Beach Erosion Impacts on Kemp's Ridley Sea Turtle Nesting Along the South Texas Coast

by

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Abstract

Beach erosion is a potential threat to Kemp's ridley sea turtle nesting populations because of a loss in nesting habitat that is critical to the survival of this endangered species. The Texas coast is experiencing beach erosion due to storms, tidal surges, overwash, and sea level rise induced by climate change. This project focuses on South Padre Island from the cut at Port Mansfield, TX to the Texas-Mexico border, south of Boca Chica. Kemp's ridley nest GPS data from 2013-2017 is mapped with shoreline change rates to identify where areas of high risk of erosion occur and if these turtles are nesting in these areas. Using GIS, spatial analysis, and statistics, results show that Kemp's ridley sea turtles are nesting in areas of high risk and very high risk. It is suggested that an interdisciplinary approach and continued monitoring of this species' nesting is necessary for improving conservation efforts.

Key words: beach erosion, *Lepidochelys kempii*, conservation

Introduction

Kemp's ridley (*Lepidochelys kempii*) sea turtles are the rarest, smallest, and most endangered sea turtle species in the world (Witzell et. al. 2007, Shaver et. al. 2017). In order to nest, the female Kemp's ridley emerges from the ocean waters and crawls onto the sandy beaches along the Texas and Mexico Gulf coasts (Caillouet et. al. 2011). Kemp's ridley sea turtles favor days with high wind speeds for nesting (Witherington and Witherington 2015). The turtles then move to the soft sand dunes to dig an egg chamber with their back flippers (National Park Service (A) 2018). Once this is done, the female goes into a trance, laying her eggs in the newly made chamber (National Park Service (A) 2018). After she has finished laying her eggs, the turtle will use her back flippers, again, to cover her eggs in sand

and once she has completed the nesting ritual, she will crawl back to sea, leaving her nest unguarded, and at risk of predators and natural disasters (Figure 1) (Spotila 2004, Witherington and Witherington 2015).

The Kemp's ridley females can wait off shore for days, scoping out a safe spot to emerge and lay their nests. Larger groups of females will emerge together for safety in numbers; these are called "arribadas" (Bevan et. al. 2016). This species of sea turtle nests during the day, which is different from all other species of sea turtles, such as loggerheads, *Caretta caretta*, or leatherbacks, *Dermochelys coriacea* (Spotila 2004). One female Kemp's ridley can lay up to 3 nests in a nesting season and will nest about every 2 years (Spotila 2004). Nesting has been a primary focus of conservation for this species for the past 50 years, with conservation hotspots along the Texas and Mexico coasts (Fuentes 2016). Most Kemp's ridley nests are found in Mexico in the state of Tamaulipas near Rancho Nuevo, the species primary nesting site, with Texas as a secondary nesting site, just north of Tamaulipas (Texas Parks and Wildlife 2019). Different conservation groups made up of government agencies and non-profits such as Sea Turtle Inc. in South Padre Island, TX, The Padre Island National Seashore (PAIS), Texas Parks and Wildlife, and the ARK (Amos Rehabilitation Keep), have cooperated with each other to prevent the Kemp's ridley sea turtle from going extinct (Texas Parks and Wildlife 2019, National Park Service (B) 2018, Sea Turtle Inc. 2019).

This project has three objectives. First, to map the occurrence of Kemp's ridley nests during 2013-2017, using geographic information systems (GIS), in the study area that is defined from the cut at Port Mansfield, Texas to the Texas-Mexico border. Second, include beach erosion patterns in these maps from the past several decades to show trends in beach narrowing where increased coastal flooding may occur resulting in a loss of nesting habitat. Third, compare the results of the first two objectives using spatial analysis to identify areas of the beach that need monitoring to prevent Kemp's ridley nests from being flooded, or inundation by high tides (National Park Service (A) 2018). This will allow conservation efforts to focus beach patrolling in areas to find a nest before it can be flooded out, terminating all the eggs in the nest.

Background

Kemp's ridley Conservation

Kemp's ridley sea turtles have been the focus of conservation groups since the 1970s. Kemp's ridley was listed as endangered in 1970 after a fast decline was detected in nesting females (Texas Parks and Wildlife 2019). The best estimate of Kemp's ridley reproducing female populations before this decline was derived from the 1947 Herrera film that captures a massive arribada near Rancho Nuevo, Mexico (Bevan et. al. 2016). A study using the film to estimate the population size of this historic arribada used density of turtles to estimate 45,760 female Kemp's ridley sea turtles (Bevan et. al. 2016). However, due to poaching of nests and turtles (juveniles and adults), their population faced a serious decline. By the 1980s, there was estimated to be fewer than 550 reproducing females in the entire world (Spotila 2004). This is the lowest estimate ever recorded for this species and spurred immediate and drastic action to save the species. In 1978, the Bi-National Recovery Plan was formed, partnering U.S. and Mexico conservation efforts to implement policy and action in hope of restoring Kemp's ridley populations (Gaskill 2018).

