**Analyzing the effectiveness of self-releasing cages to prevent raccoon predation of loggerhead (*Caretta caretta*) nests on Virginia Key**

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**Analyzing the effectiveness of self-releasing cages to prevent raccoon predation of loggerhead (*Caretta caretta*) nests on Virginia Key**

Abstract of a master's degree internship report at the University of Miami, Rosenstiel School of Marine, Atmospheric, and Earth Science. Supervised by: Bethan Linscott, PhD and Shannon Jones, MPS
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The loggerhead turtle (*Caretta caretta*) is a long-lived, ecologically important marine reptile facing many anthropogenic and ecological stressors that create challenges for conservation and population recovery. Sea turtle egg and hatchling survival are key components for population growth; however, the emergence success of many sea turtle nests is affected by predation. In Virginia Key, southeast Florida, 23% of the loggerhead nests laid in 2024 were lost to raccoon predation even with the protection of self-releasing screens. To improve sea turtle nest management on Virginia Key, this study evaluated and compared the effectiveness of three nest protection strategies in 2024 and 2025 (self-releasing screens, self-releasing cages, and self-releasing cages with extensions). There was no significant difference in nest protection between self-releasing screens (77%) and self-releasing cages (74%). However, self-releasing cages with extensions were significantly more effective in protecting Virginia Key's sea turtle nests, with only 6% of nests successfully predated (1 complete predation and 1 partial predation). I recommend continued use of self-releasing cages with extensions to protect Virginia Key sea turtle nests, and possibly the addition to small partial relocation of raccoons in highly concentrated predation areas annually.

**Keywords:** Loggerhead turtle, predation, *Caretta caretta*, Predator management, Florida

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**Table of Contents**

1.0 Introduction …… 1
2.0 Methods and Methods …… 4
2.0.2 *Sea turtle survey* …… 4
2.0.3 *Predator prevention methods* …… 5
2.0.4 *Statistical analysis* …… 7
3.0 Results ……. 7
4.0 Discussion …….. 14
5.0 Conclusions ……. 18
6.0 References ……. 19
7.0 Appendices ……. 23

**List of Tables**

**Table 1.** Equations used to calculate overall, unpredated, and partially predated emergence rates for 2024 and 2025. ..... 7

**Table 2.** Predation attempts, partial predation, and complete predation on uncaged nests, caged nests, and caged nests with the addition of extensions after raccoon removal. ..... 8

**List of Figures**

**Figure 1.** The three different predator prevention methods used to protect loggerhead nests on Virginia Key. ..... 5

**Figure 2.** The number of predation attempts Virginia Key's loggerhead caged nests experienced before partial predation, complete predation, or hatch. ..... 9

**Figure 3.** Pie chart of 2025's predation rate of uncaged nests compared to caged nests and 2024's predation rate of unscreened nests compared to screened nests on Virginia Key. ..... 10

**Figure 4.** Heat map created in QGIS Desktop 3.34.14 to show raccoon predation hotspots on loggerhead nests located on Virginia Key in 2024..... 11

**Figure 5.** Heat map created in QGIS Desktop 3.34.14 to show raccoon predation hotspots on loggerhead nests located on Virginia Key in 2025. ..... 12

**Figure 6.** The number of loggerhead nest predation attempts, complete predation, and partial predation for each type of predator prevention method on Virginia Key. ..... 13

**Figure 7.** Percent of loggerhead nests that experienced predation annually from 2012 to 2025 14

## 1.0 Introduction

Loggerhead sea turtles (*Caretta caretta*) can be found in waters around all continents excluding Antarctica (Ceriani et al., 2019). The IUCN lists loggerhead turtles as vulnerable with global population decreasing (IUCN, 2015). Historically, loggerhead populations have continued to decrease due to anthropogenic and ecological stressors. Major stressors include bycatch, beachfront development, plastic pollution, harmful algal blooms, and predation (Costa et al., 2023; Fuentes et al., 2023; Nederlof et al., 2024). The type and severity of a threat is dependent on the life stage of loggerheads. (Fuentes et al., 2023). Major threats to juvenile and adult sea turtles are bycatch, climate change, disease, and boat strikes (Fuentes et al., 2023; López-Mendilaharsu et al., 2020). Conversely, because sea turtles are terrestrial nesters major threats to sea turtle eggs and hatchlings include predation, climate change, and beach development (Costa et al., 2023; Fuentes et al., 2023; López-Mendilaharsu et al., 2020). Juvenile and adult sea turtle mortality has the greatest impact on sea turtle population stability and growth due to the loss of sexually mature individuals able to reproduce (Heppell, 1998; Leighton et al., 2010). Sea turtle egg and hatchling survival is therefore vital for population recovery because increasing emergence success and decreasing hatchling mortality increases the number of individuals replacing juveniles and adults (Mazaris, et al., 2006). Therefore, to improve population trends, conservation needs to focus on protecting all life stages of loggerheads (Fuentes et al., 2023).

For loggerheads, nest predation is one of the most critical threats to hatchling survival (Fuentes et al., 2023). Globally, loggerhead eggs are eaten by a range of predators including raccoons, coyotes, dogs, crabs, foxes, birds, and pigs (Fuentes et al., 2023). In North America, raccoons are one of the most common predators that target loggerhead nests (Engeman et al., 2016). Raccoons are generalist predators that perform area-restricted search (ARS) behavior, meaning they stay in areas where they have recently found food (Byrne & Chamberlain, 2012). As a result, unnatural food sources left by humans in high foot traffic areas like beach parks, increase raccoon density, survival, and recruitment (Foote et al., 2000). During sea turtle nesting season, raccoons have been observed to temporarily migrate to sea turtle nesting areas and teach their young to do the same (Urbanek & Sutton, 2019). Predator control is one of the most important conservation tools for marine turtle reproduction, thus determining the

most effective nest predation prevention method is essential for effective management (Engeman et al., 2011).

Methods to prevent raccoon predation range from screening to lethal and nonlethal raccoon removal depending on the location, resources available, and severity of predation (Engeman et al., 2016). The effectiveness of a prevention method is highly location-dependent (Engeman et al., 2016). For example, Garmestani & Percival (2005) found that after raccoon removal in four islands within Ten Thousand Islands National Wildlife Refuge in Florida, nest predation decreased from 76-100% to 0%. In contrast, a different study in Canaveral National Seashore (CNS), Florida, showed that raccoon removal had no significant influence on predation rates because the removal did not guarantee that raccoon population would be fully eradicated or prevent the migration of new individuals (Ratnaswamy et al., 1977). Ratnaswamy et al (1977) found that in CNS, Florida, nest screening and caging was a more effective predation prevention method compared to lethal and nonlethal removal. In situations where raccoon removal reduces nest predation, for removal to remain effective, it needs to continue indefinitely which becomes expensive (Barton & Roth, 2007).

