LOGGERHEAD SEA TURTLE (C*aretta caretta)* CONSERVATION EFFORTS: NESTING STUDIES IN PINELLAS COUNTY, FLORIDA NESTING SEASONS 2010 THROUGH 2015

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Abstract

Understanding a species is very important to manage it effectively. Effective conservation efforts require detailed, accurate information. Such information is lacking for Loggerhead Sea Turtles, *Caretta caretta,* which are currently listed as endangered. Thorough data for all marine turtles, not just Loggerhead Sea Turtles is nonexistent, such as on details of their life cycle and demography. The majority of management practices focus on nesting females, eggs, and hatchlings. Clearwater Marine Aquarium is permitted through Florida Fish and Wildlife Commission to conduct Nesting Surveys in Pinellas County, Florida. Data collected through surveys for nesting seasons 2010 through 2015, inclusive, was analyzed for trends within and between nesting seasons. Trends observed supported a high success rate of hatching success and emergence success for nests in this region. It is suggested that post beach renourishment hatching success and emergence success rates increased versus pre-renourishment. It appeared that risks associated with nest relocation are less than the risks associated with washouts and a complete loss of the nest. Nesting surveys provide useful insight into where efforts and resources should be targeted. More studies should be conducted to confirm.

Introduction

Loggerhead Sea Turtles, *Caretta caretta*, are the most abundant of all the marine turtle species in U.S. waters, nonetheless their population is decreasing (NOAA, 2014). The species continues to be threatened by incidental capture in fishing gear, direct harvest, coastal development, increased human use of nesting beaches, and pollution (NOAA, 2014). Direct harvest occurs in the Bahamas, Cuba, and Mexico, which compromises current conservation efforts. Number of individuals harvested is unknown as reported values and unreliable currently.

To protect a species effectively it must be well understood. Overall marine turtles are poorly understood due to lack of information on them. Most conservational efforts focus on protection of eggs on the nesting beaches (Crouse et al., 1987). Many questions remain unanswered about the species and if targeting reproduction is the best approach to restore the population, or if there are alternate or possibly superior management options.

Demographic parameters are difficult to measure for marine turtles. Most information is based off adult nesting females, eggs, and hatchlings (Crouse et al, 1987). Sea turtles spend relatively little time in nest, terrestrial areas. Long-term monitoring of individual organisms over a large area of beaches and in their oceanic environment is necessary to obtain complete data. There is no method engaged to understand the ages of sea turtles either, therefore the only distinctive stages are eggs, hatchlings, and mature, nesting adults (Crouse et al., 1987). Little is known about the lengthy juvenile stage between hatchling and adult. Age of sexual maturity is unknown, but is predicted to be between 12 and 30 years: a large gap (Bowen et al., 1996). This raises more questions about the species and how to manage it.

Mating is observed to occur between late March and early June. Females nest beginning in late April and continuing through early September. When a female sea turtle crawls onto a beach to prospectively lay her eggs, she may make a successful nest or she may false crawl. A false crawl is when she drags her body onto the beach leaving a track created by her shell and flippers, but does not lay her eggs. She may even make body pits or construct an egg chamber, yet she does not deposit her eggs. Possible reasons for false crawls inappropriate sand texture, temperature, or various reasons. The turtle may have been spooked by another animal or humans using flashlights or lighting their beachfront homes.

Eggs incubate between fifty and sixty-five days; hatching occurs between late June and mid-November (NOAA, 2014). Females construct between three and five nests on average per season. Females are theorized to show nest-site fidelity both within and between seasons, however it is unclear if it is due to natal homing behavior. This means that the same female will return to the same location to construct another nest and has been observed to happen within the same nesting season and different years. Other mechanisms that could explain the females faithfully returning to the same beaches are the imprinting of hatchlings, genetic programming, or social interaction (Bowen et al., 1996).

Loggerhead sea turtles, similar to other reptiles, employ temperature-dependent sex determination (TSD). Gender of the hatchlings is partially dependent on nest temperature during development (Yntema and Mrosovsky, 1980). A pivotal temperature of 26°C would result in a nest of half females and half males. A higher temperature skews the ratio to develop more females and a lower temperature develops more males (Georges, Limpus, and Stoutjesdijk, 1994). The actual mechanics of TSD are still unknown. The mean daily temperature is a poor predictor of hatchling sex ratios, though it may influence the temperature at critical development time.

