



# Sea Turtle Monitoring and Management at Cape Lookout National Seashore

## *2023 Annual Report*

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Leatherback sea turtle hatchling on the beach at Cape Lookout National Seashore. Photo credit: NPS.

## **Acknowledgments**

We would like to thank our field staff employees Chelsey Stephenson, Karen Altman, Patrick Carr Samantha Pepe, Rachael Rankin and Gabrianna Lucas; Scientist-In-Parks interns Andrea Knapp and Alanna Richman, for their efforts monitoring and protecting sea turtles at Cape Lookout National Seashore.

## Abstract

Cape Lookout National Seashore (Seashore), located on the southern Outer Banks of North Carolina from Ocracoke Inlet to Beaufort Inlet, contains many ecologically important habitats including those that support threatened and endangered sea turtle species. Sea turtle nesting activity is monitored annually from May through September. In 2023, 325 nests (300 loggerhead, 19 green, 5 leatherback and 1 Kemp's ridley) and 414 false crawls were documented at the seashore. The first nesting activity was documented on May 6, 2023, and the last nesting activity was documented on September 7, 2023. The mean clutch size was 112 eggs. Mean hatch success for all nests was 56% while mean emergence success was 52%. Mean incubation was 60 days. Erosion, flooding and sand accretion from significant storm and tide events, tropical cyclones Franklin, Idalia, Lee and Ophelia, resulted in 39 nests being washed away and another 155 nests over washed and/or submerged. The seashore documented 148 stranded sea turtles in 2023.

## Introduction

Cape Lookout National Seashore (CALO) was established to preserve the natural resources of a natural barrier island system off the North Carolina coast from Ocracoke Inlet to Beaufort Inlet. CALO's 56 miles of shoreline is informally divided into three management units and the configuration of these units is subject to ocean overwash and inlet formation. North Core Banks (NCB) is approximately 23 miles long extending from Ocracoke Inlet to Ophelia Inlet. In 2023, NCB was divided into two islands by Evergreen Inlet at mile 3. These two islands are included together as part of the NCB management unit for data collection and analysis purposes. South Core Banks (SCB) extends southward from Ophelia Inlet almost 24 miles to Barden Inlet. The Core Banks have a northeast to southwest orientation and exhibit a low-profile landscape. The Core Banks face east toward the Atlantic Ocean and toward the Pamlico and Core Sounds on the west side. The third unit, Shackleford Banks (SB) is 9 miles long and has an east-west orientation with a higher dune system and larger areas of vegetation. Shackleford Banks face south towards the Atlantic Ocean and the Back Sound on the north side.

CALO contains ecologically important habitats, such as beaches, estuarine waters, and submerged aquatic vegetation that are important to sea turtles. CALO is a significant northern nesting beach and supports among the highest number of loggerhead sea turtle (*Caretta caretta*) nests in North Carolina. CALO also provides nesting habitat for leatherback (*Dermochelyes coriacea*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles. The hawksbill (*Eretmochelys imbricata*) is only known to have stranded on the seashore. The leatherback, Kemp's ridley, and the hawksbill are listed under the Endangered Species Act as endangered and the loggerhead and green as threatened.

CALO began monitoring marine turtles in 1976. Baseline data was collected for a portion of South Core Banks during an extensive six-year study from 1978 – 1983. Nesting turtles were tagged, and nests marked during nightly patrols. Since 1984, CALO has conducted daytime monitoring to document nesting activity, strandings, protect nest sites, relocate nests in danger of being lost and

protect hatchlings. In 1990 the seashore adopted the USFWS Index Nesting beach program to standardize monitoring. Sea turtle monitoring and management at CALO follows management guidelines defined by the North Carolina Wildlife Resources Commission (NCWRC) in the *Handbook for Sea Turtle Volunteers in North Carolina (NCWRC.2006)*, U.S. Fish & Wildlife Service (USFWS) species recovery plans (NMFS and USFWS 1991, 1992, 1993, 2008; NMFS, USFWS, and SEMARNAT 2011) and the Cape Lookout National Seashore Interim Protected Species Management Plan (NPS 2006).

CALO is a popular recreation destination and attracts hundreds of thousands of visitors annually. Recreational activities include fishing, shelling, hunting, wildlife viewing, boating, beach recreation, surfing, photography, nature study, and off-road vehicle (ORV) use on the beaches. Sea turtles are affected by human disturbances, habitat loss, and predation. Human disturbance, both direct and indirect, may result in nest or hatchling loss. Depredation by mammals, birds, and ghost crabs have influenced the success of nests and hatchling emergence at CALO, as well. CALO monitors and manages sea turtles, habitat, and predators to promote successful reproduction to achieve population recovery of declining species. Sea turtle nests and hatching events are protected with closures, buffers, and regulations.

### **Cape Lookout National Seashore Off-road Vehicle Management Plan**

The 2016 Cape Lookout National Seashore Off-road Vehicle Management Plan (ORVMP) establishes ORV management practices and procedures and provides requirements on monitoring and managing protected species at CALO (NPS 2016). The ORV Plan includes establishment of temporary nesting closures, buffer distances, and wildlife protection zones. In 2021, the seashore implemented a paid permit requirement for ORV users to drive on the beach. ORV users must sign the permit attesting to their understanding of the ORV routes, rules, and management for protected species. Resource management staff record and report resource violation they observe throughout the breeding season.

### **Cooperating Agencies and Organizations**

The Seashore cooperates with numerous agencies on sea turtle protection, including the North Carolina Wildlife Resources Commission (NCWRC), the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS). The North Carolina Sea Turtle Program Coordinator receives all original stranding reports and annual nesting activity reports. NCWRC also receives all nesting activity data through the [seaturtle.org](http://seaturtle.org) website. NCWRC, under the authority of the USFWS, issues the Seashore an Endangered Species permit for the relocation of nests as well as the possession and disposition of stranded marine turtles. The Center for Marine Sciences and Technology receives, evaluates, stabilizes, and arranges longer term care of live stranded sea turtles found on the Seashore. The Karen Beasley Sea Turtle Rescue and Rehabilitation Center, the Pine Knolls Shore and Roanoke Island Aquariums receive and rehabilitates these live stranded sea turtles found on the Seashore.

The University of Georgia analyzes and reports results of an ongoing genetic mark recapture population demographics study within North Carolina, South Carolina, and Georgia of the

loggerhead Northern Recovery Unit. The US Geological Survey (USGS) sea turtle team conducts research on nesting, foraging and migratory behavior of sea turtles by satellite tagging nesting female turtles within the Seashore and tracking their seasonal movements. In a cooperative effort, Duke Marine Laboratory students and NPS staff developed a pilot night recreation study.

The United States Department of Agriculture's Wildlife Services (WS) conducts predator removal targeting coyotes and raccoons to benefit nesting sea turtles.

