Nest Fate and Productivity of American Oystercatchers, Cumberland Island National Seashore, Georgia

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Abstract.—The American Oystercatcher (*Haematopus palliatus*) is listed as a species of high priority by the U.S. Shorebird Conservation Plan and is state-listed as rare in Georgia; however, biologists have not focused on identifying the causes of egg and hatchling losses. In 2003 and 2004, continuous video monitoring was used to document reproductive success of American Oystercatchers and identify causes of nest failure at Cumberland Island National Seashore, Georgia. The modified Mayfield method and program CONTRAST were used to determine and compare survival of eggs and nestlings. Eleven pairs made 32 nest attempts during two seasons. Nine attempts were successful, fledging 15 chicks. Daily survival of clutches was 0.973 (95% CI = 0.960–0.987) for 2003, 0.985 (95% CI = 0.974–0.995) for 2004, and 0.979 (95% CI = 0.970–0.987) for combined years. Daily survival was greater on the North End, than on the South End of the island ($\chi^2_1 = 7.211$, P = 0.007). Eighteen of 20 nest failures during the egg stage and one of eight chick losses were documented. Egg predators included raccoon (*Procyon lotor,* N = 9), bobcat (*Lynx rufus,* N = 3), and American Crow (*Corvus brachyrhynchos,* N = 1). A ghost crab (*Ocypode quadata*) preyed on one chick. Other causes of nest failure were tidal overwash (N = 1), horse trampling (N = 1), abandonment (N = 2), and human destruction (N = 1). The North End of the island has one of the highest reproductive rates reported along the Atlantic coast. Predator control may be an effective means of increasing reproductive success on the South End of the island. *Received 24 January 2006, accepted 10 May 2006.*

Key words.—American Oystercatcher, Georgia, *Haematopus palliatus,* human disturbance, predation, reproductive success, shorebirds, video monitoring.

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The American Oystercatcher (*Haematopus palliatus*) is one of four high priority shorebirds listed by the U.S. Shorebird Conservation Plan (Brown *et al.* 2001) and is state-listed as rare in Georgia (Ozier *et al.* 1999). The estimated mean (±95% CI) eastern U.S. wintering population was 10,971 ± 298 individuals in 2005, which is less than the minimum for high priority status (Brown *et al.* 2005). Small population size, nesting habitat coincident with frequently disturbed Atlantic oceanfront beach, and naturally low annual fecundity are likely causing population declines (Nol and Humphrey 1994; Davis *et al.* 2001). Although biologists have investigated oystercatcher reproductive ecology on the eastern U.S. coast (Nol 1989; Corbat 1990; Davis *et al.* 2001; George 2002; McGowan 2004), we lack a clear understanding of population and reproductive trends.

Shorebird biologists have identified causes of nest failure by examining evidence de facto (Nol 1989; Corbat 1990; Davis *et al.* 2001; George 2002; McGowan 2004). Egg and chick predation by raccoons (*Procyon lotor*), domestic cats, red foxes (*Vulpes vulpes*), mink (*Mustela vison*), gulls (*Larus* spp.), and crows (*Corvus* spp.) have been identified (Nol 1989; Corbat 1990; Nol and Humphrey 1994; Davis *et al.* 2001). Human disturbance may increase predator-related mortality by flushing adults from nests, thereby exposing eggs and providing a nest location cue for predators (Skutch 1949). Unattended nests also make eggs vulnerable to hyper- and hypothermia (Rappole 1981; Toland 1999). Flooding from high spring tides and storms is a common cause of nest failure as well (Nol 1989; Corbat 1990; Davis *et al.* 2001; George 2002; McGowan 2004).

With the exception of a few chance sightings, most nest fate data are based on interpretation of signs one to four days following nest failure. Determining the cause of failure by interpreting signs can be difficult and misleading. Predator tracks and other sign left in soft sand can be diffuse and ephemeral. Many species share similar patterns of nest predation, which makes identification difficult (see Lariviere 1999 for review). A predation event may attract other predators to a nest making identification of the original predator difficult or impossible (Lariviere 1999). Weather events, such as wind and rain also eliminate evidence of predators.

The difficulty of identifying nest predators of American Oystercatchers was evident in recent studies that failed to identify causes for almost half of nest failures. In North Carolina, biologists did not identify nest predators for 47% of failures (N = 213, Davis *et al.* 2001). Recently in Georgia, researchers were unable to determine the cause of 40% of clutch losses (N = 209, George 2002). Because researchers have not focused on identification of causes of nest, egg, and hatchling losses, studies are needed to identify these causes specifically to understand factors contributing to apparently low productivity of American Oystercatchers. Our objectives were to estimate reproductive rates of American Oystercatchers at Cumberland Island National Seashore (CINS) and determine the causes of nest failure using video monitoring equipment.