It has been suggested that the important time in development for survival is the large juvenile stage (Crouse et al., 1987). Historically the largest single source of mortality in juvenile and adult marine turtles was incidental capture and drowning in shrimp trawls. Since 1992, Trawl Excluder Device (TED) have been installed on trawls and virtually eliminated the capture and drowning of marine turtles. TED also eliminated other large by-catch from trawling therefore improving hydrodynamics and fuel efficiency (Crouse et al., 1987). TED was presented as advantageous for not only the marine turtles, but also the fishery. The National Oceanic and

Atmospheric Administration (NOAA) is currently involved in research projects aimed at developing gear that will reduce sea turtle bycatch. Developing TEDs to be required in trawl fisheries and time and area closures for gillnets are examples of research initiatives that became policy and reduced accidental capture of non-target species including sea turtles (NOAA, 2014).

Most sea turtle conservation focuses on nesting beaches and early development. Nests are readily accessible and protection success is easily documented. In Florida, the Florida Fish and Wildlife Conservation Commission (FWC) oversees the monitoring and management of sea turtle nesting along Florida's coastline. FWC has developed strict protocols to be followed by permit holders. Clearwater Marine Aquarium (CMA) is located in coastal Clearwater, Florida. CMA holds a permit to conduct nesting surveys along about 20 miles of shoreline on the Gulf of Mexico in Pinellas County. Employees, interns, and volunteers work together to monitor and protect the sea turtle nests observed in this region, while collecting data and educating the public. It comes into question whether efforts put into nesting surveys and beach protection is the optimal management strategy for the species.

Methods

CMA is authorized to mark nests, conduct hatching success evaluations, rescue and release hatchlings. They are additionally authorized to relocate nests, screen nests with self-releasing screens/cages and screen nests with restraining cages. CMA is contracted to survey about 20 miles of beach in Pinellas County, Florida with a northernmost border of northern Clearwater Beach and southernmost border of Treasure Island.

(Left) A Loggerhead Sea Turtle nest has been screened with a restraining cage and has the front opened, facing seaward, during the daytime. At nighttime the cage will be secured shut to prevent sea turtle disorientation due to artificial lighting.

(Left) A Loggerhead sea turtle nest that was washed out by high tides that had a self-releasing predation cage over it.

Data collection begins April 1st and continues until the last nest observed is documented as hatched typically around the end of October. Seven days a week starting no earlier than 30 minutes before sunrise, CMA personnel use vehicles to survey the coastal beach area within their region. Typically two teams are used made up of a combination of CMA paid staff members, unpaid interns, and volunteers. Each team has two to five people on it. One team start from the northernmost point and the other team starts from the southernmost point and both drive collecting data until they meet near the middle.

Daily surveys search the beaches for signs of sea turtle nesting activity that results in either a false crawl or a nest. If a false crawl is assessed, the crawl pattern will be drawn, and data are collected including: the date observed, species of turtle, beach, closest street address, GPS coordinates, number of body pits or abandoned egg chambers, any obstructions/ possible reasons for the false crawl, the distance from the apex of the crawl to the mean high water line (MHW), distance from the apex of the crawl to the closest vegetation or structure.

If a crawl results in a nest with eggs, the crawl will be drawn and data are collected including: the date laid, species of turtle, whether the nest is in-situ or relocated, original GPS coordinates, original beach, original closest street address, whether the original beach is natural or renourished, year of renourishment, the original MHW, original distance from the nest to vegetation or structure, the position on the beach (low, middle, high) in relation to the MHW, relocation data if necessary, and distance from the rear stakes to the exact spot over the egg chamber. Nest locations are marked off for using four wooden garden stakes and fluorescent marker tape, and the front stake is labelled with the nest number and date laid.

(Left) A Loggerhead Sea Turtle nest location marked off with four stakes, fluorescent tape, and a sign designating it as a protected area.

Each nest is monitored for the duration of its incubation for any predation, vandalism, and unusual weather. If the nest is located in an area known for predation, such as North

Clearwater Beach, a self-releasing predation cage is placed over the nest the day it is laid or discovered. In areas with artificial lighting issues, a mesh restraining cage is placed over the nest after 45 days of incubation. These restraining cages have a door-like cutout on the seaward side and top of the cage. The top hatch remains zip-tied closed until hatching activity is occurring, while the seaside door remains open during the daytime to prevent desiccation, and closed during the night to prevent disorientation. Nests that have restraining cages are monitored by a volunteer called a "nest sitter" who is trained to check the nest every twenty minutes for signs of hatching during the evening hours, from sunset to 0200. Nesting "captains" manage the nest sitters, coordinate hatchling releases, and assess the health of sea turtle hatchlings prior to release.