## Methods

### Nest Monitoring and Management

Following the Cape Lookout National Seashore ORVMP, staff patrolled NCB (from Evergreen Inlet to Ophelia Inlet) and SCB daily searching for nesting activity from May 1 to September 15, 2023. Each patrol began early in the morning so that the island was checked for turtle activity by 12:00 PM. Shackleford Banks and NCB north of Evergreen Inlet to Ocracoke Inlet were monitored three times a week. Sea turtle crawl activities were recorded as nests if eggs were confirmed; as possible nests if eggs were not located but appeared to be a nest crawl; or as a false crawl, a non-egg laying emergence. Each activity location was recorded in decimal degrees using a Geographic Information System (GIS). Nest and possible nests were marked with two 2-inch, 4-foot PVC poles. One located 2 feet in front (oceanside) of the egg chamber and the other 3 feet behind (or dune side) from egg chamber according to protocol (Appendix 1). In 2023, the seashore continued to participate in a genetic mark-recapture study of nesting female loggerheads using DNA derived from eggs. The study was coordinated by the NCWRC for North Carolina and included the other Northern Recovery Unit states of Georgia and South Carolina. One egg from each nest was collected and preserved so DNA could be analyzed at the University of Georgia genetic laboratory. As part of this study sea turtle crawl and nest activity was entered into an online database at [www.seaturtle.org](http://www.seaturtle.org).

Nest losses to tidal flooding, erosion and predation are the primary threats to nesting success at CALO. Nests laid in the tidal wash zone, primary berm, and back swale are considered in danger of erosion or tidal flooding. Nests laid in locations subject to repeated flooding were relocated to a higher elevation on the primary dune in accordance with the NCWRC *Handbook for Sea Turtle Volunteers in North Carolina* (2006). Relocated nests were moved into the nearest of six designated areas. At day 50 of incubation, or earlier if hatching activity is observed, vehicles were detoured to the back road around areas where nests were located on the primary dunes. Vehicle detours were also erected around nests that were on the beach where vehicles could pass 15 feet directly behind, or dune ward of the nest. Vehicle free zones provide a rut-free corridor from the nest site to the ocean, preventing hatchlings from being run over or becoming entrapped in tire ruts and dying from predation or desiccation (Hosier et al. 1981, Lamont et al. 2002, Van de Merwe et al. 2012). Camping and campfires are not permitted in the protection zones to prevent disturbance of hatchlings by artificial lights (Peters and Verhoeven, 1994); however, camping and campfires are permitted within the seashore and sometimes occur within close proximity of sea turtle nesting and hatching activities. Any signs of disorientation and number of affected hatchlings were recorded.

Signs of predation were documented, and the approximate numbers of eggs or hatchlings affected were recorded. To discourage raccoon (*Procyon lotor*) and coyote (*Canis latrans*) predation, plastic screens anchored by rebar were placed over all nests. Nests and possible nests were monitored for hatching activity through November. Nests were excavated at 5 days after hatching to determine nest success. Possible nests were treated similarly. If a possible nest hatched it was added to the nest category, if it failed to show hatching activity after 75-80 days the site was excavated, then classified as a nest if eggs were found or as a false crawl if no eggs were found.

### Stranding Activity

Collecting information from stranded turtles is also an important phase of the Seashore Sea Turtle Monitoring Program. The Seashore documents both live and dead strandings, collects data for the NCWRC Sea Turtle Project Coordinator and the National Marine Fisheries Service (NMFS) and assists in the transportation of live strandings to rehabilitation facilities. Live strandings are immediately reported to the NCWRC to coordinate transport to a wildlife veterinarian at the Center for Marine Sciences and Technology. Cold weather patterns and soundside water temperatures in the winter months of November through January can trigger live strandings of hypothermic (“cold stunned”) sea turtles. Based on winter weather conditions searches for cold stunned sea turtles were prioritized at the Cape Lookout Bight shoreline, inlet shorelines, and other exposed soundside shorelines where cold stunned turtles have been found in the past.

## Results

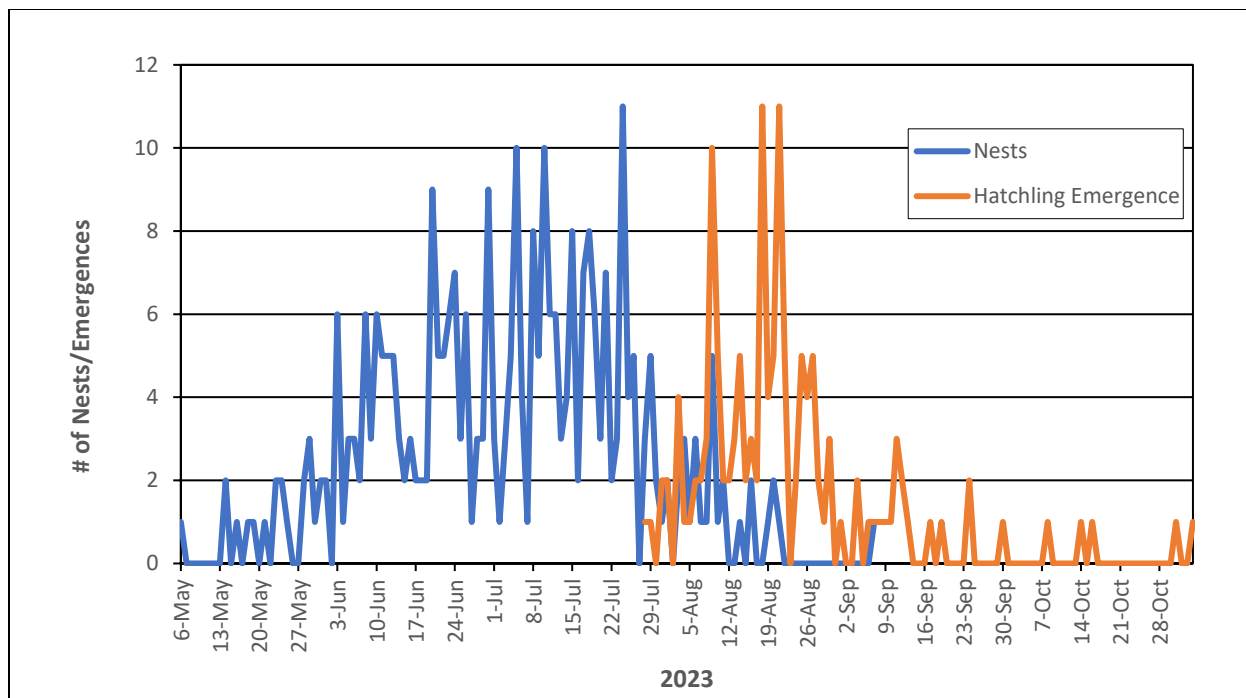
### Nest Monitoring and Management

The first recorded nesting activity in 2023 was on May 6 and the last on September 7, for a 124-day nesting season. A total of 739 activities were documented of which there were 325 nests and 414 false crawls. South Core Banks continued to have the most nests with 149, followed by North Core Banks with 145 and Shackleford Banks with 31 (Table 1.). There were 300 loggerhead nests, 19 green nests, 5 leatherback nests and 1 Kemp’s ridley nest. Figure 1. illustrates the daily nesting activity for the season along with hatching activity. Mapped original nest locations can be found in Appendix A.