Self-releasing screens and cages are effective predation prevention methods that are cheaper and more ethical alternatives to lethal and nonlethal removal (Engeman et al., 2016; Ratnaswamy et al., 1977). The initial construction of screens and cages is time-consuming and labor-intensive, yet the cages and screens are reusable (Engeman et al., 2016; Ratnaswamy et al., 1977). Additionally, screening is beneficial in areas where raccoons are native and necessary for ecosystem functioning because screens and cages do not harm raccoons (Ratnaswamy et al., 1977). For example in Florida, raccoons prey on ghost crabs and invasive iguana eggs (Barton & Roth, 2008; Meshaka et al., 2009). Barton & Roth (2008) found that maintaining a moderate raccoon population is beneficial for controlling ghost crab populations and sea turtle nest predation. Therefore, sea turtle nest predator management programs need to create plans that maintain healthy species interactions (Barton & Roth 2008; Engeman et al., 2012). Engeman et al., (2012) explained that creating a successful predator control program can be one of the most economically and biologically beneficial allocations of management resources. For every dollar spent on predator control, the value of each additional hatchling produced is over 1,069 USD (Engeman et al., 2012). However, effective management plans need to be location-specific,

budget and labor conscious, and sustainable for an area to reap the benefits associated with sea turtle nest predator control programs (Engeman et al., 2012).

Florida has the largest loggerhead nesting aggregations in the Atlantic and one of the largest globally, making it a vital location for population recovery (Ceriani et al., 2019). The main way to measure the success of sea turtle nesting is through the number of nests laid and emergence success (Bladow & Briggs, 2017). Emergence success is the percentage of successfully hatched eggs out of the total number of eggs laid (Bladow & Briggs, 2017). However, Brost et al (2015) discovered that Florida's loggerheads only have a mean emergence success around 51%. One major cause of loggerhead egg and hatchling mortality is nest predation by mammals (Brost et al., 2015). Therefore, creating effective sea turtle nest predator control programs in Florida's loggerhead nesting areas is crucial for hatchling success and population growth (Brost et al., 2015; Ceriani et al., 2019).

Based on MORAES nesting data from 2012 to 2024, Virginia Key, located in Southeast Florida, is becoming a more popular nesting habitat for loggerhead females with an average of 90 nests laid annually. Similarly, this location has a growing raccoon population which has become problematic for loggerhead hatchling success. A population assessment done by Nicholas Gonzalez of Florida Environmental & Wildlife Management Services found that Virginia Key's raccoon population exceeds carrying capacity. In Florida, raccoons' natural predators are bobcats and horned owls which are not found on Virginia Key. Additionally, there is high foot traffic on Virginia Key due to the popular beach parks and bike trails, resulting in high amounts of anthropogenic food sources for raccoons. The combination of these two factors has allowed the raccoon population on Virginia Key to exponentially increase. Over the years, as the number of nests laid on Virginia Key has increased, so has the severity of raccoon predation. In 2023, 50% of nests experienced partial or complete predation, and in 2024 that rate increased to 60%. Since 2022, loggerhead nests on Virginia Key have been screened using a 48in x 48in flat-lying self-release screen with 4in x 2in metal wiring. However, over time the raccoons have learned how to pull apart the wiring to create a hole big enough to dig down to the egg chamber and consume the eggs. As a result, metal screens have become an ineffective prevention method on Virginia Key, and a new prevention method needs to be developed and applied.

The purpose of this study was to deploy three-dimensional self-releasing metal cages on top of loggerhead nests to improve nest protection from raccoon predation. The goal of the self-releasing cages was to create a safer distance from the egg chamber so the raccoons cannot reach the eggs even if they pull the wiring apart. The hypothesis for this study was that the self-release cages would decrease raccoon predation on Virginia Key and would be a better prevention method compared to the previously deployed flat lying self-releasing screen. This project was vital as Virginia Key is becoming an increasingly prominent loggerhead nesting area in South Florida. Finding the most effective raccoon prevention method for Virginia Key is essential to increase the local loggerhead hatchling emergence success.

## 2.0 Materials and Methods

### 2.1 *Sea turtle survey*

This study was conducted by trained and permitted personnel under MTP-25-153. From April 24th to October 18th, 2025, daily sea turtle nesting surveys took place on the beaches located in Virginia Key, Florida. Once a crawl was identified as a nest, trained and permitted personnel located the egg chamber to ensure the egg chamber was centered under the self-releasing cage and between three wooden stakes with blue tape and a warning notice. The notice is to warn humans from interfering with the nesting area. Finding the egg chamber is a Florida Fish and Wildlife Conservation Commission (FWC) requirement for screening or caging nests; therefore, if the egg chamber could not be found the nest was not caged. Instead, the nest was just marked off with three wooden stakes,blue tape, and warning notice to prevent human disturbances. False crawls, which are when a female sea turtle emerges from the ocean with intent to lay a nest but returns without nesting for a variety of reasons, were also documented in case the crawl later became a missed nest found through predation or hatchling tracks. GPS coordinates of all nests and false crawls were collected using Garmin model ETREX 22x.

Nests were monitored daily for anthropogenic and ecological disturbances. Predation events were classified as either attempted or successful. Successful predation was further classified as either partial or total. Attempted predation included obvious signs of digging around/ through self-releasing cages. Successful predation was categorized as partial if not all the eggs were eaten or complete if all the eggs were eaten. The number of predated eggs was

estimated by counting eggshell fragments ≥50% as one egg. For an attempted or partial predation event, the cage was redeployed if needed and any holes created by predators were filled. If an uncaged nest was partially predated, surveyors covered up the egg chamber and installed a cage over the nest. Survey data collected for this study included nest number (N001, N002, etc.), caged (Y/N), GPS coordinates, predation events (attempted, partial, complete), number of predated eggs for each nest, total number of eggs per nest, and number of hatched eggs per nest.

