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Shorebird Monitoring and Management at Cape Lookout National Seashore

2022 Annual Report

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Photo 1. Newly hatched American oystercatcher brood, photo taken by trail camera. NPS photo.

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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. Core Banks, NCB and SCB, have a northeast to southwest orientation and exhibit a low-profile landscape. The Atlantic Ocean is to the east of Core Banks and Core Sound and Pamlico Sound are to the west. 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. The Atlantic Ocean is to the south of SB and Back Sound is to the north.

CALO contains ecologically important habitats, such as sand flats, beaches, intertidal zones, and marshes that are critical to shorebirds. These habitats support the piping plover (*Charadrius melodus*) and red knot (*Calidris cantus rufa*), both species federally listed as threatened (USFWS, 1985; USFWS, 2014). Habitats also support the gull-billed tern (*Gelochelidon nilotica*), a species listed as threatened by the North Carolina Wildlife Resources Commission (NCWRC), and NCWRC special concern species including the American oystercatchers (*Haematopus palliates*) and colonial waterbirds (royal terns [*Thalasseus maxima*], sandwich terns [*Thalasseus elegans*], least terns [*Sterna antillarium*], common terns [*Sterna hirundo*], and black skimmers [*Rynchops niger*]) (NCWRC, 2014). CALO was designated a Globally Important Bird Area by the American Bird Conservancy in 2001 in recognition of the value CALO provides to bird migration, breeding, and wintering (Audubon, 2017).

CALO is also 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. Shorebirds are affected by human disturbances, habitat loss, and predation. Human disturbance, both direct and indirect, may result in nest or chick loss. Depredation by mammals, birds, and ghost crabs have influenced the breeding success of nests and broods at CALO, as well. CALO monitors and manages shorebirds, habitat, and predators to promote successful reproduction to achieve population recovery of declining species. Shorebird nesting and foraging areas 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 (ORV Plan) 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. The ORV Plan also

outlines a required monitoring schedule for the protected species of concern. In 2021, CALO established 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 Protection Areas

Resource protection areas include nesting closures and wildlife protection zones. Nesting closures protect current and potential shorebird breeding habitat from human activity and are established prior to breeding activity where nesting has occurred in the past five years or as new breeding activity is discovered according to species. These areas are temporarily closed to public entry during the nesting season. The closures provide a disturbance free area for birds to establish territories and nest in optimal habitat. The closures are adjusted to meet disturbance buffer requirements as needed. Wildlife protection zones are established during the brood rearing phase around nesting and foraging areas to protect birds from direct and indirect human sources of recreational vehicle use mortality. Outside of the breeding season there are general resource closures to protect migrating and wintering piping plovers and their habitats.

Predator Management

Since 2017, CALO has 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 shorebirds and sea turtles. WS conducted predator trapping on SCB and SB in 2022. WS removed a total of 8 coyotes and 51 raccoons. Six coyotes were removed from SCB, and two from SB. A total of 44 coyotes and 181 raccoons have been removed from CALO by WS between 2017 and 2022.

Resource Violations

Resource management staff record resource violations they observe throughout the breeding season. In 2022, staff recorded a total of 210 violations. One hundred and fourteen were on SCB, 94 were on NCB, and two were on SB (see Appendix A, Map A1). Staff observed 47 pedestrians in bird closures, 42 vehicles in turtle closures, 40 dogs off leash, 31 vehicles in bird closures, and 45 vehicles operating otherwise out of bounds. Five other resource-related violations were recorded for variety of offenses. Resource staff corrected 40 of these observations and severe offenses were reported to law enforcement. Resource staff are unable to correct violations that are observed after-the-fact by the presence of tire tracks or footprints within closed areas.

Piping Plover (*Charadrius melodus*) Management and Monitoring

Background

The piping plover is listed as a federal threatened species by the U.S. Fish and Wildlife Service (USFWS, 1985). Piping plover monitoring at CALO began with a baseline study in 1989 (Fraser et al., 1990). Monitoring has continued annually by CALO staff since 1992. The park is a significant nesting area, containing 80% of the nesting pairs in the state of North Carolina (Johnson, 2021).

CALO also serves as a wintering and migratory site. There are three designated wintering critical habitat units within the CALO boundary (USFWS, 2008). Monitoring focuses on documenting reproductive success, implementing methods to increase the productivity of this threatened species, and non-breeding use surveys. This report contains a summary of monitoring results for 2022, comparisons to results from previous years, and discussions based on long-term monitoring of piping plovers at CALO.

Methods

Monitoring

The ORV Plan contains management guidelines and monitoring protocols (NPS 2016). Following these protocols, park staff conducted daily surveys of posted nesting habitat beginning in April. Potential habitat outside posted areas was monitored and posted as necessary. Breeding territories and pairs were identified based on observed breeding behavior. Behavior such as territorial displays, elliptical flights, nest scraping, high stepping, and copulation was recorded. Nests were located and monitored daily until they hatched or were lost.

Once nests were identified, the locations of the nests were recorded in decimal degrees using a Geographic Information System (GIS). Nest locations were marked inconspicuously with onsite objects like sticks or shells to facilitate follow-up checks. The number of eggs in the nest were monitored to determine nest initiation and full clutch completion. Full time incubation starts at clutch completion and averages 27 days. An estimated hatch date is assigned to each nest. If the nest is found at full clutch then the estimated hatch date is 25 days from nest discovery. Information about the habitat type was noted. Adults were surveyed for bands and any band codes were recorded. Motion-triggered trail cameras were installed at some exclosed nests to aid in monitoring.

Nests were checked every one to three days to monitor the status of incubation and document losses. Nest checks were recorded in the GIS. When nests were lost, CALO staff would check the area for signs of predation or other causes of nest failure. Nests that near their estimated hatch date were monitored daily for hatching. When a nest hatched, broods were monitored daily until they fledged or were lost. The number of chicks and location were recorded daily in the GIS. The last know location of broods were checked daily and if broods were not seen at that location then the search expanded to other possible foraging location in the area. Unaccounted for broods were searched for for seven days after the last sighting to be certain of the fate. Fledging occurs from 25-35 days after hatch. The fledge date is recorded when chicks are capable of strong sustained flight. Monitoring stops once chicks are fledged.

Counts of wintering and migrating piping plovers were made monthly from August to March during the non-breeding season. The counts were made near the 15th of each month. The ocean beach, inlets and soundside sandy beaches of each island were surveyed. Banded birds were searched for on the 5th, 15th, and 25th of August, September, and October during the fall migration.

Management

Nesting Closures

Management actions for piping plovers included closing nesting habitat, closing ocean beach foraging zones for chicks, predator exclosures for nests, predation management, and banding. Bird Sanctuary signs were used to close all known piping plover habitat to pedestrian and vehicular entry by April 1. Portsmouth Flats, Kathryn-Jane Flats, Swash Inlet, Old Drum Inlet, the ponds at Mile 15, New Drum Inlet, Ophelia Island, Ophelia Spit, Plover Inlet, Cape Point, and Power Squadron Spit were posted by April 1. These areas include the upper beach, dunes, sand flats, and mud flats. The active ocean beach in front of the nesting areas are not a part of the nesting habitat closure and are open for recreational use with some limitations. An additional closure was posted during the breeding season for new breeding activity at mile 10 on NCB.

In accordance with the ORV Plan, the northern mile of SCB at the Plover Inlet site is closed to vehicles once chicks hatch. The ocean beach is exceptionally narrow at this nesting site and chicks can quickly move to the oceanside. All other locations require chick presence on the beach to trigger an ocean beach foraging protection zone closure. These protection zones close sections of the ocean beach to vehicles to maintain the required 600-foot buffer between chicks and vehicle traffic. Pedestrian traffic is allowed in these foraging protection zones. NPS administrative use vehicles are allowed in the ocean beach closures to meet work requirements. Broods were monitored daily and closed sections of beach were re-opened once all chicks were either lost or fully fledged with strong flight observed.

Predator Management

In addition to regular predator removal activities conducted by WS, CALO staff protected some nests with predator exclosures if the topography of the location was suitable for exclosures and the location was accessible by vehicle. Exclosures were circular, 10 feet in diameter, made of 4”x 2” mesh wire fence anchored with steel rebar and were topped with ¾” mesh bird netting. Use of predator exclosures and monitoring adhered to the Piping Plover (*Charadrius melodus*) Atlantic Coast Population Revised Recovery Plan (USFWS, 1996).

Banding

CALO staff recorded band re-sights of individuals and nesting pairs at CALO throughout the year. Research staff from the Virginia Tech Shorebird Laboratory were permitted to band breeding pairs and chicks. Banding allows researchers to track population demographics, breeding patterns, habitat requirements, and survival. It also allows CALO staff to track individual nesting patterns and movements of birds throughout the park.

Results

Productivity

A total of 27 breeding pairs of piping plovers were documented at CALO in 2022. Twenty-one pairs nested on NCB and six pairs on SCB. Birds nested in eight distinct areas (Table 1). There were 43 nesting attempts made in 2022. The earliest nest initiation was on April 9 and the latest was on June 27. Thirty-five nests were on NCB and eight were on SCB. Of the 43 nests, 16 were re-nests. Sixteen

nests hatched and 6 chicks fledged from 4 different broods. One nest had an unknown fate, though it likely did not hatch or fledge a chick. A total of 138 eggs were documented with an average clutch size of 3.21 eggs. Field staff observed 29 hatched chicks but estimated an additional 9 chicks likely hatched but were lost before being observed. Productivity for CALO was 0.22 chicks fledged per breeding pair, compared to an average productivity of 0.57 over the previous 22 seasons. Table 2 contains nesting success data from 2000 to 2022. Figure 1 illustrates the number of pairs and chicks fledged from 1989 to 2022. Refer to Appendix A, Map A2 for a detailed map of nests and nest sites and Appendix B for individual nest productivity data for 2022.

Table 1. Piping plover reproductive success data by nesting site in 2022. *Pair 8 nested at both Swash Inlet and Mile 10 sites

Island	Nesting Area	Number of Pairs	Hatch Success	Fledge Success (chicks/pair)
North Core Banks	Portsmouth Flats	3	0.25	0.33
North Core Banks	Kathryn-Jane Flats	8	0.43	0.125
North Core Banks	Swash Inlet*	2	0.33	1.50
North Core Banks	Mile 10*	2	0.5	0.00
North Core Banks	Mile 15	1	0.00	0.00
North Core Banks	Old Drum Inlet	2	0.2	0.00
North Core Banks	New Drum Inlet	4	0.17	0.25
North Core Banks	Ophelia Island	0	n/a	n/a
South Core Banks	Plover Inlet	6	0.63	0.00

Table 2. Summary of piping plover reproductive success data at CALO from 2000 to 2022.

Year	Total Nests	Breeding Pairs	Total Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate (Chicks/pair)
				#	%	#	%	#	%	
2000	18	16	65	12	67%	43	66%	8	19%	0.5
2001	19	16	64	8	42%	24	38%	5	21%	0.31
2002	20	15	65	13	65%	43	66%	4	9%	0.27
2003	15	14	55	7	47%	23	42%	6	26%	0.43
2004	13	13	44	11	85%	37	84%	12	32%	0.92
2005	31	27	105	24	77%	69	66%	23	33%	0.85
2006	37	33	125	29	78%	87	70%	29	33%	0.88
2007	58	45	173	29	50%	79	46%	11	14%	0.24
2008	57	46	179	31	54%	88	49%	9	10%	0.20
2009	45	36	145	24	53%	83	57%	30	36%	0.83
2010	58	43	204	34	59%	98	48%	31	32%	0.72
2011	48	41	157	35	73%	102	65%	37	36%	0.90
2012	66	51	207	36	54%	98	47%	29	30%	0.57
2013	52	45	173	30	58%	97	56%	47	48%	1.04
2014	57	47	190	28	49%	88	46%	9	10%	0.19

2015	56	43	209	32	57%	105	50%	34	32%	0.79
2016	41	30	133	13	32%	23	17%	5	22%	0.17
2017	44	27	104	13	30%	27	26%	4	15%	0.15
2018	30	24	105	19	63%	56	53%	20	36%	0.83
2019	33	24	112	20	61%	65	58%	15	23%	0.62
2020	30	22	103	21	70%	65	63%	15	23%	0.68
2021	41	32	142	22	54%	68	47%	11	16%	0.34
2022	43	27	138	16	37%	38	28%	6	16%	0.22

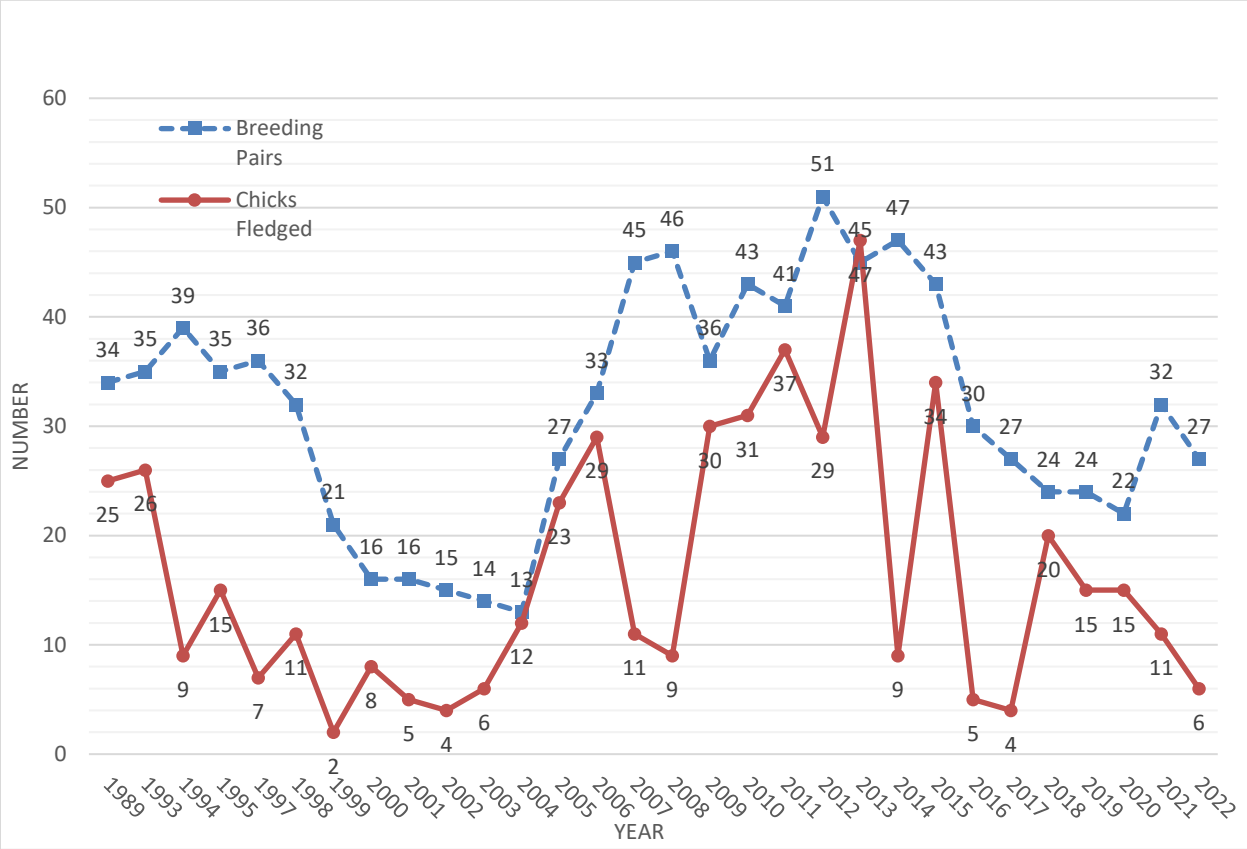

Figure 1. The number of piping plover breeding pairs and number of chicks fledged by year at CALO from 1989 to 2022.

