



Sea Turtle Monitoring and Management at Cape Lookout National Seashores

2021 Annual Report

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Loggerhead sea turtle nesting on the beach at Cape Lookout National Seashore. Photo credit: NPS, Morgan Barnes

Acknowledgments

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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 2021, 293 nests (280 loggerhead, 12 green and 1 Kemp's ridley) and 281 false crawls were documented at the seashore. The first nesting activity was documented on May 21, 2021 and the last nesting activity was documented on September 2, 2021. The mean clutch size was 118 eggs. Mean hatch success for all nests was 60% while mean emergence success was 57%. Mean incubation was 61 days. Erosion, flooding and sand accretion from significant storm and tide events, Hurricanes Henri, Larry, and Sam, resulted in 7 nests being washed away and another 169 nests over washed and/or submerged. The seashore documented 61 stranded sea turtles in 2021.

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 2021, NCB was divided into three islands by Evergreen Inlet at mile 3 and Old Drum Inlet at mile 19. These three islands are all 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 island, 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 (*Dermodochelys 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 flooded 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).

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 fee-based ORV Driving Permit, to replace the non-fee based 2017 Educational Permit, required for ORV users to drive on the beach. All vehicles need to have this permit before arriving on the islands and visibly display their window decals during the entirety of their stay. ORV users must also have a signed copy of the permit in their vehicle attesting to their understanding of the ORV routes, rules, and management for protected species.

Cooperating Agencies and Organizations

The Seashore cooperates with numerous agencies, including the North Carolina Wildlife Resources Commission (NCWRC), the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) on sea turtle protection. 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* website. NCWRC, under the authority of the USFWS, issues the Seashore an Endangered Species permit for possession and disposition of stranded marine turtles and relocation of nests. 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 research team conducts research on nesting behavior and migratory movements of sea turtles by satellite tagging nesting female turtles within the Seashore.

Methods

Nest Monitoring and Management

Per the Cape Lookout National Seashore ORVMP staff patrolled NCB and SCB daily searching for nesting activity from May 1 to September 15, 2021. Each patrol began early in the morning so that the island was checked for turtle activity by 12:00 PM. Shackleford Banks was 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 that contained no eggs. Each activity location was recorded using Global Positioning System (GPS) and the mile location rounding to the nearest tenth of a mile. Nest and possible nests were marked with 2-inch 4-foot PVC poles at 2 feet from egg chamber ocean facing and 3 feet from egg chamber dune facing according to protocol (Appendix 1). The seashore participated 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.

Nest losses to tidal flooding 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 are located on the primary dunes. Vehicle detours were also erected around nests that were on the beach where vehicles could pass 15 feet directly west. 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 were not permitted in the protection zones to prevent disturbance of hatchlings by artificial lights (Peters and Verhoeven, 1994).

Any signs of predation were noted, and the approximate numbers of eggs or hatchlings destroyed 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 December. 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 2021 was on May 21 and the last on September 2, for a 104-day nesting season. A total of 574 activities were documented of which there were 293 nests and 281 false crawls. South Core Banks continued to have the most nests with 148, followed by North Core Banks with 108 and Shackelford Banks with 37 activities (Table 1.). There were 280 loggerhead nests, 12 green 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 are in Appendix A.

Table 1. Sea Turtle Activities by Study Area in 2021.

	North Core Banks	South Core Banks	Shackleford Banks	Seashore Total
Nests	108	148	37	293
Crawls	104	148	29	281
Total Activities	212	296	66	574

The 2021 nesting season was the third highest on record with 293 nests, 2019 remains the highest year with 525 nests and 2016 is the second highest with 352 nests. Nesting in 2021 was also above the annual average of 171 nests for CALO (Figure 2 and 3).