The most experimental effort to save Kemp's ridley sea turtles was the headstart program where eggs would be caught by conservationists before touching the sand on Mexican beaches and transported to Padre Island to establish a nesting population (Spotila 2004, Shaver and Rubio 2007). This program was active from 1978 to 1992 and produced 22,263 hatchlings, however, it was debated whether the headstart program was successful due to the small amount of nesting females, 15 females, that were found on Padre Island as a result of the program and the large cost at $185,525 per nesting female nest (Spotila 2004). In recent years, a nesting female from the headstart program was spotted in Florida, opening up potential future discussion about the viability of the program and what it would mean for future conservation efforts (Shaver et. al. 2016). Other methods of conservation and recovery have yielded more promising results in the last few decades.

Shrimping has historically been a threat to Kemp's ridley populations. Before 1995, dead Kemp's ridley sea turtles would wash up on beaches in Texas and Mexico. The deaths were attributed to drowning when trapped in shrimp trawler nets (Spotila 2004). In 1990, turtle excluder devices (TEDs) were legally required on shrimp trawler nets in the United States to prevent turtles from getting caught, and in 1995, a similar law was passed in Mexico (Spotila 2004).

Kemp's ridley conservation efforts are one example of success in conserving a species on the brink of extinction. A large part of Kemp's ridley's recovery is attributed to the increase in re-nesting. Re-nesting is a process where a turtle nest is excavated, and the eggs are moved to a fenced off location that is safe from predators, humans, or tidal inundation (Sea Turtle Inc. 2019). All the nests that were mapped for this paper were then re-nested in a corral after their GPS location was recorded.

The conservation efforts mentioned earlier have all led to one of the largest success stories in recovering an endangered species from the brink of extinction. While Kemp's ridley sea turtles are still on the endangered species list, this species has grown from 550 in the 1980s to over 5,000 nesting females in 2014 (Spotila 2004, Witherington and Witherington 2015). The future of Kemp's ridley sea turtles is still uncertain with human activity still impacting sea turtle populations, including pollution of the oceans and recreational fishing causing hook-and-line captures, continued conservation efforts will be necessary for the foreseeable future of this species (Seney 2008, Platt 2013, Perrault et. al. 2017).

Figure 1: Typical habitat of Kemp's ridley nesting habitat along Padre Island. Kemp's ridley turtles will make their way up to the softer sand near the sand dunes.

Beach Erosion

Beach erosion is one of many factors that can negatively impact Kemp's ridley nesting. Thinning shorelines result in a loss of habitat, leading to fewer nesting areas and increased tidal flooding along the coast. If a sea turtle nest is washed over, flooding the nest, the eggs are no long viable, terminating the whole nest (Dewald and Pike 2013, National Park Service (A) 2018). Understanding beach erosion and its causes is important in identifying areas undergoing various rates of erosion along the Texas coast.

All along the Texas coast, beach erosion is taking place. One of the main reasons why beach erosion occurs is overwash, created by storms, pushing tides more inland (Park and Edge 2011). Studies document the high rates of erosion experienced along the Texas Coast, but focus primarily on the north

Texas coast, concluding that beach erosion is impacted by hurricanes, storm surges, and overwash, with the expectation that climate change will exacerbate beach erosion (Park and Edge 2011, Youn and Park 2018). A different study takes a closer look at the relationship of beach erosion, sea level rise, and climate change, where it was found that changes in climate and sea level rise impact beach erosion along the Texas coast (Anderson et. al. 2014). Beach erosion has been documented on Padre Island in a 2011 report, compiled by the Bureau of Economic Geology, where certain areas are experiencing shoreline retreat up to 7.5 m/year and beach advancement as high as 3.2 m/year (Paine et. al. 2011). Any beach advancement is generally attributed to anthropogenic causes, such as beach nourishment projects and the installation of jetties and has different ecological impacts on organisms that live on beaches and on or near these jetties (Morton et. al. 2005, Jones et. al. 2008, Paine et. al. 2011) .

Methods

For this project, Kemp's ridley nest GPS locations collected by Sea Turtle Inc., who records GPS data for each nest recovered, were used to map the locations, using GIS, of past nests found along the south Texas coast from Port Mansfield, Texas to the Texas-Mexico border. The study area includes the barrier island, South Padre Island and Boca Chica, a beach south of South Padre Island, TX. The years available for this project are from 2013 to 2017. A series of maps was produced for spatial analysis of the distribution of sea turtle nests and their relation to the rate of beach erosion. A spatial analysis was used to determine how many nests are located in high risk areas and to determine any trends that might be present in the data.

Beach erosion is represented by the average shoreline change calculated by the Bureau of Economic Geology along with the Coastal Studies Group and the Jackson School of Geosciences at The

University of Texas at Austin with a report compiled by Paine et. al. in 2011. The shoreline change rates were derived from studying hand drawn maps, GPS data, and satellite imagery, and aerial photos from the 1800s to 2007 and compared to georeferenced aerial photos from 2010 (Paine et. al. 2011). Risk levels are defined by the shoreline change rates represented by different colors on the maps, indicating different rates of shoreline change from 3.22 m/yr to -7.48 m/yr for Willacy and Cameron counties (Paine et. al. 2011). The rates of shoreline change for these counties were divided into 5 categories (Table 1).