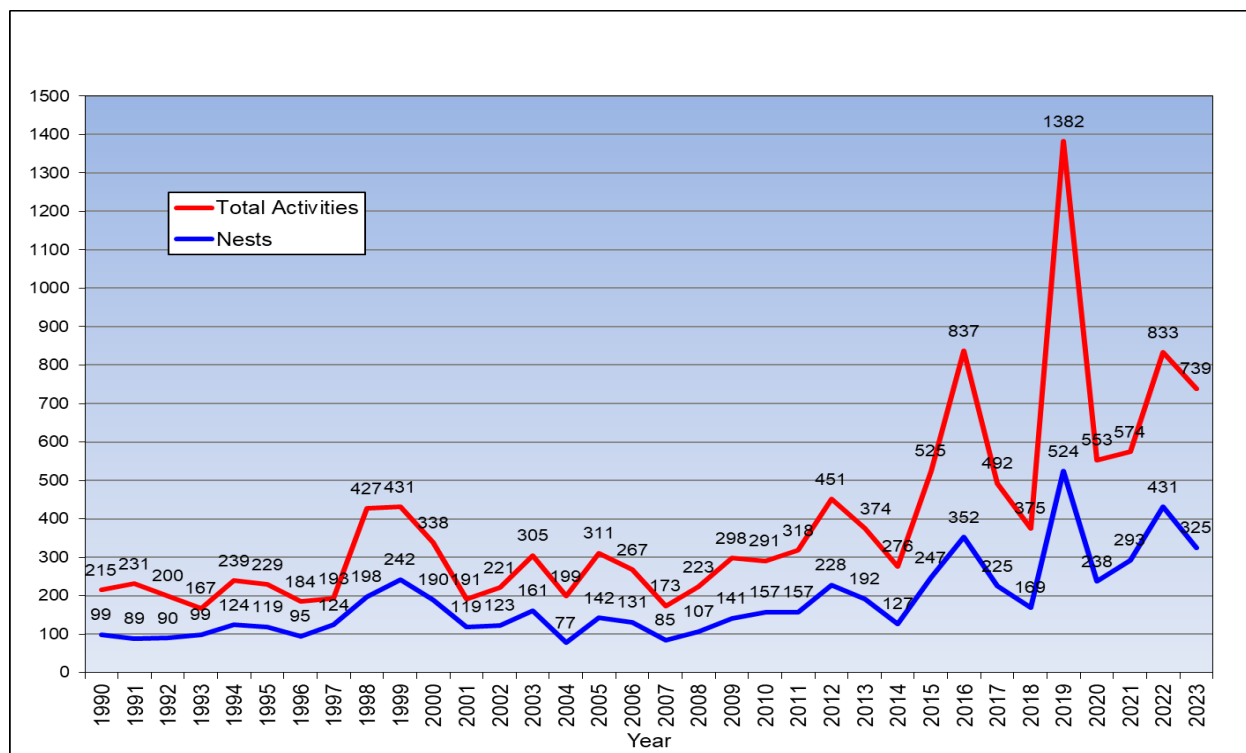
The 2023 nesting season was the fourth highest on record with 325 nests. 2019 remains the highest year with 525 nests. Nesting in 2023 was also above the annual average of 183 nests for CALO (Figure 2 and 3).

**Table 1.** Sea Turtle Activities by Study Area in 2023.

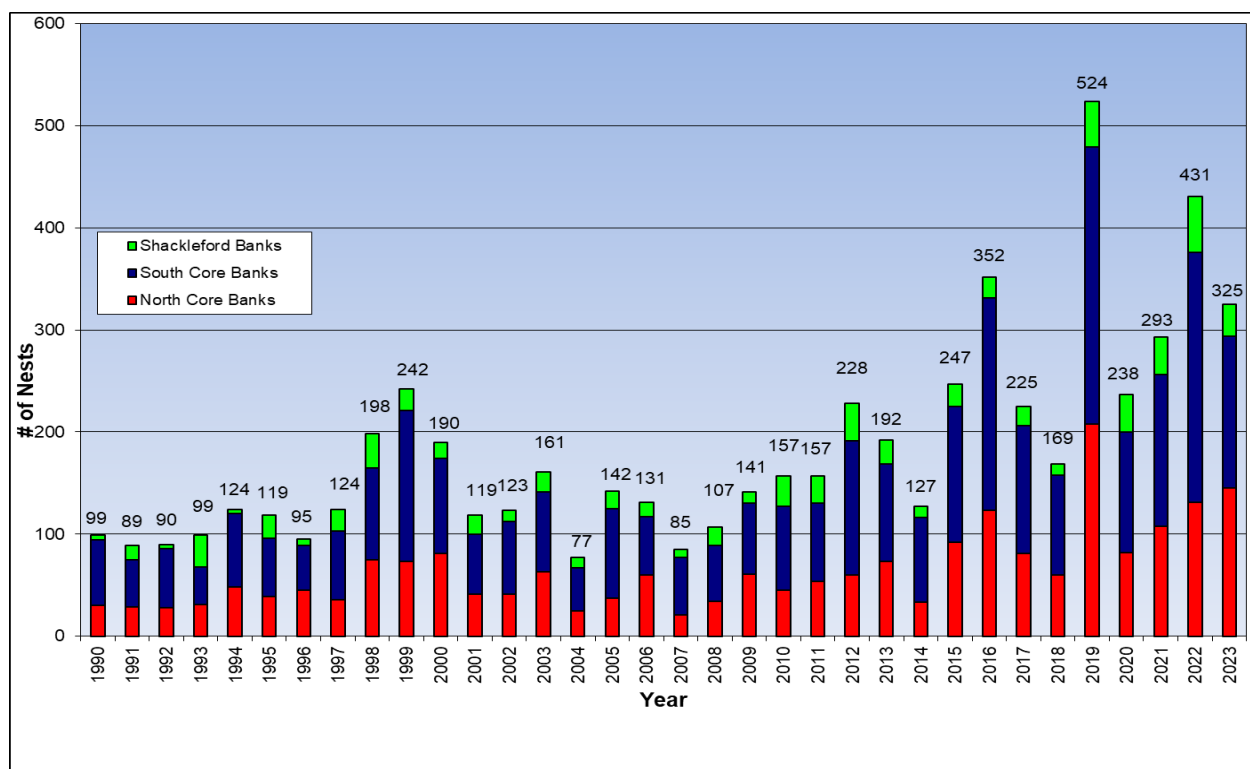
|                  | North Core Banks | South Core Banks | Shackleford Banks | Seashore Total |
|------------------|------------------|------------------|-------------------|----------------|
| Nests            | 145              | 149              | 31                | 325            |
| Crawls           | 168              | 237              | 9                 | 414            |
| Total Activities | 313              | 386              | 40                | 739            |



**Figure 1.** The daily number of nests at 7day increments, May 6 to September 7 and hatchling emergence, July 28 to November 3.