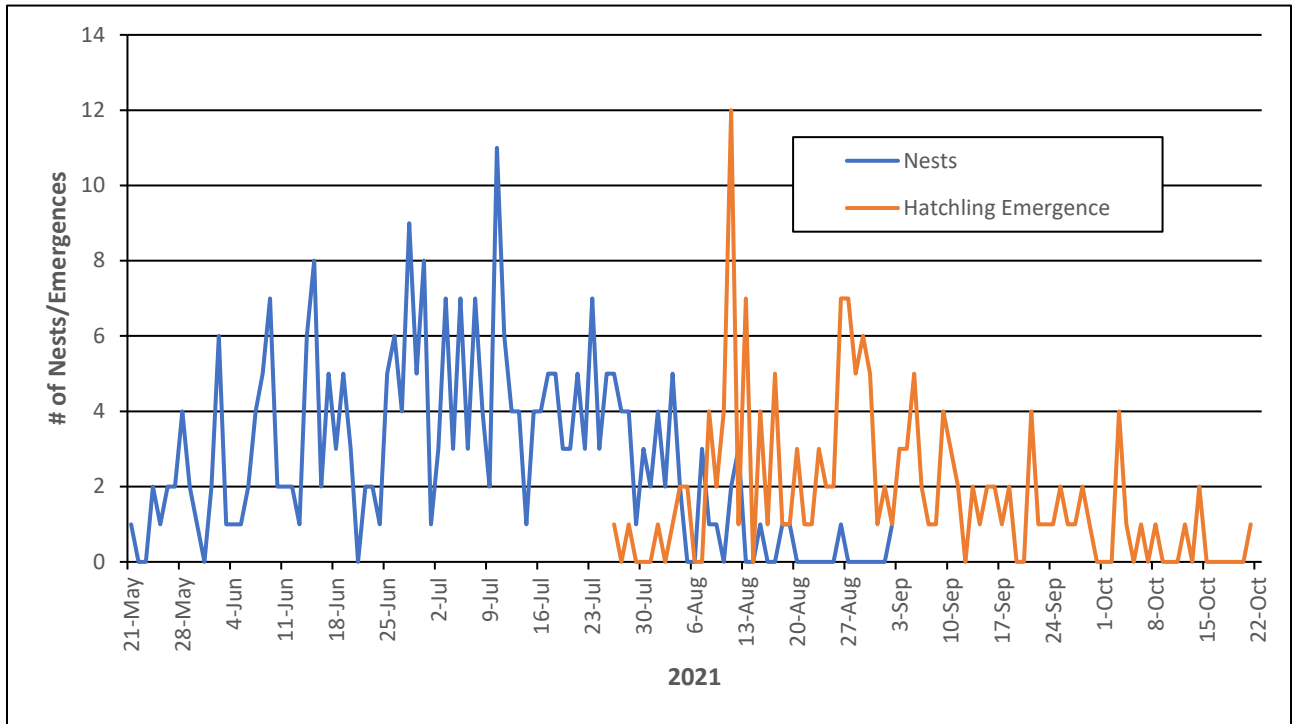


Figure 1. The daily number of nests at 7day increments, May 21 to September 2 and hatchling emergence, July 26 to October 21.