Number	Shoreline Change Range	Risk Level	Color
1	0.88-3.22	No Risk	Blue
2	-0.68-0.87	Low Risk	Green
3	-2.22- -0.69	Moderate Risk	Yellow
4	-3.78- -2.23	High Risk	Orange
5	-7.48- -3.79	Very-High Risk	Red

Table 1: This table outlines the boundaries of the different risk levels and how they are presented throughout this paper. Each risk level has a corresponding number, color, and shoreline change range.

In the series of maps (Figures 2-6), 270 nests recovered by Sea Turtle Inc. is mapped along with the rates of shoreline change. There is a total of 5 maps created for this project to give a time frame of 5 years for comparing results to each other, and potentially find any trends in nesting and its relationship to beach erosion as time passes. Each map shows the GPS location of the nests for the 5 years examined in this project, one map for each year. Roadways are included in the maps to provide some insight on how densely populated the coast is in different areas along the south Texas coast. Base maps for land and the ocean water was provided by the United States Geological Survey (USGS) and the roads GIS data was provided by the Texas Department of Transportation (USGS 2019, Texas Department of Transportation 2019). ArcMap 10.6.1 was the GIS used for this project.

Results

From 2013-2017, there was a total of 270 nests mapped along the south Texas Coast. More nests tended to be in areas of beach erosion where there is a very high or high risk. These areas of increased beach erosion are located north of South Padre Island, TX. Figures 2-6 is the series of maps made using the nesting GPS data and the shoreline change rates. Tables 3-7 is a break down of the number of nests found in each risk category by year and table 8 shows the cummulated data from the previous tables. A map and table was made for each year, 2013-2017, to show the changes from year to year both spatially and through percentages.

Each risk category covers several kilometers of the study area. The length of the shore was calculated for each risk category, from no risk to very-high risk (Table 2). It was found that the risk category that covered the most shoreline in the study area was the high risk category with an average shoreline change rate of -2.23 m/yr to -3.78 m/yr.

Risk Level	Shoreline Change Rate	Length (Kilometers)
1	0.88-3.22	6.39
2	-0.68-0.87	7.61
3	-2.22- -0.69	7.89
4	-3.78- -2.23	32.88
5	-7.48- -3.79	11.97
Total	-7.48-3.22	66.74

Table 2: A total of 66.74 km of shoreline was measured in this study using GIS. The risk level with the longest shoreline coverage was level 4, areas of high risk of beach erosion.

Since the high risk areas cover the most shoreline, the probability of the nests found in these areas was higher than the other 4 categories. This can be seen in tables 3-7 with the highest percentage of nests found every year in these high risk areas experiencing beach erosion of -2.23 m/yr to -3.78 m/yr.