**Figure 2.** Cape Lookout National Seashore Sea Turtle Activities, 1990-2023.



**Figure 3.** Cape Lookout National Seashore Sea Turtle Nests, 1990-2023.

## Hatching

The nest hatching period for 2023 began July 28 and ended November 3, a total of 99 days. The last nest was inventoried on November 29, 2022, on North Core Banks. A known total of 29,143 eggs, 16,299 hatchlings, and 1,294 hatched dead were counted. The total hatch success, number of total hatched eggs divided by number of total eggs, was 56%. The total emergence success of 52% (15,025 emerged) was calculated by subtracting the total hatched dead from the total hatched and dividing by the total number of eggs (Table 2). Live released hatchlings are considered emerged to be consistent with the long-term data set. The emergence success range for an individual nest ranged from 0% to 99%. The average clutch size was 112 eggs. It took an average of 60 days for nests to incubate to emergence. The range of incubation was from 51 days to 87 days. Thirty-nine nests were lost to erosion events, including high surf created by King tides and offshore tropical systems Idalia, Franklin, and Ophelia. A total of 155 nests were over-washed by the ocean at least once. Seventy-nine of these 155 nests hatched. The emergence success for these flooded nests was 32%. Twenty-one nests were over-washed after they were relocated.

In 2023, a total of 26 (8%) nests were relocated. The emergence rate for relocated nests was 23% and the emergence rate for insitu nests was 55% (Table 3). The percent of nest inventoried was 79%, 258 of the 325 nests were inventoried and 67 nests were washed away, buried deeply, or predated with an unknown egg count and/or unknown success. Since 1990, the thirty-three-year average emergence success is 63% for relocated nests and 63% for non-relocated nests (Table 3).



**Table 2.** Sea Turtle Hatch Summary, 1990-2023.

| Year | Nests | Mean Clutch | Flooded | Mean Incubation | Eggs   | Emerged | Emergence % |
|------|-------|-------------|---------|-----------------|--------|---------|-------------|
| 1990 | 99    | 115         | 1       | 57              | 10,376 | 7,369   | 71%         |
| 1991 | 89    | 115         | 6       | 62              | 8,393  | 5,197   | 62%         |
| 1992 | 90    | 114         | 4       | 63              | 9,419  | 6,791   | 73%         |
| 1993 | 99    | 115         | 9       | 59              | 10,365 | 7,544   | 74%         |
| 1994 | 124   | 120         | 3       | 62              | 14,459 | 11,296  | 79%         |
| 1995 | 119   | 115         | 38      | 57              | 12,357 | 6,157   | 51%         |
| 1996 | 95    | 115         | 16      | 65              | 10,091 | 5,602   | 57%         |
| 1997 | 124   | 122         | 3       | 63              | 14,824 | 10,740  | 73%         |
| 1998 | 198   | 114         | 39      | 62              | 19,672 | 13,315  | 69%         |
| 1999 | 242   | 116         | 90      | 62              | 23,224 | 11,751  | 53%         |
| 2000 | 190   | 111         | 2       | 67              | 19,527 | 13,471  | 69%         |
| 2001 | 119   | 113         | 5       | 65              | 12,358 | 9,555   | 79%         |
| 2002 | 123   | 119         | 7       | 61              | 13,657 | 10,758  | 79%         |
| 2003 | 161   | 119         | 45      | 65              | 16,440 | 10,067  | 61%         |
| 2004 | 77    | 104         | 36      | 64              | 7,309  | 3,139   | 43%         |
| 2005 | 142   | 111         | 54      | 60              | 12,423 | 6,569   | 53%         |
| 2006 | 131   | 125         | 19      | 61              | 14,808 | 10,843  | 73%         |
| 2007 | 85    | 109         | 19      | 60              | 8,759  | 6,326   | 72%         |
| 2008 | 107   | 111         | 60      | 60              | 11,063 | 6,868   | 62%         |
| 2009 | 141   | 116         | 77      | 64              | 15,130 | 7,574   | 50%         |
| 2010 | 157   | 105         | 80      | 57              | 14,666 | 7,956   | 54%         |
| 2011 | 157   | 114         | 30      | 56              | 12,910 | 8,186   | 63%         |
| 2012 | 228   | 111         | 84      | 62              | 25,293 | 16,188  | 64%         |
| 2013 | 192   | 108         | 35      | 64              | 19,744 | 13,409  | 68%         |
| 2014 | 127   | 114         | 52      | 65              | 13,077 | 7,028   | 54%         |
| 2015 | 247   | 112         | 121     | 59              | 26,160 | 14,935  | 57%         |
| 2016 | 352   | 107         | 109     | 55              | 36,047 | 23,169  | 64%         |
| 2017 | 225   | 111         | 102     | 62              | 22,292 | 14,070  | 63%         |
| 2018 | 169   | 111         | 45      | 60              | 14,542 | 8,654   | 60%         |
| 2019 | 524   | 114         | 247     | 60              | 46,141 | 24,378  | 53%         |
| 2020 | 238   | 111         | 94      | 58              | 22,507 | 12,758  | 57%         |
| 2021 | 293   | 118         | 169     | 61              | 32,356 | 19,237  | 57%         |
| 2022 | 431   | 112         | 139     | 61              | 43,216 | 30,874  | 68%         |
| 2023 | 325   | 112         | 155     | 60              | 29,143 | 15,025  | 52%         |