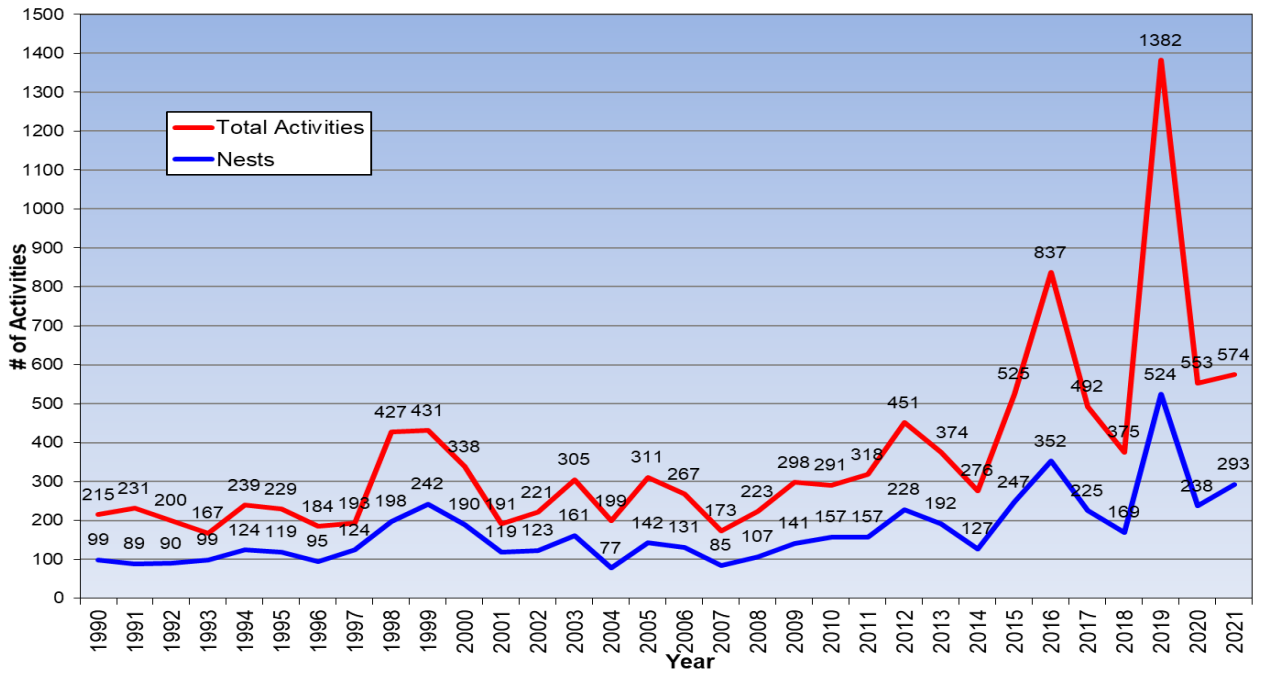


Figure 2. Cape Lookout National Seashore Sea Turtle Activities, 1990-2021.

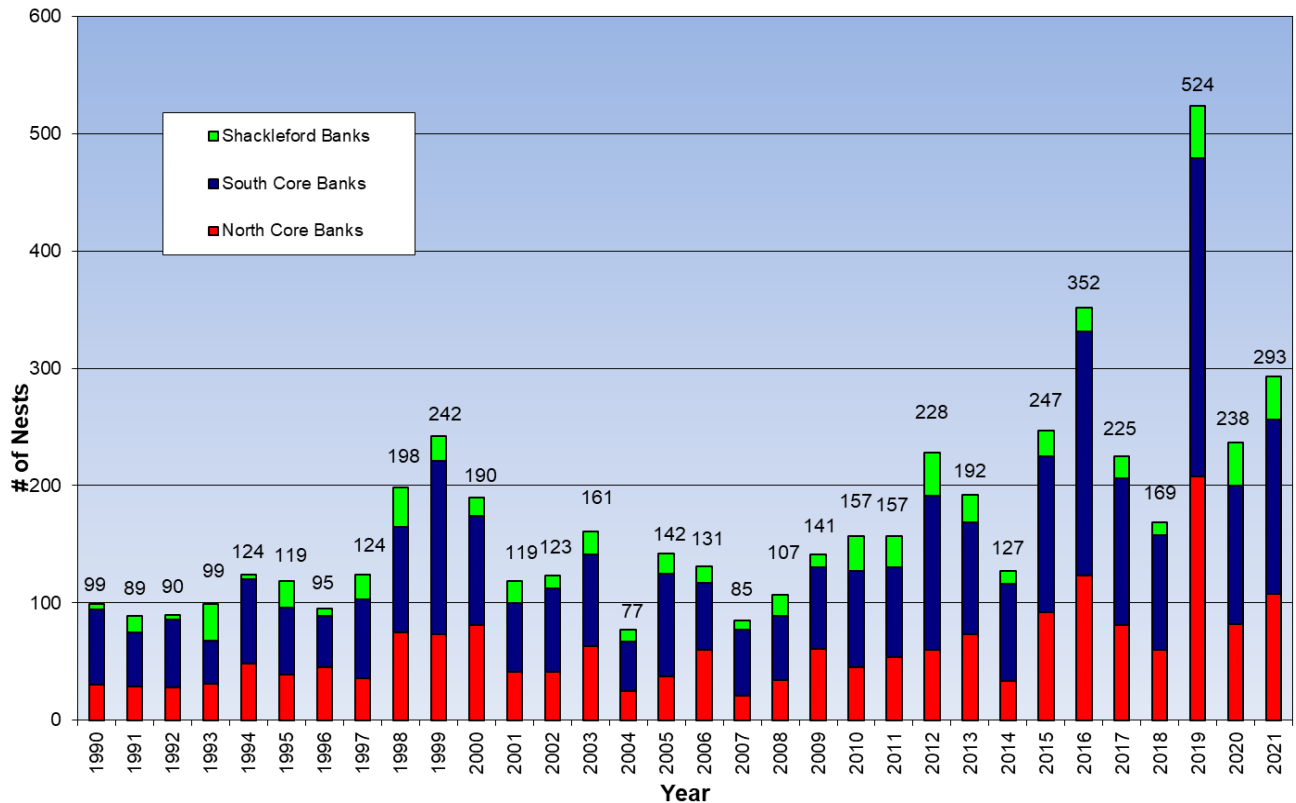


Figure 3. Cape Lookout National Seashore Sea Turtle Nests, 1990-2021.

