



Sea Turtle Monitoring and Management at Cape Lookout National Seashore

2022 Annual Report

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

Acknowledgments

We would like to thank our field staff members Chelsey Stephenson, Nathan Pinson, Patrick Carr, Ellie Sherman, Taylor Smith and Alice Stitzer; interns Jessica Panton and Jessica Byers, and volunteer Dee Holt for their tenacious efforts monitoring and protecting sea turtles at Cape Lookout National Seashore.



Seasonal staff and interns look on as a Kemp's Ridley returns to the ocean after a daytime nesting event. Photo credit: NPS.

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 2022, 431 nests (423 loggerhead, 4 green, 3 Kemp's ridley and 1 leatherback) and 408 false crawls were documented at the seashore. The first nesting activity was documented on May 6, 2022, and the last nesting activity was documented on September 6, 2022. The mean clutch size was 112 eggs. Mean hatch success for all nests was 71% while mean emergence success was 68%. Mean incubation was 61 days. Erosion, flooding and sand accretion from significant storm and tide events, Hurricanes Earl, Fionna and Ian, resulted in 24 nests being washed away and another 139 nests over washed and/or submerged. The seashore documented 279 stranded sea turtles in 2022.

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 2022, 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. In 2022 Florence Island attached to the northern tip of SBC, extending the survey unit by approximately a half mile. 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 (*Dermochelys 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 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, 2022. 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 2022, 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.

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 2022 was on May 6 and the last on September 6, for a 124-day nesting season. A total of 833 activities were documented of which there were 431 nests and 402 false crawls. South Core Banks continued to have the most nests with 245, followed by North Core Banks with 131 and Shackelford Banks with 55 (Table 1.). There were 423 loggerhead nests, 4 green nests, 3 Kemp’s ridley nests and 1 leatherback 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 2022 nesting season was the second highest on record with 431 nests. 2019 remains the highest year with 525 nests. Nesting in 2022 was also above the annual average of 179 nests for CALO (Figure 2 and 3).

Table 1. Sea Turtle Activities by Study Area in 2022.

	North Core Banks	South Core Banks	Shackleford Banks	Seashore Total
Nests	131	245	55	431
Crawls	138	239	25	402
Total Activities	269	484	80	833