Nest Failures and Chick Mortality

In 2022, predator exclosures were used to protect 17 (40%) nests. Of the nests with exclosures, eight (47%) hatched. Six exclosed nests were lost to flooding, two were abandoned, and one was lost to ghost crab predation. Predator exclosures were not used on 26 (60%) nests and 8 of these nests hatched (31%). In total, 26 nests did not hatch; 11 were lost to unknown reasons, eight were lost to flooding, five were predated, and two were abandoned (Table 3). Of the five predated nests, four

were by ghost crab and one was by an unidentified mammalian predator. One nest had an unknown fate, though it is assumed that it did not fledge a chick.

Due to the mobile nature of precocial chicks and lack of prolonged observations, the cause of chick mortality is largely unknown. Park staff estimated that 38 chicks hatched in 2022 and six of those survived to fledging (16%). Twelve of the hatched nests suffered complete brood loss. All 32 chick losses were classified as unknown.

Table 3. Causes of piping plover nest failure in 2022.

Nesting Site	Nests	Total Lost	Predation	Weather	Abandoned	Unknown
Portsmouth Flats	4	3	1	1	0	1
Kathryn-Jane Flats	14	8	3	2	1	2
Swash Inlet	3	2	0	1	1	0
Miles 10	2	1	0	1	0	0
Mile 15	1	1	0	0	0	1
Old Drum Inlet	5	4	0	1	0	3
New Drum Inlet	6	5	0	1	0	4
Ophelia Island	0	n/a	n/a	n/a	n/a	n/a
Plover Inlet	8	2	1	1	0	0
Total	**43**	**26**	**5**	**8**	**2**	**11**

Beach Protection Zones and Brood Foraging

The area between Ophelia Inlet and mile 25, 1.8 mile in length, was established as a protection zone for piping plover, American oystercatcher, and colonial waterbird chicks from May 24 to July 29th. This area was closed to recreational ORV's and only NPS monitors were allowed to operate vehicles in this area. Piping plover chicks were present at Ophelia Inlet from May 25, when the first nest hatched, to July 17, when the last brood failed. However, the beach closure was extended to July 29th to protect American oystercatcher and colonial waterbird chicks. On NCB, piping plover chicks did not use the ocean beach and there were no wildlife protection zones established for plovers during the 2022 season.

Chicks from all broods foraged on soundside beaches, sand flats, mudflats, ponds, and ephemeral pools in areas off-limits to vehicles and, in most cases, all entry. In 2022, brood locations were recorded in a GIS to track brood movements and home ranges. Foraging ranges were calculated for broods that fledged at least one chick using the Minimum Bounding Geometry tool in ArcGIS Pro. Brood foraging ranges varied from 1.04 acres to 7.67 acres, with an average range of 4.93 acres (see Appendix A, Map A3). The farthest distance traveled away from the nest for all brood observations was 0.36 miles in which two chicks traversed a long distance to reach a foraging pond.

Migrating and Wintering Piping Plovers

Park wide non-breeding piping plover surveys were conducted each month in 2022 in January through March and August through December. A total of 1,208 piping plovers were documented during non-breeding surveys from 129 separate observations (see Appendix A, Map A4; Appendix C). The highest number of non-breeding piping plovers were recorded in August with 481 birds seen at CALO (Table 4).

Of the 1,208 birds, 809 (67%) were recorded as unbanded and 130 (11%) were recorded as banded. Of the 130 banded birds, field staff obtained full band combinations for 113 birds. Two hundred and sixty-nine birds were recorded as unknown banding status. Staff recorded banded birds from both the Atlantic Coast and Great Lakes piping plover populations.

In addition to monthly surveys, staff recorded an additional 136 observations totaling 715 piping plovers during 2022. These were typically opportunistic sightings, some occurring during the breeding season, and did not follow any survey protocol.

Table 4. Number of non-breeding piping plover individuals observed each month of 2022.

Island	January	February	March	August	September	October	November	December
NCB	4	3	40	381	117	34	21	34
SCB	14	2	1	91	304	51	20	51
SB	1	0	2	9	6	8	11	3
Total	**19**	**5**	**43**	**481**	**427**	**93**	**52**	**88**

Banding

Virginia Tech Shorebird Laboratory researchers trapped and banded four new adults from four nests with individual field readable codes. Three previously banded adults were recaptured and resampled. No chicks were banded in 2022. Of the 55 individuals nesting at CALO, 28 (51%) were banded and 27 (49%) were unbanded. One male nested with a different female on its second nesting attempt. Seven (26%) pairs were completely unbanded while 20 (74%) pairs had at least one individual banded. Of note, two of these banded birds have nested at CALO during seven nesting seasons. GF(A5P) is a female that was banded as a chick in 2015 and has produced four fledglings since 2016. GF(715) is a male that has fledged three chicks since 2016. See Appendix B for nesting pair band combinations.

Egg Floating

When nests are found at full clutch the stage the incubation is unknown. Egg floating can be used to estimate the incubation age of the nest. Trained CALO staff may float eggs for certain nests that are found at full clutch when management decisions need to be based on estimated hatch dates or when suitability for trapping needs to be assessed. In 2022, CALO staff floated 2 eggs from one nest and VT researchers floated one egg from a second nest.

Discussion

Piping plover productivity was low in 2022, driven heavily by a spring storm event. Productivity of 0.22 chicks per pair in 2022 was below the CALO average of 0.57 and well below the United States Fish and Wildlife Service goal of 1.5 chicks per pair. Five fewer pairs nested at CALO compared to the previous season. Nearly all reproductive metrics were below average in 2022, including hatch success and chick survival.

A stationary low-pressure system produced a coastal storm that stalled offshore of CALO from May 8 through May 11. This storm produced days of gale force winds, coastal flooding, and significant ocean overwash. Of the 12 piping plover nests that were active at the time of the storm, eight were directly washed out. Four nests survived the storm but none of those nests produced fledglings. This event led to a near complete re-start of the breeding season post-storm. In addition to direct impacts on nests, the storm likely influenced the rest of the breeding season.

Heavy ocean overwash during the May storm scoured sand from some nesting areas and dumped a layer of fresh sand on other sites, resulting in the transformation of many shell beds into barren sand flats. Piping plovers prefer dense shell beds that camouflage eggs and typically do not like to nest in open sand flats. Piping plovers were slow to re-nest after this storm event, likely due to habitat changes after the storm. Twelve pairs did not lay their first nests until the end of May or June, which is very late for a typical breeding season. In addition, seven to nine additional males retained territories throughout the breeding season but were unable to recruit females, possibly due to poor habitat conditions. It is unknown how the storm influenced this sex disparity, but the lack of breeding females did contribute to the decrease in nesting pairs in 2022.

Ghost crabs were the primary predator of known nest losses in 2022. Four nests were lost due to ghost crab predation, including one predation event that field staff observed at a distance through their optics. Trail cameras captured ghost crab disturbance at another nest on three separate occasions in which a plover was able to successfully fight off a ghost crab within the predator exclosure. Partial clutch loss, where eggs disappear during incubation but viable eggs remain, occurred at several nests and it is suspected that ghost crabs are responsible for these egg losses.

While 50% of nest losses were attributed to weather and predation, 42% of losses were of unknown cause. Park staff trialed the installation of movement-triggered trail cameras at some piping plover nests to determine the cause of nest failures. Cameras captured photos of raccoons, cats, and coyotes outside of predator exclosures. Several photos were captured of piping plovers defending their eggs against ghost crabs within the exclosures. However, no predation events were recorded. Unfortunately, the use of trail cameras was discontinued on NCB when exclosure use was stopped as there is concern that cameras could attract mammalian or avian predators to unexclosed nests. The continued use of trail cameras on exclosed nests in future seasons is recommended to better understand the source of piping plover nest loss.

The use of predator exclosures was much lower in 2022 than previous seasons. Park staff encountered several problems with predator exclosures on NCB. One exclosure needed to be removed after a pair would not incubate the nest after installation. Two other exclosed nests were

abandoned. Several other pairs were slow to accept the predator exclosures after installation. A decision was made by park biologists to discontinue the use of predator exclosures on NCB mid-season. Overall, plover pairs on NCB appeared to be less invested in their nests compared to prior breeding seasons. No predator exclosure issues were experience on SCB and the use of exclosures continued at the Plover Inlet site. The discontinuation of exclosures on NCB may have resulted in a decrease in hatch success.

Park staff observed a record high count of non-breeding plovers at CALO in 2022 with 481 and 427 plovers counted during the August and September surveys, respectively. This indicated that while breeding habitat may have been negatively impacted by the May storm, there may have also been positive effects on foraging habitat through the increase of moist sand and mudflats preferred for foraging by non-breeding plovers.

American Oystercatcher (*Haematopus palliates*) Management and Monitoring

Background

American oystercatchers are ground-nesting shorebirds that are native to North Carolina. They are common nesters throughout CALO, particularly on the ocean beach. They have been listed since 2008 as a North Carolina Special Concern species by the NCWRC (NCWRC, 2014). Their choice of nesting habitat makes them particularly vulnerable to disturbance by park visitors and off-road vehicles.

Monitoring American oystercatcher nesting at CALO began in 1995. A researcher from Duke University studied nesting on SCB and found low reproductive success (Novick, 1996). The research documented chick mortality caused by off-road vehicles. Researchers from North Carolina State University (NCSU) and CALO staff have also recorded vehicle traffic chick mortality (Schulte and Simons, 2015). Between 1997 and 2015, NCSU and CALO staff have conducted censuses, monitored nesting success, and banded American oystercatchers primarily on the Core Banks. Between 2016 and 2022, solely CALO staff conducted American oystercatcher monitoring. Monitoring and management are conducted following CALO's ORV Plan. Data in this summary report are presented from the last 19 breeding seasons, 2004 to 2022, during which all barrier island habitat at CALO was monitored regularly.

Methods

Monitoring

The ORV Plan contains management guidelines and monitoring protocols (NPS, 2016). Following this protocol, park staff conducted surveys of SB for nesting birds twice a week beginning in April. Daily surveys of nesting habitat on NCB and SCB also began in April and breeding monitoring continued seven days per week until the end of the nesting season. All ocean habitat and accessible interior and soundside habitat was monitored for breeding activity. Marsh islands were not monitored or included in this report.

Once nests were identified, the locations of the nests were recorded in decimal degrees using a GIS. Nest locations were marked inconspicuously with either a stake or objects like sticks or shells to facilitate follow-up checks. Information about the habitat type was also noted. Adults were surveyed for bands and any band codes were recorded. Motion-triggered trail cameras were installed at some nests to aid in monitoring.

Nests were checked every 1 to 3 days to monitor the status of incubation and document losses. Daily nest checks were recorded in the GIS. When a nest was lost, CALO staff would check the area for signs of predation or other causes of nest failure. When a nest hatched, chicks were monitored daily until they fledged or were lost. For reporting purposes, chicks were considered fledged at 35 days old based on a standard established by the American Oystercatcher Working Group in 2010. For management purposes, chicks were considered fledged when strong flight was observed.

Management

Nesting Closures

Management actions for oystercatchers on Core Banks included closing a 20’ by 20’ area around a nest with “Bird Sanctuary” signs if the nest was in danger of being run over by off-road vehicles or stepped on by pedestrians. Generally, nests found in the dunes were not posted. There is concern that predators might learn to associate posts with nests. Small posted areas may also unnecessarily attract curious park visitors and cause disturbance.

In addition to the closure around the nest, a 600-foot buffer was established around each nest to reduce disturbance. McGowan and Simons (2006) found evidence that human recreational disturbance can alter incubation behavior. This buffer allowed vehicle and pedestrian traffic to pass by on the lower beach by the ocean shoreline, but prevented stopping, parking, or camping near the nest that could reduce nest attendance by parents. The buffer zone was defined by two sets of 18” X 18” yellow signs placed on each side of a nest. Nests located in interior areas and within previously established wildlife closures did not receive buffer signs.

One day before the expected time of hatch, the ocean beach in that area was closed to vehicles with traffic routed to the backroad, a sand trail behind the primary dunes. In areas where there is no backroad, Bird Sanctuary signs were expanded to create a closed area for broods on the upper beach while allowing traffic to travel on the lower beach with a lowered speed limit of 15mph. In these areas, signs were posted on the lower beach to warn ORV operators of the presence of chicks in the area. In all areas, broods were monitored daily and closed sections of beach were re-opened once all chicks were either lost or fully fledged with strong flight observed.

Banding

Park staff recorded band re-sights of individuals and nesting pairs at CALO throughout the breeding season. In addition, trained biologists and technicians captured and banded American oystercatcher adults and chicks under a current USGS banding permit. Banding allows researchers to track

population demographics, breeding patterns, habitat requirements, and survival. It also allows CALO staff to track individual nesting patterns and movements of birds throughout the park. Band re-sights and banding efforts are tracked and shared with partners through the American Oystercatcher Band Database. Details on American oystercatcher band combinations can be found at the website: http://www.amoywg.org/banding-re-sighting/.

Results

Productivity

In 2022, 46 pairs of American oystercatchers nested at CALO, 26 pairs on NCB, 19 pairs on SCB, and one pair on SB. (Table 5, Appendix A, Map A5; Appendix D). Counts were for pairs on or near the ocean beach and did not include marsh islands. The first nest of the season was found on March 30 and the last nest was found on June 19.