Hatching

The nest hatching period for 2021 began July 26 and ended October 21, a total of 87 days. The last nest was inventoried on December 14, 2021 on South Core Banks. A known total of 32,356 eggs, 19,237 hatchlings, and 775 hatched dead were counted. The total hatch success, number of total hatched eggs divided by number of total eggs, was 60%. The total emergence success of 57% (19,237 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 was from 0% to 99%. The average clutch size was 118 eggs. It took an average of 61 days for nests to incubate to emergence. The range of incubation was from 51 days to 74 days. Seven nests were lost to erosion events, including high surf created by Hurricanes Henri, Larry, and Sam. A total of 169 nests were over-washed by the ocean at least once. Seventy-seven of these 169 nests hatched. The emergence success for these 169 flooded nests was 43%. Seven nests were over-washed after they were relocated.

Table 2. Sea Turtle Hatch Summary, 1990-2021.

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%

In 2021, a total of 28 (10%) nests were relocated. The emergence rate for relocated nests was 67% and the emergence rate for in situ nests was 56% (Table 3). Of the 293 nests, 274 were inventoried

and 19 nests were washed away or predated with an unknown egg count and/or unknown success. Since 1990, the thirty-one-year average emergence success is 64% for relocated nests and 63% for non-relocated nests (Table 3).

Table 3. Emergence Success for Relocated versus Non-Relocated Nests, 1990-2021.

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%
Mean	39%	64%	63%	89%

Predation

In 2021, staff recorded total or partial nest predation by coyotes (*Canis latrans*) at 7 nests. Five nests were predated on Shackleford and two on SCB. No nests were recorded to have coyote predation on NCB. Raccoon predation was documented at 2 nests on NCB. Ghost crab predation took place at both NCB and SCB affecting 16 nests.

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 could disorientate hatchlings (Cox et al., 1994). In 2021 there were 39 vehicle violations of turtle closures documented. Thirty-one nests had disorientated hatchling tracks recorded with a total of 921 hatchlings impacted. In addition, the disorientation of emerging hatchlings into a visitor’s campsite was documented at Cape Point on SCB.

STRANDINGS

In 2021, 61 strandings occurred at CALO. 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 (33). There were also 18 loggerheads and 10 Kemp’s ridleys. Nine were stranded on the inshore soundside and 52 turtles were stranded on the offshore oceanside. 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. All beaches associated with the Cape Lookout Bight and Power Squadron Spit are technically ocean facing. There were 18 live strandings which occurred primarily around a cold stun event in January and 43 dead turtles. Cold stunned turtles were transported out of the park, assessed by wildlife veterinarians at the NC State Center for Marine Sciences and Technology and sent to The Karen Beasley Sea Turtle Rescue and Rehabilitation Center or NC Aquarium at Pine Knolls Shore for rehabilitation. All stranded turtles were scanned for external and Passive Integrated Transponder (PIT) tags. Three PIT tag recaptures were found in 2021. All recaptures were green turtles, 2 were live animals and one dead. Both live turtles were recovered from NCB, one of which was a cold stunned. The third turtle was recovered fresh dead from SCB. This animal had previously been retrieved as a cold stunned from Pamlico Sound in January 2020, rehabilitated and released on May 28, 2020. Figure 4, Figure 5, and Table 4 provide stranding data by year and species from 1990 to 2021. Appendix A Map 2 illustrates stranding locations in the seashore.

Figure 4. Sea Turtle Strandings at Cape Lookout National Seashore by Month, 2021.