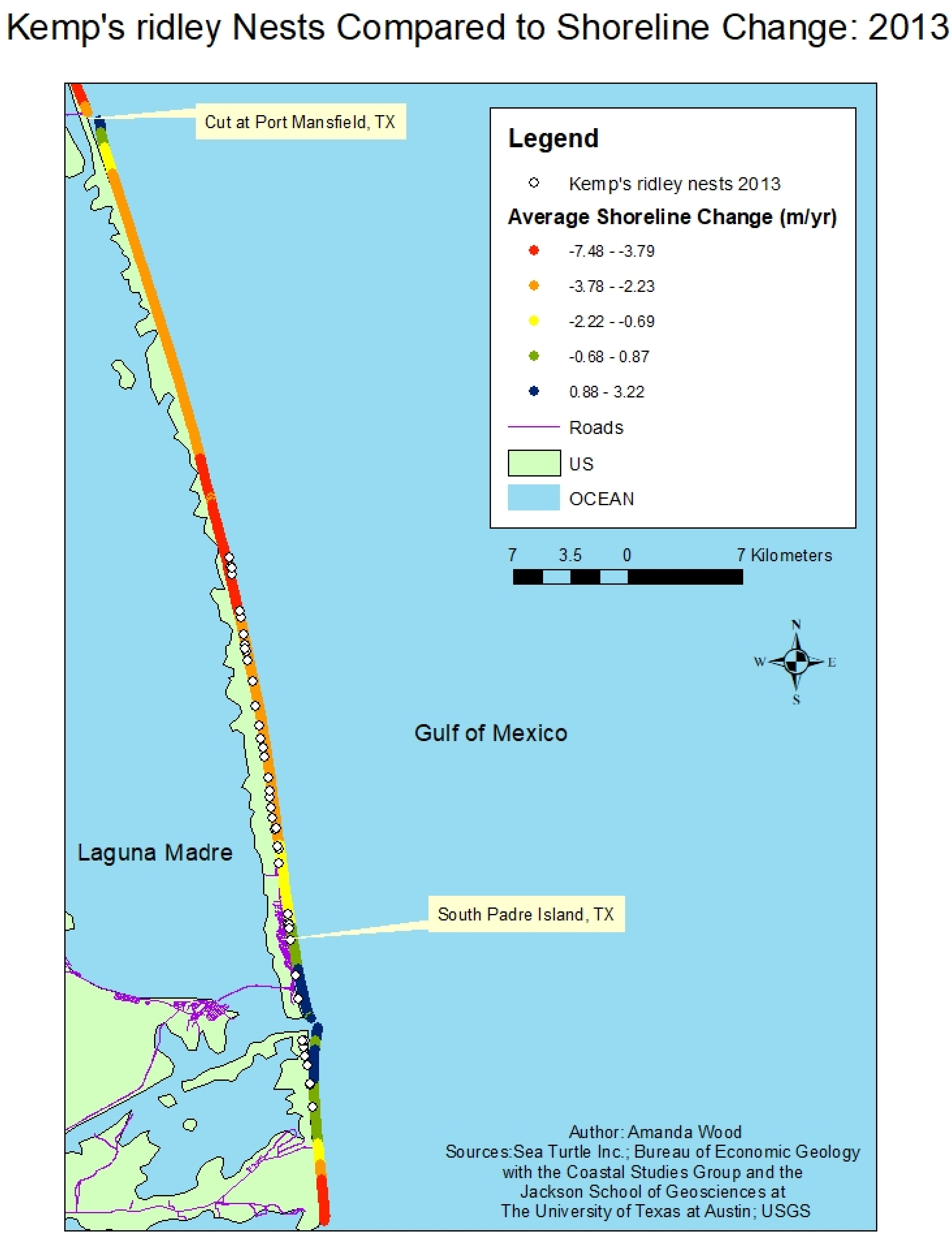

Figure 2: Kemp's ridley nests found in 2013 were closer to South Padre Island compared to later years.