STUDY AREA

Field investigations were conducted at CINS, a 14,736-ha barrier island on the southeastern Georgia coast (30°N, 81°W). The oceanfront beach of the northern (4 km, North End, Fig. 1) and southern portions of the island (11 km, South End) were characterized by well-developed back beach and dune systems that provided nesting habitat for several avian species, including Least Terns (*Sterna antillarum*), Gull-billed Terns (*S. nilotica*), Wilson's Plovers (*Charadrius wilsonia*), and 10-12 pairs of American Oystercatchers. Heavy erosion from wind and wave action truncated dunes in the middle portion of the island (13 km), subsequently the area provided little nesting habitat. The South End of the island was wide (2 km) and distance from primary dune to interdune scrub ranged from approximately 200-300 m. The North End was a narrow peninsula bounded by the Atlantic Ocean to the east and Christmas Creek to the north and west. Interdune habitat and maritime forest formed the southern border of the North End.

Potential nest predators on CINS included bobcat (*Lynx rufus*), raccoon, mink, nine-banded armadillo (*Dasypus novemcinctus*), feral hog, white-tailed deer (*Odocoileus virginianus*), American alligator (*Alligator mississippiensis*), feral horse, and several avian species (Johnson *et al.* 1974). Feral hogs have been trapped or

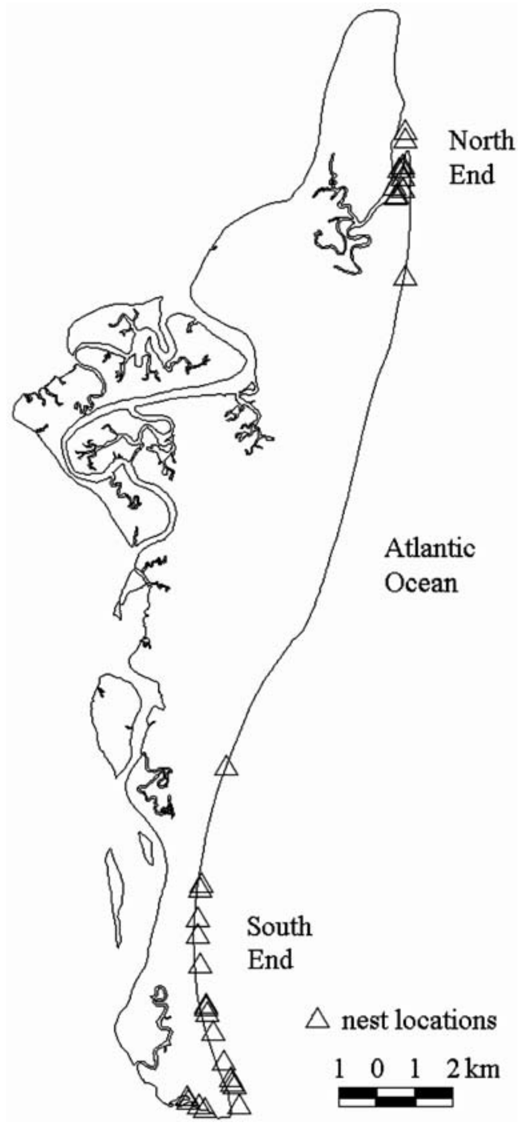

Figure 1. Cumberland Island National Seashore, Georgia, and locations of American Oystercatcher nest sites during 2003 and 2004 breeding seasons.

hunted periodically since 1975. By 2004, approximately 4,800 hogs had been culled (J. Fry, CINS, pers. comm.). Raccoon control was sporadic and limited to nuisance individuals and those that posed a direct threat to loggerhead sea turtle (*Caretta caretta*) nests. National Park Service (NPS) employees removed <30 raccoons from the island in 2003 and 2004 (W. E. O'Connell, CINS, pers. comm.).

Because NPS facilities were located primarily on the South End, most tourist activity occurred there. Forms of human disturbance on the oceanfront beach included pedestrian, boat, and vehicle (all-terrain vehicles, pick-up trucks, sport utility vehicles) traffic. The North End, designated as wilderness by NPS, was free of most human disturbance, except NPS employees, long-distance hikers, and residents who had beach driving permits (N = 326, C. Gregory, GADNR, pers. comm.).

