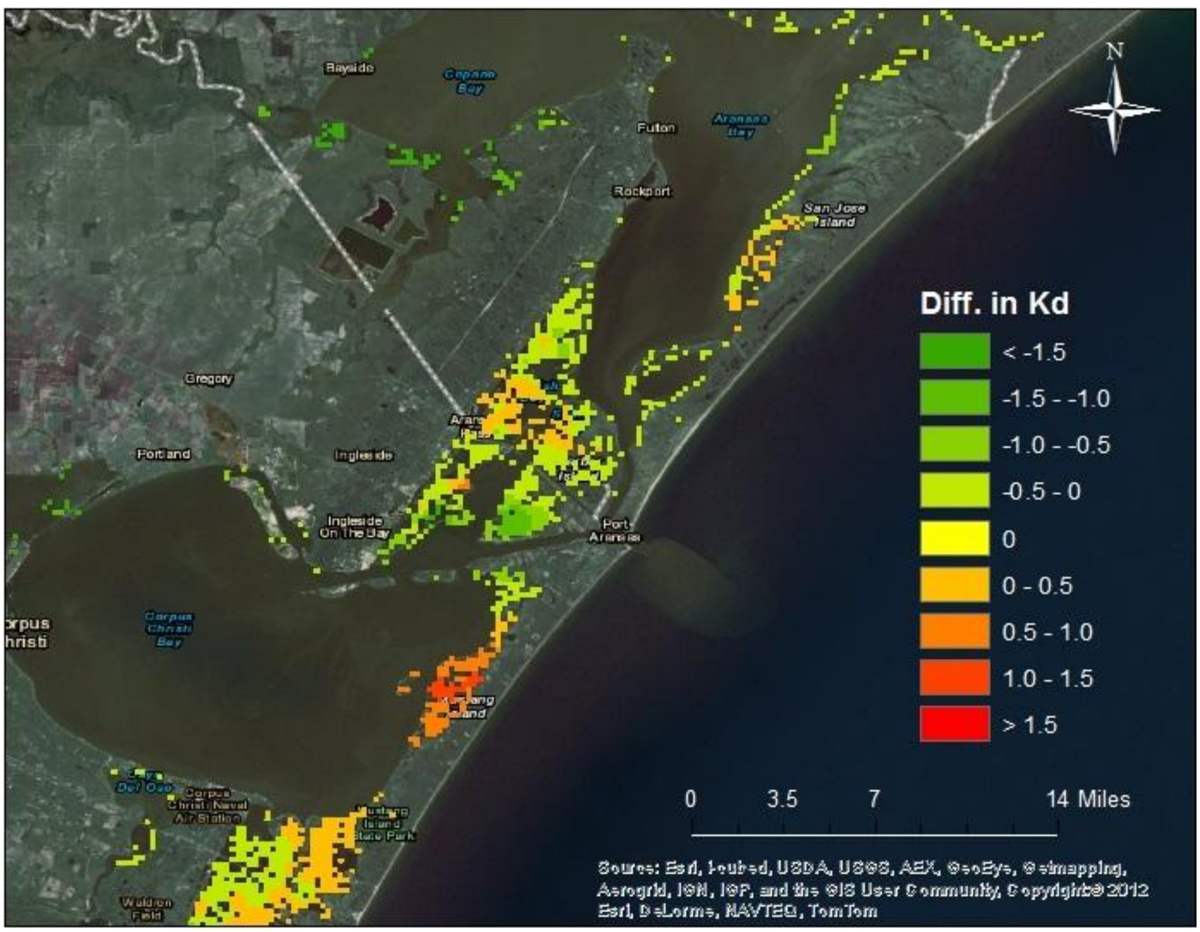



**Figure 15: MANERR and CCBAY Differences in the Light Attenuation Coefficient ($K_d$) from 2011-2012.**

**Upper Laguna Madre**

Increases in $K_d$ were observed in the southern parts of the Upper Laguna Madre (Figure 16), although these areas showed general increases in seagrass percent cover (Figure 13). Areas with large decreases in attenuation near the center of Figure 16 did not experience substantial increases in seagrass percent cover (Figure 13). However, the general trend in ULM seems to be a decrease in attenuation (Figure 16), and we do see a general trend of increased seagrass percent cover as well (Figure 13).