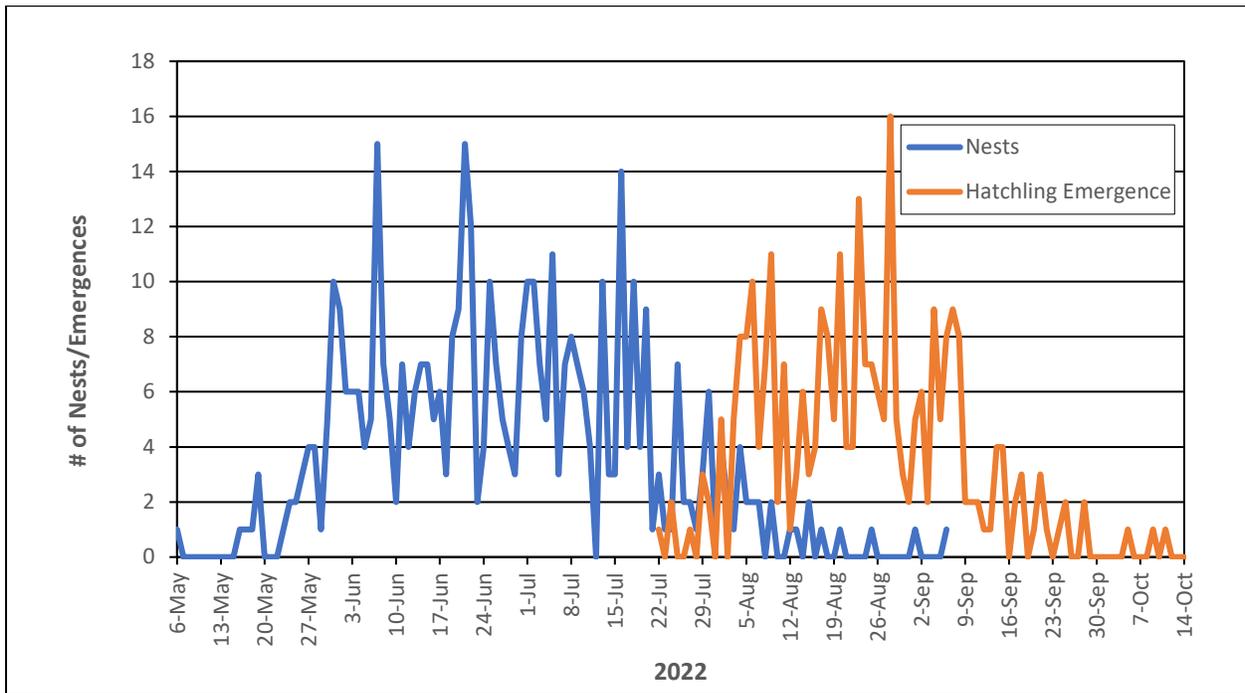


Figure 1. The daily number of nests at 7day increments, May 6 to September 6 and hatchling emergence, July 22 to October 11.

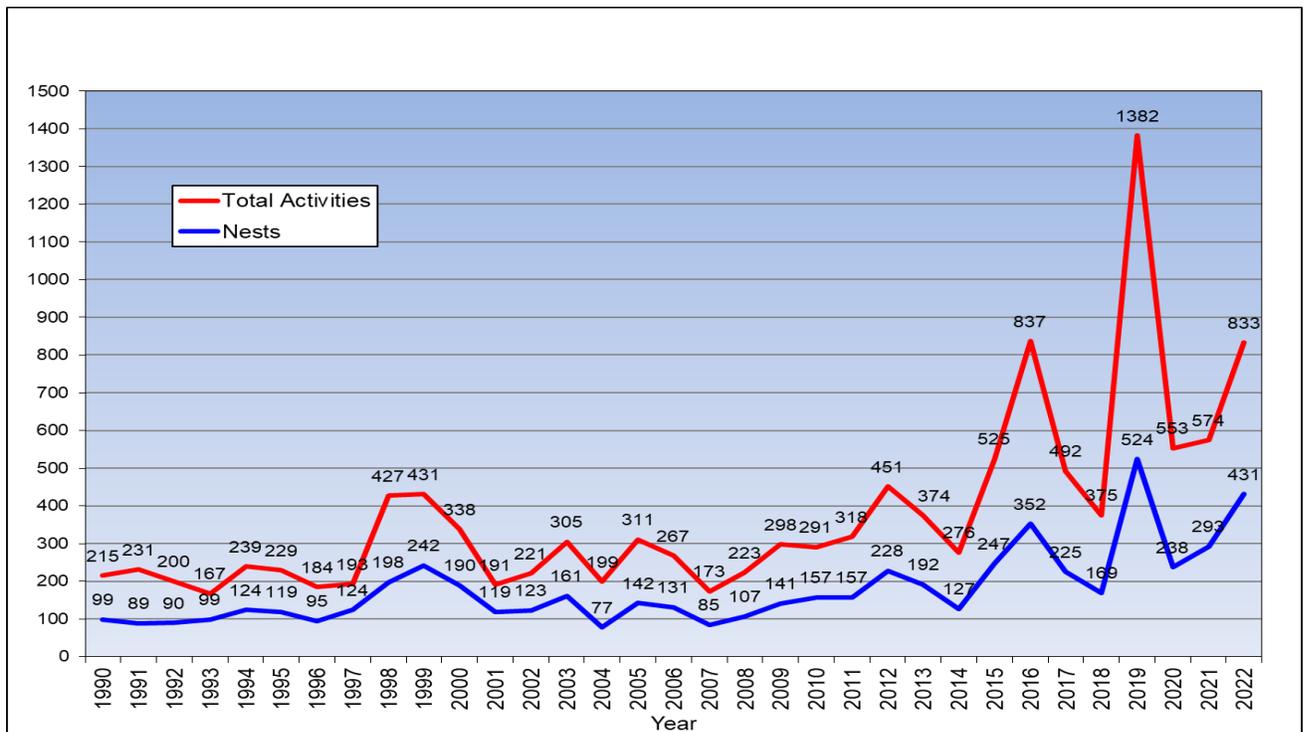


Figure 2. Cape Lookout National Seashore Sea Turtle Activities, 1990-2022.