**Table 3.** Emergence Success for Relocated versus Non-Relocated Nests, 1990-2023.

| Year | Percent of Nests Relocated | Emergence Rate Relocated | Emergence Rate Non-Relocated | Percent of Nests Inventoried |
|------|----------------------------|--------------------------|------------------------------|------------------------------|
| 1990 | 69%                        | 71%                      | 74%                          | 94%                          |
| 1991 | 63%                        | 57%                      | 76%                          | 97%                          |
| 1992 | 43%                        | 71%                      | 76%                          | 97%                          |
| 1993 | 54%                        | 74%                      | 73%                          | 90%                          |
| 1994 | 79%                        | 80%                      | 73%                          | 96%                          |
| 1995 | 55%                        | 61%                      | 38%                          | 86%                          |
| 1996 | 73%                        | 56%                      | 64%                          | 89%                          |
| 1997 | 74%                        | 69%                      | 86%                          | 95%                          |
| 1998 | 59%                        | 77%                      | 55%                          | 85%                          |
| 1999 | 51%                        | 49%                      | 59%                          | 79%                          |
| 2000 | 63%                        | 66%                      | 74%                          | 93%                          |
| 2001 | 50%                        | 81%                      | 76%                          | 89%                          |
| 2002 | 45%                        | 73%                      | 84%                          | 93%                          |
| 2003 | 41%                        | 47%                      | 75%                          | 86%                          |
| 2004 | 44%                        | 63%                      | 23%                          | 97%                          |
| 2005 | 34%                        | 42%                      | 61%                          | 79%                          |
| 2006 | 39%                        | 85%                      | 64%                          | 90%                          |
| 2007 | 24%                        | 79%                      | 70%                          | 95%                          |
| 2008 | 30%                        | 57%                      | 64%                          | 92%                          |
| 2009 | 25%                        | 61%                      | 46%                          | 92%                          |
| 2010 | 13%                        | 75%                      | 51%                          | 89%                          |
| 2011 | 27%                        | 36%                      | 78%                          | 62%                          |
| 2012 | 22%                        | 74%                      | 61%                          | 99.5%                        |
| 2013 | 28%                        | 61%                      | 71%                          | 95%                          |
| 2014 | 29%                        | 69%                      | 46%                          | 90%                          |
| 2015 | 16%                        | 54%                      | 58%                          | 94%                          |
| 2016 | 26%                        | 60%                      | 66%                          | 96%                          |
| 2017 | 31%                        | 64%                      | 62%                          | 89%                          |
| 2018 | 26%                        | 53%                      | 63%                          | 71%                          |
| 2019 | 9%                         | 57%                      | 52%                          | 77%                          |
| 2020 | 10%                        | 66%                      | 55%                          | 84%                          |
| 2021 | 10%                        | 67%                      | 56%                          | 94%                          |
| 2022 | 10%                        | 65%                      | 68%                          | 90%                          |
| 2023 | 8%                         | 23%                      | 55%                          | 79%                          |
| Mean | 38%                        | 63%                      | 63%                          | 89%                          |

## **Predation**

Staff recorded total or partial nest predation by coyotes, raccoons, and ghost crabs in 2023. Coyotes predated a total of 30 nests (9%), 24 on SCB and 6 on Shackleford. No nests were recorded to have coyote predation on NCB; however, racoon predation was documented at eight nests. No racoon predation was documented on SCB or SB. Ghost crab predation was documented at both NCB and SCB affecting a minimum of 10 nests.

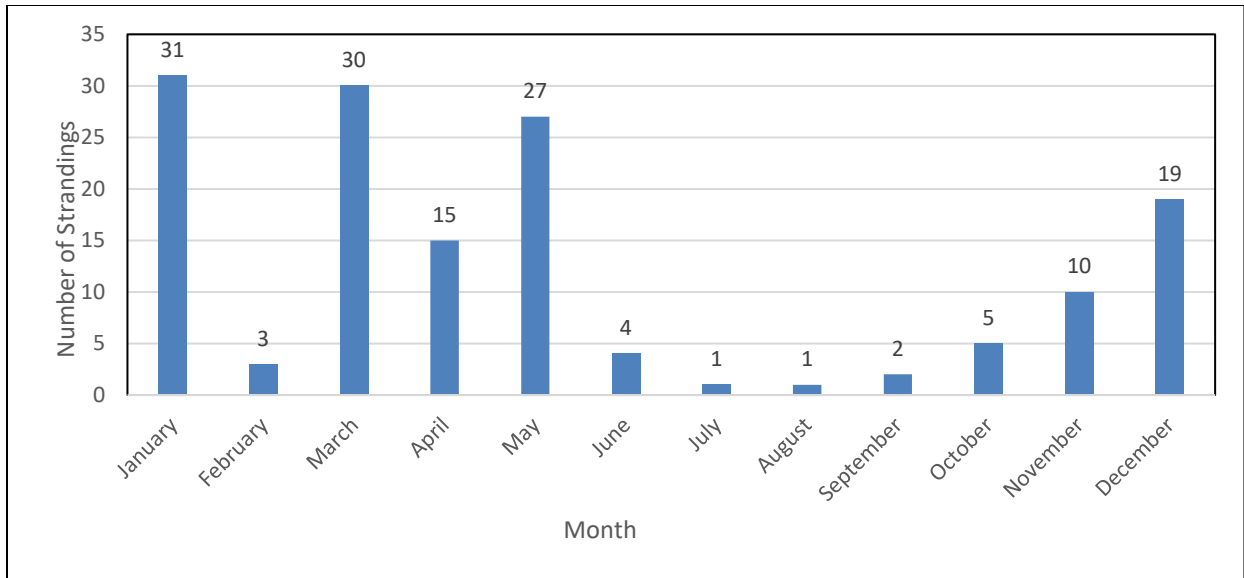
In 2017, CALO entered into annual interagency agreements with the United States Department of Agriculture's Wildlife Services (WS) to conduct predator removal targeting coyotes and raccoons to benefit nesting sea turtles. WS continued predator trapping only on SCB in 2023. A total of four coyotes and eight raccoons were removed. Since 2017, WS has removed a total of 48 coyotes and 189 raccoons from CALO.

## **Human Disturbance**

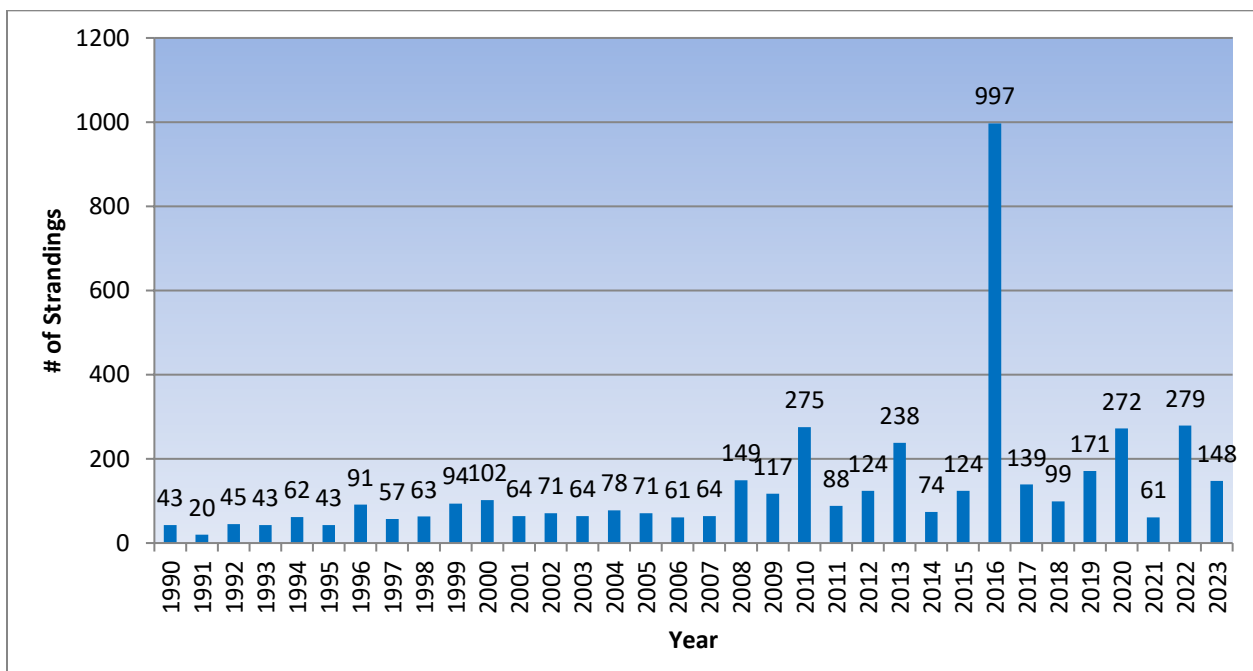
Off-road vehicles disregarding beach closures threaten the survival of nests and hatchlings. Hatchlings are at risk of being directly crushed and/or becoming trapped in tire ruts. At night, vehicle and other artificial lights from beach camps, cabins and beach fires could disorientate hatchlings (Cox et al., 1994). In 2023 there were 39 vehicle violations of turtle closures documented. Twenty-nine nests had disorientated hatchling tracks recorded with a total of 683 hatchlings impacted.