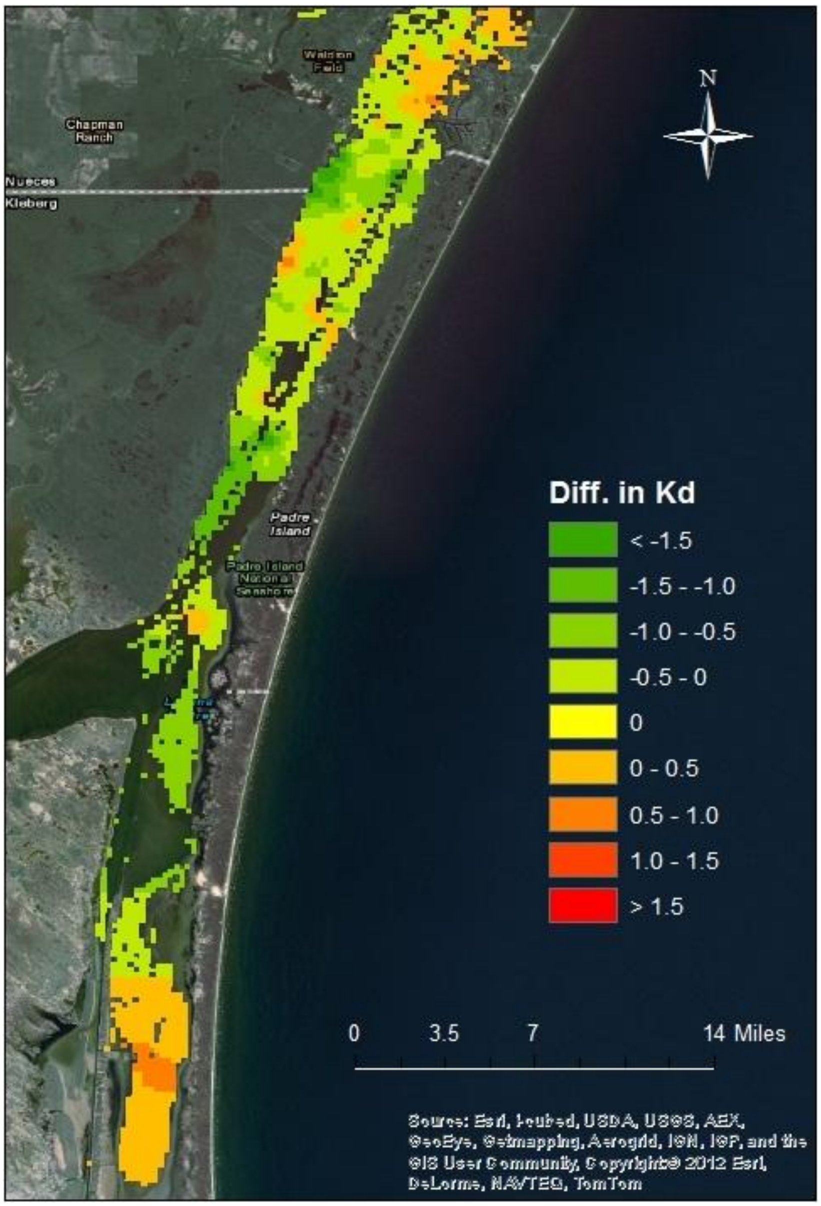



**Figure 16: ULM Differences in the Light Attenuation Coefficient ($K_d$) from 2011-2012.**

**Lower Laguna Madre**

The general trend in LLM was an increase in light attenuation (Figure 17). There is a thin strip in the northern part of the region that showed decreases in light attenuation that did correspond to increases in seagrass percent cover (Figure 14). However, since the levels of light attenuation are so varied throughout the rest of the area (Figure 17), no real correlation to differences in seagrass percent cover can be seen (Figure 14).

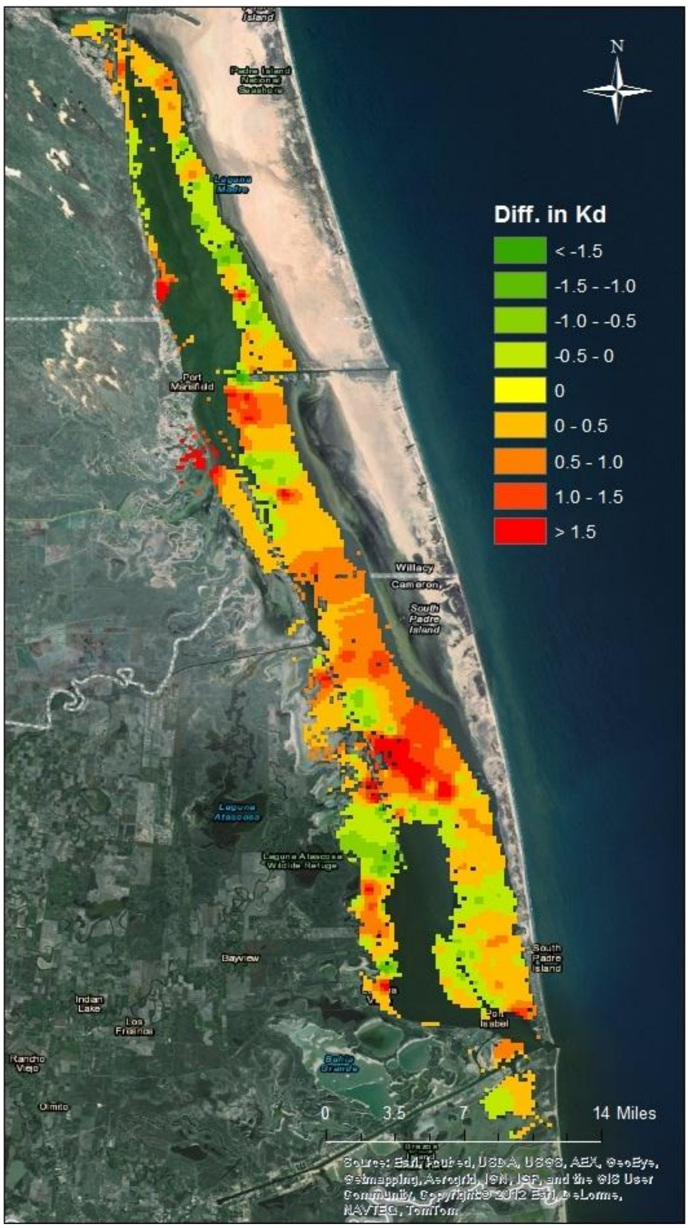



**Figure 17: LLM Differences in the Light Attenuation Coefficient ($K_d$) from 2011-2012.**

# Part IV – Differences in Salinity and Comparisons to Seagrass Percent Coverage

Since the Laguna Madre is a hypersaline estuary, the Texas coast is an interesting study area for salinity and how it may be affecting seagrass growth. From 2011-2012, salinity ranged from 16.72-56 ppt in the MANERR/CCBAY region, from 39.55-81.14 ppt in the ULM region, and from 29.85-75.26 ppt in the LLM region.