Eighty-one nests were documented at CALO; 46 on NCB, 34 on SCB, and one on SB. Hatch success was 50% for NCB, 21% for SCB, and 0% for SB. NCB produced 0.27 chicks per nesting pair while SCB and SB produced no chicks. A total of twenty nests hatched at CALO and fledged 7 chicks producing an overall fledge rate of 0.15 for the seashore. (Table 5). Since 2004, fledge rates have ranged from 0.00 to 1.17 per pair with a mean rate of 0.51 from 2004-2022 (Table 6, Figure 2).

Table 5. American oystercatcher reproductive success by island in 2022.

Island	Breeding Pairs	Total Nests	Nests Hatched	Chicks Fledged	Fledge Rate
South Core Banks	19	34	7	0	0.00
North Core Banks	26	46	13	7	0.27
Shackleford Banks	1	1	0	0	0.00
Total	**46**	**81**	**20**	**7**	**0.15**

Table 6. Summary of American oystercatcher reproductive success data at CALO from 2004-2022.

Year	Total Nests	Nests Hatched	Breeding Pairs	Chicks Fledged	Fledge Rate
2004	71	38 (54%)	52	45	0.86
2005	66	26 (39%)	54	18	0.33
2006	70	23 (33%)	52	26	0.50
2007	99	21(21%)	61	31	0.51
2008	91	17 (19%)	57	15	0.26
2009	83	20(24%)	61	21	0.34
2010	113	28 (25%)	62	34	0.55
2011	114	29 (25%)	62	37	0.60
2012	99	31 (31%)	58	42	0.72
2013	104	32 (31%)	63	25	0.40
2014	87	39 (37%)	65	40	0.62
2015	112	37 (33%)	66	50	0.76
2016	121	17 (14%)	70	17	0.24
2017	133	5 (4%)	70	0	0.0

2018	123	28 (23%)	69	39	0.57
2019	84	33 (39%)	58	32	0.55
2020	85	28 (33%)	49	27	0.55
2021	74	40 (54%)	54	63	1.17
2022	81	20 (25%)	46	7	0.15

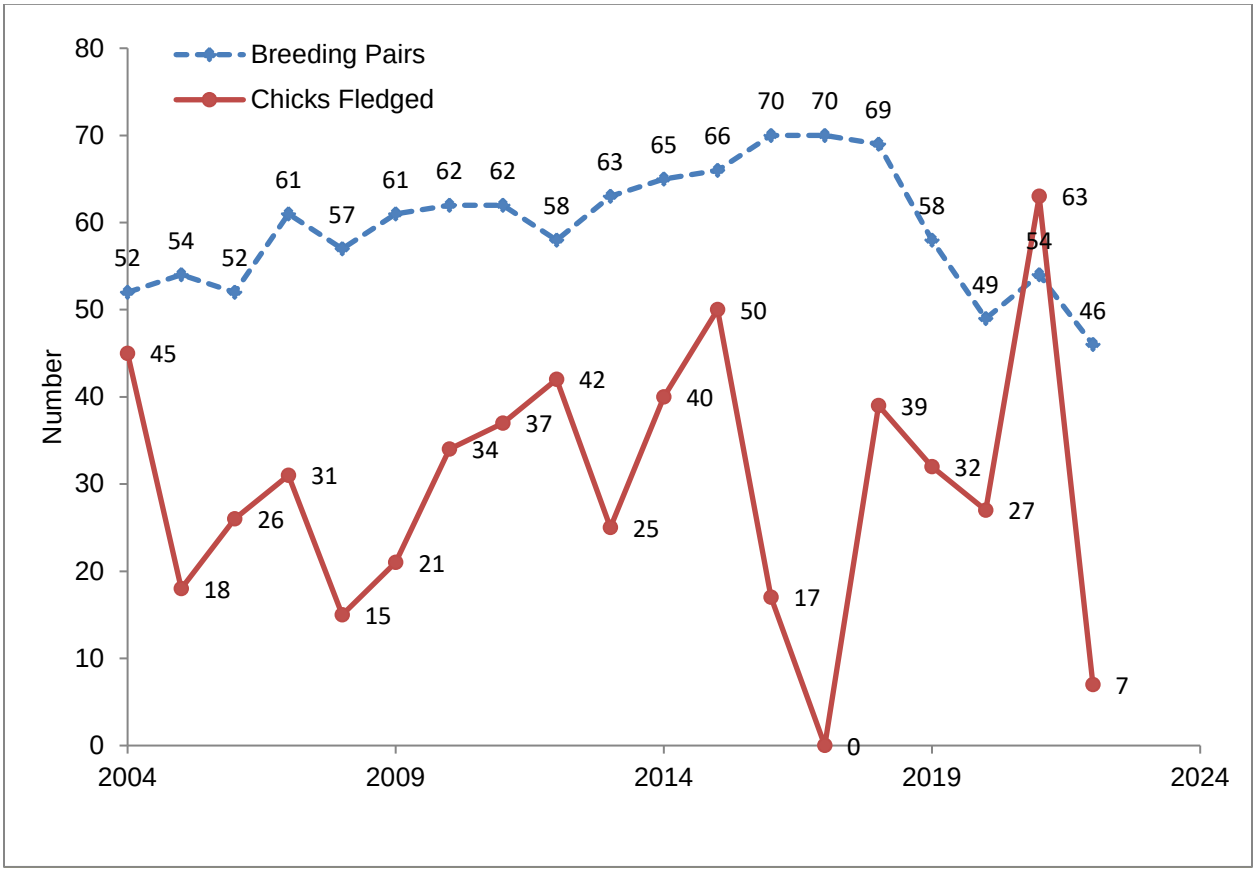

Figure 2. The number American oystercatcher breeding pairs and number of chicks fledged by year at CALO between 2004 and 2022.

Nest Failures

Sixty-one nests failed in the 2022 breeding season. Twenty (33%) were lost due to predation, 17 (28%) were due to weather, 17 (28%) were unknown causes, six (10%) were abandoned, and one (2%) was lost due to human interaction (Table 7). Coyote was the primary predator in 2022, accounting for 13 nest loses (Table 8). Four additional nests were predated by raccoons, two by ghost crabs, and one by an unidentified predator. One nest was found abandoned after visitors set up camp around the nest before it had been detected by park staff. Causes of American oystercatcher nests failures from 2013 to 2022 are described in Table 9.

Table 7. Causes of American oystercatcher nest failure in 2022.

Island	Predation	Flooding/Storms	Abandoned	Human Interaction	Unknown
South Core Banks	14	7	4	0	2
North Core Banks	6	10	2	1	14
Shackleford Banks	0	0	0	0	1
Total	20	17	6	1	17

Table 8. Recorded American oystercatcher nest predators in 2022.

Island	Coyote	Raccoon	Ghost crab	Unidentified Predator
South Core Banks	12	0	1	1
North Core Banks	1	4	1	0
Total	13	4	2	1

Table 9. Causes of American oystercatcher nest failure, 2013-2022.

Year	Total Nests	Nests Lost	Predation	Flooding/ Storms	Human Interaction	Abandoned	Unknown
2013	104	72 (69%)	21 (29%)	3	1	1	46
2014	87	49 (56%)	15 (30%)	6	0	1	27
2015	112	75 (67%)	41 (54%)	0	0	4	30
2016	121	104 (86%)	68 (65%)	2	2	2	30
2017	133	128 (96%)	76 (59%)	16	1	7	33
2018	123	95 (77%)	51 (54%)	3	2	3	36
2019	84	51 (61%)	25 (49%)	0	0	3	23
2020	85	57 (67%)	18 (32%)	2	1	3	30
2021	74	34 (46%)	15 (44%)	2	2	3	12
2022	81	61 (75%)	20 (33%)	17	1	6	17

Chick Mortality

Park staff observed 39 chicks from 20 hatched nests. However, chicks are often difficult to detect and can be lost before technicians are able to observe them. CALO staff estimates that 45 chicks likely hatched. Seven of these 45 chicks successfully fledged, with a chick survival probability of 16%. Fifteen of the hatched nests suffered complete brood loss. Due to the mobile nature of precocial chicks and the lack of prolonged observations, the cause of chick loss is largely unknown. However, it is strongly suspected that a significant weather event led to the loss seven broods, while coyote predation may have contributed to the loss of three other broods.

Banding

Seven chicks on Core Banks were captured by CALO staff and banded with individual field readable codes. An additional four chicks were banded from unmonitored broods on Morgan Island and Cedar Hammock. Three previously unbanded adult American oystercatchers were trapped and banded on

North Core Banks. On SCB, two banded birds were re-captured and outfitted with location-tracking backpacks as part of an outside research project. Of the 92 individuals nesting at CALO, 62 (67%) were banded, 28 (30%) were unbanded, and two (2%) had unknown banding status. Only one (2%) known pair was completely unbanded and 44 (96%) had at least one of the pair banded. See Appendix D for nesting pair re-sight data and 2022 chick bands.

Discussion

American oystercatcher productivity in 2022 was one of the lowest on record. CALO produced only seven chicks resulting in a productivity of 0.15 chicks per pair, compared to a record high of 63 chicks fledged the previous season. In addition, the nesting pair count continues to decrease since a high of 70 pairs in 2017. Hatch success and chick survival were both low in 2022. Low overall productivity in 2022 was primarily driven by the combination of a spring storm event and predation pressure. While CALO staff documented nests for 46 pairs of American oystercatchers in 2022, an additional six pairs maintained breeding territories throughout the season.

A low-pressure system in May produced gale force winds and ocean overwash that directly impacted early season nests. Before the storm, seven broods and 38 nests were active. All seven broods failed during the storm. Of the 38 nests, only five survived. Only two of those five nest successfully produced fledges. Twelve nests were directly washed out or blown over by the storm, and five were abandoned likely due to severe weather conditions. Early season nests are typically the most successful, so having nearly all the first nests destroyed by the storm severely impacted the overall productivity of the season.

Predation pressure, particularly by coyotes on SCB, also heavily influenced productivity in 2022. Coyotes were known to predate at least 13 nests at CALO, 12 of those being on SCB. Coyotes likely also predated oystercatcher chicks, though it is difficult to quantify to what extent. High coyote presence was also thought to impede re-nesting of pairs on SCB, resulting in an overall lower number of nesting attempts and pairs on SCB compared to previous years. Four pairs maintained breeding territories on SCB but nests were never found. These pairs either had nests that failed before staff could locate them, or they never nested due to predator harassment or another unknown cause. One pair did nest on SB in 2022 but the nest failed quickly. Coyote activity is thought to be the driving factor precluding American oystercatcher nesting interest on SB. While raccoon and ghost crab predation events were recorded in 2022, coyotes were clearly the most significant predator.

Coyotes have been active on SCB since 2014 and it is unclear why coyotes target American oystercatcher nests and chicks more some years than others. The 2021 season produced a record number of chicks on SCB while coyotes were present on the island. However, 2022 saw high levels of coyote predation on nests. A better understanding of predator population dynamics on the island and a predator tracking study could better inform management actions for nesting shorebirds.

Resource staff trialed the use of motion-triggered trail cameras to monitor American oystercatcher nests in 2022. The objective of this project was to obtain more information on the cause of nest failures and to compare the field observed signs, such as predator tracks, to camera photos or videos. The cameras documented two raccoon predation events on American oystercatcher nests. There were

no observable tracks or signs of predation at these nests when they were checked after failure and they would have otherwise been documented as unknown causes. Cameras captured photos of a cat and two additional raccoons passing by nests without predating them. Non-predator species captured on camera include a cow, nutria, laughing gull, killdeer, and common tern. Camera installation was limited by the number of cameras available.

Colonial Waterbird Monitoring and Management

Background

The inlet spits, sandflats, inshore islands, and the point at CALO provide nesting habitat for several species of colonial waterbirds. The least tern (*Sternula antillarum*), common tern (*Sterna hirundo*), gull-billed tern (*Gelochelidon nilotica*), black skimmer (*Rynchops niger*), sandwich tern (*Thalasseus elegans*) and royal tern (*Thalasseus maxima*) nest at CALO in single species and mixed species colonies.

Methods

Management

Historical nesting sites were signed and closed to pedestrian and vehicle entry by April 1. Reoccurring nesting sites include Morgan Island, Power Squadron Spit, Cape Point, Ophelia Inlet, New Drum Inlet, Old Drum Inlet, Kathryn-Jane Flats, and Portsmouth Flats. In addition to reoccurring nesting sites, all additional potential nesting habitat at CALO was monitored and closures were installed once breeding activity was observed.

Closures were adjusted and expanded throughout the breeding season to maintain a 150-ft buffer between the closure boundary and the nearest nest. If chicks were present on the lower beach vehicles were restricted and/or detoured to avoid flightless chicks. Closures were removed when breeding activity ended.

Monitoring

Colonies were monitored daily to ensure protection within closure boundaries. Colony counts were conducted weekly. Breeding pairs were counted by either a perimeter count of incubating pairs or a total number adult count. Total adult counts were then divided by two to ascertain the number of breeding pairs. No correction factor was employed in the results. The assumption being that all birds present within the breeding colony site are there as breeders. When observed, the number of nests, chicks, and fledges was also recorded. GPS point locations were obtained for the center of each colony and recorded in a GIS. Fledge success for each colony was observationally rated as high, medium, low, none, or unknown.

CALO participated in the state-wide annual least tern census from May 14 to June 4. CALO staff counted all colonies that were active on Core Banks during the window and results were shared with state biologists.

Results

In 2022, 28 colonial waterbird colonies were observed at CALO (Table 10). Seventeen colonies were on NCB, 10 were on SCB, and one was on Morgan Island (Appendix A, Map A6). There were no colonies on SB. Morgan island was posted for nesting activity and royal tern and sandwich terns nesting activity was observed but no pair count or productivity monitoring was conducted. Of the 28 colonies, seventeen were single species colonies and eleven were multi-species colonies. Six species of colonial waterbird nested at CALO that included the least tern, black skimmer, common tern, sandwich tern, royal tern, and gull-billed tern. Twenty colonies occupied reoccurring nesting sites that were posted at the beginning of the season. Eight colonies were observed outside of the posted areas and were subsequently posted. Five colonies were ranked as no success, 14 had low success, five had medium success, three had high success, and one had unknown success.

Four hundred and sixty-two pairs of least terns were counted at CALO during the annual least tern census window (Figure 3). In addition, 153 black skimmer pairs, 69 gull-billed tern pairs, and 19 common tern pairs were counted during the census window. A peak of 250 pairs of black skimmers were counted on Florence Island on September 8.

Table 10. Summary of colonial waterbird colonies in the Seashore in 2022. LETE=least tern, BLSK= black skimmer, COTE= common tern, GBTE= gull-billed tern, ROTE = royal tern, SATE = sandwich tern.