## **Strandings**

One hundred forty-eight strandings were documented in 2023. All strandings were reported to the NCWRC and were documented with a "Sea Turtle Stranding and Salvage Network" stranding report. Green turtles accounted for the majority of the strandings with 114 reports. There were also 18 Kemp's ridleys, 14 loggerheads and 1 unknown. Twenty-three were stranded on the inshore (sound side) of the island and 125 turtles were stranded on the offshore (oceanside) of the island. It should be noted that the line of demarcation separating sound and oceanic waters lies at the Cape Lookout lighthouse. Backside waters north of the lighthouse are considered inshore and all waters to the south are oceanic. Beaches associated with the Cape Lookout Bight and Power Squadron Spit are considered oceanside. There were 35 live strandings, which occurred primarily around two cold stun events in January and March. Cold stunned turtles were transported out of the park, assessed by wildlife veterinarians at the NC State Center for Marine Sciences and Technology, and then sent to The Karen Beasley Sea Turtle Rescue and Rehabilitation Center, NC Aquarium at Pine Knolls Shores or to the Sea Turtle Assistance and Rehabilitation (STAR) Center located at the NC Aquarium at Roanoke Island for rehabilitation. All stranded turtles were scanned for external and Passive Integrated Transponder (PIT) tags. Only one tag recapture was found in 2023. Figure 4, Figure 5, and Table 4 provide stranding data by year and species from 1990 to 2023. Appendix A Map 2 illustrates stranding locations in the seashore.



**Figure 4.** Sea Turtle Strandings at Cape Lookout National Seashore by Month, 2023.



**Figure 5.** Sea Turtle Stranding Totals at Cape Lookout National Seashore, 1990-2023.

**Table 4.** Cape Lookout National Seashore Sea Turtle Strandings, 1990-2023.

| Year | Stranding Totals | Logger-head | Green | Kemps's Ridley | Leather-back | Hawksbill | Unknown |
|------|------------------|-------------|-------|----------------|--------------|-----------|---------|
| 1990 | 43               | 33          | 7     | 1              | 2            | 0         | 0       |
| 1991 | 20               | 16          | 2     | 1              | 0            | 0         | 1       |
| 1992 | 45               | 30          | 13    | 1              | 1            | 0         | 0       |
| 1993 | 43               | 29          | 6     | 5              | 2            | 0         | 1       |
| 1994 | 62               | 30          | 24    | 5              | 2            | 0         | 1       |
| 1995 | 43               | 27          | 7     | 6              | 1            | 0         | 2       |
| 1996 | 91               | 63          | 21    | 4              | 3            | 0         | 0       |
| 1997 | 57               | 49          | 1     | 7              | 0            | 0         | 0       |
| 1998 | 63               | 43          | 8     | 12             | 0            | 0         | 0       |
| 1999 | 94               | 36          | 41    | 15             | 2            | 0         | 0       |
| 2000 | 102              | 46          | 40    | 11             | 4            | 0         | 1       |
| 2001 | 64               | 38          | 15    | 9              | 2            | 0         | 0       |
| 2002 | 71               | 33          | 26    | 5              | 7            | 0         | 0       |
| 2003 | 64               | 44          | 9     | 7              | 2            | 1         | 1       |
| 2004 | 78               | 45          | 28    | 4              | 1            | 0         | 0       |
| 2005 | 71               | 37          | 21    | 6              | 0            | 2         | 5       |
| 2006 | 61               | 35          | 16    | 8              | 0            | 0         | 2       |
| 2007 | 64               | 19          | 38    | 1              | 0            | 0         | 6       |
| 2008 | 149              | 29          | 116   | 2              | 0            | 0         | 3       |
| 2009 | 117              | 36          | 66    | 14             | 0            | 0         | 1       |
| 2010 | 275              | 131         | 116   | 27             | 0            | 0         | 0       |
| 2011 | 88               | 18          | 44    | 26             | 0            | 0         | 0       |
| 2012 | 124              | 25          | 73    | 25             | 1            | 0         | 0       |
| 2013 | 238              | 26          | 187   | 23             | 1            | 0         | 1       |
| 2014 | 74               | 24          | 32    | 17             | 0            | 0         | 1       |
| 2015 | 124              | 23          | 78    | 21             | 1            | 0         | 1       |
| 2016 | 997              | 40          | 938   | 12             | 2            | 0         | 5       |
| 2017 | 139              | 10          | 113   | 13             | 3            | 0         | 0       |
| 2018 | 99               | 20          | 57    | 15             | 1            | 0         | 5       |
| 2019 | 171              | 12          | 148   | 7              | 1            | 0         | 3       |
| 2020 | 286              | 20          | 258   | 8              | 0            | 0         | 0       |
| 2021 | 61               | 18          | 33    | 10             | 0            | 0         | 0       |
| 2022 | 279              | 23          | 230   | 26             | 0            | 0         | 0       |
| 2023 | 148              | 14          | 114   | 18             | 1            | 0         | 1       |

## Discussion

The nesting and hatching season started on May 6 and ended on November 3, lasting 182 days total. Peak hatching season was affected by King tides and back-to-back storms, including Hurricanes Franklin, Idalia, Lee and tropical storm Ophelia. While CALO was spared the direct impact of landfall from hurricanes in 2023, the beaches were scoured by strong winds and powerful swells as the storms churned by. A total of 39 nests were directly lost to tidal surge and erosion from these storms while another 155 nests recorded over-wash and/or sand accumulation during incubation. Seventy nine of the 155 nests recorded to have over-wash, hatched. Only 15,025 hatchlings emerged from the 325 nests. The average incubation rate was 60 days in 2023. The earliest hatch was at day 51 of incubation. The management plan calls for closed areas around the nests at day 50 to allow for tire ruts to smooth out before hatching. However, there needs to be flexibility in barricade application to allow for higher summer temperatures that speed up incubation. The incubation period decreases with increasing ambient temperature (Bustard and Greenham, 1968). Barricades should be erected at day 40-45 if nesting season air temperatures are above average and nests are showing signs of early hatching.