**Mission-Aransas National Estuarine Research Reserve and Corpus Christi Bay**

Salinity in the MANERR/CCBAY region showed a general decrease from 2011-2012 (Figure 18). However, areas showing the most decrease did not correspond to areas with substantial seagrass percent cover decreases (Figure 12). Similarly, areas where salinity did increase, specifically Copano Bay (Figure 18), did not correspond to increases in seagrass percent cover (Figure 12).

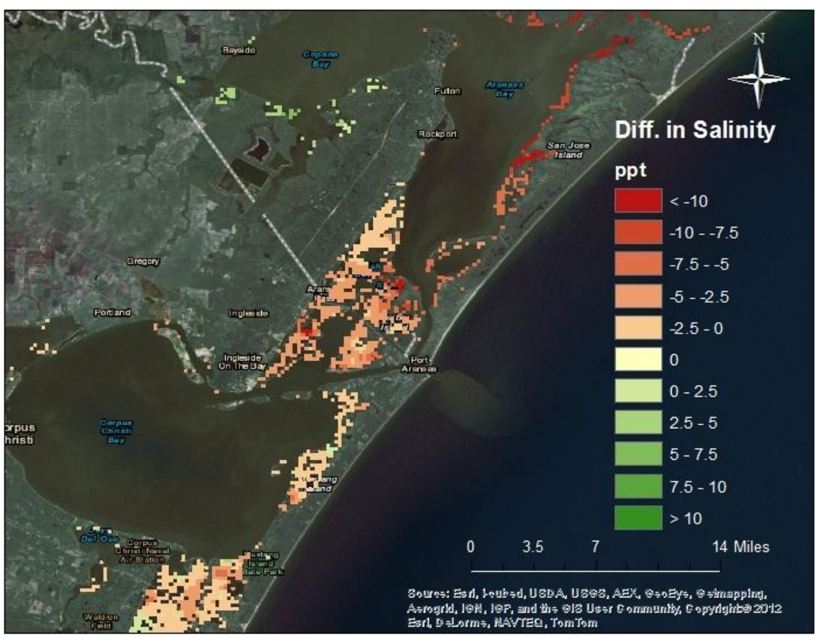



**Figure 18: MANERR and CCBAY Differences in Salinity from 2011-2012.**

**Upper Laguna Madre**

Salinity in the ULM showed large decreases in the southern stations and the northern-most stations (Figure 19). However, these areas did show substantial decreases in seagrass percent cover (Figure 13). Areas showing moderately increased salinity along the northwestern shore of Padre Island (Figure 19) showed only slight increases in seagrass percent cover (Figure 13).

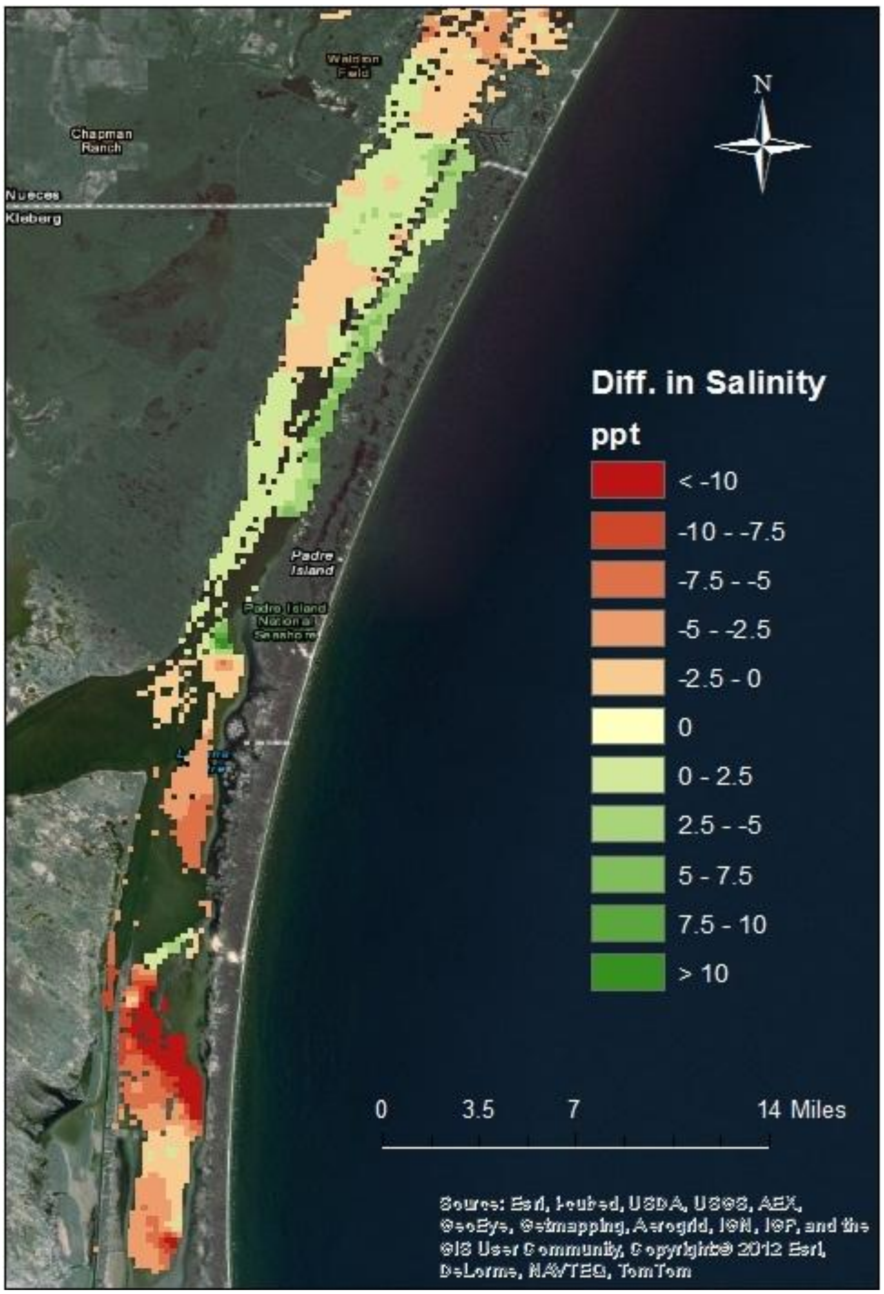



**Figure 19: ULM Differences in Salinity from 2011-2012.**

**Lower Laguna Madre**

Very large decreases in salinity can again be seen in the LLM (Figure 20). However, the areas where salinity shows the greatest decrease do not necessarily show substantial decrease in seagrass percent cover (Figure 14).