(Above) Loggerhead sea turtle hatchlings rehabilitate at CMA to regain strength before release.

The 2012 Sand Key Beach Renourishment Project replenished eroded sand on South Sand Key, Belleair Beach, Indian Rocks Beach, Indian Shores, North Redington Beach, and Redington Shores. The other beach locations were not replenished in 2012 and are considered to have natural sand on them.

(Above) CMA Intern Felicia and volunteer Randy carefully excavate a hatched nest.

A nest is considered to have had a "hatching event" after three hatchlings or their tracks are observed to have emerged from the nest. Nest inventories are conducted around 72 hours after the first hatching event or at day 70 of incubation. During an inventory, a nest is carefully excavated until eggs or eggshells are reached. Excavation is by hands and all the contents of the nest are removed. Contents are then separated into categories: hatched eggs (empty eggshells), live hatchlings, dead hatchlings, pipped eggs with live hatchlings, pipped eggs with dead hatchlings, and unhatched eggs. A pip occurs when the turtle has broken the shell but is not completely free of the shell. The number of hatched eggs is determined by counting the number of broken shells that are more than 50% complete as one egg and disregarding smaller pieces.

(Above) During nest excavation, shells are piled together to organize into categories.

Relocation is a process in which beach surveyors that possess the appropriate permits remove eggs from a threatened, turtle constructed nest to a new, human dug by hand nest in a chosen site. Relocation is commonly done as a last resort effort when a female has laid her nest too close to the high tide line and it is in danger of being submerged under water or washed out by the tide. Per FWC protocol, a relocation must be completed before the day of egg deposition. After 0900 a nest is considered unmovable because the eggs have already began to develop and must remain in their current orientation.

From data collected in the field, hatching success and emergence success is computed. Hatching success is the ratio of the number of eggs that were hatched in comparison to the total number of eggs in the nest. Emergence success is the ratio of the total number of hatchlings that made it successfully out of the nest in comparison to the total number of eggs, accounting for any dead hatchings still in the nest during inventory.

Data collected for the nesting seasons in 2010, 2011, 2012, 2013, 2014, and 2015 were analyzed. Only data considered complete for nests were considered. False crawl data were omitted from this study. As such, nests that were washed out in poor weather or nests that the clutch was not found were excluded from analyses. Treasure Island was excluded from the study because CMA no longer surveys the area as it once did. Trends were noted if they were similar to biological context. Change in hatching success or emergence success locations within nesting seasons or between seasons was assessed. One-way ANOVA tests were used with an alpha value of 0.05 to test statistical significance of these trends. If variance was observed it may help refine future nest conservation efforts.

Results & Discussion

Caution should be taken when interpreting results from the 2015 nesting season. During this season, large amounts of rainfall resulted in increased tidal ranges and sub sequentially higher rates of nest washouts. Nests that did not have complete data sets including inventory data following hatching was omitted, which for this season particularly included a large amount of the total nests observed. The quality of data in this study was impacted by the use of multiple surveyors and by unusual weather resulting in high tides.

Analyses were conducted to compare biological data within and between nesting seasons and among geographic nesting sites. Of the 484 total nests laid within the 2010 to 2015 nesting seasons, inclusive, 37% of all nesting was observed on Belleair Shore and Indian Rocks Beach (Fig. 1). Nests were observed on other sites at lesser rates (Fig. 1). The highest rates of Loggerhead Sea Turtle nest deposition within the study sites overall were observed in the 2013 and 2014 nesting seasons (Fig. 2). These two seasons combined compromised 49% of all nests. The 2015 nesting season gives the impression of only having 52 nests laid, however this number was significantly skewed by elimination of incomplete data due to high nest washout by high tides due to very high rainfall.

A Loggerhead Sea Turtle female will lay between 80 and 120 eggs per nest (Yntema and Mrosovsky, 1980). Data collected from Pinellas County support this range (Fig. 3). It was observed that as nesting density increased, the number of eggs deposited increased equally, showing positive correlation (Fig. 4). This trend could be detrimental to the population if less turtles come on beach to nest and less eggs are deposited.