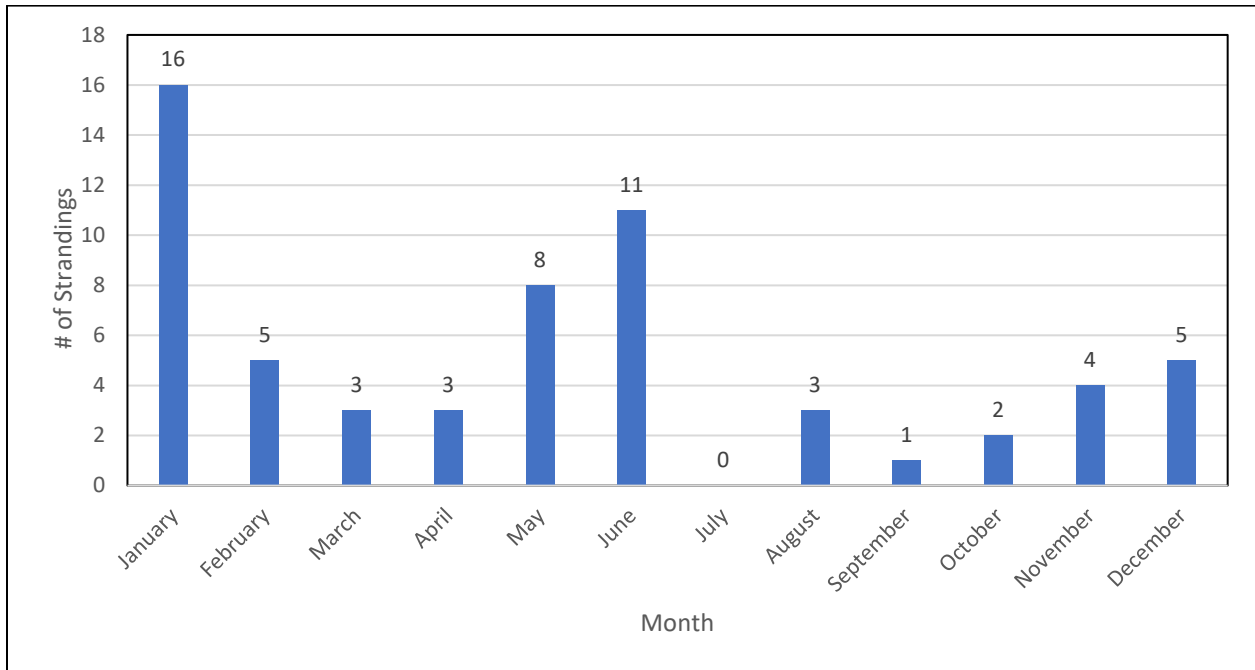


Figure 5. Sea Turtle Stranding Totals at Cape Lookout National Seashore, 1990-2021.