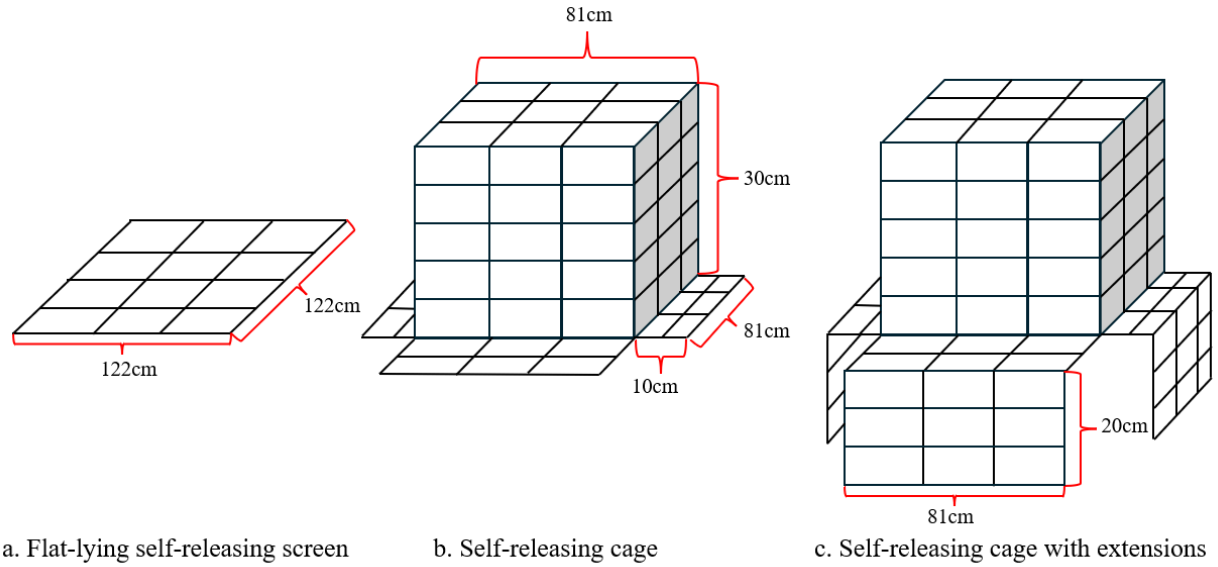


**Figure 1.** The three different predator prevention methods used to protect loggerhead nests on Virginia Key. Flat-lying self-releasing screens were used from 2022 to 2024 (a.) self-releasing cages were used from April 24th to July 20th, 2025 (b.) and self-releasing cages with extensions were used from July 20th to October 18th, 2025 (c.).

2.2 *Predator prevention methods*

All self-release cages were made with 4 in x 2 in mesh metal wiring to allow hatchlings to emerge without disturbance while still deterring predators. To create each cage, a 64 in x 32 in piece of metal wiring was cut with wire cutters. 16 in from each end of the metal piece was then folded 90 degrees to make the top and two sides of the cage. Scraps of remaining metal wiring

and plastic zip ties were used to create two 32 in x 12 in sides. To make storage easier the sides were only attached to the top of the cage so the cage could be folded until deployment. During cage deployment, cages were folded into a 3D structure and the bottom 4 in of each side was folded out 90 degrees to create a flared base. Plastic zip ties were used to attach the sides of the cages together and the cages had the following dimensions: 32 in x 32 in x 12 in. Once constructed, cages were placed on top of the sand with the identified egg chamber centered under the cage. Cages were held down with 2 metal stakes on each side. Finally, the flared base and metal stakes were covered up with sand and three wooden stakes were hammered in the ground surrounding the cage to mark the nest to avoid human disturbances.

Depending on the tide height during the nesting survey, we would run a “high tide day” or “low tide day”. On high tide days we would have 2 surveyors on the UTV cover Virginia Key Main Beach Park while another 2 walked Historic Beach Park and Rosenstiel as high tides significantly shortened the beach and operating the UTV was not possible. If a nest was found by the pair walking, they would use a self-releasing screen as opposed to a cage because the screens were more portable for walking. To add some more protection to the nest, the screen was elevated by placing a stack of rocks behind the egg chamber. Stakes were hammered into all four sides of the screen and then the nest was marked off with 3 wooden stakes and blue tape.

After raccoons learned how to lift the edges of the self-releasing cage enough for them to crawl under the metal wiring, we decided to adjust the cages in July. These adjustments included 32in x 8in extensions made from the same 4 in x 2 in mesh metal wiring. Once constructed the extensions were connected with zip ties to the flared base on all four sides. Once the extensions were connected, we dug trenches on all four sides so we could lay the extensions at a 90-degree angle up and down. The extension was then held down as the trench was filled back up with sand. We also placed large heavy rocks on all four corners of the cage because those areas did not have any caging, and we were concerned that raccoons would be able to get through in those areas. We later made adjustments to the rocks by burying them into the sand so they would weigh down the corners of the extension while making it more difficult for the raccoons to dig the rocks out. Furthermore,by burying them into the sand, the chances of a hatchling getting stuck during emergence was reduced.

2.3 *Statistical analysis*

A Chi-Squared test was performed to test the hypothesis that the self-releasing cages are a more effective predation prevention method compared to the flat lying self-releasing screens. The data used for the Chi-Squared test compared predation prevention method and predation status (predated or not predated) and only includes nests caged in 2025 or screened in 2024. Similarly, another Chi-Squared test was performed to see if there was a difference in protection between self-releasing cages compared to self-releasing cages with extensions. Additionally, there were 3 different emergence rates calculated for both 2024 and 2025 including overall emergence rate, partially predated emergence rate, and unpredated emergence rate (Table. 1).

**Table 1.** Equations used to calculate overall, unpredated, and partially predated emergence rates for 2024 and 2025.

| **Emergence rate** | **Equation** |
|---|---|
| Overall | $\frac{Total\ number\ of\ hatched\ eggs}{Total\ number\ of\ eggs\ laid} * 100$ |
| Unpredated | $\frac{Total\ number\ of\ hatched\ eggs}{Total\ number\ of\ eggs\ laid} * 100$ |
| Partially predated | $\frac{Total\ number\ of\ hatched\ eggs}{Total\ number\ of\ eggs\ remaining\ after\ predation} * 100$ |

**3.0 Results**

3.1 *2025's nesting season*

During the 2025 sea turtle nesting season on Virginia Key, there were 84 confirmed loggerhead nests with 66 caged nests. Overall, there were 155 raccoon predation events, consisting of 118 predation attempts, 15 partial predations, and 22 complete predations (Table 2). 68% of all Virginia Key's loggerhead nests experienced some degree of predation with 37% total predation. Raccoons took an average of 3 attempts (1-4 range) to completely or partially predate a caged nest (Figure 2). 6 out of 15 of the partially predated nests had predation attempts after

being predated (1-6 range). Caged nests that had no successful predation had an average of 4 attempts (1-10 range). 4 nests were predated after they were laid before survey took place: 1 complete predation and 3 partial predations. 72% of uncaged nests were predated compared to 26% of caged nests (Figure 3a., 3b.). The overall emergence rate for the 84 loggerhead nests on Virginia Key was 45%. For nests that had no predation the emergence rate was 74% and partially predated nests had an emergence rate of 32%.

Throughout the nesting season there were adjustments made to our predator prevention methods. From July 12th to July 20th, we installed extensions onto all the remaining cages and any new nests (Figure 1c.). There were 85 predation attempts, 1 complete predation, and 1 partial predation on nests that had a cage with extensions attached (Table 2.). Additionally, we were notified that from July 24th to July 28th, the USDA trapped and removed around 175 raccoons from jetty 0 to jetty 4. There were no predation events for four days after the raccoon removal but by the fifth day we saw predation attempts on nests located in jetty 0 and predation events on all the remaining nests persisted until October 1st.