The average hatching success for all of the nesting seasons was 74.8% (SD 24.05) (Fig. 4). Most locations and most nesting seasons were close to the average. The hatching success had no significant difference between nesting seasons (ANOVA P=0.34) (Table 2). Belleair Beach had the highest hatching success and emergence success. The one-way ANOVA test produced a p-value greater than 0.05, accepting the null hypothesis. There was no statistically significant difference between the various beaches studied in Pinellas County during the 2010-2015 nesting seasons, inclusive.

The average emergence success of all the nesting seasons was 71.9% (SD 25.8) (Fig. 5). Success at beach locations varied from 63.8% in North Redington Beach to 78.6% in Belleair Beach. The one-way ANOVA test produced a p-value less than 0.05 and the test statistic is greater than the F critical value therefore we reject the null hypothesis. There is a statistically significant difference between the values. Emergence success had a statistically significant difference between sites (ANOVA P=0.04) (Table 3). Higher average success rates observed on Belleair Beach (78.7%) and South Sand Key (78.0%) compared to North Redington Beach (63.8%).

In 2014 post- beach renourishment project, 55 nests were observed on the natural beaches and 52 nests were observed on the renourished beaches. In 2013, there was 74 nests observed on natural beaches and 58 nests observed on renourished beaches (Fig. 6). Following the renourishment project there was a significant increase of nests laid on renourished beaches, but there was a similar increase on natural beaches. A one-way ANOVA test produced a p-value greater than 0.05, therefore there is no statistically significant difference between natural and renourished beaches nesting density. This pegs the question: does beach renourishment affect nesting densities just within its own borders or also including adjacent beaches? There is still the variable of yearly variation that may have a stronger influence on nesting density.

Hatching success had no statistically significant difference within the two years prior to renourishment (ANOVA P=0.85) or within the two years post renourishment (ANOVA P=0.30). Hatching success had no statistically significant difference between natural beaches prior versus post (ANOVA P=0.15). Hatching success had statistically significant difference between renourished beaches prior versus post renourishment (ANOVA P=0.03). Hatching success averaged higher post renourishment (79.0%) versus pre-renourishment (70.9%).

Emergence success had no statistically significant difference within the two years prior to renourishment (ANOVA P=0.99) or within the two years post renourishment (ANOVA P=0.23) Emergence success had no statistically significant difference between natural beaches prior versus post (ANOVA P=0.27). Emergence success had statistically significant difference between renourished beaches prior versus post (ANOVA P=0.03). Emergence success averaged higher post renourishment (76.9%) versus pre-renourishment (68.6%).

It can be suggested that post renourishment hatching success and emergence success rates increased versus pre-renourishment. However, only the presence of a statistically significant difference is supported. The 2012 Sand Key Beach Renourishment Project may play a role in the increased nesting density and should be further explored over a longer time span with multiple beach renourishment projects.

During the Sand Key Beach Renourishment Project, 27 of 69 nests were relocated, an unusually high proportion. During the 2013 nesting season, only 2 of 133 nests were relocated. Relocated nests and natural nests did not have any statistically significant difference between hatching success rates (ANOVA $p=0.68$) and emergence success rates (ANOVA $p=0.94$) for all sites and years. It appears that risks associated with moving nests are less than the risks associated with washouts and a complete loss of the nest.

Due to the nature of this species and the effect of temperature on embryonic development, effects of climate change should be investigated. Climate change will cause greater variations in temperatures on nest-site beaches, which could predictively skew the population's sex ratio. Most of the research on temperature dependent sex determination was explored inside a lab, with controlled temperatures (Georges et al., 1994). A natural nest would experience daily temperature fluctuations and during the whole incubation period and results could differ from laboratory generated findings (Georges et al., 1994).

To accurately predict the margin between a male-producing versus female-producing nest both mean nest temperature and the magnitude of daily temperature fluctuation must be considered. This study focused on just the nesting population within the Gulf side of Florida. Does the region affect the nest temperature as well? Do nests further north have lower temperatures overall than those in southern regions? It should be explored if there is indeed a difference and maybe the different regions produce different genders.

Conclusion

Data collected and analyzed from nest surveys by employees, interns and volunteers provide useful insight into where efforts and resources can best be targeted to promote conservation and management of sea turtles. More studies should be conducted to confirm.

A major concern of beach renourishment projects is the effect it may have on marine turtle nesting. There is statistically insignificant difference of hatching success between two years prior to beach renourishment and two years post renourishment natural and renourished successes, supporting that the process does not detrimentally affect the species, subsiding the concern. Renourishment of beaches increase the size of the beaches providing more area for nesting. With the increased area more turtles can nest, therefore renourishment projects may be beneficial.