METHODS

Daily surveys along the beachfront were conducted to locate breeding pairs and nests during the 2003 and 2004 breeding seasons (Mar-Aug). Surveys were from vehicle and on foot. Nest locations were recorded using the global positioning system (GPS) (Garmin GPS 12), nests were marked with a small florescent marker (paint stirrer) placed approximately 3 m seaward of the nest, and number of eggs present was recorded. Video monitoring equipment was placed at each nest site within 24 h of locating it. This equipment consisted of a miniature black and white infrared camera (1.5-2.0 m from nest) and a time-lapse recorder (19-20 m from nest), powered by a 12-volt deep-cycle battery (Sabine *et al.* 2005). Batteries were replaced every 60 h and VHS tapes were replaced every 120 h. During each battery change, nests were checked for missing or damaged eggs. Maintenance of video equipment at the nest site was limited to morning and evening hours (before 08.00 h or after 18.00 h), moderate climatic conditions, and to ≤7 min to minimize impact to eggs or chicks.

On days when no battery or tape change was necessary, nests were monitored from a distance (*ca.* 50 m), minimizing disturbance to incubating birds. When a nest failed, video-monitoring equipment was removed and the tape was reviewed to identify the cause. If eggs hatched, video equipment was left in place until chicks left the nest (2-3 d). Chicks were monitored daily with binoculars or spotting scopes until failure or fledging. If a chick was lost, the area was searched for carcasses (100-m radius).

Hatching and fledging success were calculated as a percentage of total nest attempts (apparent success) and daily survival of clutches and chicks was estimated using the modified Mayfield method (Mayfield 1961, 1975; Bart and Robson 1982; Hines 1996). We compared daily survival estimates between nesting stages, years, and North and South Ends using the program CONTRAST (Hines and Sauer 1989). Because of low sample sizes, we pooled data between years and locations to compare daily survival estimates between nesting stages. We made year and location comparisons based on daily survival estimates calculated from combined nesting stages, and were considered different if $P < 0.05$.

RESULTS

Productivity

Eleven breeding pairs established territories in 2003 and ten pairs established in 2004 (Table 1). In 2003, pairs made 19 nest attempts. Six nest attempts were renests, and two were second renests. Six (32%) hatched at least one egg. In 2004, ten pairs made 13 nest attempts. Six (46%) hatched at least one egg. Seven and three pairs made one and two attempts, respectively. Combined years apparent hatching success was 38%. Mean clutch size was 2.5 eggs per nest (N = 32, mode = 2.00, 95% CI = 2.3–2.7). Mean incubation period, calculated using nests with known initiation dates, was 29.1 d (N = 9, 95% CI = 27.3–30.9). For two years, 15 chicks fledged from nine clutches (28%); six from four clutches (21%) in 2003 and nine from five clutches (38%) in 2004. All pairs that fledged a chick did so on the first nesting attempt. Three pairs that hatched at least one egg did not fledge chicks.

Combined years daily survival estimate during incubation was 0.973 (N = 32, 95% CI = 0.961–0.985) and 0.991 (N = 12, 95% CI = 0.982–1.00) for brood rearing. Daily survival estimates between stages were different ($\chi^2_1 = 5.671$, $P < 0.02$). Based on a mean incubation period of 29 d, the probability of at least one egg in a clutch hatching was 0.452. Assuming chicks fledged within 35 d (Nol and Humphrey 1994), survival from clutch initiation to fledging was 0.329.

Combined nesting stage daily survival estimates were 0.973 (95% CI = 0.960–0.987) for 2003 and 0.985 (95% CI = 0.974–0.995)

Table 1. Hatching and fledging success of American Oystercatchers at Cumberland Island National Seashore, Georgia, 2003 and 2004.

Year	No. pairs	No. clutches	No. clutches that hatched chicks (%)	No. clutches that fledged chicks (%)	% hatched clutches that fledged chicks	No. chicks fledged
North End						
2003	5	6	5 (83)	4 (67)	80	6
2004	5	7	3 (43)	3 (43)	100	6
South End						
2003	6	13	1 (8)	0 (0)	0	0
2004	5	6	3 (50)	2 (33)	67	3
Total		32	12 (38)	9 (28)	75	15

for 2004, and were not different ($\chi^2_1 = 1.724$, n.s.). Combined estimated daily survival for both years was 0.979 (95% CI = 0.970–0.987). Nineteen nests were found on the South End and 13 on the North End for combined years (Fig. 1). Daily survival estimates for the North End (0.990, 95% CI = 0.982–0.998) and the South End (0.965, 95% CI = 0.948–0.981) were different ($\chi^2_1 = 7.2$, $P < 0.01$).

Nest Fate

Twenty-three (72%) of 32 nest attempts failed. Twenty failed during the egg stage and three during the hatchling stage. Eighteen of 20 (90%) failures during the egg stage (Sabine *et al.* 2005) were documented. Chicks were difficult to video monitor because they left the nest site 24-48 h after hatching; consequently, only one chick loss was documented on videotape.