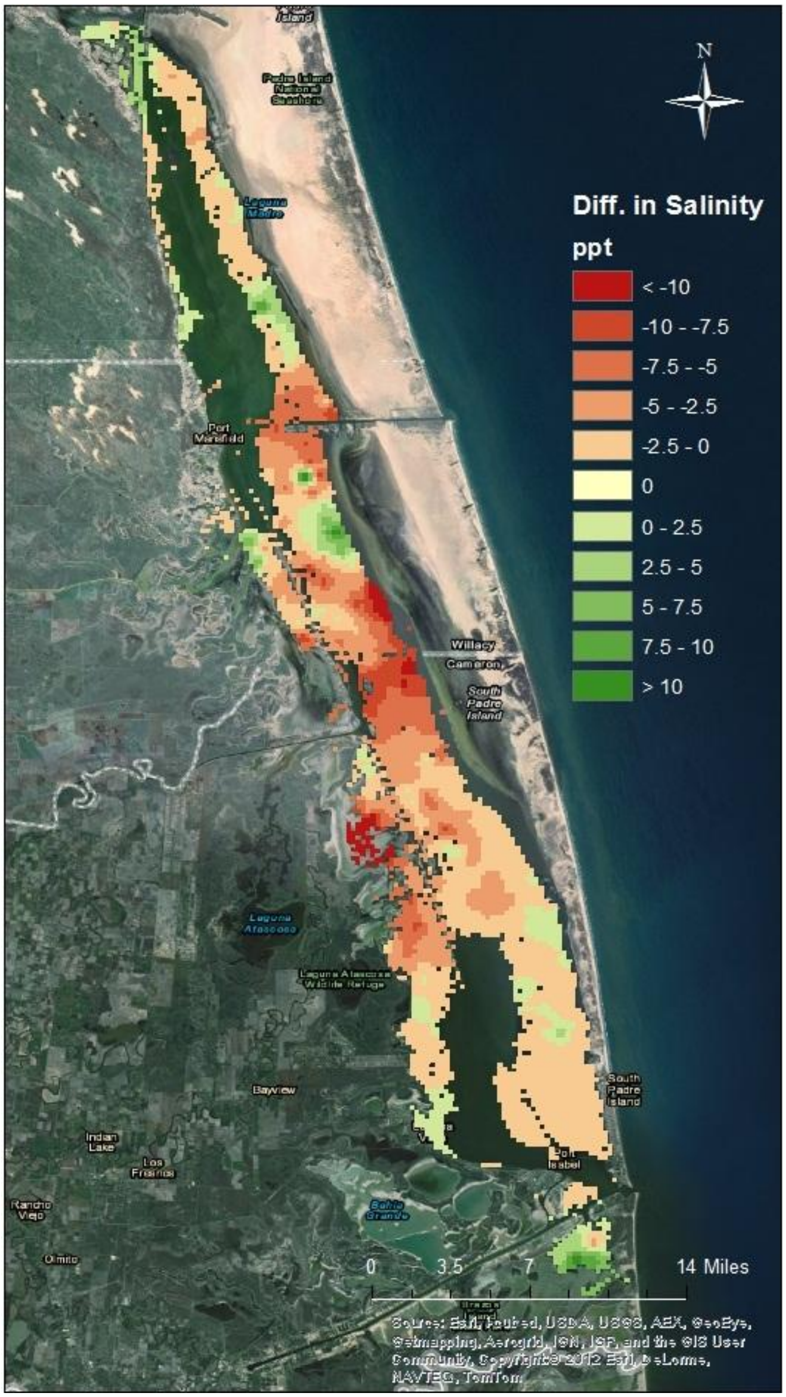



**Figure 20: LLM Differences in Salinity from 2011-2012.**

# Part V – Differences in pH and Comparisons to Seagrass Percent Coverage

Seagrasses seem to be relatively tolerant to small changes in pH. From 2011-2012, pH ranged from 6.79-9.13 in the MANERR/CCBAY region, from 6.99-9.01 in the ULM region, and from 7.0-9.04 in the LLM region.

**Mission-Aransas National Estuarine Research Reserve and Corpus Christi Bay**

Interestingly, areas of pH increase in the MANERR/CCBAY region are distinctly separated from areas with pH decrease (Figure 21). The lower areas of pH decline do not correspond to any decrease in seagrass percent cover (Figure 12), although some sites to the northeast of Aransas Pass do show decreases in percent cover. Areas of pH increase towards the center of this region showed both increases and decreases in seagrass percent cover (Figure 12).