Relocated nests had statistically insignificant difference in hatching success rates and emergence success rates compared to each other or natural nest. Therefore concerns about relocation of nests negatively affecting reproductive success is unsupported.

Hatching success rates was statistically insignificantly different for the study area. However, emergence success rates was statistically significantly different. The data supported that Belleair Beach had the highest emergence success rates. Long term studies should be conducted to understand the cause of the variation in emergence success within the study sites.

Efforts made on nesting beaches should be continued as a management tool for the species. In order to effectively protect and manage this species however, more needs to be done.

The main focus is on the nesting population currently. Efforts should not cease, but instead should expand to include more of the life stages of marine turtles within the ocean zones. What is the biggest threat to post-hatchlings? To juveniles? Are they threatened mostly by predators or are humans impacting their numbers more than we could predict? Marine turtles need to be tagged to document survival rates through development to adulthood furthermore to reproductive stages. Long term studies need to be conducted so the populations are well defined. All is conjecture without numbers to support it. More questions lie ahead and should be addressed to truly save this species.

Climate change will likely impact nest success and sex ratio of hatchlings. Long term and in depth studies should be conducted to develop understanding of Temperature Dependent Sex Determination to be able to predict the impact of climate change. It can be confidently predicted that there will be an impact by increased temperatures on the sex ratios, favoring female development with warmer temperatures.

Acknowledgments

I would like to acknowledge people who made my internship possible. Clearwater Marine Aquarium for provided nest data and the opportunity to gain hands-on experience with conservation of sea turtle. Lindsey Flynn, Associate Sea Turtle Biologist at CMA, helped me gather resources and served as my contact in Florida even after my departure. The employees, volunteers, and interns who dedicated their time to the management of sea turtle nests over the years. A huge thank you to the interns who I spent many early mornings searching the sand for sea turtle tracks. Last but not least, I would like to thank my thesis advisor Dr. Joseph Buttner who provided me guidance, inspiration, and encouragement throughout this project.

Tables

Table 1. Number of Nests Per Year In-situ vs Relocated
(# Total=484)

Year	In-Situ	Relocated
2010	63	4
2011	45	12
2012	42	27
2013	131	2
2014	103	3
2015	50	2

Table 2. The one-way ANOVA test of the hatching success data from Pinellas County during the nesting seasons 2010-2015, inclusive, accepts the null hypothesis.

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	57052.01	5	11410.4	1.161243	0.340186	2.38607
Within Groups	530605.3	54	9826.025			
Total	587657.3	59				

Table 3. The one-way ANOVA test of the emergence success data from Pinellas County during the nesting seasons 2010-2015, inclusive, rejects the null hypothesis.

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3700.843	5	740.1686	2.473498	0.043375	2.38607
Within Groups	16158.94	54	299.2396			
Total	19859.78	59				