ID	Island	Mile	Site	Census Pairs Count	Peak Pairs Count	Success
NC14	NCB	2.36	North Portsmouth	2 LETE	9 LETE	None
NC14	NCB	2.48	Portsmouth Back Flats	6 LETE	6 LETE	None
NC02	NCB	3.00	Evergreen Inlet	9 LETE, 2 BLSK	10 LETE	Low
NC09	NCB	3.30	Mid Portsmouth	9 LETE	71 LETE	Low
NC13	NCB	3.64	South Portsmouth	5 LETE	12 LETE	Low
NC06	NCB	5.97	High Hills	35 LETE	53 LETE, 2 BLSK	Low
NC07	NCB	6.65	Kathryn-Jane Flats	15 LETE	32 LETE	Medium
NC16	NCB	9.27	Swash	-	3 LETE	Medium
NC10	NCB	10.79	Mile 10	2 LETE	18 LETE	Low
NC17	NCB	11.24	Mile 11	-	4 LETE	Low
NC03	NCB	15.08	Mile 15	6 LETE	7 LETE	None
NC04	NCB	18.62	North Old Drum	25 LETE, 76 BLSK. 23 GBTE, 8 COTE	54 LETE, 56 BLSK, 6 GBTE, 1 COTE	Medium
NC05	NCB	19.14	South Old Drum	89 LETE	145 LETE, 19 BLSK, 3 COTE	High
NC11	NCB	21.26	Mile 21	1 LETE	2 LETE	Medium
NC12	NCB	21.66	North New Drum	12 LETE	12 LETE	Low
NC01	NCB	22.00	New Drum Flats	46 LETE	46 LETE	Low
NC08	NCB	22.98	Ophelia	15 LETE	24 LETE	Low

SC06	SCB	24.00	North Plover Inlet	15 LETE, 7 BLSK, 30 GBTE, 8 COTE	55 LETE, 119 BLSK, 28 GBTE, 5 COTE	High
SC08	SCB	24.00	Florence Island	61 LETE, 4 GBTE,	250 BLSK	High
SC02	SCB	24.53	Mid Plover Inlet	48 LETE, 27 BLSK, 5 GBTE, 2 COTE	87 LETE, 20 BLSK, 4 GBTE	Low
SC01	SCB	24.75	South Plover Inlet	26 LETE, 34 BLSK, 11 GBTE, 1 COTE	108 LETE, 2 BLSK, 1 GBTE,	Low
SC04	SCB	31.20	Mile 31	14 LETE	20 LETE	Low
SC05	SCB	34.11	Mile 34	2 LETE	8 LETE	None
SC10	SCB	35.51	Mile 35	-	12 LETE	Low
SC09	SCB	36.42	Mile 36	-	6 LETE	None
SC07	SCB	38.50	Mile 38	9 LETE	24 LETE	Low
SC03	SCB	43.75	Cape Point	10 LETE, 1 BLSK	35 LETE, 1 BLSK	Medium
MI01	MI	-	Morgan Island	not surveyed	ROTE, SATE (no count)	unknown

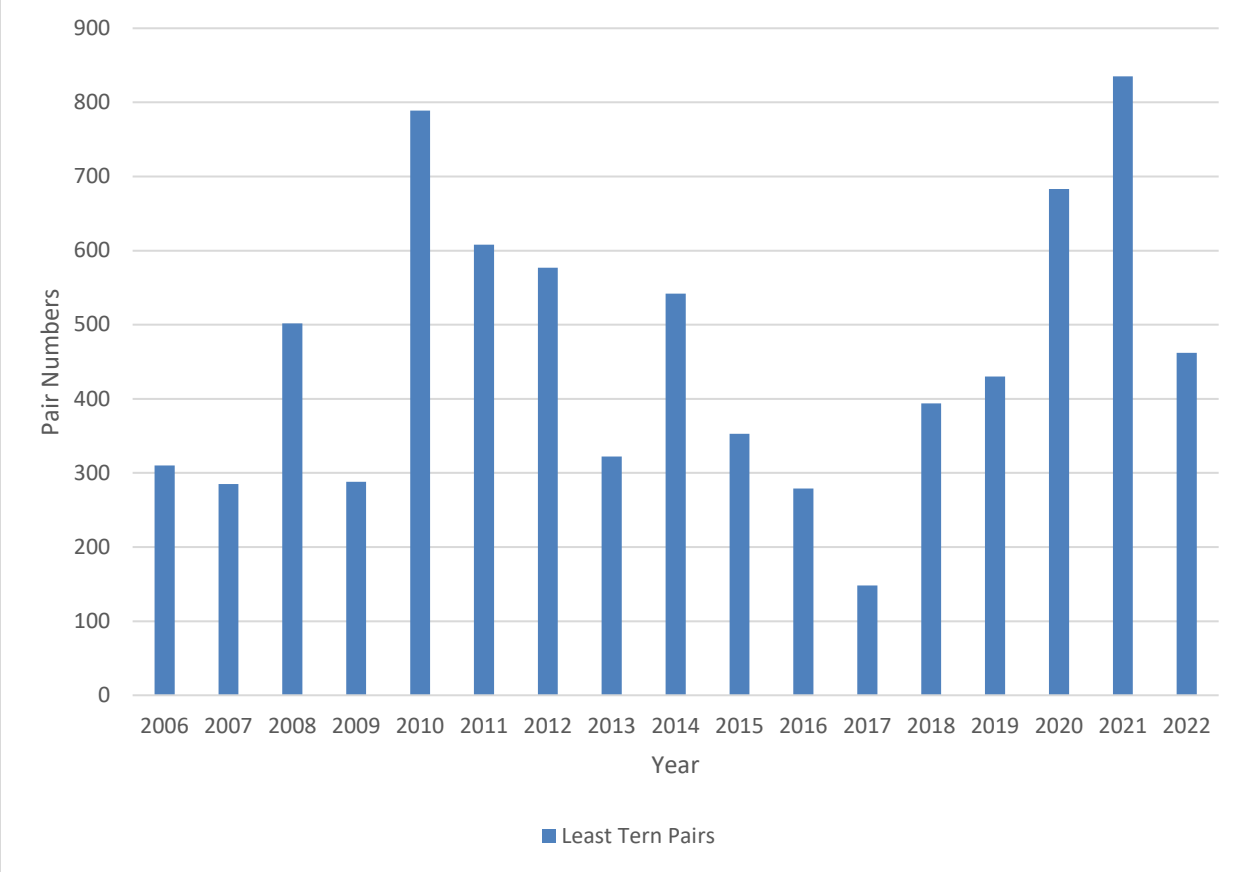

Figure 3. Least tern window census counts at CALO from 2006 to 2022.

Discussion

Productivity in colonial waterbird colonies is difficult to determine under current monitoring protocols at CALO. Three colonies were rated as high success, two at Plover Inlet on SCB and one at Old Drum on NCB. The colony at Old Drum produced a high number of tern fledges, while the colonies at Plover Inlet produced high numbers of black skimmer chicks. The majority of colonies were rated with productivity between medium and none. Although there was a relatively high number of colonies, several of these colonies were smaller than 10 pairs. The May least tern census counted 462 pairs nesting in the park, 44% lower than the previous peak year in 2021. While it is comparable with the average pair count of 459 over the past 17 seasons, it does show a significant decrease after several years of increasing pair counts.

Low pair counts may be due to habitat changes caused by the May storm. Colonial waterbirds typically start nesting at the end of April or early May and the storm arrived right when colonies were becoming established. The storm not only interrupted the recruitment of birds and washed out existing nests, it also produced habitat changes that impacted the rest of the season. The storm scoured many colonial nesting areas, resulting in smaller high elevation shell bed areas for birds to nest. Birds may have simply left the area after the storm to find better nesting habitat elsewhere. High concentrations of coyote tracks were also recorded at Plover Inlet on SCB. Although individual colonial waterbird nests are not monitored at CALO, it is suspected that coyote predation played a factor in poor productivity.

Red Knot (*Calidris canutus rufa*) Monitoring

Background

Serious declines in the population of red knots (*Calidrus canutus rufa*) led the U.S. Fish and Wildlife Service to provide protection under the Endangered Species Act. In December 2014, the red knot was designated as a threatened species (USFWS, 2014). Red knots use CALO as a stopover site in spring and fall migration. While not as important as some other coastal sites, CALO may still contribute to the survival of this species.

Previous monitoring of red knots at CALO was limited to surveys as part of a broader shorebird study in 1992 and 1993 (Dinsmore et al., 1998). NCB had greater numbers of red knots than anywhere else in the Outer Banks and reported a relative density of 34 birds per kilometer, but surveys in that study did not include any of the areas south of New Drum Inlet.

Methods

Surveys for red knots were made of the ocean beach and inlet areas on Core Banks, NCB and SCB, beginning in mid-March through the end of October. Survey frequency and timing followed the International Shorebird Census guidelines for spring and fall. Counts were done near the 5th, 15th, and 25th of the month from March 15 to June 5 and from July 15 to October 25. An additional survey was coordinated on May 19 with a USFWS southeast coast aerial survey. In 2022, the two-mile

section of beach between Ocracoke Inlet to Evergreen was not included in surveys due to irregular access across Evergreen Inlet.

Surveys were conducted by the park biologist or biological science technicians who have experience identifying shorebirds. Surveys were at different times of day, tides and weather conditions. Monitors recorded the number of red knots observed, the mile location, the latitude and longitude, the amount of human disturbance, tide level, and the accuracy of the count in a GIS.

Results

Spring migration counts peaked on May 25 with 2,997 birds counted across the Core Banks (Figure 4). The May 19 ground truthing count recorded 2,447 birds on the Core Banks. Fall migration peaked on August 15 with 253 red knots counted across the Core Banks. Spring migration from March 15 to June 5 averaged 557 birds across both islands. The fall migration from July 15 to October 15 averaged 35 birds across both islands.

NCB averaged 163 birds per survey throughout the survey period. SCB averaged 107 birds per survey. NCB had the highest count of 2,210 birds on May 25, with a relative abundance of 69 birds per kilometer (Table 11). SCB had the highest count of 787 red knots on May 25, with a relative abundance of 20 birds per kilometer. Red knots were distributed over the length of Core Banks from 2006 to 2022 (Figure 5; Appendix A, Map A7).

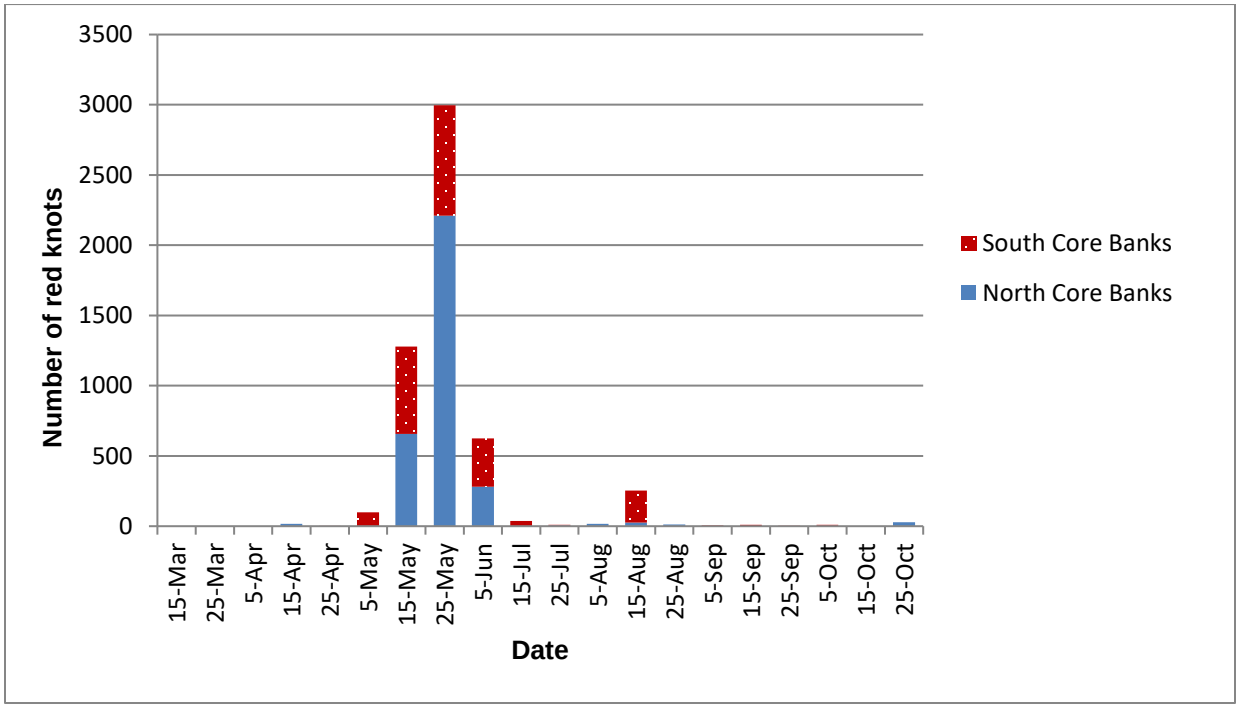

Figure 4. Number of red knots counted at CALO in 2022.

Table 11. Red knot relative abundance on NCB from 1992-2022.