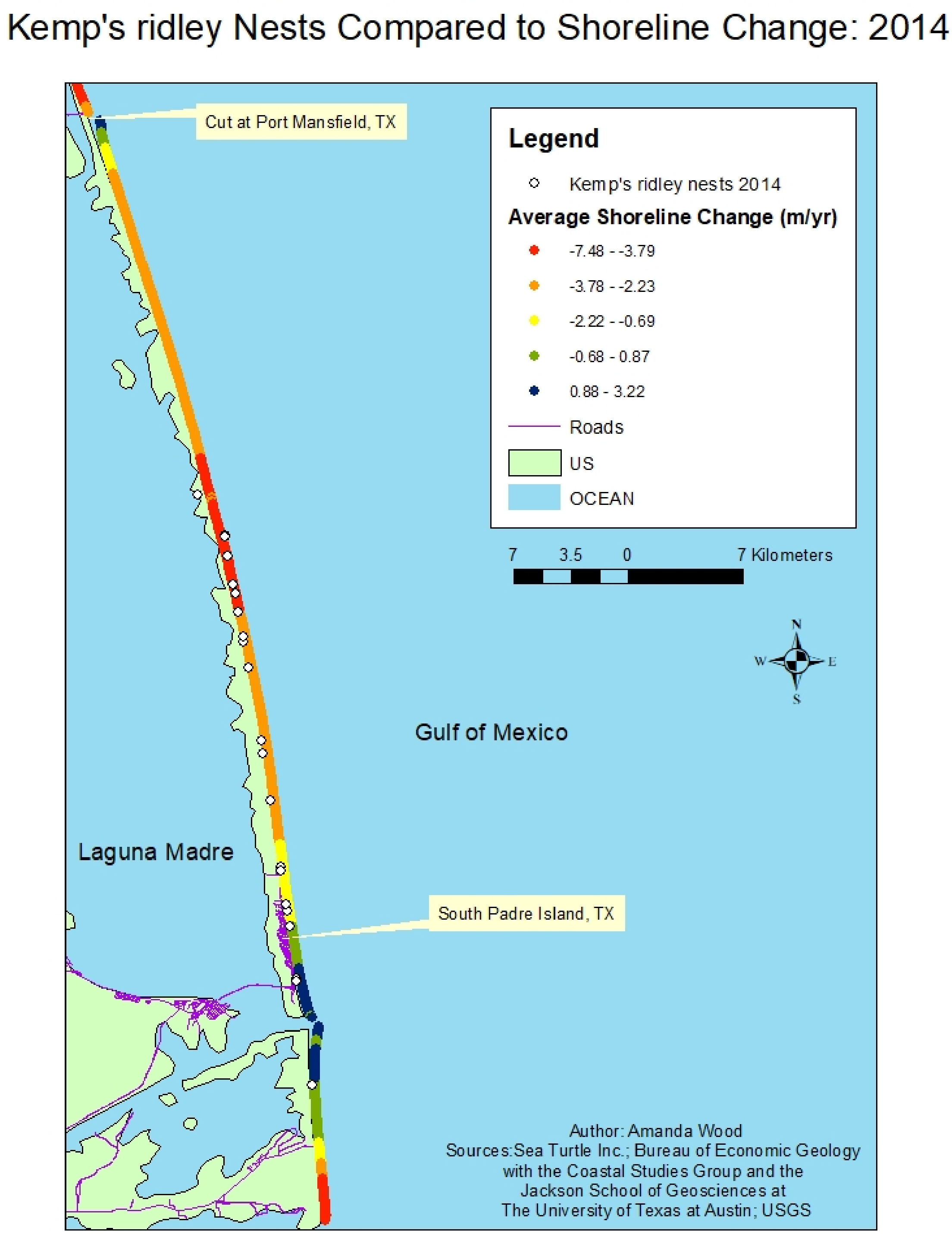

Figure 3: There were fewer nests recorded in 2014 than any other year in this project. There is a similar distribution to 2013.

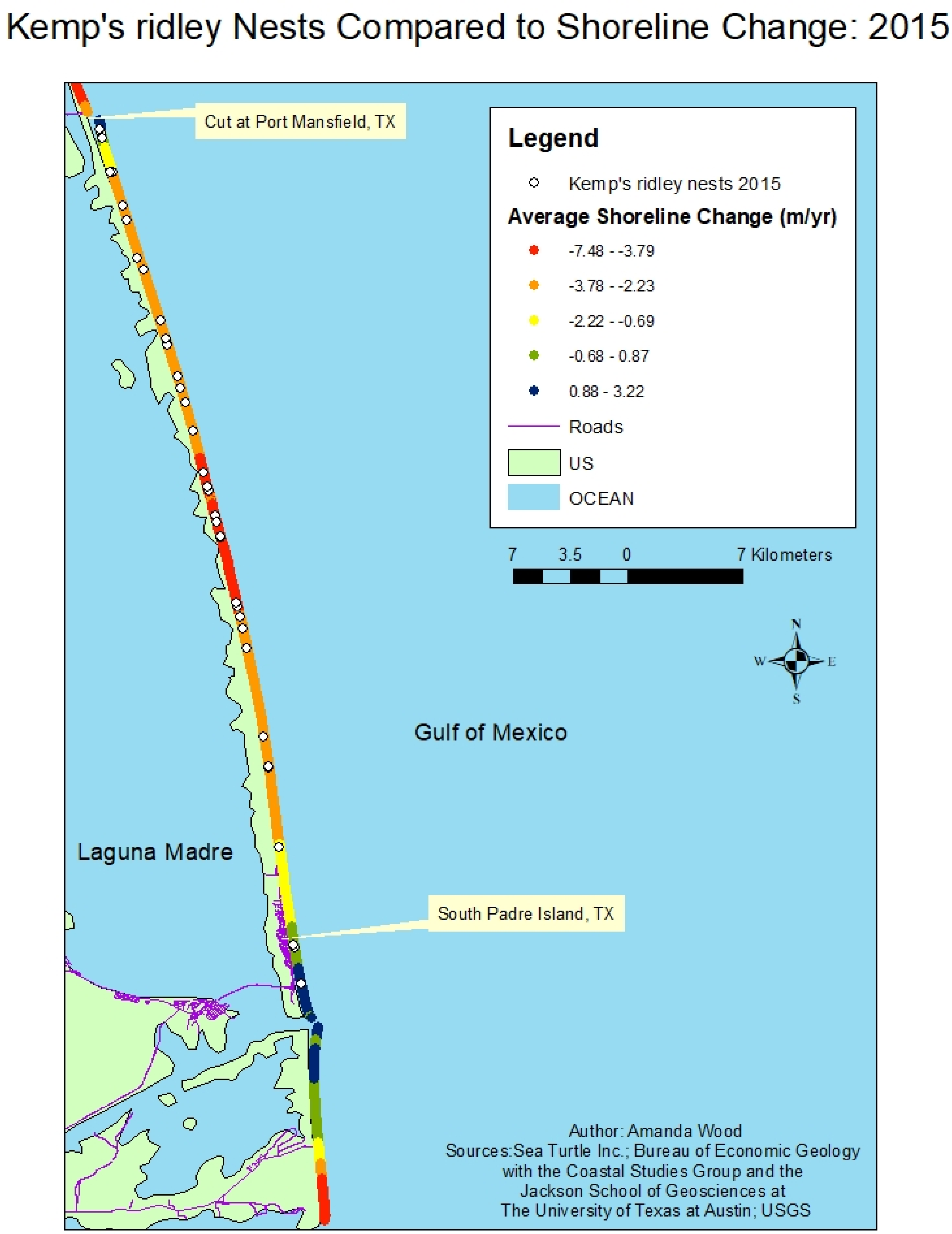

Figure 4: In 2015, there were no nests recovered south of South Padre Island on Boca Chica. Nests were found more north than the previous 2 years.