Nest depredation continues to be a concern from coyotes, raccoons, and ghost crabs. Ghost crab predation was documented at 10 nests; however, ghost crab activity was noted at additional nests throughout the seashore without the number of egg or hatchling losses recorded. An accurate count of losses to ghost crabs is often difficult to quantify as they frequently burrow directly into nests to take eggs and/or hatchlings. Raccoon predation was limited to NCB in 2023 where targeted predator control was absent. A total of eight nests on NCB recorded raccoon presence. Coyotes have become increasingly efficient in targeting sea turtle nests. Several nests on SCB and SB were predated by coyotes in the night, shortly after being laid. Staff found the remains of these nests the next morning during turtle patrol. Any whole eggs that remained at the nest site were reburied and monitored for hatching. These nests had minimal hatching success. Also, on SCB, cases of coyotes opportunistically foraging on undeveloped eggs from hatched nests once the protective screens had been removed were documented. A leatherback nest, with removed screen to allow for larger hatchlings, was dug up after the initial hatch making the hatch success inventory impossible. Coyote tracks were also discovered on the beach amongst hatchling tracks at three hatched SCB nests. It is unknown in these cases how many, if any, hatchlings were predated by the coyotes. There weren't any documented cases of coyotes successfully digging a turtle nest through the protective screen; however, on SCB tracks were found walking over the screens of nests. Working through an interagency agreement, the United States Department of Agriculture Wildlife Services were able to remove 4 coyotes and 8 raccoons from the Seashore this late summer through targeted trapping. This limited removal of coyote and raccoons meets the 2008 USFWS Sea Turtle Recovery Plan, Objective 7, to minimize nest predation. Predator control should continue in future years to reduce predation on sea turtle nests.

The seashore continued to participate in a genetic mark-recapture study of the northern recovery unit of sea turtles in 2023. CALO has participated in this study since 2010. Preliminary results can be viewed at [www.seaturtle.org](http://www.seaturtle.org). At time of writing, the study had 282 (89%) of the DNA samples assigned with 126 individual nesting females documented in 2023. The mean nest per female was 2.72 nests with a maximum of six nests assigned to one female. Twenty six females were recorded to have had only one nest. The mean inter-nesting period was 13.23 days. The mean nesting site fidelity for an individual female recorded was 32.96 miles, with a minimum distance between nests of 0.02 miles and the maximum of 257 miles. DNA samples for the latter shows this female initially nesting on Isle of Palms, SC and then traveling 257 miles to nest at CALO, NC. The Seashore should continue to participate in this study to support recovery actions in the Northern Recovery Unit loggerhead population.

For the third year, seashore staff worked closely with the US Geological Survey (USGS) sea turtle research team to tag nesting female turtles as they came to shore at night. Between June 21 and June 28, 2023, a total of 8 turtles were captured, tagged with external metal flipper tags, internal PIT tags and satellite tags. Seven were loggerheads and one green were captured. One loggerhead turtle had previously been captured and flipper tagged in July of 1991 at Bald Head Island, NC. The turtle was recaptured, and one new metal tag applied in June of 1996 at Bald Head Island. Then she was observed at Cape Lookout during a false crawl in June of 2003. She still carried the metal tag from 1996 when she was recaptured at Cape Lookout on June 26, 2023. This female has 29 nests documented by tagging encounters and egg DNA recaptures over 32 years. Researchers continue to follow these turtles to document nesting, foraging and migratory habits.

In the summer of 2017, a study on Shackleford Banks and Bogue Banks revealed that the highest densities of nests occurred in areas with lowest light levels. (Windle et al. 2018). Cape Lookout has been impacted by numerous storm and tidal events over the past several years. Storm surge continues to change the duneline and cause over-wash on the Core Banks. These geomorphic changes to the nesting habitat could not only influence nesting patterns and the amount of ambient light affecting nesting sea turtles, but also lead to disorientation in emerging hatchlings that rely on moonlight reflecting off the water to navigate to the ocean. Recreational night activity and the amount of artificial light on the Seashores nesting beaches is poorly understood. A light pollution study is needed for the Core Banks to effectively manage for nesting sea turtles. Twenty-nine (9%) nests had disorientated hatchling tracks recorded throughout the Seashore in 2023, with a total of 683 hatchlings impacted. Nineteen of these nests were on SCB and 10 on NCB. Duke Marine Laboratory students and NPS staff continued a night recreation study in June of 2023. Nine study nights were sampled covering the ocean beaches from Ramp 35b to the Rock Jetty on SCB. Effort varied from 5 to 10 miles surveyed and sample times covered from 8pm to 5 am. The sampling revealed 92 campsites (54 with lights and 38 without lights), 30 campfires, and 9 vehicles in motion after 8pm. The campsite light types documented included string lights, flood lights, lanterns, headlamps, campfires, and vehicle lights from parked vehicles. Fifty nine percent of the campsites were lighted. Lights out at campsites ranged from 12:30 am to 2:10 am, though six campsites had lights on all night. More research is needed to scientifically measure the amount of light and nighttime recreational use of the nesting beaches.

Cape Lookout National Seashore continues tracking two sea turtle nesting beach conservation measures. The first goal is that the sea turtle false crawl to nest ratio is less than or equal to 1:1 (annually). In 2023 this performance measure was not met with 414 false crawls and 325 nests for a ratio of 1.27:1. This has been the trend of a greater number of false crawls than nests since 2014. It is thought that the wide and flatter beaches of the Seashore, particularly North Core Banks, influences a greater occurrence of false crawls. Nighttime disturbance of nesting sea turtles could also cause a higher false crawl rate. More research is needed to measure the amount of light and nighttime recreational use of the nesting beaches to determine any impact to the false crawl rate. The second conservation goal states that CALO should have 20 percent or greater of the state's total sea turtle nests for the last five years. There was an average of 1600 nests for the last five years in North Carolina. In 2023, the Seashore had 20% of the state's total sea turtle nests for the previous five years.