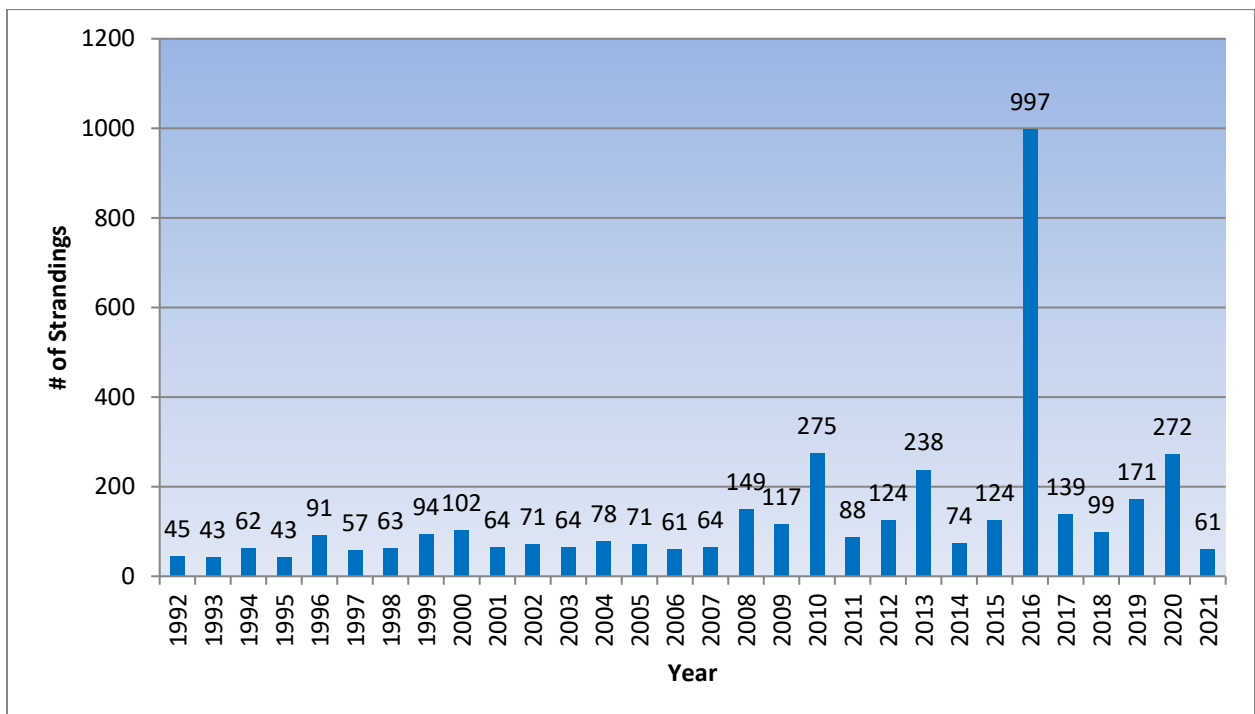


Table 4. Cape Lookout National Seashore Sea Turtle Strandings, 1990-2021.

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

Discussion

The nesting and hatching season started on May 21 and ended on December 14, lasting 208 days total. Peak hatching season was affected by Hurricanes Henri, Larry, and Sam. All 3 hurricanes passed offshore of the Seashore beaches. Hurricane Henri was the closest, passing within 200 miles as a Category 1 hurricane. Both Larry and Sam were listed as major hurricanes, a strong Category 3 and a Category 4 respectively. A total of 7 nests were directly lost to tidal surge and erosion from these storm events and another 169 nests recorded over-wash and/or sand accumulation during incubation. Seventy-seven of the 169 nests recorded to have over-wash, successfully hatched. The average incubation rate was 61 days in 2021. 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 and raccoons. A coyote's ability to dig further and deeper under wire screens makes protection of nests difficult. Working through an interagency agreement, the United States Department of Agriculture Wildlife Services were able to remove 8 coyotes and 72 raccoons from the Seashore this spring and 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 the genetic mark-recapture study of the northern recovery unit of sea turtles in 2021. Preliminary results can be viewed at www.seaturtle.org. The study has 90.1% of the DNA samples assigned with 95 individual nesting females documented in 2021. The mean nest per female was 2.98 nests with a maximum of seven nests assigned to one female. The mean inter-nesting period was 13.79 days. There were 29 potential unobserved nests reported. The Seashore should continue to participate in this study to learn more about the Northern Recovery Unit loggerhead population.

Additionally, in 2021 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 28 and July 16, a total of 9 turtles were captured, tagged with both metal flipper tags and PIT tags as well as outfitted with a satellite tag tracking device. Researchers continue to follow these turtles to document nesting and migratory habits

Cape Lookout has been impacted by several storm and tidal events over the past several years: including major impacts from Hurricanes Florence (2018) and Dorian (2019). Storm surge continues to change the duneline and cause over-wash on the Core Banks. These geomorphic changes to the nesting habitat could influence nesting patterns and influence the ambient light on nesting sea turtles. Recreational night activity and the amount of artificial light on the Seashores nesting beaches is poorly understood. Thirty-one nests had disorientated hatchling tracks recorded throughout the

Seashore in 2021, with a total of 921 hatchlings impacted. In one incident at Cape Point on SCB, hatchlings were misorientated towards campers with additional artificial lighting at their camp. The camp was approximately 100 feet away from the nest with lights around the perimeter described by the campers as “fairly bright”. Once sea turtle hatchlings were discovered at their campsite the visitors directed hatchlings to the water with use of a flashlight and/or carried them in buckets to the water. Exact number of hatchlings affected in this single event is unknown but described as “many” by the visitors. A total of 124 hatchlings are known to have emerged from this nest. More research is needed to measure the amount of light and nighttime use of the nesting beaches. 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). A light pollution study is needed for the Core Banks to effectively manage for nesting sea turtles.