**Table 2.** Predation attempts, partial predation, and complete predation on uncaged nests, caged nests, and caged nests with the addition of extensions after raccoon removal. The addition of extensions on the majority of existing caged nests was done on July 12th and July 13th and finished by July 20th. The raccoon removal took place from July 24th to July 28th.

| Nest treatment | Number of nests | Predation attempts | Partial predation | Complete predation |
|---|---|---|---|---|
| Uncaged | 18 | 1 | 7 | 12 |
| Caged | 35 | 32 | 7 | 10 |
| Raccoon removal + cage extensions | 31 | 85 | 1 | 1 |
| **Total** | **84** | **118** | **15** | **23** |

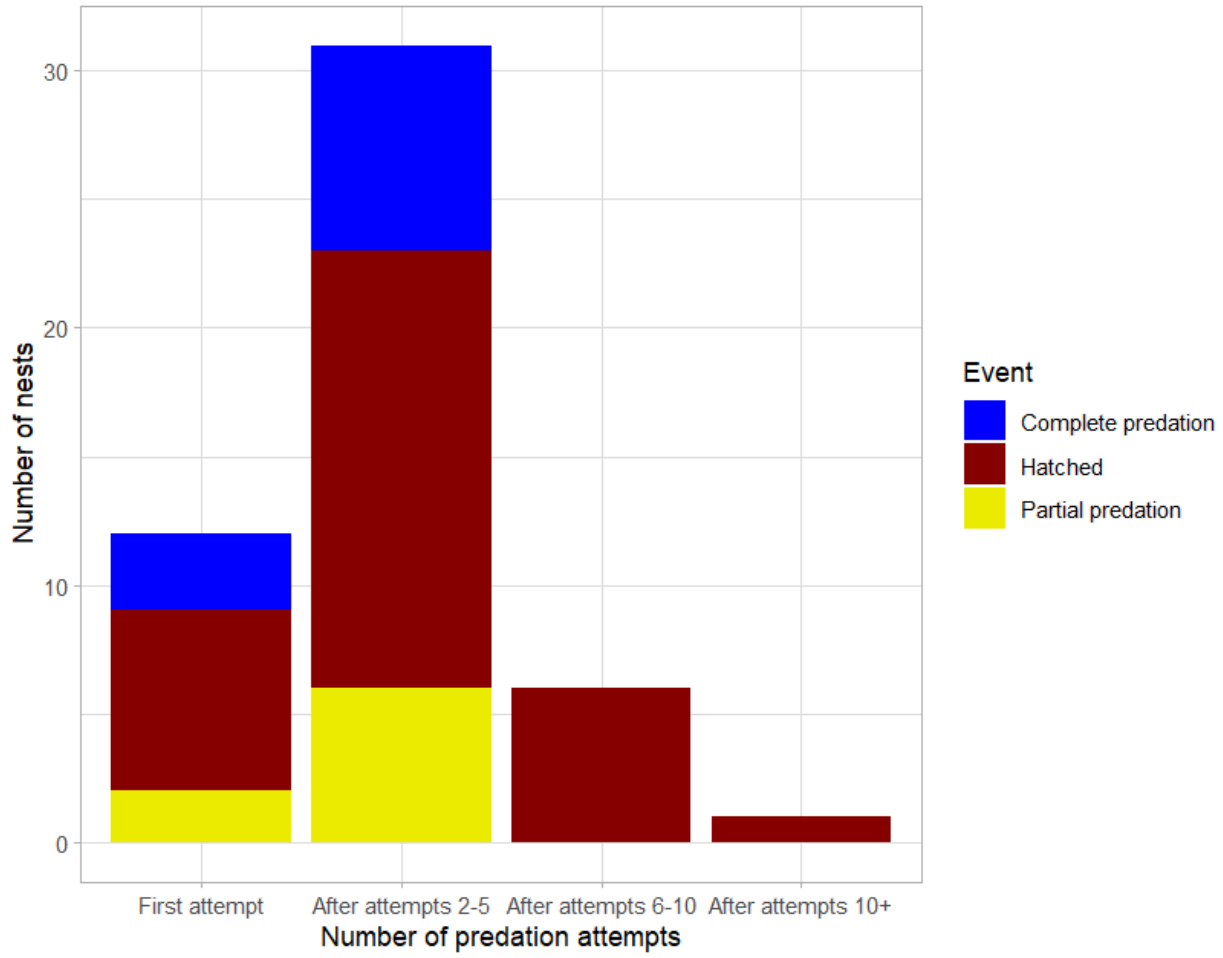


**Figure 2.** The number of predation attempts Virginia Key's loggerhead caged nests experienced before partial predation, complete predation, or hatch. 6 nests experienced predation attempts after being partially predated so those nests were counted in both 'partial predation' and 'hatched'.