Year	Date	Peak Count	Kilometers	Relative Abundance
1992-1993	-	-	34	34
2006	May 5	618	30.3	20
2007	May 15	718	30.6	23
2008	Apr 15	1287	30.6	42
2009	May 25	525	36	14
2010	May 15	927	36	26
2011	May 15	648	36	18
2012	April 25	1370	29.8	46
2013	May 25	854	29.8	29
2014	May 15	2666	29.8	89
2015	May 15	2201	29.8	74
2016	May 15	2124	29.8	71
2017	May 15	1741	29.8	58
2018	May 25	1710	36	48
2019	May 5	395	36	11
2020	May 5	999	25.7	39
2021	May 15	954	25.7	37
2022	May 25	2210	32	69

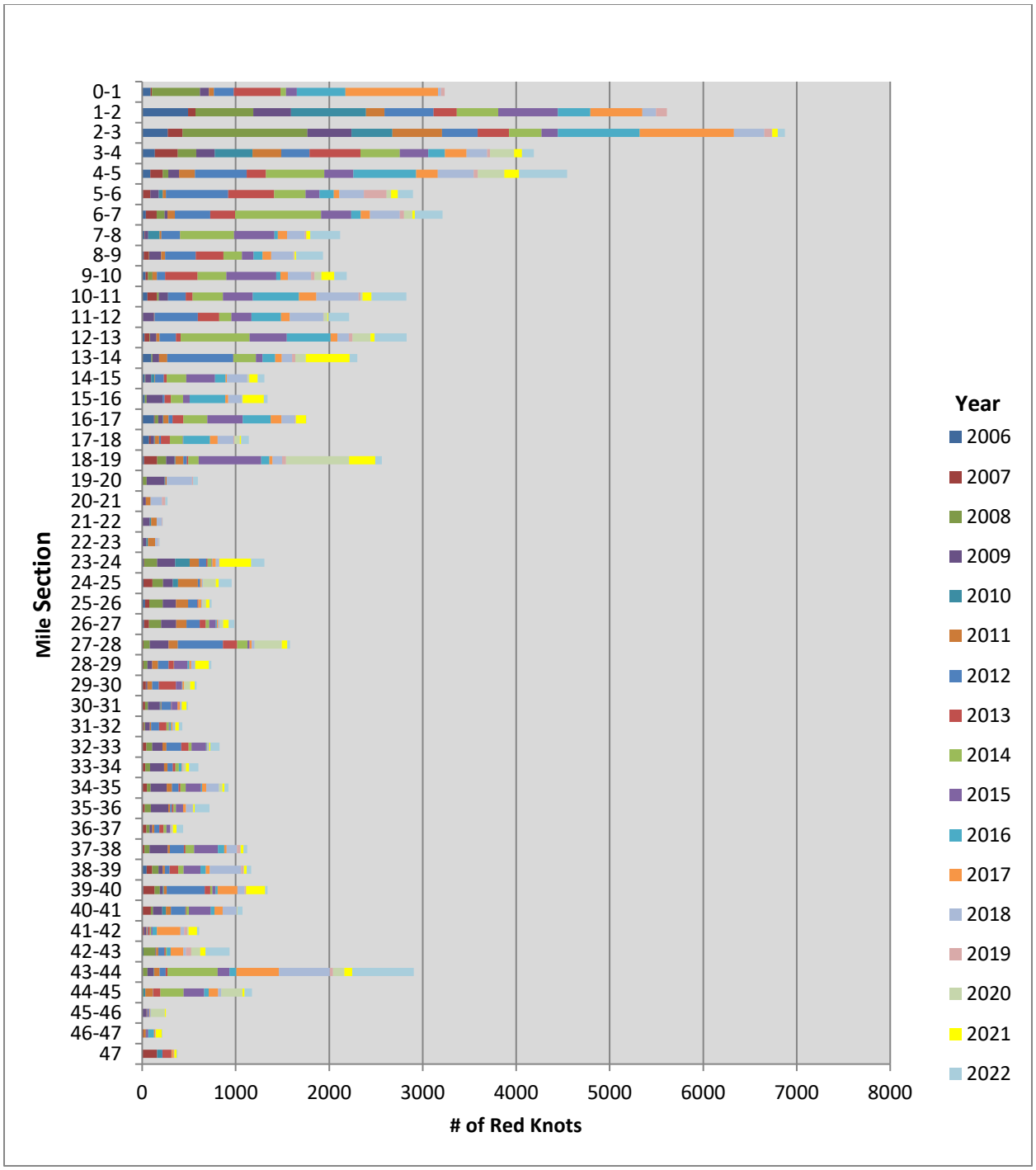

Figure 5. Total number of red knots counted in each mile section from 2006 to 2022.

Discussion

Monitoring in 2022 confirmed CALO as a stopover site for red knots, particularly during the spring migration. Spring migration counts peaked at 2,997 red knots in 2022, the highest count on record at CALO. A total of 5,402 red knots were observed during migration surveys. These numbers are likely lower than the actual count of red knots at CALO, as the top two miles of NCB were not included in the surveys due to irregular access across Evergreen Inlet. The northern portion of NCB is considered a hotspot for red knots, so it is expected that flocks likely occurred in this area not included in the survey. Relative abundance of 69 birds per km on NCB was much higher than the 17-year average of 39 birds per km. Peak numbers for red knots were seen at miles 5, 7-9, and 11-13 on NCB, showing somewhat of a shift in distribution to the middle of the island. The highest numbers of red knots on SCB were seen at mile 42-43 along the Cape. This data highlights the importance of CALO as a stopover site for migrating red knots. Although the Outer Banks may not be as important as some other sites in the region such as Delaware Bay, it still provides habitat that may be important for the recovery and long-term survival of red knots.

Wilson's Plover (*Charadrius wilsonia*) Management and Monitoring

Wilson's plover pairs were surveyed annually at the same time as the piping plover window census of June 1 to June 9 from 2007 to 2016. Wilson's plovers are now surveyed at a minimum of every three years in line with the NCWRC coast wide survey, with additional annual surveys conducted when time allows. A park-wide survey was conducted in 2022 and recorded a total of 114 pairs and 10 singles (Table 12). Pairs were counted in the same nesting areas as piping plovers and any additional habitat throughout the park. Nests and broods were recorded when found or observed opportunistically, but nest and brood fates were not tracked. Thirty nests and one brood were recorded during the 2022 season. Though pair numbers were down from a record high in 2021, Wilson's plover pairs appear stable to increasing at CALO since 2007 (Figure 6).

Table 12. Wilson's plover census results June1-9, 2022.

Island	Nesting Area	Number of Pairs	Singles
North Core Banks	Ocracoke Inlet	0	3
North Core Banks	South Portsmouth Flats	11	1
North Core Banks	Kathryn-Jane Flats	7	1
North Core Banks	Mile 17.5	1	0
North Core Banks	Old Drum Inlet	9	2
North Core Banks	Miles 19-20	3	0
North Core Banks	New Drum Inlet	5	1
North Core Banks	Ophelia Island/Spit	8	0
South Core Banks	Plover Inlet	38	2
South Core Banks	Mile 25	3	0
South Core Banks	Miles 35-34	2	0
South Core Banks	Cape Point	2	0
South Core Banks	Power Squadron Spit	15	0
Shackleford Banks	Barden Inlet	1	0
Shackleford Banks	Corral Area	4	0
Shackleford Banks	Whale Creek Bay	3	0
Shackleford Banks	Middle Island	1	0
Shackleford Banks	Beaufort Inlet	1	0

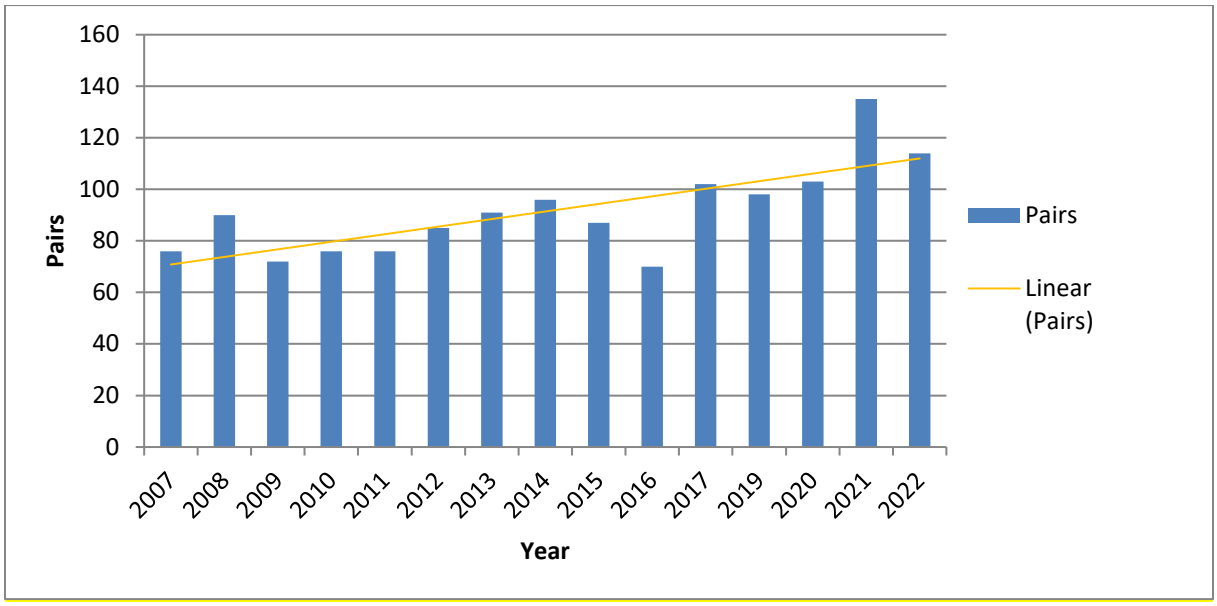

Figure 6. Number of Wilson's plover counted at CALO 2007- 2022.

Conclusions and Recommendations

Overall, 2022 was a poor year for shorebird and colonial waterbird productivity at CALO. Pair counts for piping plovers, American oystercatchers, least terns, and Wilson's plovers were all down from 2021. Productivity for piping plovers and American oystercatchers were well below average. However, CALO did observe record high migration counts for non-breeding piping plovers and red knots.

The 2022 nesting season was heavily influenced by a spring storm in May. This low-pressure system stalled offshore for three days, producing days of gale force winds, storm surge, and overwash of nesting areas. Early May is a very unfortunate time for a storm event, as most American oystercatcher and piping plover pairs have laid their first nests, some early nests have hatched with young chicks, and colony initiation is beginning. Nearly all active nests and broods were destroyed during this storm, with only a few protected nests surviving. In addition to the destruction of nests, the overwash modified nesting areas, particularly open shellbed areas preferred by piping plovers and least terns. The impacts to habitat lasted well beyond the storm event and likely influenced nesting interest and success for the duration of the breeding season. While American oystercatchers, who typically prefer nesting on the upper beach along the dune line, were quick to re-nest after the storm, piping plovers took much longer to re-nest and many males had difficulty recruiting females to their territory, potentially due to habitat impairment. First nests for shorebirds tend to be the most successful at CALO, so it's unsurprising that late season nests laid after the May storm had poor success rates. Only seven American oystercatcher chicks and six piping plover chicks fledged from NCB, while no American oystercatcher or piping plover chicks fledged from SCB.

Poor success of post-storm shorebird nesting on SCB is thought to be driven by coyote pressure. Coyote predation was documented at 12 American oystercatcher nests on SCB, and coyotes are suspected to have taken American oystercatcher chicks, as well. Re-nesting rates were low on SCB and field observations of heavy coyote traffic suggest that birds may have been discouraged from nesting by frequent coyote presence. It is unclear why coyotes target ground-nesting bird nests more some years than others. Coyote trapping efforts continued on SB and SCB in 2022 but trapping success was low. It is recommended that predator trapping continue at CALO in the future, but changes to timing and trapping methods should be considered.

Piping plover nest and chick survival was low on NCB. While 62% of nests on SCB hatched, no chicks were fledged. Unfortunately, the cause of chick loss remains largely unknown. The majority of known piping plover nest losses were from weather and ghost crab predation in 2022. However, 42% of piping plover nest losses were due to unknown causes in 2022. It is recommended that trail camera installation continue on exclosed nests in 2023 to better understand the impacts of ghost crabs and other predator species on piping plover nests and young chicks. In addition, it is recommended that predator exclosure use resume on NCB in the future, but that exclosure use should be adaptively managed based on future conditions.

Resource monitoring schedules at CALO remain challenging for a relatively limited field staff. Field staff were responsible for monitoring 46 pairs of American oystercatchers, 27 pairs of piping plovers,

27 colonial waterbird colonies, and 375 sea turtle nests across three islands and 48 miles of habitat. Staff must regularly check shorebirds nests, survey for new nests, monitor for hatching, and check broods daily. This rigorous monitoring schedule determines management actions such as adjusting or establishing wildlife protection zones for nests and chicks. Quick detection of shorebird brood movements requires diligent monitoring and often triggers unplanned closures and sign work that require staff availability. As piping plovers continue to colonize new habitat on NCB, staff must monitor all areas of the island for plover activity outside of established bird closures. In addition, piping plover predator exclosure deployment requires two to three trained employees per nest. Lastly, colonial waterbird productivity is very difficult to determine under current monitoring protocols. Productivity monitoring of colonies would require more intensive monitoring and additional field staff. In 2022, CALO staff temporarily employed an additional three biological on top of the baseline staff of four biological science technicians and two interns. While this temporary increase in staff did improve workloads, it is recommended that staff levels should be increased to eight qualified biological science technicians to ensure the ORV Plan daily monitoring and management requirements are met and to improve monitoring efforts of colonial waterbirds.

Lastly, shorebird banding programs should continue across Core Banks. Banded individuals allows for the accurate monitoring of breeding birds and productivity thus improving the quality of data collected at CALO. Since Virginia Tech began piping plover banding in 2015, pair movement between nesting sites along Core Banks, pair movement between CALO and Cape Hatteras National Seashore, and movement between Atlantic states has been documented. There is more to learn about the piping plover breeding population such as survivorship and site fidelity that require multiple years of study. In addition, banded non-breeding piping plovers can be used to study migratory and winter use of CALO. It appears that NCB is a major migratory use area, and it should continue to be studied to determine the details and duration of use in relation to the greater Atlantic flyway. Banding of American oystercatcher chicks and adults should also be continued to assist CALO management efforts and long-term population monitoring.