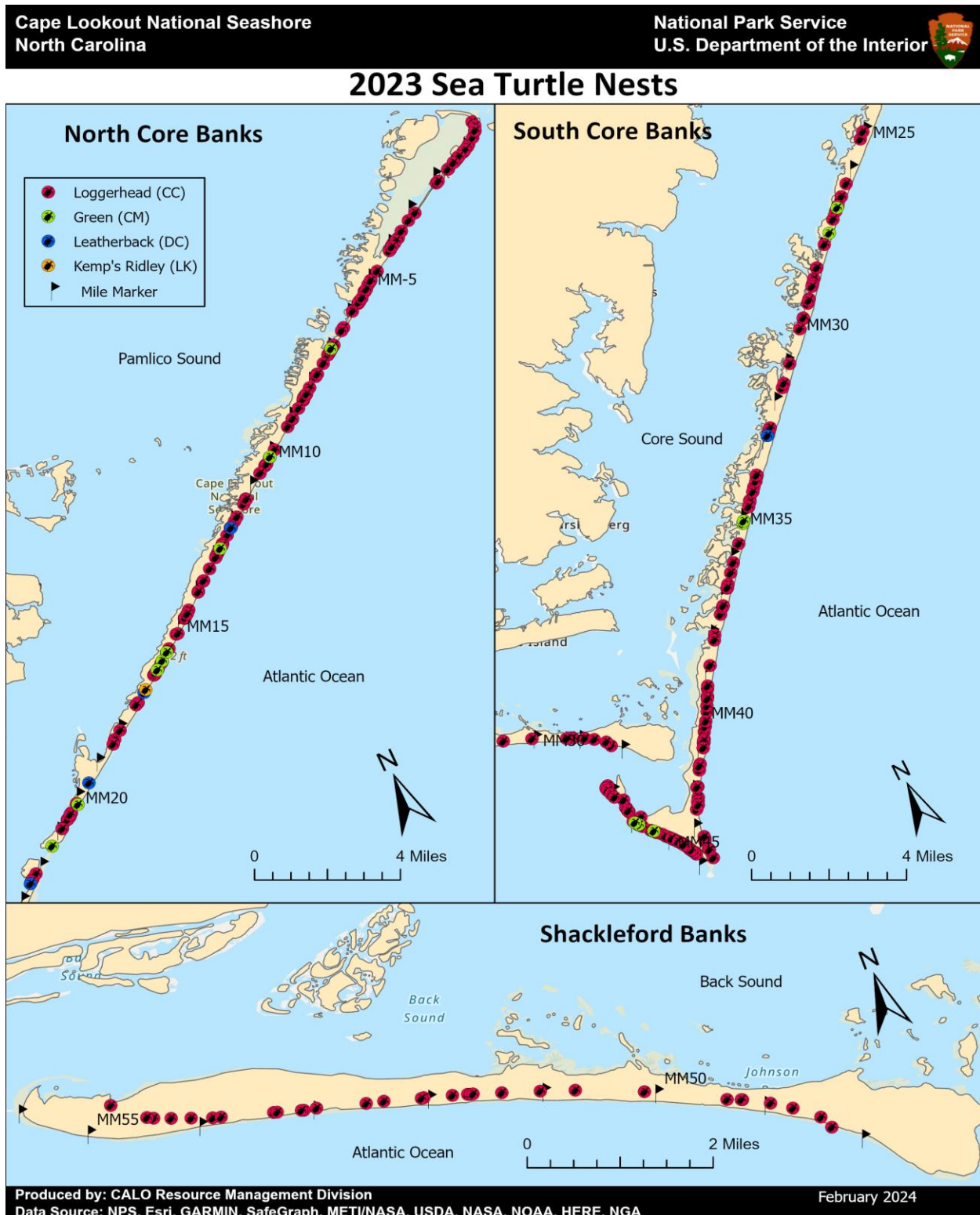
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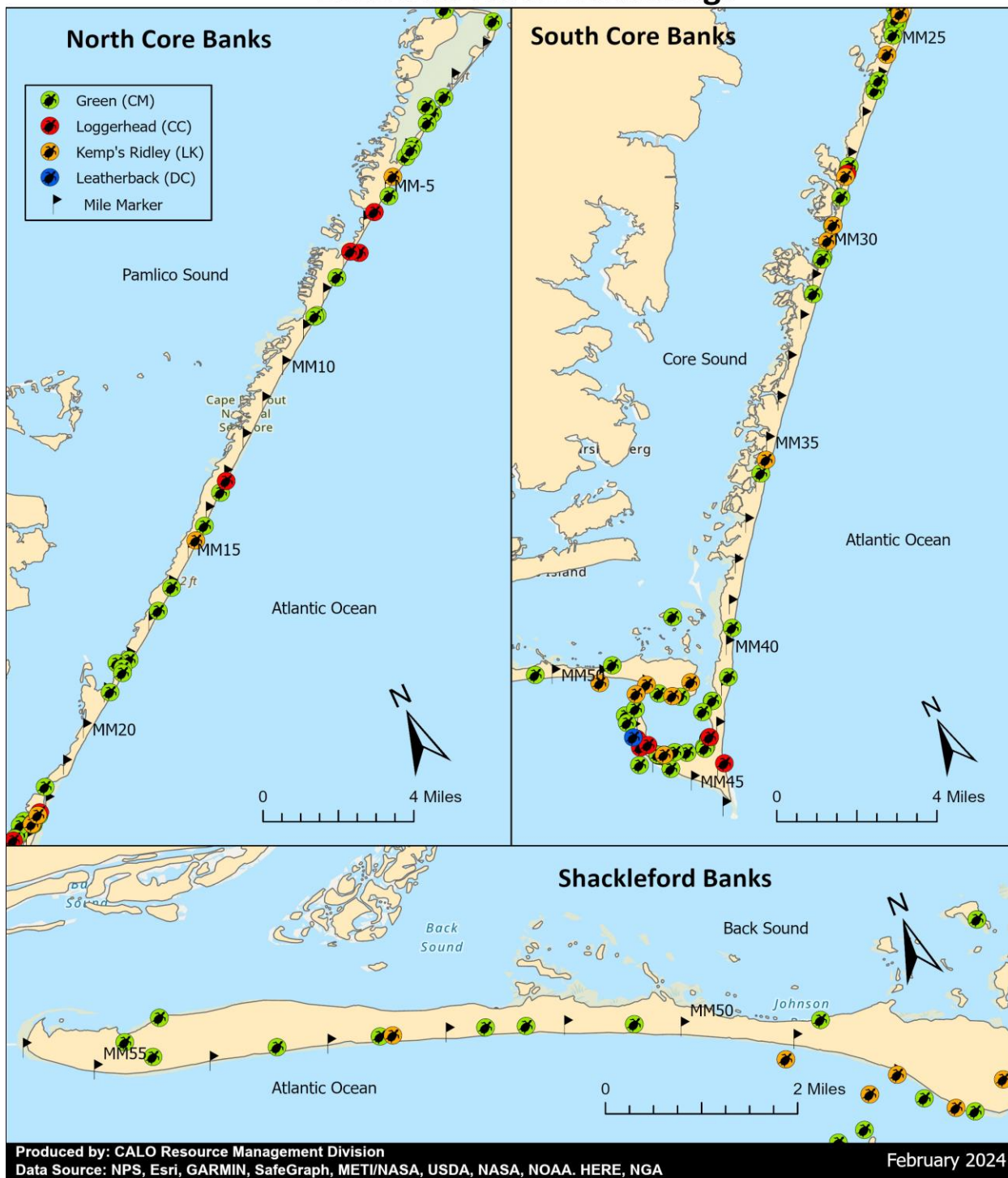
## Appendix A. 2023 Sea Turtle Maps.



Map 1. Cape Lookout National Seashore Sea Turtle Nesting Activity in 2023.



## 2023 Sea Turtle Strandings



Map 2. Cape Lookout National Seashore Sea Turtle Stranding Activity in 2023.