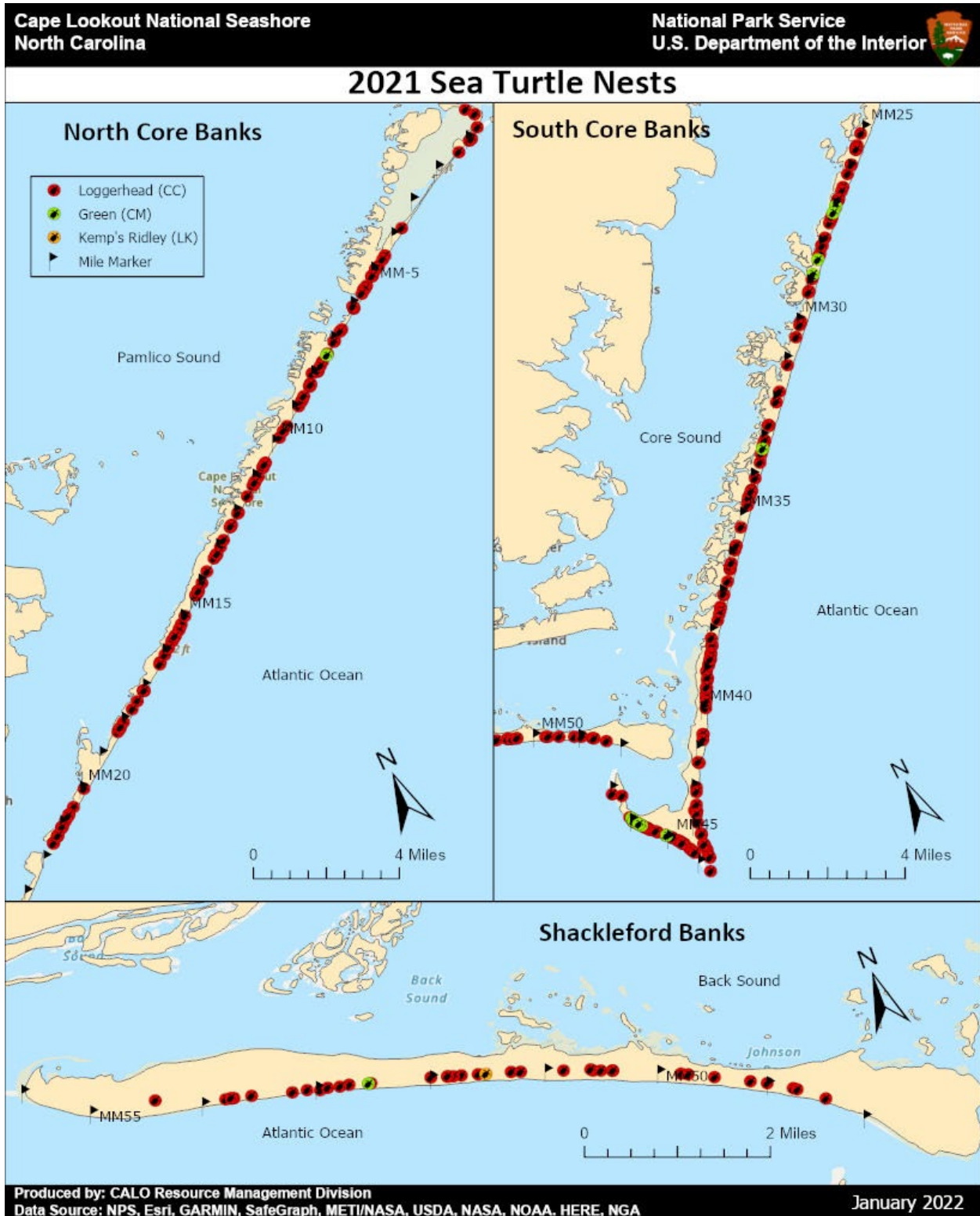
Cape Lookout National Seashore continues tracking two sea turtle nesting beach conservation measures. The first goal is that the sea turtle false crawl to nest ratio is less than or equal to 1:1 (annually). In 2021 this performance measure was met with 281 false crawls and 293 nests for a ratio of 0.96:1. This reverses 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 1483 nests for the last five years in North Carolina. In 2021, the Seashore had 20% of the state’s total sea turtle nests for the previous five years.