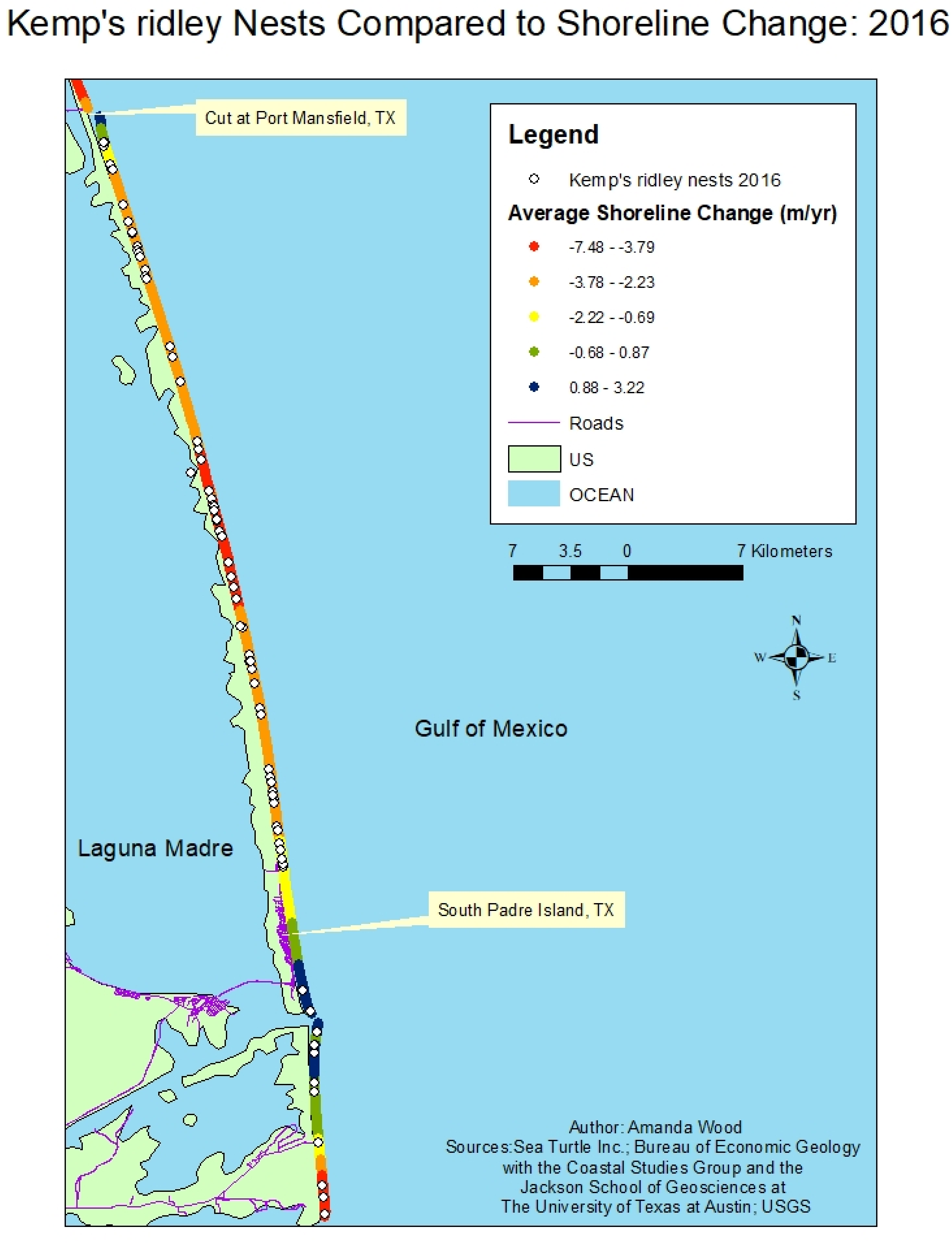

Figure 5: 2016 had more nests recorded and had a wider dispersal than previous years. Nests were found south, on Boca Chica, and north, near the cut at Port Mansfield.