Figures

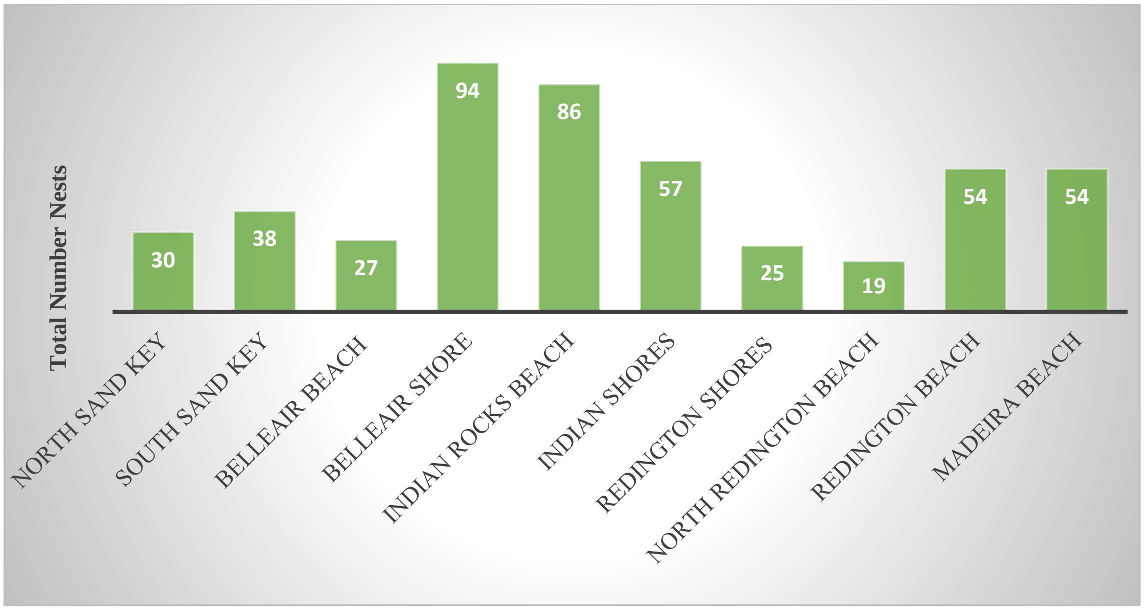

Figure 1. The total number of Loggerhead Sea Turtle nests (n=484) observed in Pinellas County 2010-2015 by location varied significantly.

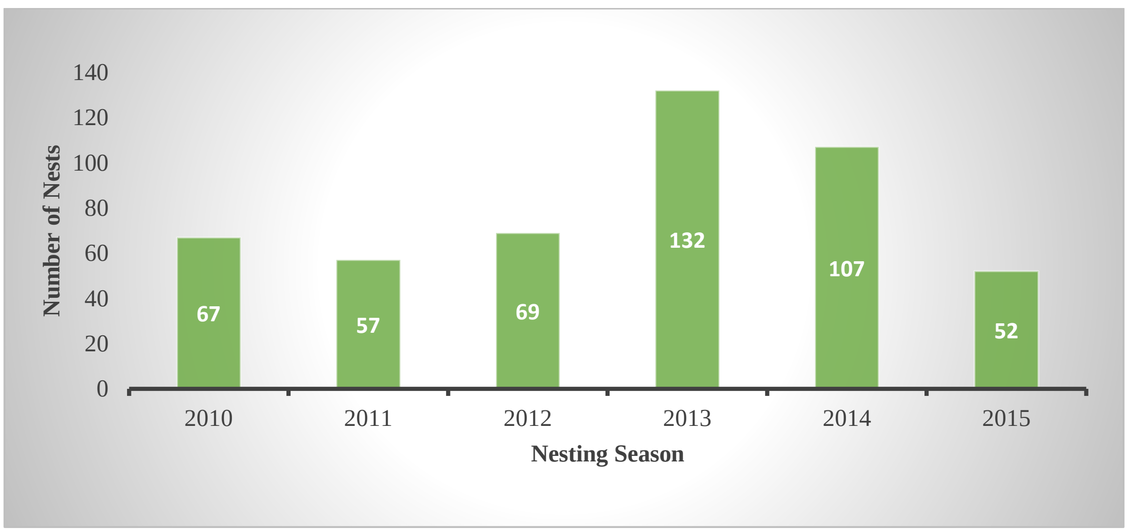

Figure 2. The total number of Loggerhead Sea Turtle nests observed in Pinellas County varied by season, 2010 through 2015, inclusive.