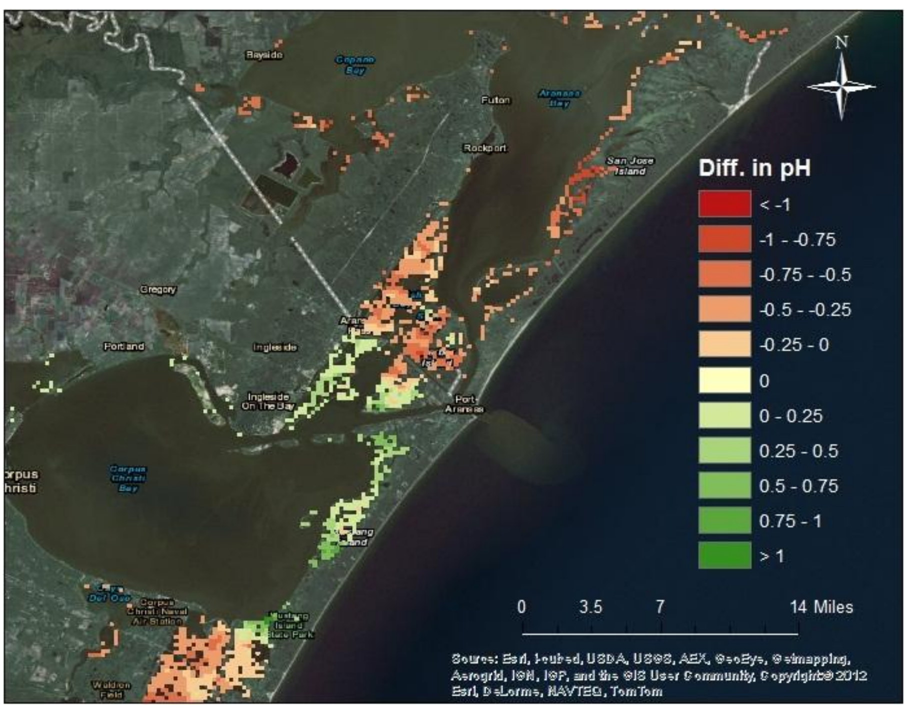



**Figure 21: MANERR and CCBAY Differences in pH from 2011-2012.**

**Upper Laguna Madre**

Generally, large decreases in pH were seen throughout the ULM, with the exception of areas in the northern half that are located to the east of a chain of spoil islands, which due to these islands likely experience less water exchange (Figure 22). The aforementioned areas showed some increase in seagrass percent cover (Figure 13), however the general increase in seagrass percent cover observed was seen throughout the other areas with decreases in pH (Figure 22).

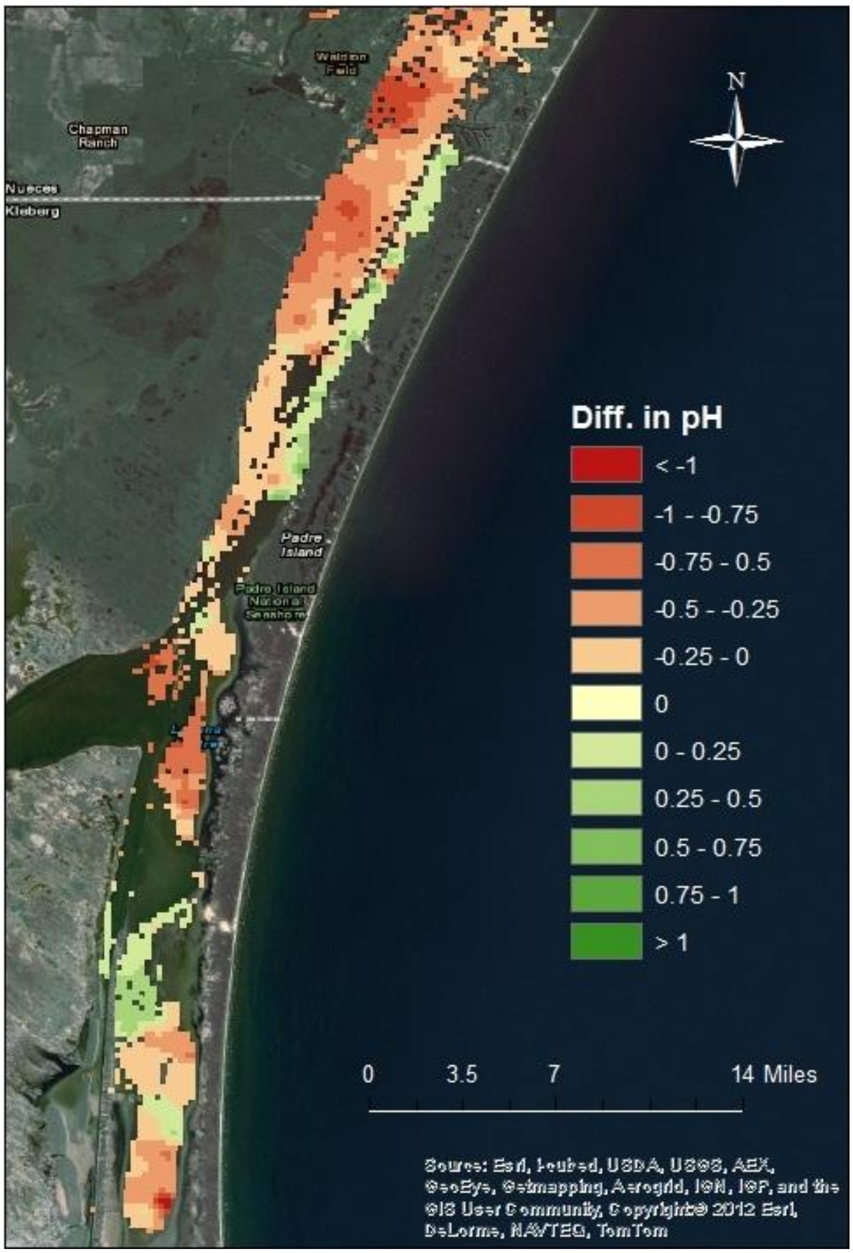



**Figure 22: ULM Differences in pH from 2011-2012.**

**Lower Laguna Madre**

In contrast to the ULM and most of the MANERR/CCBAY regions, the LLM region showed many areas with increases in pH (Figure 23). Two large areas of pH decrease are seen in the center of the region and to the south. This southern drop in pH corresponds to decreases in seagrass percent cover (Figure 14). The only other areas of decreased seagrass percent cover occurred directly to the north of the central area showing the drop in pH (Figure 23).