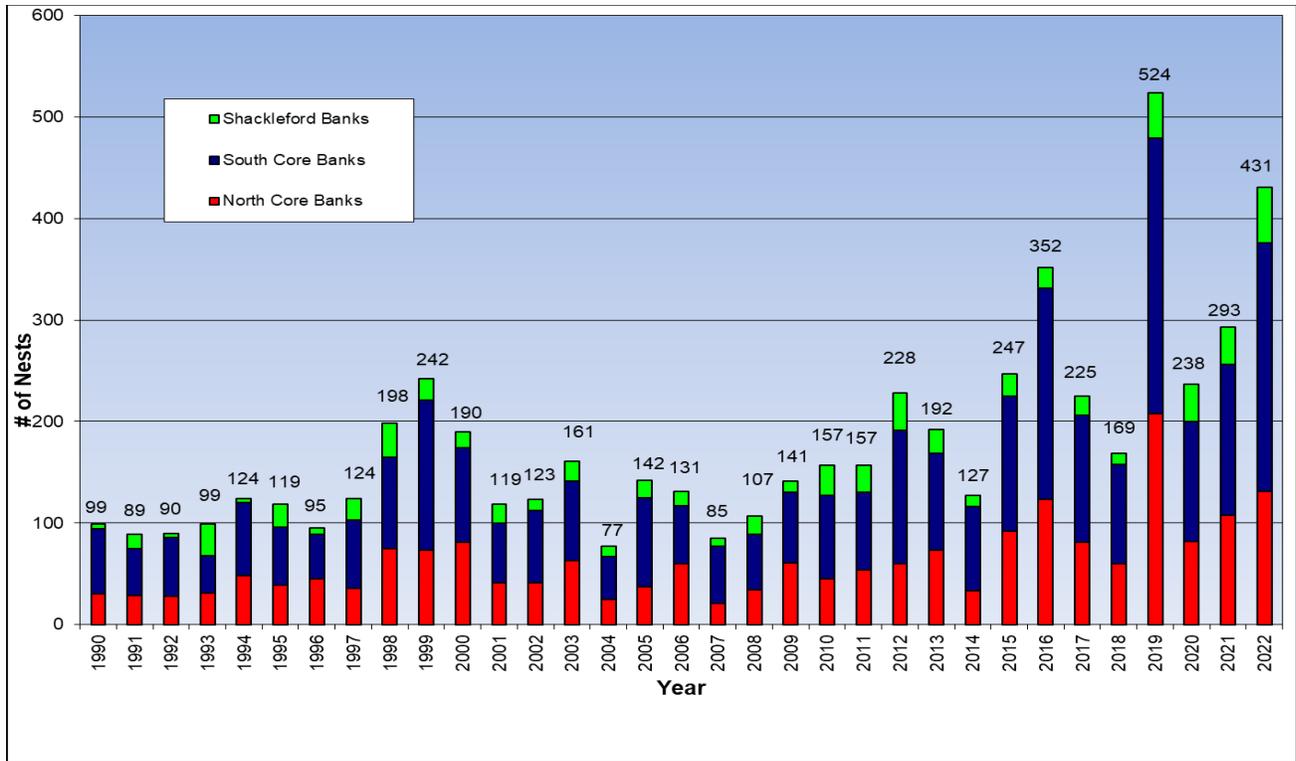


Figure 3. Cape Lookout National Seashore Sea Turtle Nests, 1990-2022.

Hatching

The nest hatching period for 2022 began July 22 and ended October 11, a total of 81 days. The last nest was inventoried on November 21, 2022, on South Core Banks. A known total of 43,216 eggs, 30,874 hatchlings, and 1,501 hatched dead were counted. The total hatch success, number of total hatched eggs divided by number of total eggs, was 71%. The total emergence success of 68% (30,874 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 61 days for nests to incubate to emergence. The range of incubation was from 52 days to 74 days. Twenty-four nests were lost to erosion events, including high surf created by King tides and offshore Hurricanes Earl, Fiona and Ian. Four of these nests were lost while in their hatching window and recorded as having the final hatching status as unknown. A total of 139 nests were over-washed by the ocean at least once. Ninety-four of these 139 nests hatched. The emergence success for these flooded nests was 47%. Six nests were over-washed after they were relocated.