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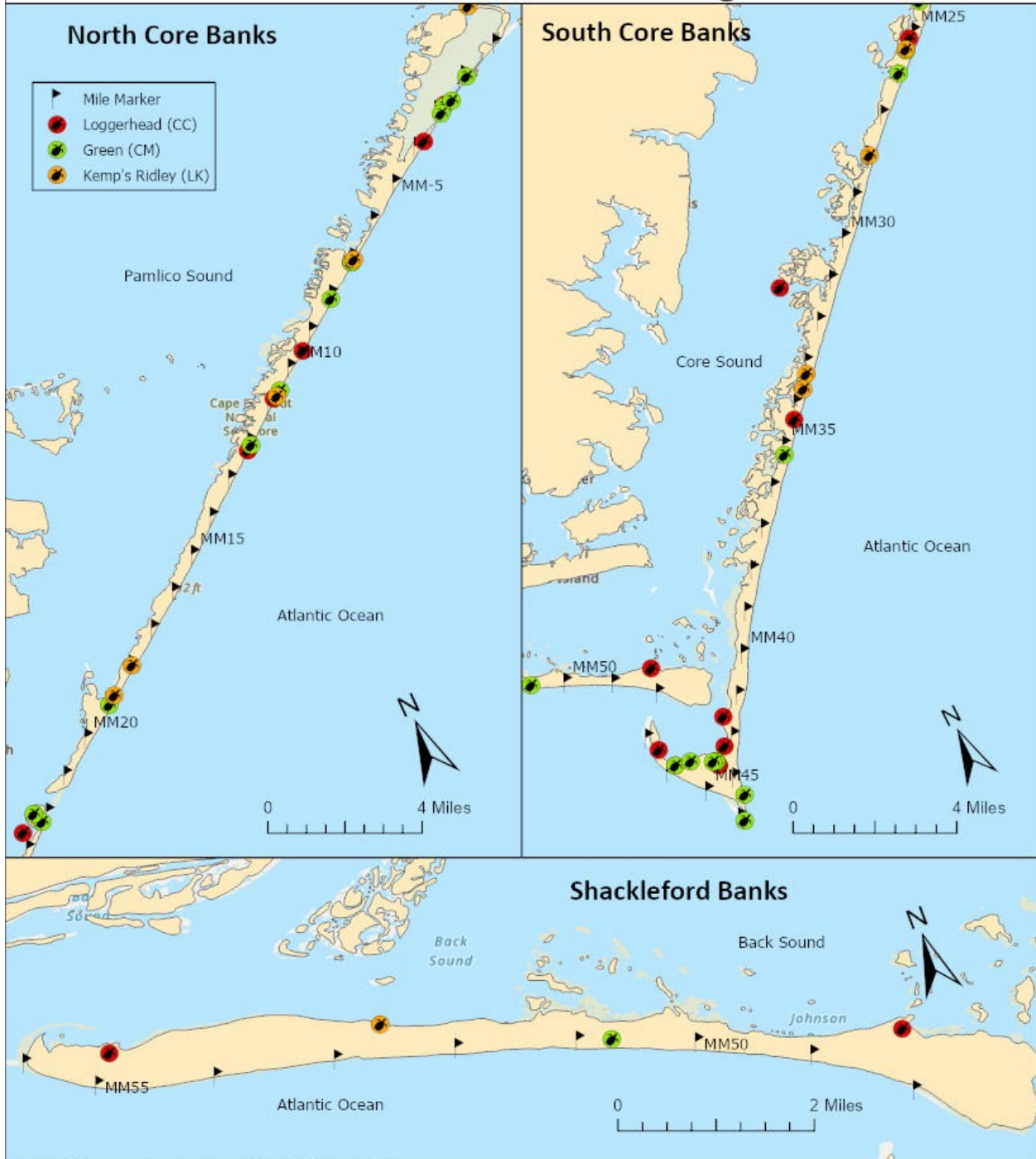
Appendix A. 2021 Sea Turtle Maps.



Map 1. Cape Lookout National Seashore Sea Turtle Nesting Activity in 2021.



2021 Sea Turtle Strandings



Produced by: CALO Resource Management Division
Data Source: NPS, Esri, GARMIN, SafeGraph, METI/NASA, USDA, NASA, NOAA, HERE, NGA

January 2022

Map 2. Cape Lookout National Seashore Sea Turtle Stranding Activity in 2021.