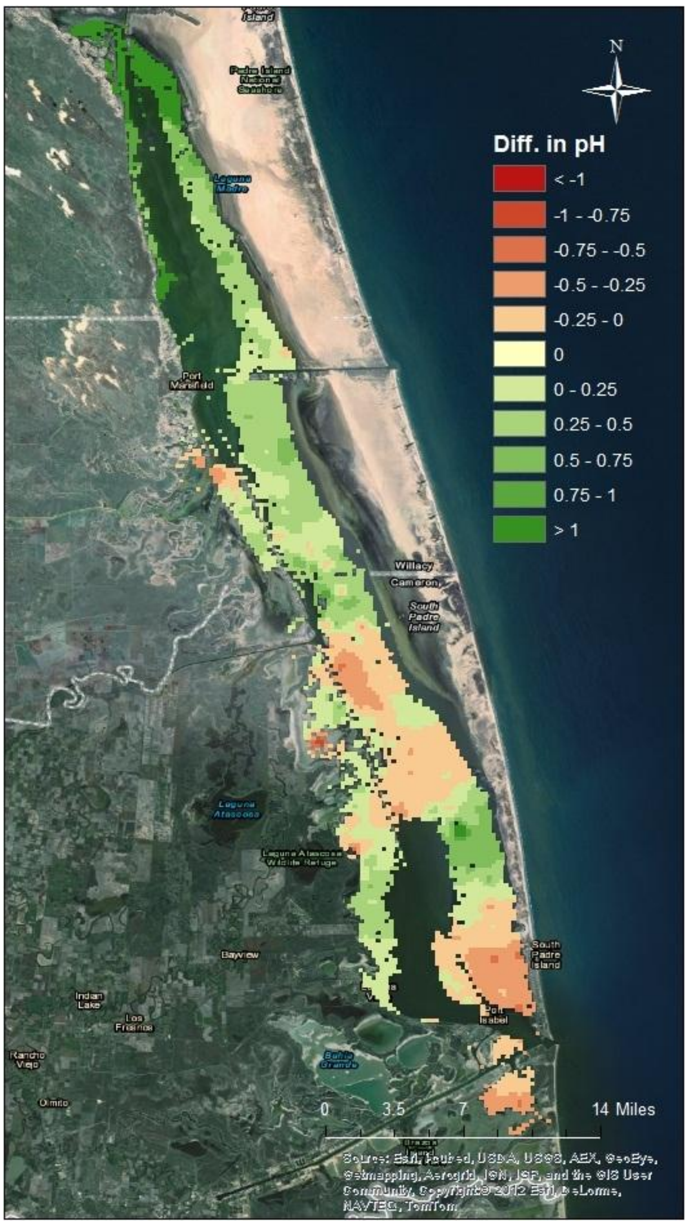



**Figure 23: LLM Differences in pH from 2011-2012.**

# Part VI – Differences in Dissolved Oxygen and Comparisons to Seagrass Percent Coverage

High dissolved oxygen (D.O.) concentrations generally indicate healthy marine/estuarine systems, so D.O. concentration may be a good indicator of seagrass health. D.O. ranges from 1.87-15.54 mg/L in the MANERR/CCBAY region, from 1.34-11.96 mg/L in the ULM region, and from 2.37-13.2 mg/L in the LLM region.

**Mission-Aransas National Estuarine Research Reserve and Corpus Christi Bay**

Many stations in the MANERR/CCBAY showed substantial decreases in dissolved oxygen (Figure 24). Surprisingly, the general spread of areas with decreased D.O. seem to correspond quite well with areas where seagrasses experienced an increase in percent cover (Figure 12). Likewise, areas of increased D.O. concentrations (between Port Aransas and Aransas Pass) correspond well to areas of decreases in seagrass percent cover (Figure 12).

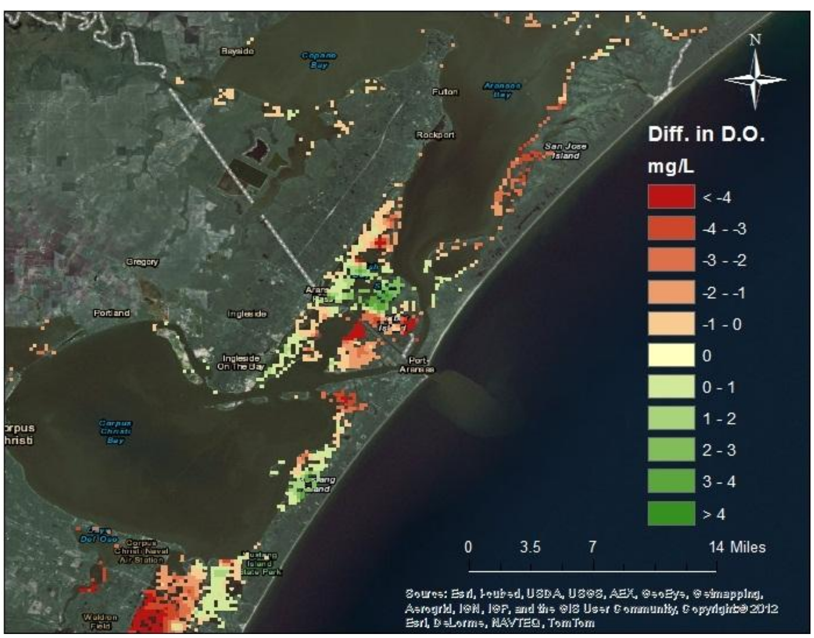



**Figure 24: MANERR and CCBAY Differences in D.O. from 2011-2012.**

**Upper Laguna Madre**

Two isolated areas in the north of the ULM experienced substantial increases in D.O. concentration (Figure 25), and these areas showed varied differences in seagrass percent cover. The area towards the center of the region experienced an increase in seagrass percent cover, while the more northern area of increased D.O. showed slight decreases in seagrass percent cover (Figure 13). The general trend of large increases in D.O. is mostly correlated to light to moderate increases in seagrass percent cover (Figure 13).