In 2022, a total of 42 (10%) nests were relocated. The emergence rate for relocated nests was 65% and the emergence rate for insitu nests was 68% (Table 3). Of the 431 nests, 386 were inventoried and 45 nests were washed away or predated with an unknown egg count and/or unknown success. Since 1990, the thirty-two-year average emergence success is 64% for relocated nests and 63% for non-relocated nests (Table 3).

Table 2. Sea Turtle Hatch Summary, 1990-2022.

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%

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%
2022	10%	65%	68%	90%
Mean	39%	64%	63%	89%

Predation

Staff recorded total or partial nest predation by coyotes, racoons, and ghost crabs in 2022. Coyotes predated a total of 27 nests, 18 on Shackleford and 9 on SCB. A minimum of 1,022 eggs were known to have been predated. There were 11 nests where coyote predation was so severe that an estimated egg loss could not be determined. No nests were recorded to have coyote predation on NCB; however, racoon predation was documented at four nests, affecting over 185 eggs and 1 hatchling. No racoon predation was documented on SCB or SB. Ghost crab predation was documented at both NCB and SCB affecting a minimum of 17 nests, 36 eggs and 6 hatchlings.

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 racoons to benefit nesting sea turtles. WS continued predator trapping on SCB and SB in 2022. A total of 8 coyotes and 51 racoons were removed. Six coyotes were removed from SCB, and two from SB. Since 2017, WS has removed a total of 44 coyotes and 181 racoons 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 2022 there were 40 vehicle violations of turtle closures documented. Ninety-two nests had disorientated hatchling tracks recorded with a total of 1,507 hatchlings impacted.

Strandings

Two hundred seventy-nine strandings were documented in 2022, the second highest year on record. The first being 2016 with a total of 997 strandings. 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 230 reports. There were also 23 loggerheads and 26 Kemp's ridleys. Fifty-four were stranded on the inshore (sound side) of the island and 225 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 111 live strandings, which occurred primarily around two cold stun events in January and December. 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. Two PIT tag recaptures were found in 2022. Figure 4, Figure 5, and Table 4 provide stranding data by year and species from 1990 to 2022. Appendix A Map 2 illustrates stranding locations in the seashore.

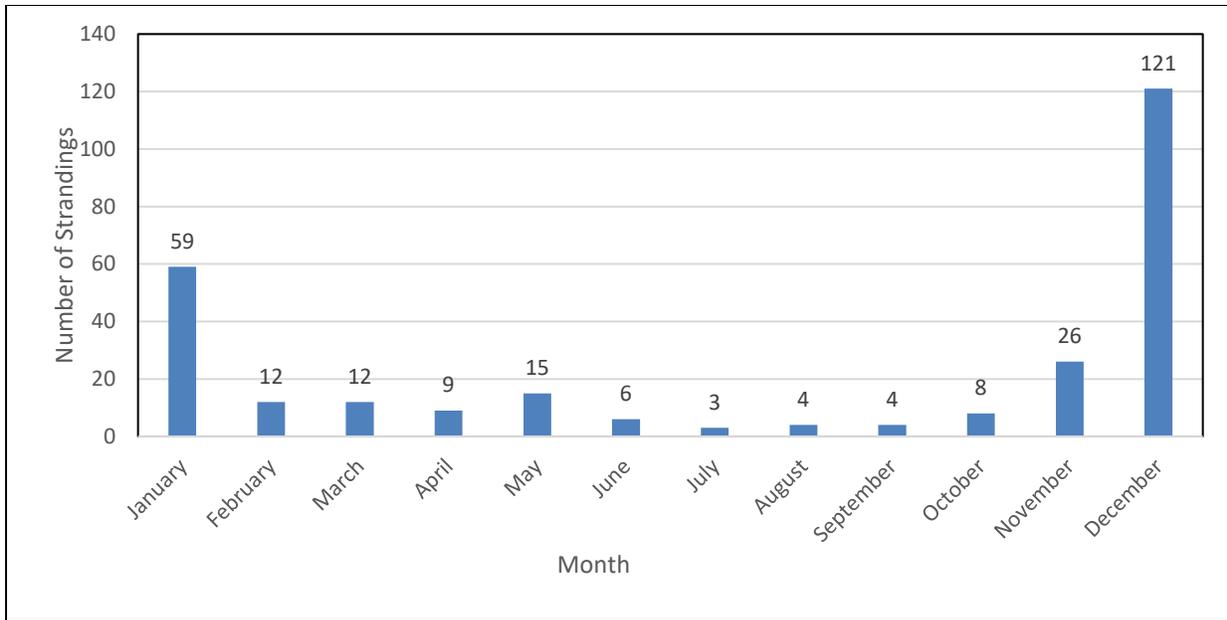


Figure 4. Sea Turtle Strandings at Cape Lookout National Seashore by Month, 2022.