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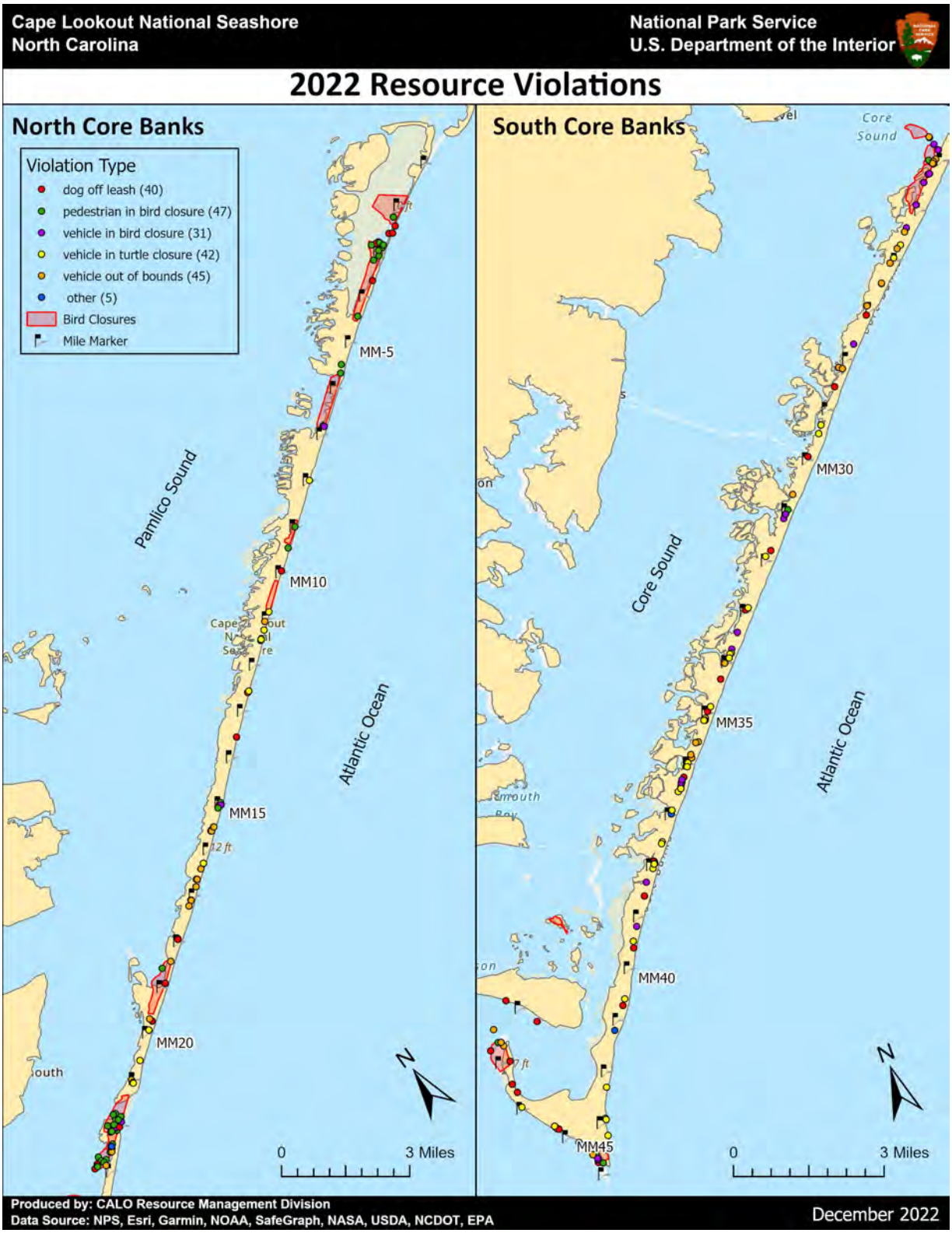
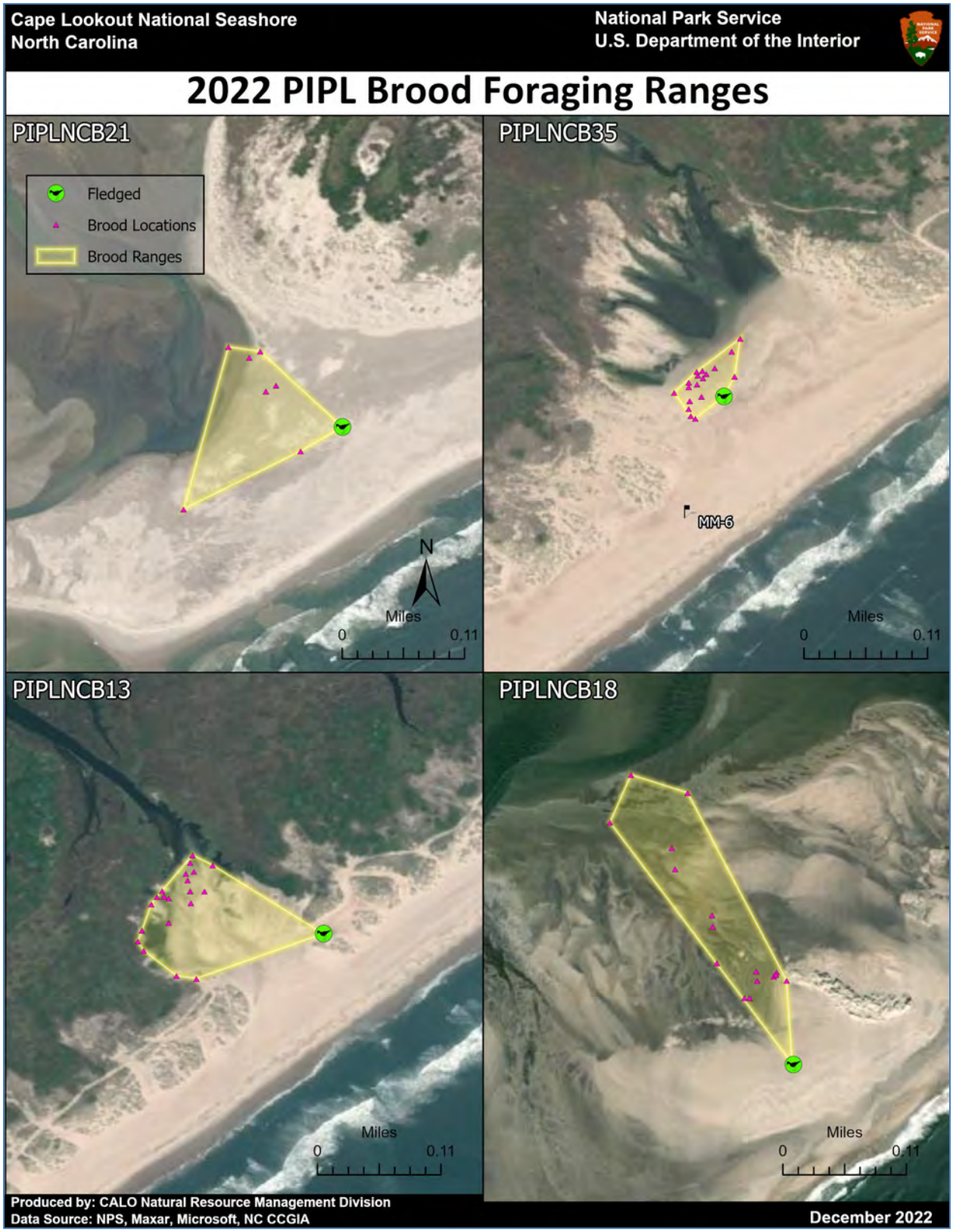
Appendix A. Maps

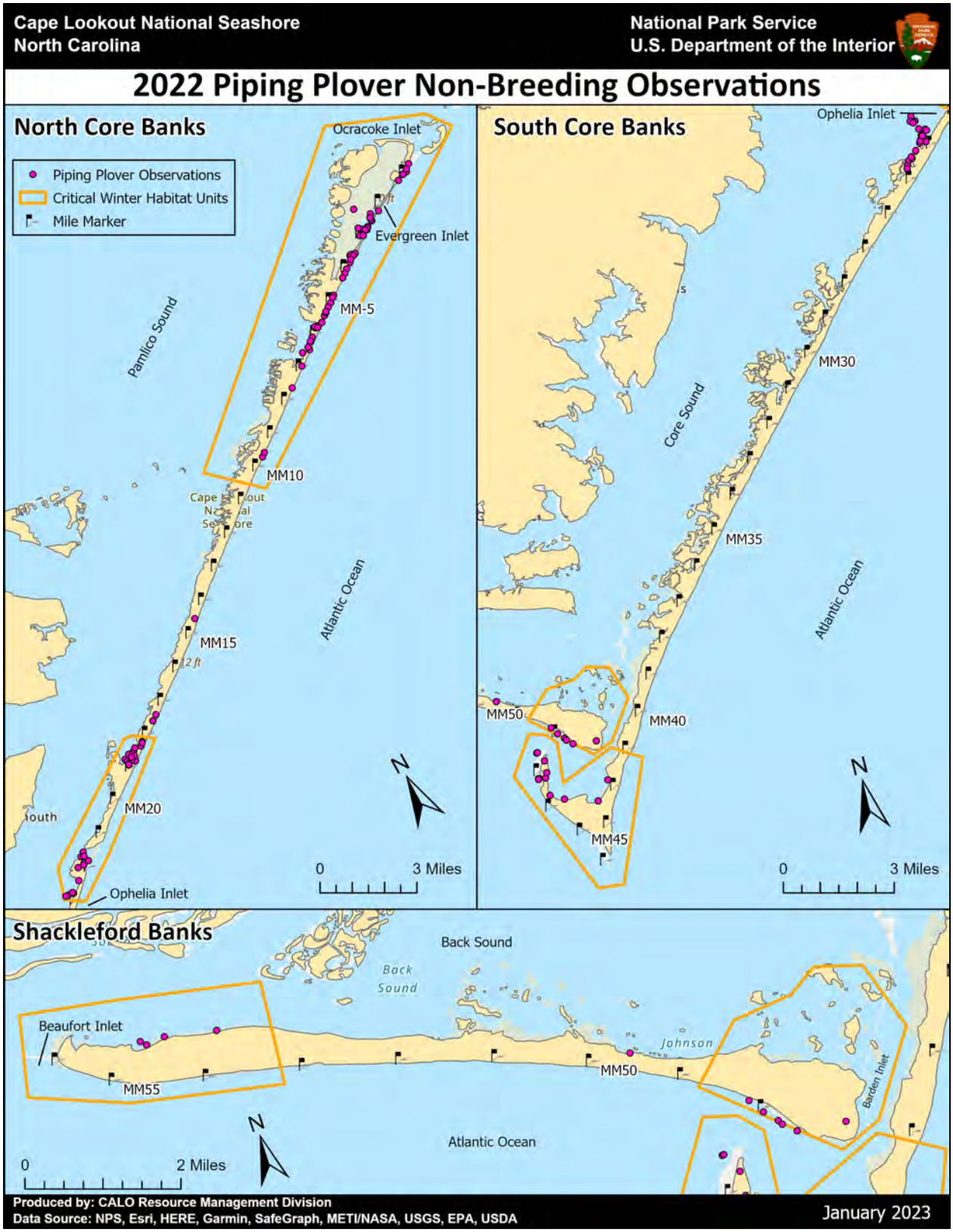


Map A1. Resource violations at CALO in 2022.

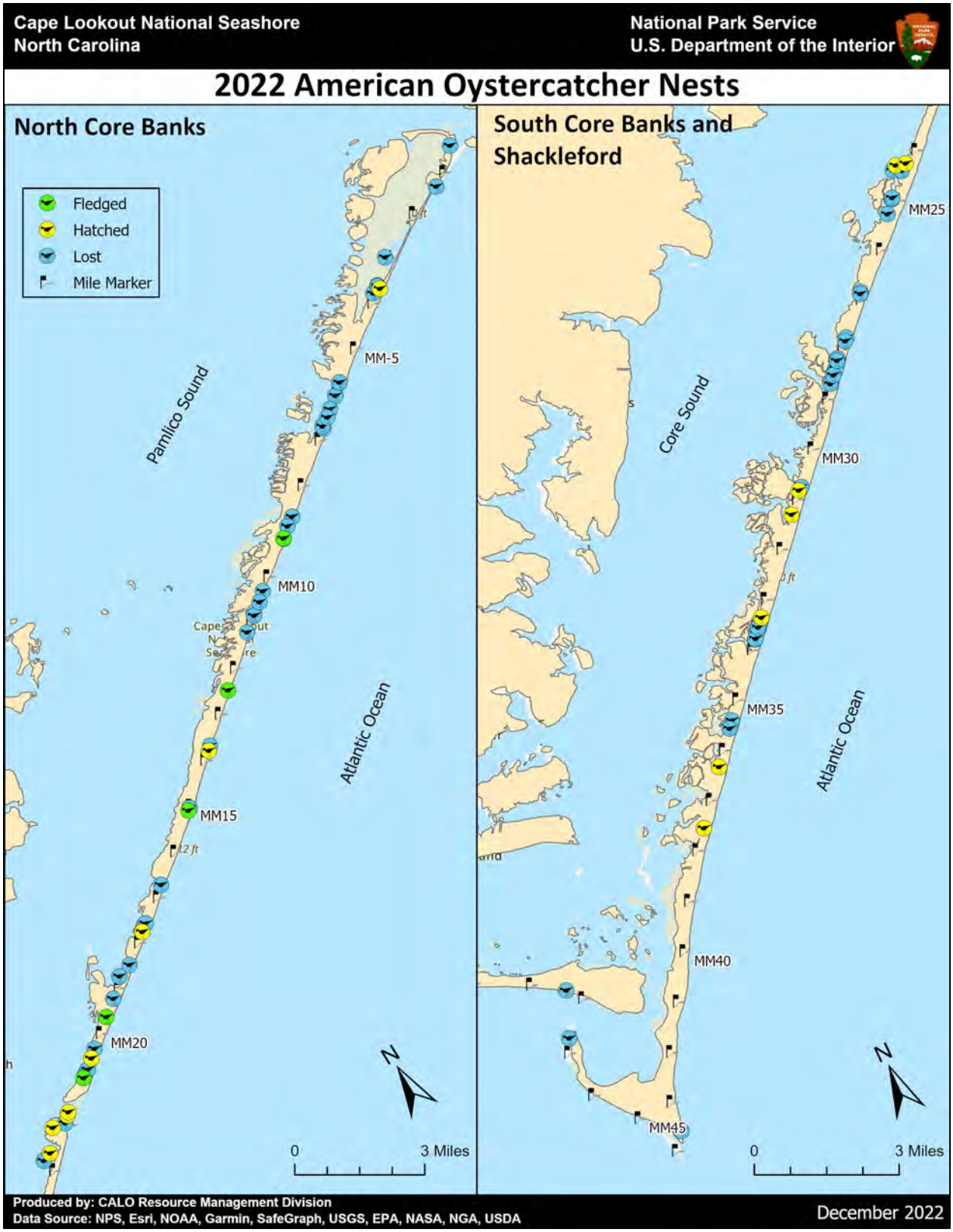
Map A2. Piping plover nest locations at CALO in 2022.