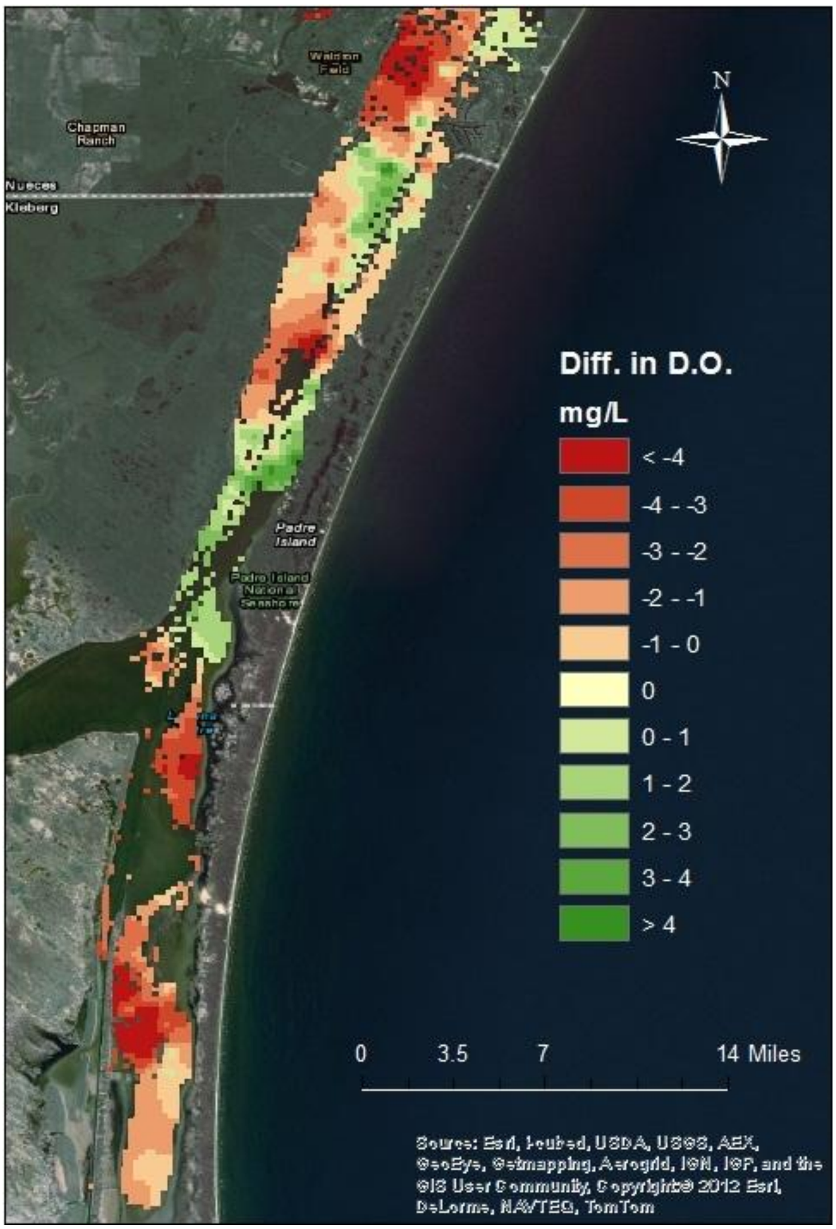



**Figure 25: ULM Differences in D.O. from 2011-2012.**

**Lower Laguna Madre**

Similarly to the MANERR/CCBAY region, areas of increased D.O. concentration in the LLM (Figure 26) seem to generally correspond to areas of decreases in seagrass percent cover (Figure 14). The North and South of the LLM show substantial increases in D.O. concentration, while the central-south part of LLM shows mostly substantial decreases in D.O. concentration (Figure 26).