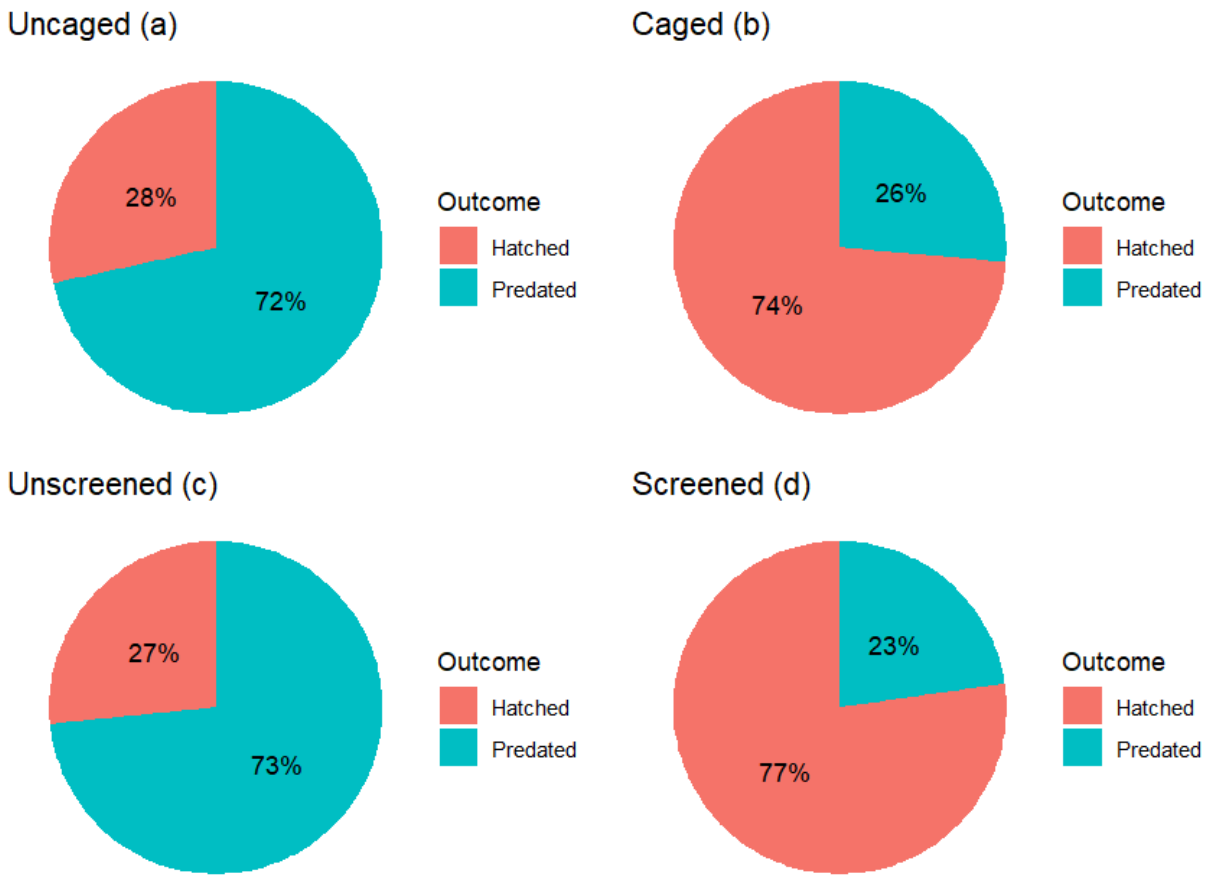


**Figure 3.** Pie chart of 2025's predation rate of uncaged nests (a) compared to caged nests (b) and 2024's predation rate of unscreened nests (c) compared to screened nests (d) on Virginia Key.

3.2 *Comparing anti-predator methods*

2024's sea turtle nesting season had 70 confirmed nests with 46 of them screened. 60% of all nests experienced predation with 17 completely predated and 15 partially predated. 23% of screened nests were predated, while 73% of unscreened nests were predated resulting in a total predation rate of 36% (Figure 3c., 3d.). The overall emergence rate for the 70 loggerhead nests on Virginia Key in 2024 was 55%. For nests that had no predation the emergence rate was 79% and partially predated nests had an emergence rate of 56%.

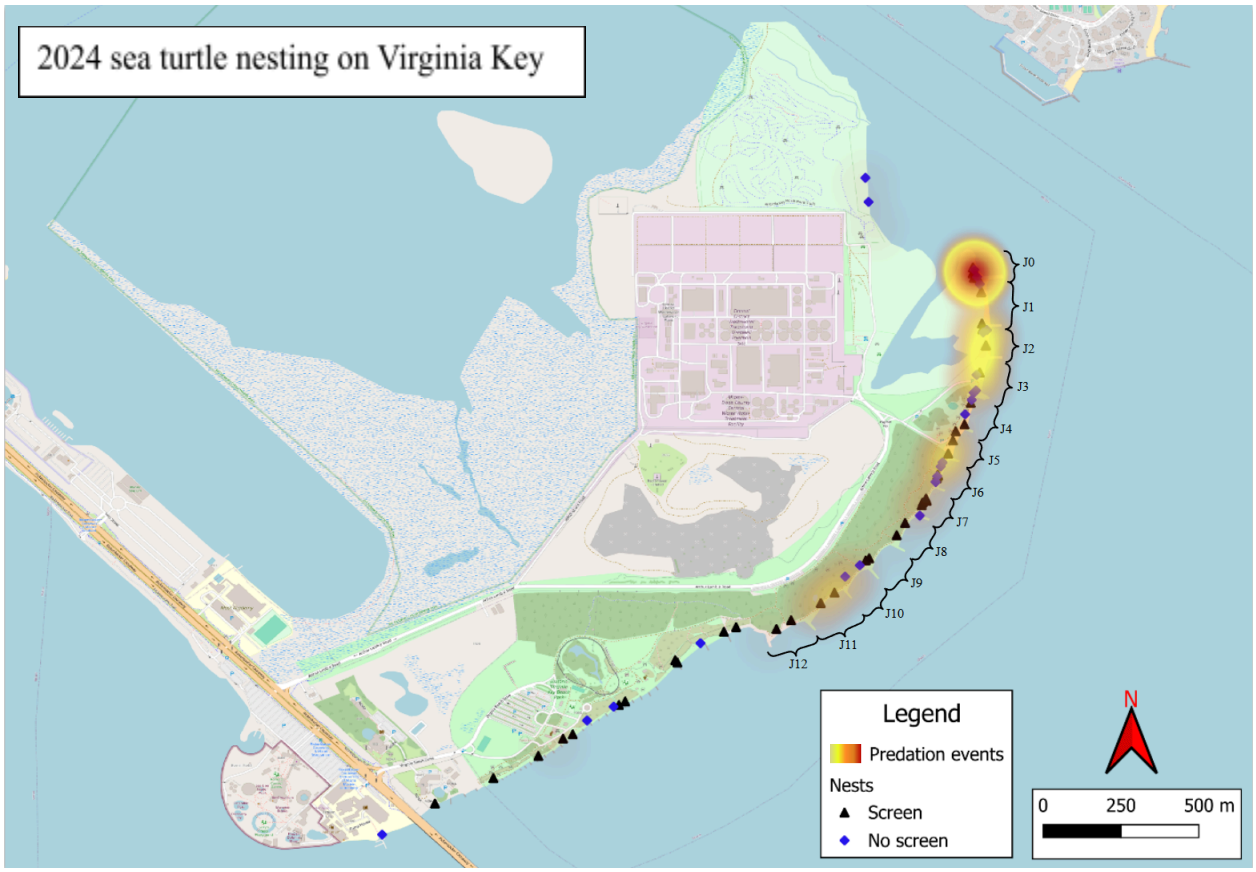


**Figure 4.** Heat map created in QGIS Desktop 3.34.14 to show raccoon predation hotspots on loggerhead nests located on Virginia Key in 2024. Jetties are marked and numbered with black brackets.