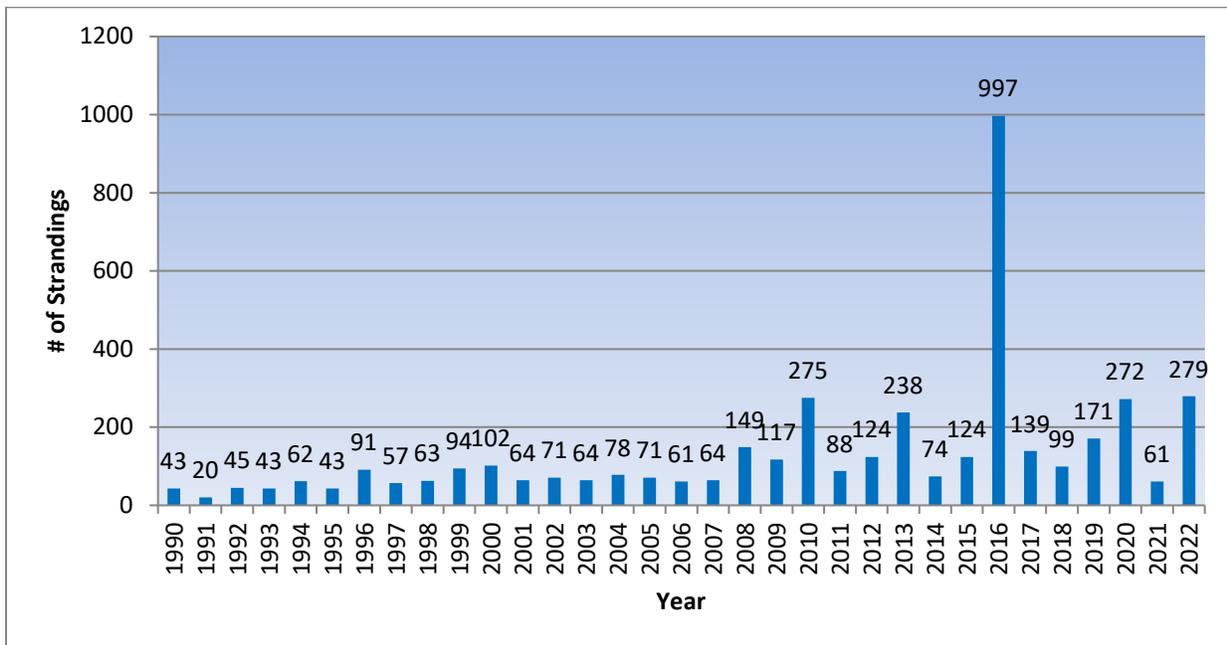


Figure 5. Sea Turtle Stranding Totals at Cape Lookout National Seashore, 1990-2022.

Table 4. Cape Lookout National Seashore Sea Turtle Strandings, 1990-2022.

Year	Stranding Totals	Logger-head	Green	Kemp'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

Discussion

The nesting and hatching season started on May 6 and ended on November 21, lasting 200 days total. Peak hatching season was affected by King tides and back-to-back September storms, including Hurricanes Earl, Fiona, and Ian. While CALO was spared the direct impact of landfall from