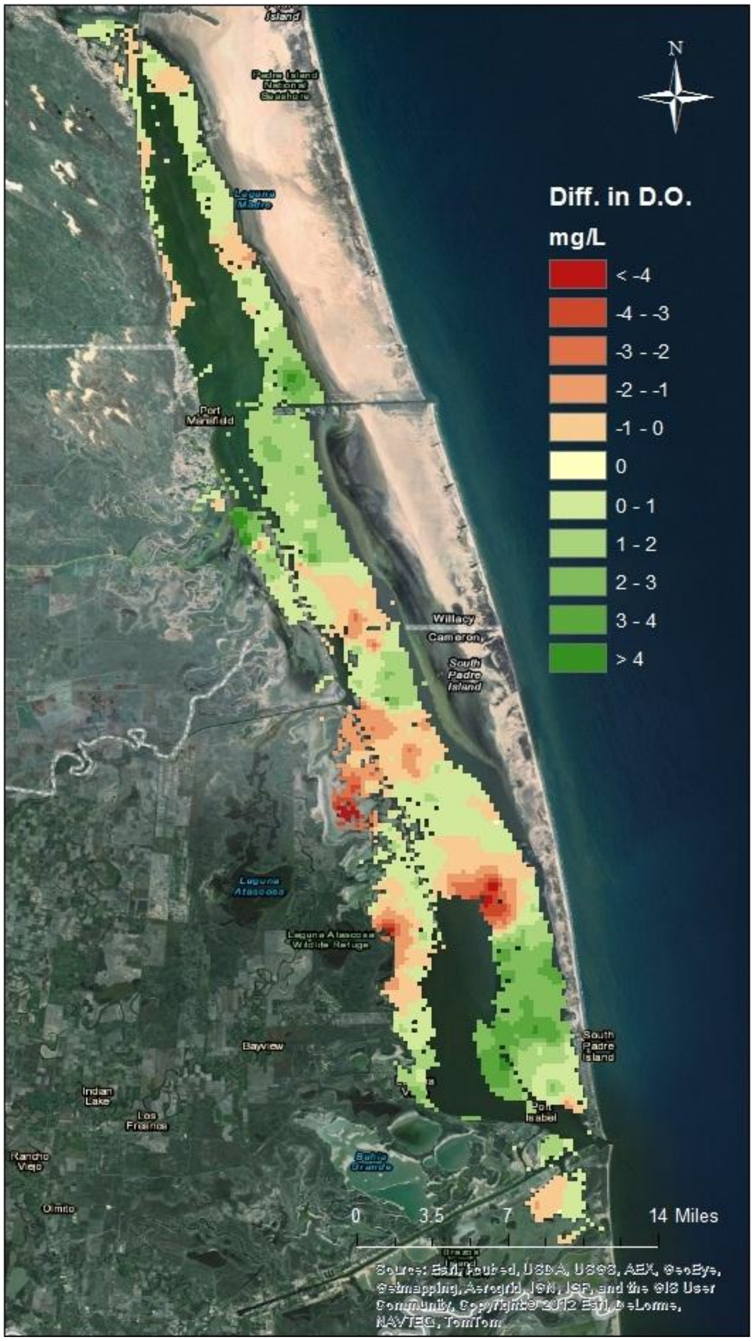



**Figure 26: LLM Differences in D.O. from 2011-2012.**

# Part VII – Conclusions

**Seagrass Percent Cover**

The seagrass *H. engelmanii* showed extremely minimal cover and hardly any change between 2011-2012. *R. maritima* was present at only about half the number of stations in 2012 than it was in 2011. *S. filiforme* showed mostly growth but some decline, the majority of this was < 25 % increase/decrease in percent cover. *T. testudinum* showed areas of light-moderate increase in percent cover, and also areas of light-moderate decrease. *H. wrightii*, the dominant species of seagrass in Texas, showed mostly decreases in percent cover in the MANERR/CCBAY, but mostly increases in the ULM and LLM. *H. wrightii* was the only seagrass to show multiple areas of both moderate to high increase and decrease in percent cover. Total seagrass cover followed a similar pattern, showing areas of moderate to high decrease in the MANERR/CCBAY and parts of the LLM, but a general pattern of light to moderate increase throughout the ULM and the rest of the LLM. Areas of high increases in percent cover were also observed in the northern region of the LLM.

**Light Attenuation**

Changes in light attenuation did not correspond well to changes in seagrass percent cover. It is likely that the seagrasses are fairly hearty with regards to changes in light attenuation. Also, attenuation readings can change from day to day based on the amount of suspended material in the water column at any given time, and so perhaps not much can be learned from only one sampling per station once a year. It is not surprising, therefore, that comparing this instantaneous attenuation measurement to seagrass percent cover, which is more or less constant throughout the season, does not show any correlation. Ideally, average light attenuation could be measured over an extended period of time and the noise of day-to-day changes removed so that a more accurate long-term representation of water column light levels could be compared with changes in seagrass percent cover for a more meaningful analysis.

**Salinity**

Changes in salinity from 2011-2012 do not seem to have much correlation to changes in seagrass percent cover. Areas of these systems that experience freshwater inflow likely experience large fluctuations in salinity that vary with rainfall and river run-off. Perhaps examination of specific salinity values rather than the amount of change could give a better representation of why seagrasses are growing in their respective locations. Also, salinity tolerance is seagrasses is species-specific, so examination of individual species rather than total cover may yield better conclusions about salinity tolerance.

**Dissolved Oxygen Concentration**

Surprisingly, the D.O. interpolations yielded more or less opposite patterns than the seagrass percent cover interpolations did. Decreases in D.O. corresponded fairly well with increases in seagrass percent coverage. However, D.O. is highly variable, even at small temporal scales. Similarly to light attenuation, using only one value per year to represent D.O. for a sampling station is an inaccurate representation of the fluctuation that is almost certainly occurring. The time of day can greatly influence the amount of D.O. in the water, and perhaps sampling protocols should be re-visited so that D.O. is only recorded during specified times of the morning, before the seagrasses senesce and release oxygen in the afternoons.

**General Conclusions**

IDW interpolation seems to be a good way to represent changes in seagrass percent cover visually, since the viewer can quickly get a sense of what change is occurring and at what scale. For water quality parameters, IDW interpolations are a good idea in theory, however for much of the data in this monitoring project they do not seem to be appropriate. Water quality indicators such as light attenuation and D.O., at least, are highly varied based on the time of day, so interpolating one value from each year does not give an accurate picture of what is going on. Interpolation may be a better method if more long-term averages were used rather than these once-a-year values, which many times indicated sharp increases or declines, but which in reality were probably much more smooth and much less varied from year to year.

# Part VIII – Acknowledgements

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# Part IX – References

ArcGIS Resource Center. “IDW (Spatial Analyst).” *help.arcgis.com*. ESRI. 29 June 2011. Web. 29 November 2012. <http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//009z0000006m000000.htm>

Dunton, K.H., Kopecky, A.L. and Maidment, D. 2005. Monitoring design criteria and biological indicators for seagrass conservation in Texas coastal waters. Final report for Regional Environmental Monitoring and Assessment Program, EPA.

Texas Parks and Wildlife (TPWD). 1999. Seagrass conservation plan for Texas. TPWD: Resource Protection Division, Austin, TX, USA.