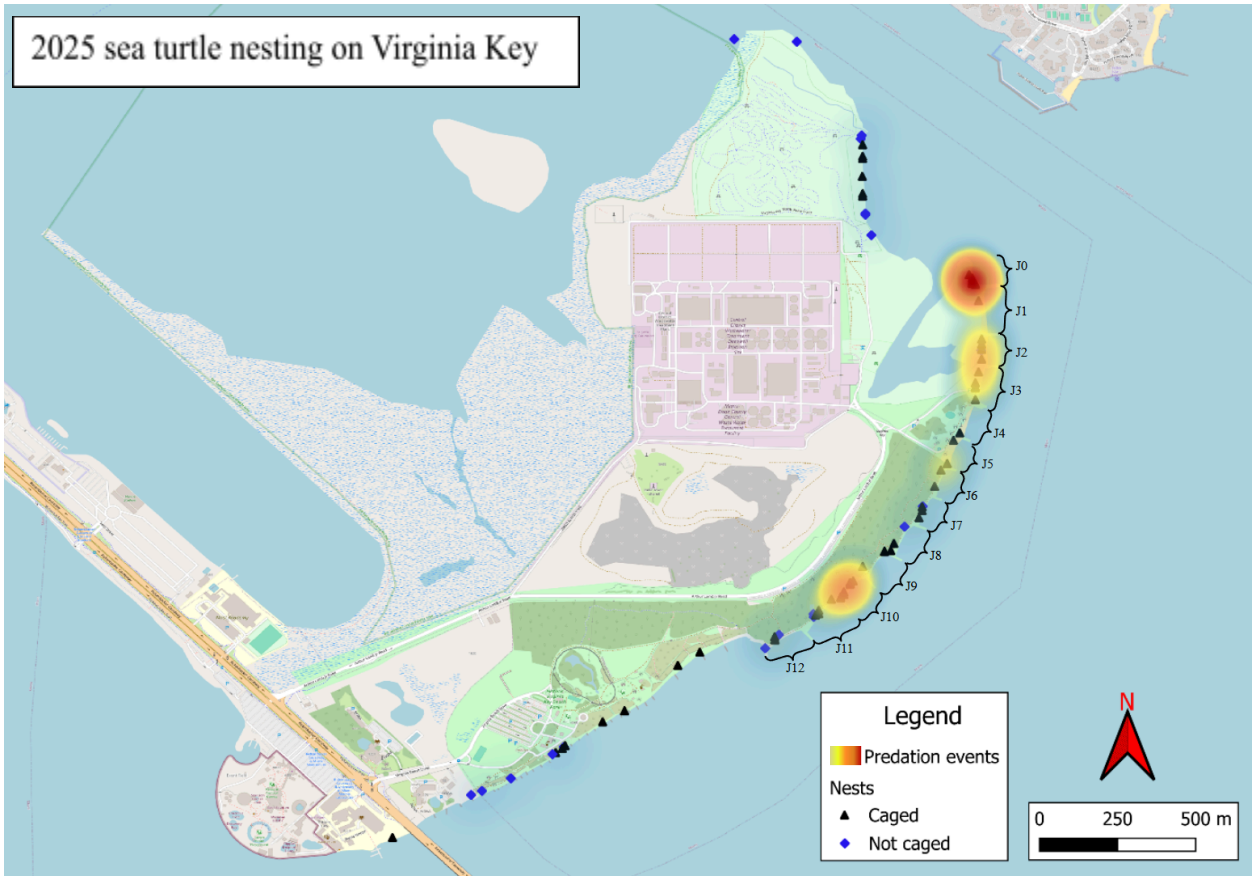


**Figure 5.** Heat map created in QGIS Desktop 3.34.14 to show raccoon predation hotspots on loggerhead nests located on Virginia Key in 2025. Jetties are marked and numbered with black brackets.

2024 and 2025 had high concentrations of predation events from jetty 0 to jetty 3 (Figure 4. and Figure 5.). In 2024, jetties 0 and 6 had the highest number of successful predation events (Figure 4.). 2025 had the highest number of successful predation events in jetties 2 and 3. Additionally, 2025 had the highest concentration of predation attempts around jetties 0 and 10 (Figure 5.). There were no predation attempts recorded for 2024 while 76% of the predation events in 2025 were attempts (Figure 6.). Predation events in 2024 consisted of 60% partial predations and 40% complete predations. 2025 had 3% more predation on caged nests compared to 2024' screened nests (Figure 3b., 3d.). A chi-square test was performed to determine whether self-releasing cages were more effective than self-releasing flat-lying screens at protecting loggerhead nests from raccoon predation. There was no significant change in protection from successful predation (partial/complete) between the two nest protection methods,

Chi-squared=1.63, Df=1, P=0.20. Another chi-square test was performed to determine whether the addition of extensions on the self-releasing cages and partial raccoon removal was more effective at protecting loggerhead nests from raccoon predation compared to the self-releasing cage alone. There was a significant change in protection between the two nest protection methods, Chi-squared=14.2, Df=1, P=$1.62*10^{-4}$.

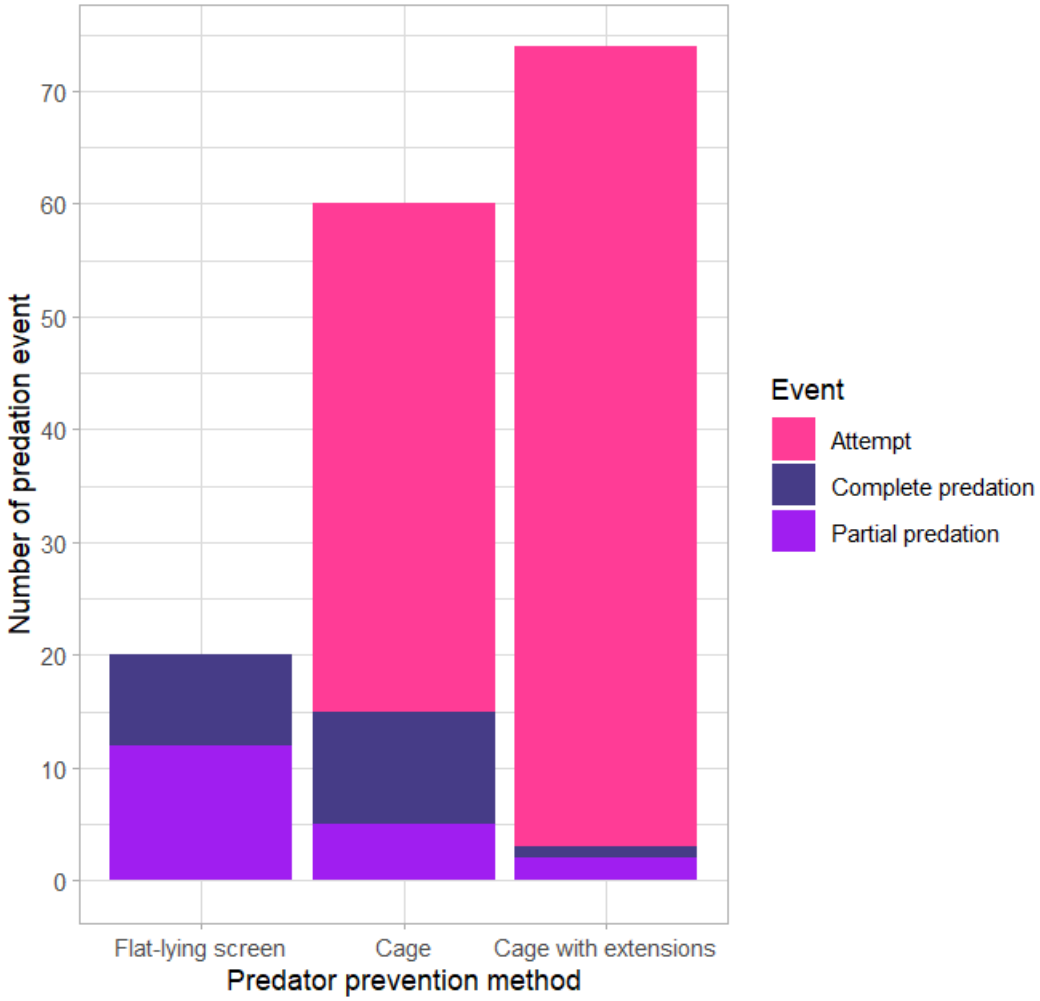


**Figure 6.** The number of loggerhead nest predation attempts, complete predation, and partial predation for each type of predator prevention method on Virginia Key. Flat-lying screen data was obtained from May 1st, 2024, to August 30th, 2024. Self-releasing cage data was from May 15th, 2025, to July 12th, 2025. Self-releasing cage with extensions data was from July 13th, 2025 to October 17th, 2025.