hurricanes in 2022, the beaches were scoured by strong winds and powerful swells as the storms churned by. Earl, a Category 2 hurricane, passed offshore coinciding with the full moon and lunar King tides creating a long period of high, powerful swell. The effects of Fiona and Ian, both strong Category 4 storms, were felt for days and from hundreds of miles away. All three storms changed the landscape of the beach impacting the remaining sea turtle nests. A total of 24 nests were directly lost to tidal surge and erosion from these storms while another 139 nests recorded over-wash and/or sand accumulation during incubation. Ninety-four of the 139 nests recorded to have over-wash, successfully hatched. Despite these impacts 30,874 hatchlings emerged from 431 nests, the highest emergence numbers on record. The average incubation rate was 61 days in 2022. The earliest hatch was at day 52 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 17 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 2022 where targeted predator control was absent. A total of five 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. There was an incident on SCB where a coyote appeared to be harassing a female attempting to lay a nest. Coyote tracks were documented following alongside the turtle's entrance track from the ocean up the beach to where, and around, an abandoned nest chamber was found. After abandoning the nest cavity, and presumably after the coyote gave up on possibility of fresh eggs (based on tracks), the female successfully nested further down the beach. Also, on SCB, numerous cases of coyotes opportunistically foraging on undeveloped eggs from hatched nests once the protective screens had been removed were documented. 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 seven nests and minimally digging at the screens of two others. Coyotes may have been getting enough nourishment from eggs poached at nests before the screens were placed or after they were removed and predated hatchlings as they emerged that the motivation to exert energy navigating around the screens wasn't high. Coyote presence proves to be highly destructive on turtle nesting beaches. Working through an interagency agreement, the United States Department of Agriculture Wildlife Services were able to remove 8 coyotes and 51 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 a genetic mark-recapture study of the northern recovery unit of sea turtles in 2022. CALO has participated in this study since 2010. Preliminary results can be viewed at www.seaturtle.org. At time of writing, the study only had 193 (44.7%) of the DNA samples assigned with 100 individual nesting females documented in 2022. The mean nest per female was 2.63 nests with a maximum of four nests assigned to one female. Nine females were recorded to have had only one nest. The mean inter-nesting period was 14.58 days. The mean nesting site fidelity for an individual female recorded was 19.45 miles, with a minimum distance between nests of 0.21 miles and the maximum of 212 miles. DNA samples for the latter shows this female initially nesting on NCB at CALO, laying her second nest approximately 93 miles to the north in Corolla, NC and then traveling over 200 miles to nest a third time near Southport, NC. The Seashore should continue to participate in this study to support recovery actions in the Northern Recovery Unit loggerhead population.

For the second 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 20 and June 30, 2022, a total of 13 turtles were captured, tagged with external metal flipper tags and internal PIT tags. Seven of these turtles, 6 loggerheads and 1 green, were also outfitted with a satellite tag tracking device. The green turtle had previously been captured, flipper tagged, and PIT tagged in August of 2015 at the Archie Carr National Wildlife Refuge in Florida. 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. Ninety-two (22%) nests had disorientated hatchling tracks recorded throughout the Seashore in 2022, with a total of 1,548 hatchlings impacted. Sixty-two of these nests were on SCB and 30 on NCB. Twenty-five were in ramp-to-ramp closures where vehicles were detoured to the back road and 68 were in partial closures where vehicles were detoured on the beach behind the nest. There were 11 nests on SCB where hatchlings were discovered on the back road and in the Great Island Cabins camp area. A total of 96 hatchlings were recovered from these areas, including nine dead hatchlings that had been run over. Additionally, there were two incidents on SCB where visitors reported hatchlings coming into their camp at night. Both incidents were just north of Ramp 43, with the camps up near the dune line and nests closer to the tideline with beach detours around them. Campfires and lights were the suspected reason for these disorientations. Duke Marine Laboratory students and NPS staff piloted a night

recreation study in June of 2022. Ten study nights were sampled covering the ocean beaches from Ramp 35b to the Rock Jetty on SCB. Effort varied from 2 to 10 miles surveyed. On three nights only 2 miles were covered by foot at the lighthouse ocean beach area for a part of the night. On 7 nights vehicles were used to cover 5 to 10 miles from 8pm to 5am. The sampling revealed 91 campsites (60 with lights and 31 without lights), 33 campfires, and 3 vehicles in motion after 9pm. The campsite light types documented included string lights, flood lights, lanterns, headlamps, campfires, and vehicle lights from parked vehicles. Sixty-six percent of the campsites were lighted. Lights out at campsites ranged from 10:00 pm to 2:02 am with an average light out by 11:19 pm. More research is needed to scientifically measure the amount of light and nighttime recreational use of the nesting beaches.