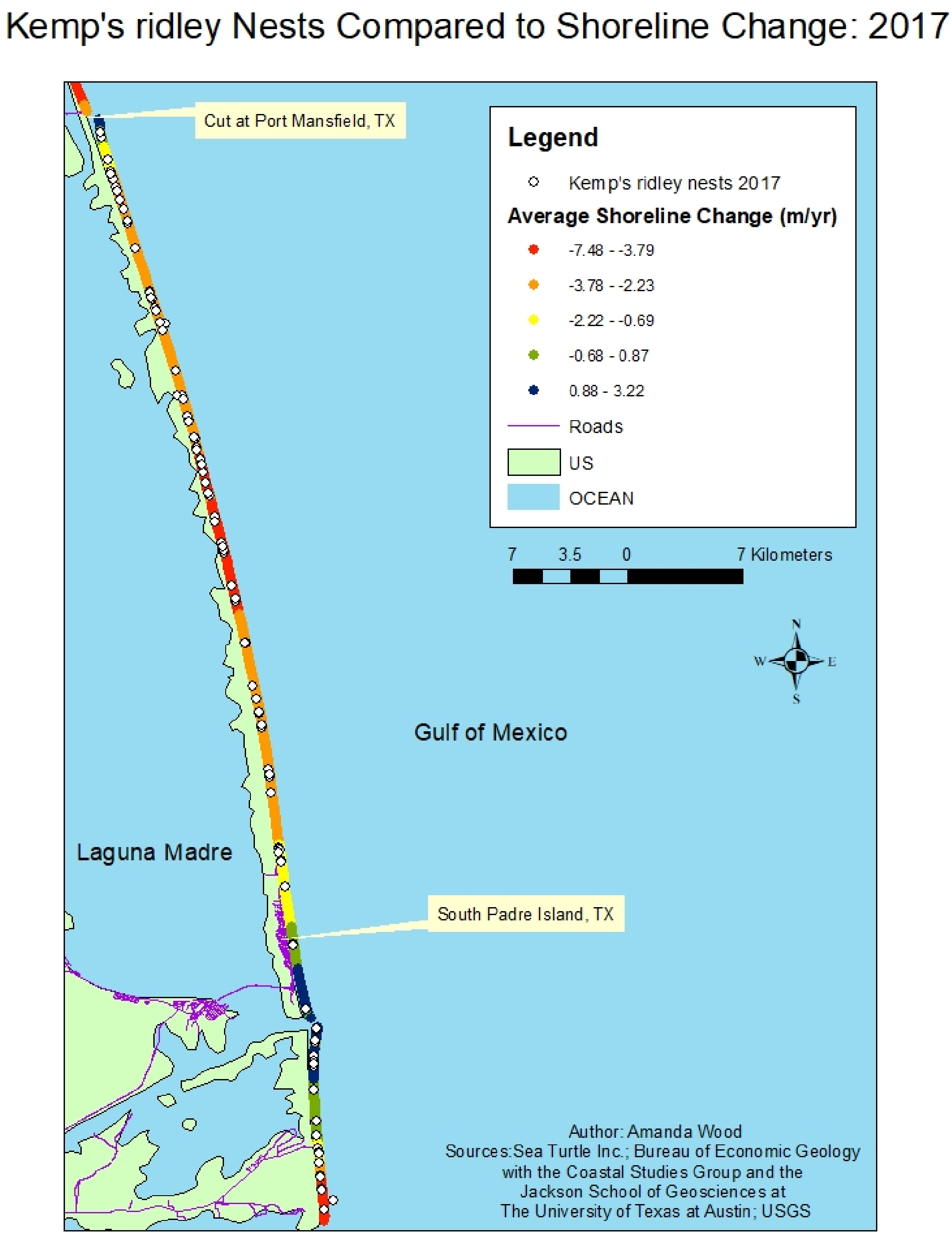

Figure 6: 2017 had the most nests recorded in the 5 years of nesting data used in this project. Nests were found south, all along Boca Chica, and as north as the cut at Port Mansfield, TX.

How Many Nests Found in each Risk Level 2013

Risk Level	Number of Nests	Percentage of Nests
1	5	11.63
2	7	16.28
3	7	16.28
4	20	46.51
5	4	9.3

Table 3: There was a total of 43 nests mapped for 2013. The high risk category had the most nests at 20.

How Many Nests Found in each Risk Level 2014

Risk Level	Number of Nests	Percentage of Nests
1	2	9.09
2	1	4.55
3	5	22.73
4	8	36.36
5	6	27.27

Table 4: 22 nests were mapped for 2014. The high risk category had the most nests again, however, it was a smaller percentage than 2013 at 36.36%.

How Many Nests Found in each Risk Level 2015

Risk Level	Number of Nests	Percentage of Nests
1	3	8.33
2	3	8.33
3	7	19.45
4	14	38.89
5	9	25

Table 5: There was a total of 36 nests mapped for 2015. Again, the high risk category had the most nests.

How Many Nests Found in each Risk Level 2016

Risk Level	Number of Nests	Percentage of Nests
1	5	7.04
2	5	7.04
3	11	15.49
4	33	46.48
5	17	23.95

Table 6: 71 nests were mapped for 2016 and marks the start of a bounce back in the number of nests at a nearly 50% increase from 2015. 46.48% of nests were found in the high risk category this year.

How Many Nests Found in each Risk Level 2017

Risk Level	Number of Nests	Percentage of Nests
1	8	8.16
2	8	8.16
3	20	20.41
4	45	45.92
5	17	17.35

Table 7: There were 98 nests mapped for 2017; the largest number of nests mapped of all the years covered in this project. Again, more nests were found in areas of high risk than any other category.

Figure 7 shows the nesting activity of nests found in each risk level along Padre Island, south of the cut at Port Mansfield, and along Boca Chica. A percentage breakdown was calculated to give another perspective of where the majority of these nests were found over the 5 years. About 44% of all nests were found in level 4 areas, areas of high risk, and about 20% were found in level 5 areas, areas of very high risk.