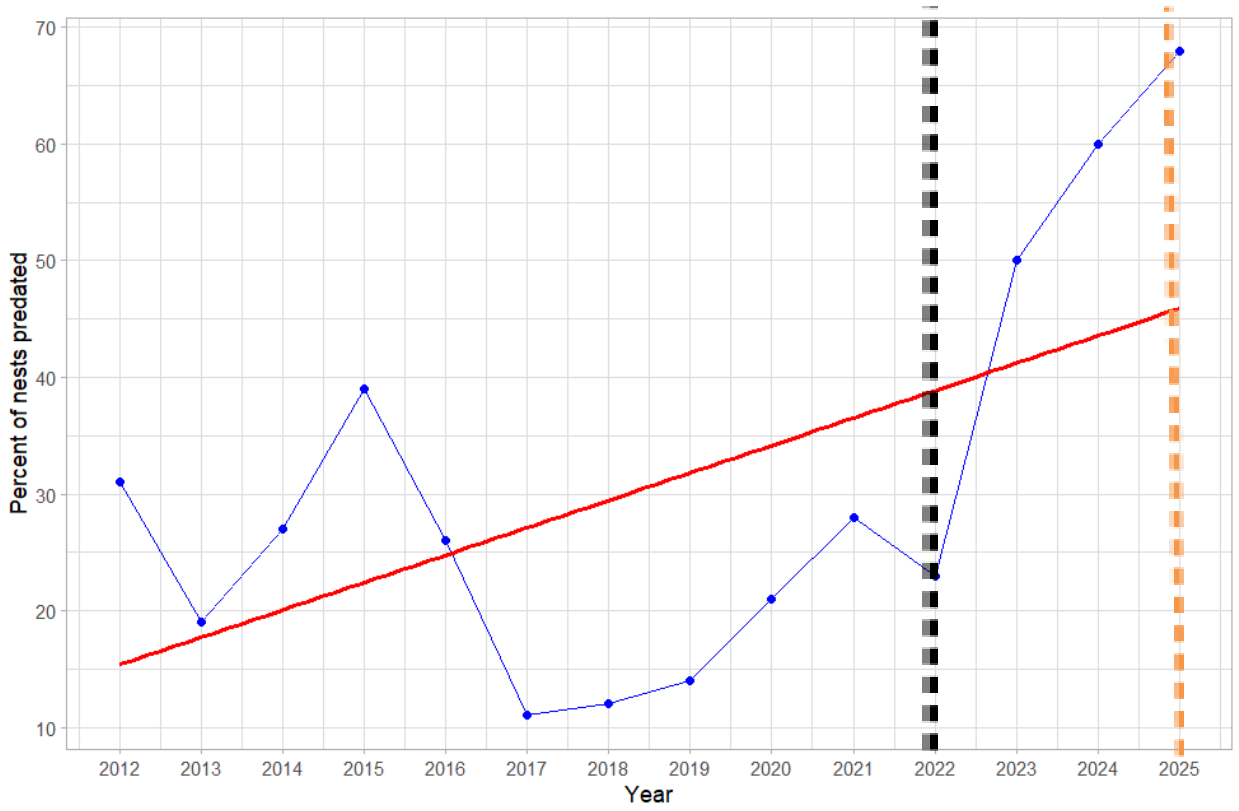


**Figure 7.** Percent of loggerhead nests that experienced a predation event annually from 2012 to 2025. The predation events include partial, complete and attempted predation. The black dotted line indicates when MORAES started screening loggerhead nests. The green dotted line indicates the year MORAES started caging loggerhead nests.

## 4.0 Discussion

Both flat-lying self-releasing screens and self-releasing cages have successfully reduced the rate of raccoon predation on Virginia Key's loggerhead nests. The effectiveness between the two methods were almost identical with a difference of 3% in predation rate. However, there was a difference in the frequency of partial predations and attempts between the two methods. When utilizing the flat-lying screens, nests were partially predated two times more than cages nests because raccoons were able to reach the egg chamber by pulling the wiring apart. Similarly, there were no recorded predation attempts on the screened nest yet caged nests saw 118 attempts. Partially predated nests have been seen to have an increased likelihood of being predated again

and have lower emergence rates (Welicky et al., 2011). Both 2024 and 2025 had significantly lower emergence rates on partially predated nests. 2024's emergence rate for partially predated nests was 56% compared to 79% for unpredated nests. Similarly, 2025's partially predated emergence rate was 32% compared to 74% for unpredated nests. Low emergence rates have been linked to bacteria presence and abundance (Capri et al., 2023; McMaken et al., 2023; Soslau et al., 2011). Therefore, I believe predation introduces bacteria that prevents the remaining eggs from developing properly resulting in a lower emergence rate for partially predated nests (Capri et al., 2023; McMaken et al., 2023; Soslau et al., 2011).

The concentration of nest predation events was similar between 2024 and 2025 nesting seasons. Both seasons saw a high concentration in predation events from jetty 0 to jetty 3 with 2025 having the most successful predation events from jetty 2 to jetty 3 and the most attempts in jetty 0 and jetty 10. Conversely, 2024 had the most successful predation events in jetty 0 and jetty 6. The changes in jetty locations between 2024 and 2025 could be attributed to variation in nesting density at each jetty annually. Once the self-releasing cages were introduced, raccoons took 61 days to figure out how to bypass the cages. A majority of the caged nests that were predated only experienced 1 to 2 attempts before raccoons were successful. The two main methods raccoons used on the cages were sitting on top of the cage digging from above and digging holes around the cage. By sitting on top of the cage, raccoons could weigh down the cages and bend the wiring. Thus, if an egg chamber was shallow enough they could eat a portion or all of the nest. From digging around the cages, raccoons discovered the edges of the cage's flared base and would pull it up to create a hole big enough to fit their body through. Once the raccoon managed to get through the small opening there was nothing protecting the nest, allowing them to eat the entire clutch. Furthermore, the metal stakes were not strong enough to hold the edges of the cages down and were easily pulled out of the sand. Due to this flaw, we lost 8 nests in less than a month and had to figure out how to modify the cages to hold the edges down.