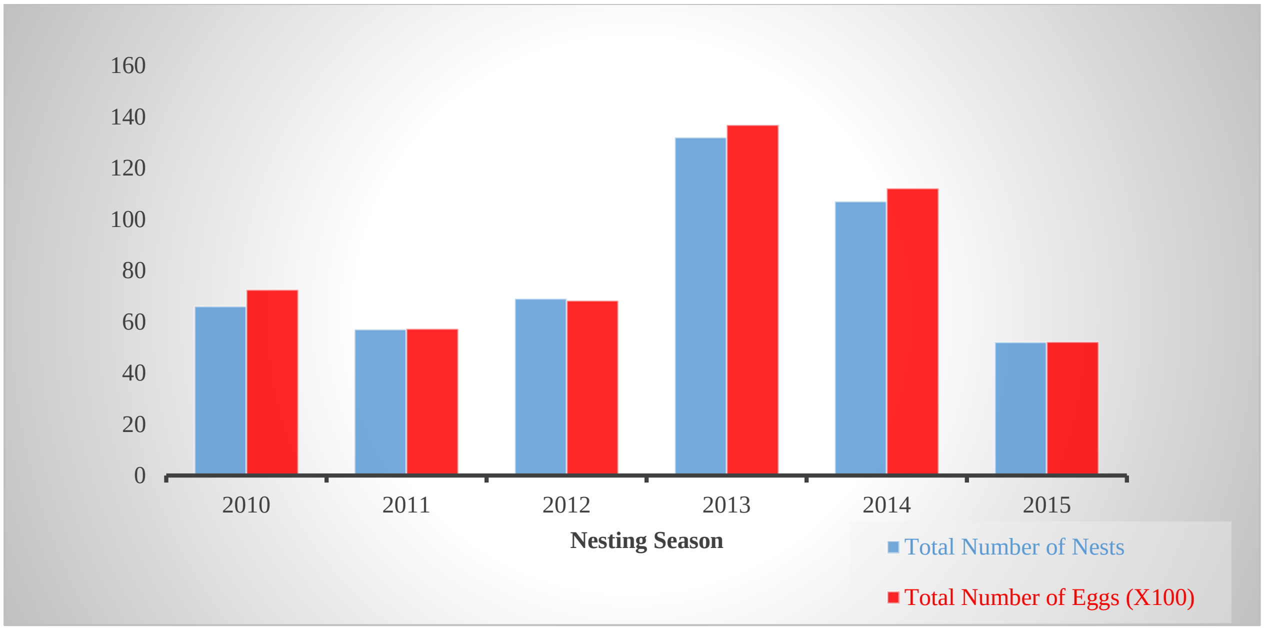

Figure 3. The total number of Loggerhead Sea Turtle nests and total number of eggs deposited(X100) per year (2010-2015) observed in Pinellas County followed similar trends.

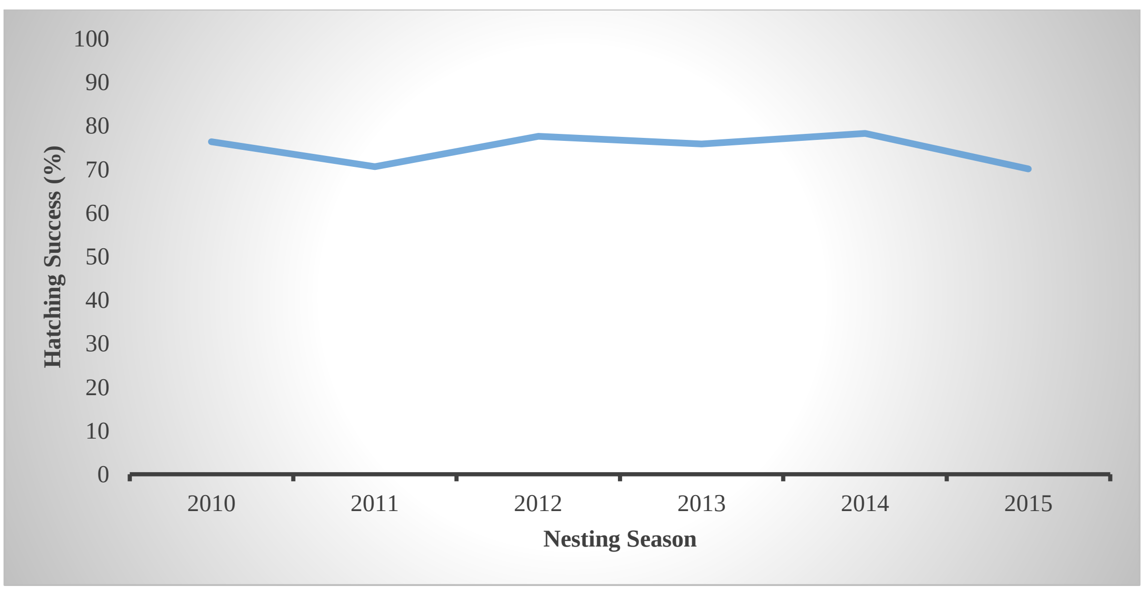

Figure 4. Average hatching success rate of Loggerhead Sea Turtle nests observed (2010-2015) had no statistically significant difference between nesting seasons.