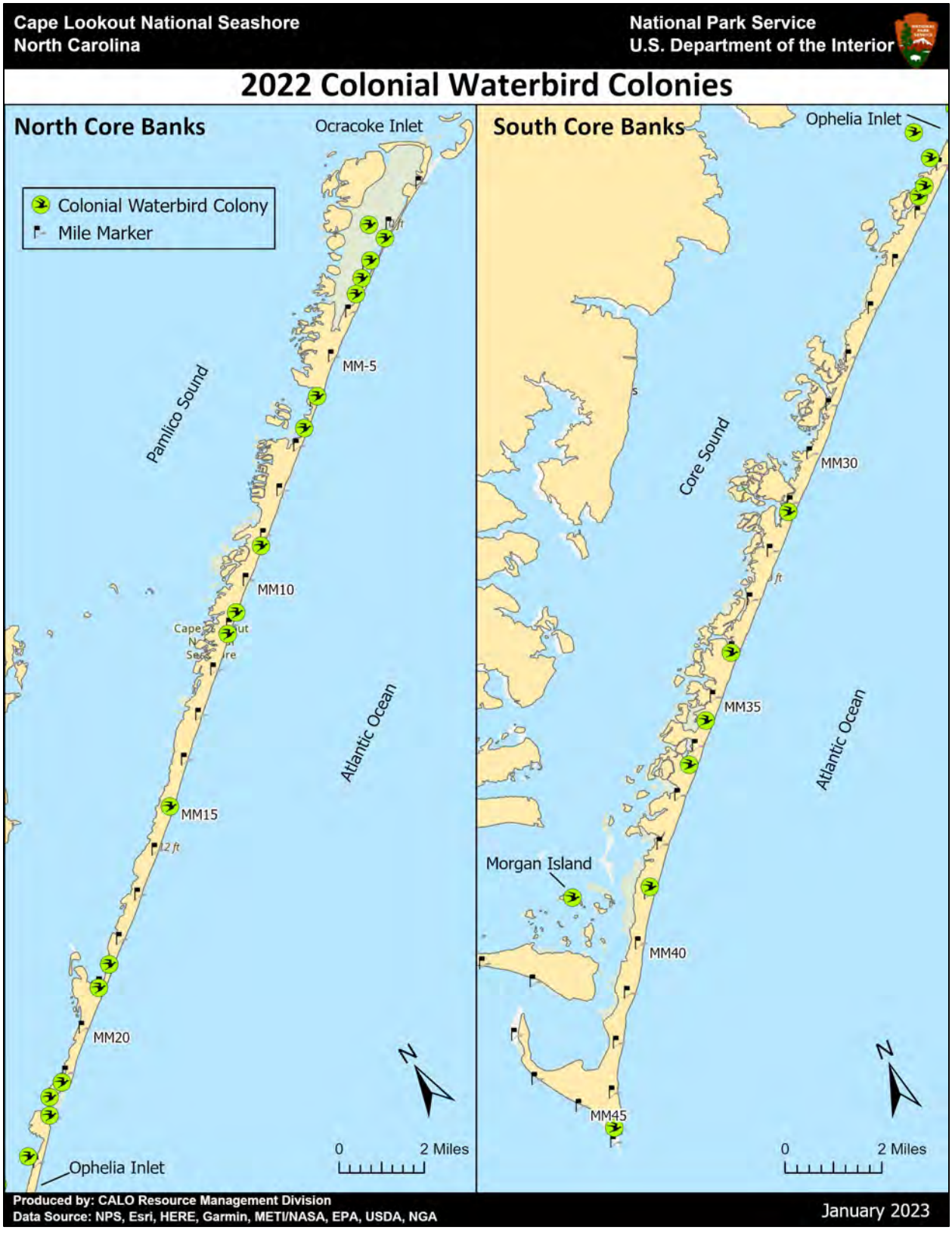
Map A3. Piping plover chick foraging ranges for broods that fledges at least one chick at CALO in 2022.



Map A3. Non-breeding piping plover locations at CALO in 2022.



Map A5. American oystercatcher nests at CALO in 2022.



Map A5. Colonial waterbird colony locations at CALO in 2022.

Map A6. Red knot flock observations at CALO in 2022.

Appendix B. 2022 Piping Plover Productivity Data

Table B1. North Core Banks productivity data for 2022. North Core Banks totals: 21 breeding pairs, 35 total nests, 11 hatched nests, 6 fledged chicks.

Nest ID	Pair	Mile	Site	Adult 1	Adult 2	Found Date	Exclosure Date	Eggs Laid	Nest Fate	Outcome Summary
PIPLNCB01	1	19.35	Old Drum	GF(9KT)	KG:RY	04/09/22	04/16/22	4	Hatched	Brood failed 5/20/2022 due to unknown cause.
PIPLNCB02	2	19.08	Old Drum	GF(938)	UNB	04/21/22	05/01/22	4	Lost	Nest failed 5/12/2022 due to severe weather.
PIPLNCB03	3	5.82	Kathryn-Jane	GF(26N)	GF(YAE)	04/23/22	05/01/22	2	Lost	Nest was abandoned on 5/7/2022 due to unknown reason.
PIPLNCB04	4	21.74	New Drum	GF(XJ1)	UNB	04/24/22	04/25/22	4	Lost	Nest failed 5/12/2022 due to severe weather.
PIPLNCB05	5	5.90	Kathryn-Jane	GF(V4P)	GF(NY8)	04/26/22	04/27/22	4	Lost	Nest failed 5/12/2022 due to severe weather.
PIPLNCB06	6	9.28	Swash	GF(4M3)	GF(0M6)	04/27/22	05/03/22	3	Lost	Nest failed 5/12/2022 due to severe weather.
PIPLNCB07	7	3.83	Portsmouth	GF(2H7)	UNB	04/29/22	N/A	4	Lost	Nest failed 5/12/2022 due to severe weather.
PIPLNCB08	8	9.00	Swash	GF(54N)	UNB	04/30/22	05/07/22	4	Lost	Nest abandoned 5/8/2022, the day after exclosure installation.
PIPLNCB09	9	6.41	Kathryn-Jane	GF(CXM)	GF(3PE)	04/30/22	N/A	1	Lost	Nest found failed on 4/30/2022 due to ghost crab predation.
PIPLNCB10	10	10.27	Mile 10	GF(P6A)	UNB	05/01/22	05/07/22	4	Lost	Nest failed 5/12/2022 due to severe weather.
PIPLNCB11	11	6.79	Kathryn-Jane	GF(X79)	GF(T0L)	05/07/22	N/A	2	Lost	Nest failed 6/5/2022 due to unknown reason.
PIPLNCB12	12	6.60	Kathryn-Jane	UNB	UNB	05/07/22	N/A	3	Lost	Nest failed 5/12/2022 due to severe weather.
PIPLNCB13	6	9.30	Swash	GF(0M6)	GF(4M3)	05/22/22	05/29/22	4	Fledged	Fledged 3 unbanded chicks on 7/22/2022 at 30 days old.
PIPLNCB14	3	5.84	Kathryn-Jane	GF(26N)	GF(A5P)	05/28/22	N/A	4	Hatched	Brood failed on 7/9/2022 due to unknown cause.
PIPLNCB15	13	6.30	Kathryn-Jane	GF(A79)	UNB	05/28/22	N/A	2	Lost	Nest failed on 5/29/2022 due to ghost crab predation.
PIPLNCB16	14	22.15	New Drum	GF(L5C)	GF(PEU)	05/29/22	N/A	2	Lost	Nest failed 6/5/2022 due to unknown cause.
PIPLNCB17	12	6.61	Kathryn-Jane	GF(K4E)	UNB	06/01/22	N/A	3	Hatched	Brood failed by 7/6/2022 due to unknown reason.

PIPLNCB18	15	21.84	New Drum	GF(LYJ)	UNB	06/02/22	06/08/22	4	Fledged	Fledged one unbanded chick on 8/2/2022 at 30 days old.
PIPLNCB19	2	19.15	Old Drum	GF(938)	UNB	06/03/22	N/A	1	Lost	Nest failed on 6/4/2022 due to unknown cause.
PIPLNCB20	1	19.41	Old Drum	GF(9KT)	KG:RY	06/03/22	N/A	4	Lost	Nest failed on 6/22/2022 due to unknown cause.
PIPLNCB21	16	2.40	Portsmouth	GF(C2A)	GF(U9J)	06/04/22	N/A	4	Fledged	Fledged one unbanded chick on 7/25/2022 at 27 days old.
PIPLNCB22	4	21.71	New Drum	GF(XJ1)	UNB	06/10/22	N/A	4	Lost	Nest failed 6/25/2022 due to unknown reason.
PIPLNCB23	7	3.95	Portsmouth	GF(2H7)	UNB	06/11/22	N/A	4	Lost	Nest failed 6/25/2022 due to unknown cause.
PIPLNCB24	9	6.55	Kathryn-Jane	GF(CXM)	GF(3PE)	06/11/22	N/A	2	Lost	Nest failed 6/12/2022 to due to mammalian predation.
PIPLNCB25	2	19.14	Old drum	GF(938)	UNB	06/12/22	N/A	3	Lost	Nest failed 6/29/2022 due to unknown cause.
PIPLNCB26	17	6.16	Kathryn-Jane	OK:LG	UNB	06/15/22	N/A	4	Hatched	Brood failed by 7/18/2022 due to unknown cause.
PIPLNCB27	13	6.26	Kathryn-Jane	GF(A79)	GF(EET)	06/15/22	N/A	2	Hatched	Brood failed by 7/15/2022 due to unknown cause.
PIPLNCB28	9	6.58	Kathryn-Jane	GF(CXM)	GF(3PE)	06/17/22	N/A	4	Hatched	Brood failed by 7/14/2022 due to unknown cause.
PIPLNCB29	18	4.54	Portsmouth	GF(UUM)	UNB	06/19/22	N/A	3	Lost	Nest failed on 6/26/2022 due to ghost crab predation.
PIPLNCB30	8	10.85	Mile 10	GF(54N)	UNB	06/24/22	N/A	3	Hatched	Brood failed on 7/23/2022 due to unknown reason.
PIPLNCB31	11	6.72	Kathryn-Jane	GF(T0L)	GF(X79)	06/24/22	N/A	3	Lost	Nest failed 7/1/2022 due to unknown cause.
PIPLNCB32	14	22.20	New Drum	GF(L5C)	GF(PEU)	06/24/22	N/A	3	Lost	Nest failed 6/30/2022 due to unknown cause.
PIPLNCB33	19	21.86	New Drum	GF(715)	UNB	06/27/22	N/A	3	Lost	Nest failed 7/25/2022 due to unknown reason.
PIPLNCB34	20	15.14	Mile 15	UNB	UNB	07/01/22	N/A	3	Lost	Nest failed on 7/22/2022 due to unknown cause.
PIPLNCB35	21	5.94	Kathryn-Jane	UNB	UNB	07/09/22	N/A	3	Fledged	Fledged 1 unbanded chick on 8/17 at 30 days old.

Table B2. South Core Banks productivity data for 2022. South Core Banks totals: 6 breeding pairs, 8 total nests, 5 hatched nests, 0 fledged chick.

Nest ID	Pair	Mile	Site	Adult 1	Adult 2	Found Date	Exclosure Date	Eggs Laid	Nest Fate	Outcome Summary
PIPLSCB01	1	24.54	Plover Inlet	UNB	UNB	04/25/22	04/29/22	3	Hatched	Brood failed 6/6/2022 due to unknown cause.

PIPLSCB02	2	24.35	Plover Inlet	UNB	UNB	05/02/22	05/08/22	4	Hatched	Brood failed on 6/12/2022 due to unknown cause.
PIPLSCB03	3	24.00	Plover Inlet	GF(JHY)	UNB	05/06/22	05/07/22	4	Lost	Nest failed 5/12/2022 due to severe weather.
PIPLSCB04	3	24.00	Plover Inlet	DG(JHY)	UNB	05/28/22	06/01/22	4	Lost	Nest failed 6/11/2022 due to ghost crab predation.
PIPLSCB05	4	24.92	Plover Inlet	OY:KO	UNB	06/02/22	06/06/22	3	Hatched	Brood failed 7/3/2022 due to unknown cause.
PIPLSCB06	5	23.92	Plover Inlet	UNB	UNB	06/04/22	06/06/22	4	Hatched	Brood failed 7/3/2022 due to unknown cause.
PIPLSCB07	6	24.47	Plover Inlet	UNB	UNB	05/04/22	N/A	1	Unknown	Outcome of nest unknown.
PIPLSCB08	3	24.00	Plover Inlet	DG(JHY)	UNB	06/20/22	06/22/22	4	Hatched	Brood failed 7/17/2022 due to unknown cause.

Appendix C. Monthly Counts of Non-Breeding Piping Plovers 2008-2022

Table C1. Total number of non-breeding plovers observed on North Core Banks, South Core Banks, and Shackleford Banks during each monthly survey from 2008 to 2022

Date	North Core Banks	South Core Banks	Shackleford banks	CALO Total
January-08	0	2	11	13
February-08	0	6	10	16
March-08	6	6	10	22
August-08	41	28	17	86
September-08	16	20	10	46
October-08	25	9	20	54
November-08	11	4	9	24
December-08	9	7	8	24
January-09	6	18	13	37
February-09	2	9	12	23
March-09	10	17	-	27
August-09	83	26	2	111
September-09	144	33	10	187
October-09	22	19	13	54
November-09	18	12	12	42
December-09	12	14	23	49
January-10	17	8	11	36
February-10	8	5	11	24
March-10	-	10	6	16
August-10	125	23	4	152
September-10	70	32	17	119
October-10	35	13	4	52
November-10	8	19	9	36
December-10	4	3	6	13
January-11	6	2	7	15
February-11	7	0	8	15
March-11	12	8	13	33
August-11	81	26	0	107
September-11	29	8	20	57
October-11	26	19	6	51
November-11	7	3	11	21
December-11	2	4	11	17
January-12	0	2	5	7

February-12	0	2	10	12
March-12	5	1	-	6
August-12	82	32	4	118
September-12	112	7	9	128
October-12	0	3	12	15
November-12	3	7	5	15
December-12	6	6	2	14
January-13	-	4	3	7
February-13	4	0	10	14
March-13	5	9	4	18
August-13	93	6	15	114
September-13	115	15	23	153
October-13	17	-	-	17
November-13	6	5	5	16
December-13	12	3	4	19
January-14	0	12	0	12
February-14	0	0	9	9
March-14	7	42	4	53
August-14	98	44	9	151
September-14	69	12	1	82
October-14	12	12	0	24
November-14	13	6	4	23
December-14	4	14	3	21
January-15	2	9	4	15
February-15	-	-	-	-
March-15	-	21	19	40
August-15	95	15	15	125
September-15	42	20	8	70
October-15	17	3	14	34
November-15	0	4	8	12
December-15	5	18	2	25
January-16	10	16	9	35
February-16	15	13	9	37
March-16	2	15	8	25
August-16	-	-	10	10
September-16	30	17	25	72
October-16	10	31	3	44
November-16	2	20	1	23
December-16	0	2	1	3
January-17	7	0	2	9

February-17	-	-	-	-
March-17	-	-	-	-
August-17	46	0	8	54
September-17	68	2		70
October-17	24	22	14	60
November-17	8	1	11	20
December-17	11	4	10	25
January-18	0	0	0	0
February-18	9	1	0	10
March-18	-	-	-	-
August-18	161	19	2	182
September-18	31	3	0	34
October-18	40	0	9	49
November-18	3	0	8	11
December-18	0	2	5	7
January-19	-	-	-	-
February-19	4	22	13	39
March-19	23	11	9	43
August-19	127	-	-	127
September-19	7	34	2	43
October-19	4	16	6	26
November-19	11	7	3	21
December-19	0	3	13	16
January-20	-	-	-	-
February-20	8	0	3	11
March-20	1	7	0	8
August-20	220	46	7	273
September-20	79	37	2	118
October-20	16	14	0	30
November-20	14	26	3	43
December-20	5	8	18	31
January-21	12	20	7	39
February-21	15	13	10	38
March-21	12	5	1	18
August-21	78	53	20	151
September-21	135	44	25	204
October-21	54	27	27	108
November-21	30	3	2	35
December-21	29	3	1	33
January-22	4	14	1	19

February-22	3	2	0	5
March-22	40	1	2	43
August-22	381	91	9	481
September-22	117	304	6	427
October-22	34	51	8	93
November-22	21	20	11	52
December-22	34	51	3	88

Appendix D. 2022 American Oystercatcher Productivity Data

Table D1. North Core Banks productivity data for 2022. North Core Banks totals: 26 breeding pairs, 46 total nests, 13 hatched nests, 7 fledged chicks.