Ultimately, we decided to add vertical extensions to all four sides of the cage. Having the extensions buried in the sand straight up and down would prevent raccoons from being able to pull the extension up. The addition of extensions onto the cages made a drastic difference with only 2 out of 31 nests successfully predated (1 partial and 1 complete predation). Similarly, the two nests that were predated could have been easily avoided. When the extensions were put on

one of the predated nests, the zip ties were placed too far apart allowing raccoons to pull apart the extension and base of the cage. The hole was then big enough for the raccoon to fit through the cage and fully predated the nest. Once we ensured that zip ties were placed close together when connecting the extensions there were no situations where raccoons were able to pull the cage away from the extension. The other issue we faced with adding the extensions was some raccoons figured out there were gaps at each corner where they could locate the end of the extension and pull it up to create an opening big enough to fit through. To remedy this, when we dug the trenches around the cage to attach the extensions we placed large heavy rocks on all four sides to weigh the corners down. Additionally, by burying the rocks in the ground we prevented hatchling from disorienting or becoming trapped under the rocks. In the future it may be beneficial to cut the extensions longer than the cage's width so all four corners of the extensions could be connected. Yet I still believe because the cage wiring is easily manipulated the additional weight from the rocks prevents raccoons from creating any opening. After fixing those two minor issues, we experienced 36 predation attempts with no successful attempts on the remaining nests.

While I do believe the extensions made the biggest difference in protecting loggerhead nests, the removal of 175 raccoons in areas where we were experiencing the highest concentration of predation did seem to alleviate some of the predation pressures. Globally, non-native and native predators are one of the leading causes of sea turtle nest mortality (Butler et al., 2020; Fuentes et al., 2023). Both non-native and native predators can have severe impacts on sea turtle nest success (Butler et al., 2020). However, predator management for native species is more complex compared to non-native management (Butler et al., 2020; Engeman et al., 2016). Native species serve a purpose in the ecosystems thus complete removal cannot be performed to protect sea turtle nests (Barton & Roth, 2008; Butler et al., 2020; Engeman et al., 2016). Raccoons are native to Virginia Key and are vital for controlling invasive iguana populations thus permanent removal is not feasible (Meshaka et al., 2009). However, with no natural predators on Virginia Key to control raccoon populations, occasional partial relocation in addition to caging sea turtle nests may be needed to maintain a healthy ecosystem and reduce predation pressures on sea turtle nests (Barton & Roth 2008; Engeman et al., 2012; Meshaka et al., 2009).

Important factors to consider when analyzing nest predation rates are nesting volume and predator population (Engeman et al., 2012). Having an extremely high nesting volume in a

location where nest predators are present is more beneficial because predators are unable to prey on a significant amount of nests resulting in a low predation rate (Engeman et al., 2012). Conversely, an area with a low nesting volume will experience heavier predation pressures and higher predation rates because each nest represents a larger proportion of the total (Engeman et al., 2005; Engeman et al., 2012). Similarly, predator abundance is going to have a bigger impact on locations with fewer nests (Engeman et al., 2005; Engeman et al., 2012). For example, Engeman et al (2002) analyzed nest predation at two different locations on Jupiter Island, Florida, Hobe Sound National Wildlife Refuge (HSNWR) and Saint Lucie Inlet Preserve State Park (SLIPSP). During this study, HSNWR saw a 9.4% predation rate on 1062 nests compared to SLIPSP which had a 53% predation rate on 287 nests. Overall, areas with lower nesting volumes do lose fewer eggs/hatchlings compared to areas with higher nesting volumes (Engeman et al., 2002; Engeman et al., 2012). However, that does not mean areas with fewer nests should not receive adequate predator management (Engeman et al., 2002).

Most North American beaches that experience nest predation use some form of anti-predation method with varying success rates (Antworth et al., 2006; Butler et al., 2020; Ratnaswamy et al., 1977). Antworth et al., (2006) found that once Canaveral National Seashore, Florida had a 99.7% screening effort, nest predation dropped to 5%. Compared to a previous year with a 10% screening effort resulting in 65% predation rate (Antworth et al., 2006). As a result, nest predation rates are dependent on screening efforts (Antworth et al., 2006). However, some locations in the southeast United States experience substantial predation rates even with anti-predation methods (Butler et al., 2020; FWC, 2024). From 2009 to 2018, 12 of Georgia's barrier islands experienced an average predation rate of around 13% while utilizing screens (Butler et al., 2020). Native raccoons had the second highest predation rate making up around 36% of total egg loss (Butler et al., 2020). Butler et al., (2020) stated that over the 12 years, raccoons were responsible for the loss of 30,988 eggs. 13% may not seem like a high percentage however because sea turtles face many anthropogenic and ecological threats, mitigating egg loss can aid population recovery (Mazaris, et al., 2006). Therefore, it may be beneficial for places like Georgia's barrier islands to implement this study's method of utilizing self-releasing cages with extensions. Especially in places where raccoon removal is not possible due to ecological or financial implications (Barton & Roth, 2008; Engeman et al., 2016; Ratnaswamy et al., 1977; Meshaka et al., 2009).

Night surveys could also improve predator management by increasing screening effort ensuring most if not all nests are screened/caged (Antworth et al., 2006; Miller, 1999). In order for a nest to be caged, the FWC requires surveyors to locate the egg chamber (FWC, 2016). However, female sea turtles camouflage their nests through sand scattering with some species even creating decoy nests to confuse predators (Burns et al., 2020; Miller, 1997). As a result, locating the egg chamber during morning surveys is more tedious because surveyors have to find the egg chamber based on visually analyzing crawls (FWC, 2016). Similarly, some nests may not have obvious signs of nesting and get labeled as a false crawl reducing the number of nests screened (FWC, 2016). Therefore, performing night surveys where surveyors follow nesting females to mark their egg chamber ensures that a higher percentage of nests are being caged and protected (Antworth et al., 2006; Miller, 1999). Additionally, carrying out night surveys would make morning surveys easier because surveyors would only have to focus on installing screens and cages which can be time-consuming and labor-intensive (Engeman et al., 2016; Ratnaswamy et al., 1977).

## 5.0 Conclusions

Overall, the purpose of this study was to analyze the effectiveness of using self-release cages to protect sea turtle nests on Virginia Key. Through this study I created a modified self-releasing cage that provides extra protection to sea turtle nests without causing harm to predators or hatchlings. Raccoons are incredibly intelligent animals thus predator management programs in places like Virginia Key have to constantly monitor and adapt predator control plans to remain effective. The addition of self-releasing cages with extensions has proven to have a high success rate at protecting sea turtle nests on Virginia Key. I would highly recommend that other beaches struggling with high predation rates utilize self-releasing cages with extensions, as they add additional protection and anchor cages down more compared to metal stakes.

The only caveat to this method is constructing and deploying cages with extensions can be seen as labor-intensive and time-consuming, which could create issues for beaches with a higher nesting volume. However, this could open the door for community projects to be held before and throughout the season where volunteers can help build self-releasing cages and extensions. Similarly, because the installation can be labor-intensive the need for nesting survey volunteers will increase. However, that creates an opportunity for more locals to get involved in sea turtle conservation.

## 6.0 References


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## 7.0 Appendices


**Figure 8.** Photograph of the first version of a self-releasing cage after installment.


**Figure 9.** Photograph of the flat lying self-releasing screen after installment.


**Figure 10a.** Photograph of the second version of a self-releasing cage after adding extensions.

**Figure 10b.** Photograph of the second version of a self-releasing cage adding rocks to the corners.


**Figure 10c.** Photograph of the second version of a self-releasing cage covering up extensions and rocks.