How Many Nests Found in each Risk Level 2013-2017

Risk Level	Number of Nests	Percentage of Nests
1	23	8.5
2	24	8.89
3	50	18.52
4	120	44.44
5	53	19.63

Table 6: Risk Levels are defined at 1=No Risk, 2=Low Risk, 3=Moderate Risk, 4=High Risk, and 5=Very High Risk. The number of nests found in each risk area and the percentages for each risk category were calculated. This is a cumulative look at all nests from 2013-2017.

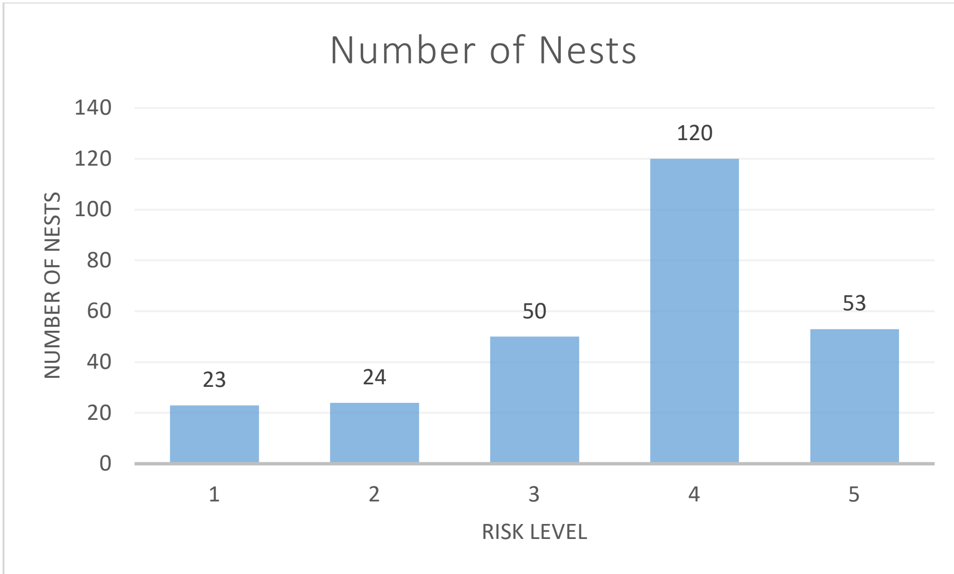

Figure 7: A majority of nests were found in areas of high risk of beach erosion. 120 nests were found in High Risk areas and 53 nests were found in Very High-Risk areas. That is about 64% of all the nests found.

The maps revealed the risk areas for high risk and very high risk were much larger than the areas of moderate to no risk. This contributed to the likelihood of a Kemp's ridley sea turtle nesting in the areas colored in orange or red. There was a greater possibility for turtles to choose these spots to nest, simply because of the greater area. As the literature suggests, Kemp's ridley sea turtles wait for a prime opportunity to nest by scoping out the beach from off shore, and this may have also impacted the results where turtles will find a location away from urbanized areas in South Padre Island, TX where beach erosion is more prevalent than the more populated areas of the coast (Caillouet et. al. 2011). This is shown by the roads, indicating urbanization and human activity along those regions of Padre Island.

Discussion

There are many factors that may influence a Kemp's ridley sea turtle's decision to nest, and the areas that may seem the most favorable are potentially very risky and have a higher possibility of experiencing coastal flooding. Near South Padre Island, TX, there have been beach nourishment programs to increase beach surface areas and protect private property from flooding, but these are more heavily populated areas (Reyna 2013). This is one of the reasons why the dark green areas are mostly located in the urbanized areas, since there are businesses, restaurants, hotels, and homes. Areas next to channels, such as the cut at Port Mansfield and the channel in-between South Padre Island and Boca Chica where jetties have been built, are experiencing sediment build up from longshore drift, impacting the shoreline change averages (Morton et. al. 2005).

The more rural areas in the north and center portions of South Padre Island don't have this mitigation of beach erosion. Different factors may impact these areas such as; hurricanes, wind, tidal surges, and sea level rise (Park and Edge 2011). There is less of a drive to mitigate the consequences of these factors since there are no private buildings or coastal towns in these areas. This contributes to these large areas where nesting habitat is disappearing for the Kemp's ridley sea turtle.

Conclusion

Along the Texas coast, Kemp's ridley sea turtles are losing nesting habitat. Loss of habitat due to beach erosion potentially leads to more nests becoming overwashed with water from tidal flooding, terminating the viability of turtle nests. Increased patrols and re-nesting programs are vital in the continued conservation of this endangered species. It is important for conservation efforts to focus more time in the areas of high and very high risk and ensure corrals where the eggs are relocated and re-nested are in a prime spot, protected from tidal flooding.

Climatologists' predictions and models for climate change are anticipating sea level rise to continue as our global temperatures continue to increase. Because of this, beach erosion is also expected to continue and future monitoring and research on sea turtle nest distribution is encouraged for the future (Anderson et. al. 2014). Replication of this type of research, using an interdisciplinary approach will give conservationists the tools to protect all species of sea turtles from beach erosion and the consequences that may follow.

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