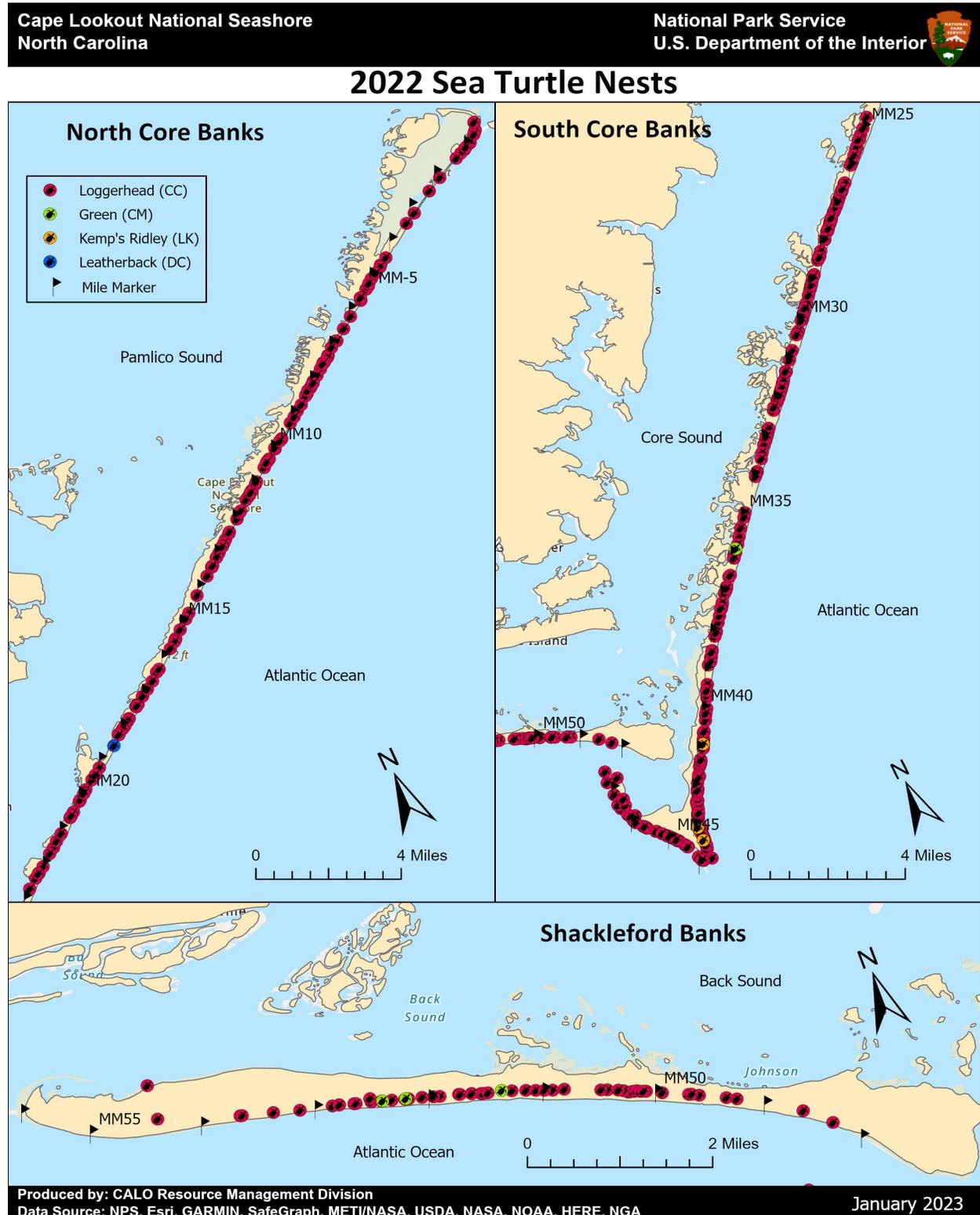
Cape Lookout National Seashore continues tracking two sea turtle nesting beach conservation measures. The first goal is that the sea turtle false crawl to nest ratio is less than or equal to 1:1 (annually). In 2022 this performance measure was met with 408 false crawls and 431 nests for a ratio of 0.95:1. 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 1453 nests for the last five years in North Carolina. In 2022, the Seashore had 30% of the state's total sea turtle nests for the previous five years.