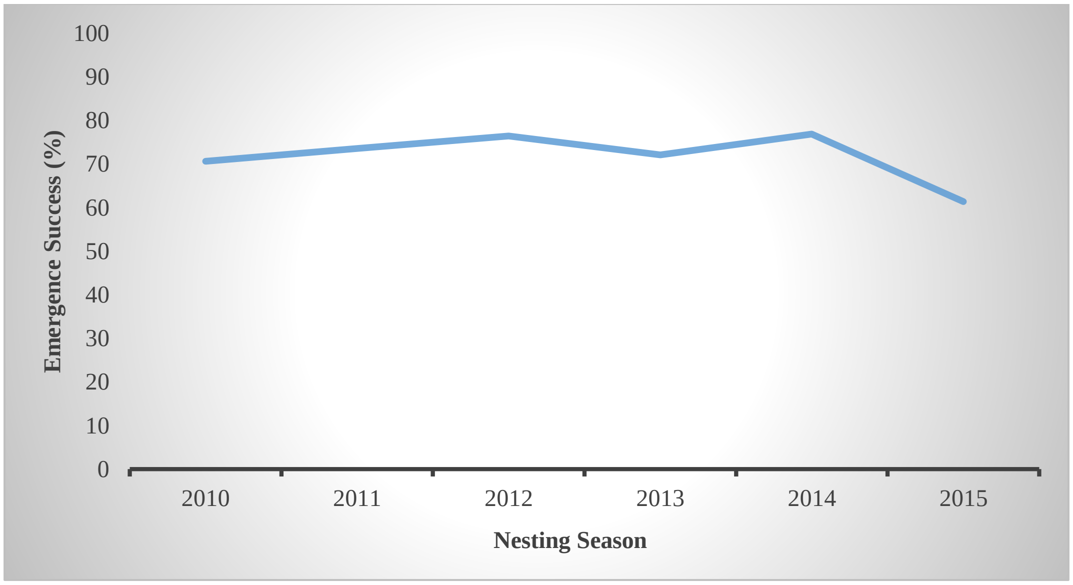

Figure 5. Average emergence success of Loggerhead Sea Turtle nests observed (2010-2015) had no statistically significant difference between nesting seasons.

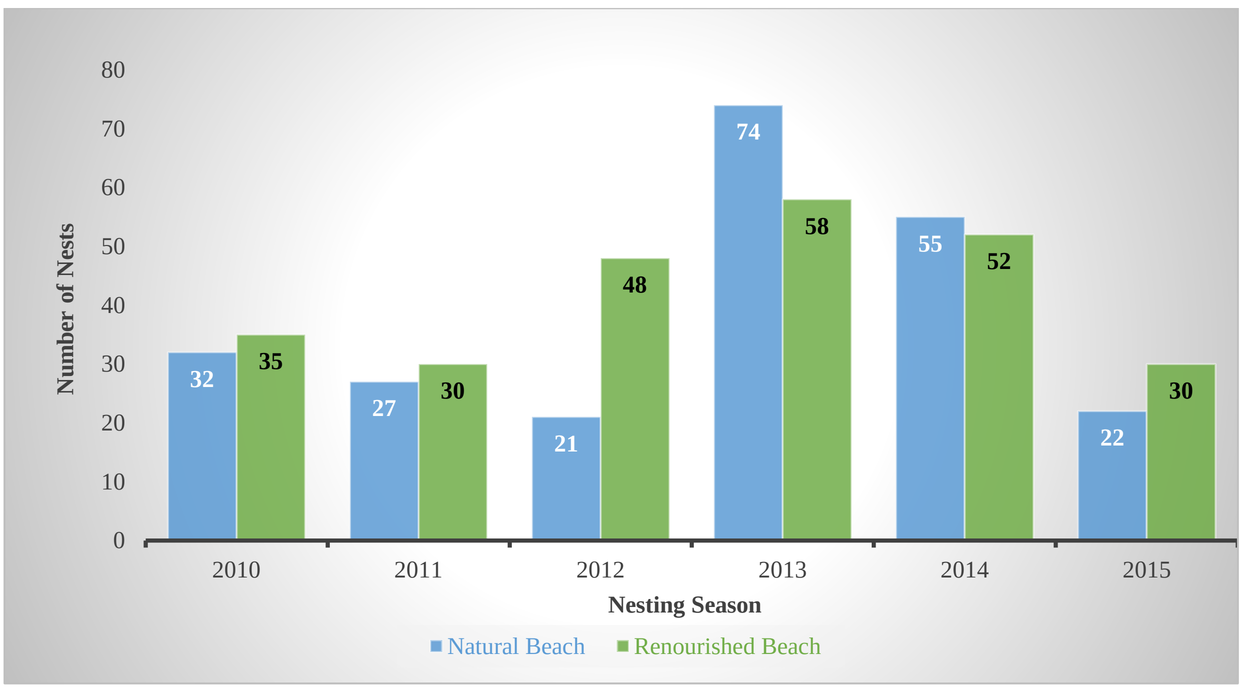

Figure 6. Total number of Loggerhead Sea Turtle nests (n=484) observed on Natural Beaches vs Renourished Beaches per year varied.

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