Nest	Pair	Adult 1	Adult 2	Mile	Found Date	Eggs	Closure	Outcome Summary
AMOYNCB01	1	DG(P5)	UNB	22.41	04/04/22	3	interior	Brood failed by 5/12/2022, likely due to severe weather.
AMOYNCB02	2	DG(TF)	UNB	21.88	04/13/22	3	interior	Brood failed by 5/12/2022, likely due to severe weather.
AMOYNCB03	3	DG(TN)	UNB	18.53	04/15/22	4	600' buffer	Nest failed on 5/12/2022 due to severe weather.
AMOYNCB04	4	DG(EJ9)	UNB	22.74	04/15/22	3	interior	Brood failed on 5/13/2022, likely due to severe weather.
AMOYNCB05	5	DG(EKH)	UNB	15.08	04/16/22	3	600' buffer	Nest failed on 5/12/2022, washed out during severe weather.
AMOYNCB06	6	DG(CCE)	UNB	6.80	04/17/22	3	600' buffer	Nest failed on 4/29/2022 due to unknown cause.
AMOYNCB07	7	DG(CMP)	DG(CNN)	5.79	04/19/22	3	interior	Nest failed on 5/12/2022 due to unknown cause.
AMOYNCB08	8	DG(EKK)	UNB	3.10	04/19/22	2	interior	Nest failed on 4/27/2022 due to unknown cause.
AMOYNCB09	9	DG(C07)	DG(C08)	20.95	04/20/22	2	600' buffer	Nest failed on 5/12/2022 due to severe weather.
AMOYNCB10	10	DG(C93)	UNB	20.38	04/21/22	3	600' buffer	Nest failed 5/8/2022 due to raccoon predation.
AMOYNCB11	11	DG(CK0)	DG(WF)	9.20	04/21/22	3	600' buffer	Nest failed 5/12/2022, abandoned likely due to severe weather.
AMOYNCB12	9	DG(C07)	DG(C08)	21.84	04/21/22	1	none	Nest found abandoned on 4/21/2022, likely abandoned due to human interaction.
AMOYNCB13	12	DG(M0)	UNB	19.68	04/21/22	3	600' buffer	Fledged 2 chicks, DG(EU7) and DG(EU8), on 7/4/2022 at 45 days old.
AMOYNCB14	13	DG(CML)	DG(CEA)	13.73	04/22/22	3	600' buffer	Nest failed 5/12/2022 due to severe weather.
AMOYNCB15	14	DG(CE1)	DG(T3)	10.85	04/23/22	1	600' buffer	Nest failed 4/24/2022 due to unknown cause.
AMOYNCB16	15	DG(CY)	UNB	3.67	04/23/22	3	interior	Nest failed 5/12/2022 due to unknown reason.
AMOYNCB17	16	DG(CL1)	UNB	1.37	04/23/22	3	none	Nest failed by 5/15/2022 due to unknown cause.
AMOYNCB18	17	DG(WM)	UNB	0.49	04/23/22	3	none	Nest failed by 5/15/2022 due to unknown cause.
AMOYNCB19	18	DG(CE3)	UNB	6.07	04/23/22	3	interior	Nest failed 5/7/2022 due to unknown cause.
AMOYNCB20	19	DG(EKE)	UNB	17.62	04/25/22	1	600' buffer	Nest failed 5/12/2022 due to severe weather.
AMOYNCB21	20	DG(C5W)	DG(CY6)	12.52	04/25/22	3	600' buffer	Fledged 2 chicks, DG(EU5) and DG(EU6), on 7/7/2022 at 43 days old.
AMOYNCB22	14	DG(CE1)	DG(T3)	11.27	04/25/22	2	600' buffer	Nest failed 5/12/2022 due to ghost crab predation.
AMOYNCB23	21	DG(CA)	UNB	8.70	04/27/22	3	600' buffer	Nest failed 5/12/2022 due to unknown reason.
AMOYNCB24	22	DG(CET)	UNB	22.92	05/02/22	2	interior	Nest abandoned 5/12/2022 likely due to severe weather.
AMOYNCB25	23	DG(CE0)	UNB	3.50	05/03/22	3	interior	Nest failed 5/12/2022 due to severe weather.

AMOYNCB26	24	DG(EWA)	UNB	16.76	05/04/22	3	600' buffer	Nest failed 5/12/2022 due to severe weather.
AMOYNCB27	6	DG(CCE)	UNB	6.76	05/05/22	3	interior	Nest abandoned 5/12/2022 likely due to severe weather.
AMOYNCB28	14	DG(CE1)	DG(T3)	10.90	05/22/22	3	600' buffer	Nest failed 5/12/2022 due to raccoon predation.
AMOYNCB29	10	DG(C93)	UNB	20.59	05/24/22	2	600' buffer	Brood failed on 6/21/2022 due to unknown cause.
AMOYNCB30	3	DG(TN)	UNB	18.81	05/24/22	3	interior	Nest failed 6/5/2022 due to raccoon predation.
AMOYNCB31	5	DG(EKH)	UNB	15.14	05/24/22	3	600' buffer	Fledged 1 chick, DG(EWU), by 7/30/2022 at 44 days old.
AMOYNCB32	13	DG(CML)	DG(CEA)	13.82	05/24/22	3	600' buffer	Brood failed 7/11/2022, likely due to coyote predation.
AMOYNCB33	11	DG(CK0)	DG(WF)	9.20	05/24/22	3	600' buffer	Fledged 1 chick, DG(EWN), on 8/2/2022 at 42 days old.
AMOYNCB34	18	DG(CE3)	UNB	6.37	05/24/22	2	interior	Nest failed 6/15 due to unknown cause.
AMOYNCB35	21	DG(CA)	UNB	8.90	05/25/22	3	600' buffer	Nest failed 6/17 due to unknown cause.
AMOYNCB36	15	DG(CY)	UNB	3.69	05/25/22	3	interior	Nest abandoned 6/3 due to unknown cause.
AMOYNCB37	7	DG(CMP)	DG(CNN)	5.79	05/25/22	2	interior	Nest failed on 6/24/2022 due to coyote predation.
AMOYNCB38	9	DG(C07)	DG(C08)	21.00	05/26/22	2	600' buffer	Fledged 1 chick, DG(EWP), on 7/31/2022 at 40 days old.
AMOYNCB39	2	DG(TF)	UNB	21.79	05/26/22	2	interior	Brood failed by 6/30/2022 due to unknown cause.
AMOYNCB40	19	DG(EKE)	UNB	17.82	05/26/22	2	600' buffer	Brood failed by 6/23/2022 due to unknown cause.
AMOYNCB41	25	DG(EH6)	UNB	10.35	05/26/22	2	600' buffer	Nest failed 5/31/2022 due to unknown cause.
AMOYNCB42	26	DG(CUP)	UNB	19.26	05/27/22	2	interior	Nest abandoned on 6/21/2022 due to unknown reason.
AMOYNCB43	6	DG(CCE)	UNB	6.56	05/28/22	3	interior	Nest failed on 6/19/2022 due to unknown cause.
AMOYNCB44	1	DG(P5)	UNB	22.00	05/29/22	3	interior	Nest failed on 6/23/2022 due to unknown reason.
AMOYNCB45	14	DG(CE1)	DG(T3)	10.58	06/08/22	2	600' buffer	Nest failed 6/24/2022 due to raccoon predation.
AMOYNCB46	15	DG(CY)	UNB	3.71	06/19/22	2	interior	Brood failed 7/20/2022 due to unknown cause.

Table D2. South Core Banks productivity data for 2022. South Core Banks totals: 19 breeding pairs, 34 total nests, 7 hatched nests, 0 fledged chicks.

Nest	Pair	Adult	Adult	Mile	Found	Eggs	Closure	Outcome Summary
AMOYSCB01	1	DG(K0)	UNB	33.43	03/30/22	3	600' buffer	Brood failed 5/12/2022, likely due to severe weather.
AMOYSCB02	2	R(5F)	DG(R8)	37.57	04/08/22	3	600' buffer	Brood failed 5/12/2022, likely due to severe weather.
AMOYSCB03	3	DG(CL9)	UNB	31.34	04/11/22	3	600' buffer	Brood failed 5/12/2022, likely due to severe weather.
AMOYSCB04	4	DG(AL)	UNB	24.48	04/16/22	3	interior	Brood failed 5/12/2022, likely due to severe weather.
AMOYSCB05	5	DG(AP)	DG(YP)	33.82	04/13/22	3	600' buffer	Nest failed 4/21/2022 due to an undetermined predator.
AMOYSCB06	6	DG(33)	DG(LN)	25.00	04/14/22	3	interior	Nest failed 4/21/2022 due to coyote predation.
AMOYSCB07	7	DG(CUM)	DG(C3A)	28.46	04/16/22	3	600' buffer	Nest failed 5/12/2022 due to coyote predation.

AMOYSCB08	8	DG(YM)	UNB	28.55	04/20/22	3	600' buffer	Nest failed 5/12/2022 due to severe weather.
AMOYSCB09	9	DG(CJR)	DG(CUK)	28.24	04/20/22	3	600' buffer	Nest failed 4/25/2022 due to coyote predation.
AMOYSCB10	10	DG(EMN)	DG(CFA)	25.42	04/20/22	3	600' buffer	Nest failed 5/12/2022 due to severe weather.
AMOYSCB11	11	DG(CRK)	DG(CK6)	27.83	04/21/22	3	600' buffer	Nest failed 5/12/2022 due to severe weather.
AMOYSCB12	12	R(AHJ)	UR-Red	36.37	04/21/22	3	600' buffer	Brood failed 5/26/2022, likely due to coyote predation.
AMOYSCB13	13	DG(UL)	DG(CC6)	43.65	04/22/22	3	600' buffer	Nest abandoned 5/3/2022 due to unknown reason.
AMOYSCB14	14	DG(CK1)	UNB	30.88	04/22/22	3	600' buffer	Brood failed 5/21/2022, likely due to coyote predation.
AMOYSCB15	15	DG(CM0)	DG(CNC)	24.58	04/23/22	3	interior	Nest failed 5/12/2022 due to severe weather.
AMOYSCB16	16	DG(J0)	DG(CAN)	35.60	04/24/22	2	600' buffer	Nest failed 5/26/2022 due to coyote predation.
AMOYSCB17	17	DG(C77)	DG(UJ)	26.90	04/25/22	3	600' buffer	Nest failed 5/12/2022 due to coyote predation.
AMOYSCB18	5	DG(AP)	DG(YP)	33.70	04/28/22	3	600' buffer	Nest abandoned 5/12/2022, likely due to severe weather.
AMOYSCB19	6	DG(33)	DG(LN)	25.00	05/02/22	3	interior	Nest failed 5/12/2022 due to severe weather.
AMOYSCB20	9	DG(CJR)	DG(CUK)	28.32	05/07/22	1	600' buffer	Nest failed 5/12/2022 due to unknown cause.
AMOYSCB21	18	DG(68)	UNB	28.73	05/07/22	2	600' buffer	Nest abandoned 5/12/2022, likely due to severe weather.
AMOYSCB22	5	DG(AP)	DG(YP)	33.83	05/24/22	3	600' buffer	Nest failed 6/6/2022 due to unknown reason.
AMOYSCB23	11	DG(CRK)	DG(CK6)	27.88	05/25/22	2	600' buffer	Nest failed 6/2/2022 due to coyote predation.
AMOYSCB24	1	DG(K0)	UNB	33.53	05/26/22	1	600' buffer	Nest abandoned 5/30/2022 due to unknown reason.
AMOYSCB25	17	DG(UJ)	DG(C77)	26.95	05/26/22	2	600' buffer	Nest failed 6/11/2022 due to coyote predation.
AMOYSCB26	19	UNB	UNB	47.28	05/26/22	2	interior	Nest failed 5/29/2022 due to coyote predation.
AMOYSCB27	7	DG(C3A)	DG(CUM)	28.43	05/26/22	2	600' buffer	Nest failed 6/7/2022 due to coyote predation.
AMOYSCB28	9	DG(CUK)	DG(CJR)	28.28	05/26/22	2	600' buffer	Nest failed 6/11/2022 due to coyote predation.
AMOYSCB29	8	DG(YM)	UNB	28.58	05/27/22	2	600' buffer	Nest failed 6/7/2022 due to ghost crab predation.
AMOYSCB30	15	DG(CM0)	DG(CNC)	24.51	05/27/22	3	interior	Nest abandoned 6/5/2022 due to unknown reason.
AMOYSCB31	4	DG(AL)	UNB	24.34	05/28/22	3	interior	Brood failed 6/27/2022 due to unknown reason.
AMOYSCB32	14	DG(CK1)	UNB	30.79	06/04/22	1	600' buffer	Nest abandoned 6/9/2022 due to unknown reason.
AMOYSCB33	16	DG(J0)	DG(CAN)	35.59	06/08/22	2	600' buffer	Nest failed 6/16/2022 due to coyote predation.
AMOYSCB34	1	DG(K0)	UNB	33.60	06/11/22	1	600' buffer	Nest found failed on 6/11/2022 due to coyote predation.

Table D3. Shackleford Banks productivity data for 2022. Shackleford Banks totals: 1 breeding pair, 1 total nest, 0 hatched nests, 0 fledged chicks.

Nest	Pair	Adult	Adult	Mile	Found	Eggs	Closure	Outcome Summary
AMOYSB01	1	UNK	UNK	48.60	05/29/22	2	none	Nest failed 5/31/2022 due to unknown cause.