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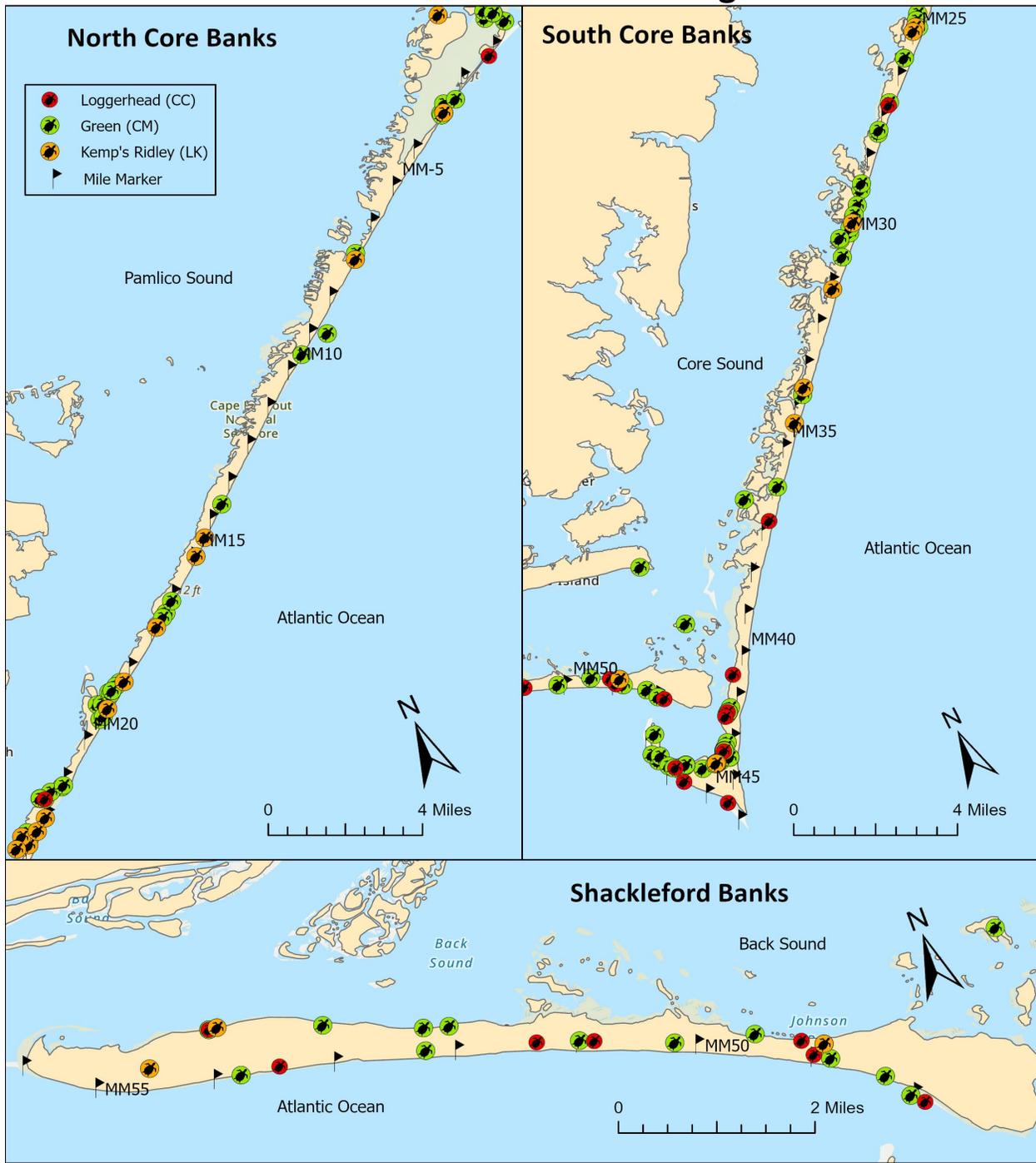
Appendix A. 2022 Sea Turtle Maps.



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



2022 Sea Turtle Strandings



Produced by: CALO Resource Management Division

Data Source: NPS, Esri, GARMIN, SafeGraph, METI/NASA, USDA, NASA, NOAA, HERE, NGA

January 2023

Map 2. Cape Lookout National Seashore Sea Turtle Stranding Activity in 2022.