Predation was the primary cause of nest failure, accounting for 13 losses during the egg stage and one chick loss. Egg predators included raccoon (N = 9), bobcat (N = 3), and American Crow (*C. brachyrhynchos,* N = 1). One chick was preyed on by a ghost crab (*Ocypode quadrata*), just after hatching. Except for one predation by a crow, all occurred at night. Other causes of nest failure included tidal overwash (N = 1), horse trampling (N = 1), abandonment (N = 2) after 34 and 35 d of incubation, and destruction by a child (Fig. 2).

Figure 2. Child destroying an American Oystercatcher's nest, Cumberland Island National Seashore, Georgia, 2004. The nest failure was documented by video monitoring equipment.

Rate and cause of nest failure was variable by location. Mammalian predation was more frequent on the South End. Seven raccoon and three bobcat predation events occurred on the South End, compared with only two raccoon predation events on the North End. Predation by other species occurred only on the North End (ghost crab, American Crow). Other causes of nest failure, including horse trampling, tidal overwash, and human destruction also only occurred on the South End.

DISCUSSION

Productivity

Mean clutch size on CINS was similar to clutch sizes documented in other studies. Clutch sizes in other regions of Georgia were relatively small ($\bar{x} = 2.3$, N = 32, Corbat 1990; $\bar{x} = 2.0$, N = 209, George 2002, respectively). Studies in both Florida (Toland 1999) and Virginia (Nol *et al.* 1984) documented a mean clutch size of 2.6 (N = 58 and 257, respectively).

Hatching (32%, 2003; 46%, 2004, apparent nest success) and fledging (21%, 2003; 38%, 2004) success at CINS was high, compared with other studies in Georgia. In the 1980s, only two of 19 (6.3%) nests hatched at least one egg with 13 nest outcomes known (Corbat 1990). This decade, 15% apparent hatching success (N = 209), and 7% apparent fledging success was found in Georgia (George 2002). In Florida, apparent fledging success was higher (57%, N = 58; Toland 1999). Hatching success of 14% (N = 114) was documented in Virginia (Nol 1989).

Hatching and fledging success differed between the North and South Ends of CINS. In North Carolina, hatching success was variable also, ranging from 4-23% (N = 996, McGowan 2004), as was hatching success in Georgia (0-30%, N = 209, George 2002). High variability in reproductive success among oystercatchers appears to be common, and indicates that local factors strongly influence reproductive success (e.g., predation, human activity), even within a single island setting. It is unclear how current reproductive rates are affecting population trends, although high annual survival rates and long life spans may help to sustain populations with low and variable reproduction. Occasional spikes in reproductive success may be sufficient to sustain or even increase a population (Davis 1999); however, historical records indicate that the population is in decline south of Virginia (Davis *et al.* 2001).

Nest Fate

Mammalian predation was the primary cause of nest failure at CINS and it influenced reproductive success between North and South Ends. All predation events at the South End were by mammals. In North Carolina, 77% of nest failures were due to predation and raccoons were the primary mammalian predator, based on interpretation of evidence at the nest site (Davis *et al.* 2001). Bobcats were a previously undocumented predator of American Oystercatcher nests. Bobcats, however, were restored to CINS in 1988 (Baker *et al.* 2001). Other biologists documented a negative correlation between predator abundance and reproductive success. In North Carolina, daily survival of nests increased following red fox control on Hatteras Island, North Carolina ($Z = 3.2$, $P < 0.01$, $N = 43$ nests, McGowan 2004). Also, lower reproductive success was found on islands with known raccoon populations compared to those without ($Z = 7.9$, $P < 0.001$, $N = 852$ nests).

Differences in predation rates and sources may be affected by differences in environmental and anthropogenic influences between the North and South Ends. Primary predators on the South End were raccoons and bobcats, both of which could easily travel the short distance from the forested island interior to nesting sites (200-300 m). Human presence may maintain higher mammalian predator populations on the South End as well (Prange *et al.* 2003). Raccoon sightings and sign were greater in areas of increased human activity in North Carolina (Novick 1996; Davis *et al.* 2001). Raccoon and bobcat signs appeared to be more abundant around areas of frequent human activity at CINS (J. B. Sabine, pers. obs.). Access to nests on the North End by mammalian predators may have been restricted because of the distance from forest to nesting sites (1-2 km). Predation on the North End was by species that are commonly found on the beach (ghost crab, American Crow) regardless of proximity to forested habitat.

In areas of frequent human activity, pedestrians were commonly observed in close proximity to nests, causing oystercatchers to leave their nests. Pedestrians rarely noticed oystercatcher alarm calls and display activities (J. B. Sabine, pers. obs.). Human presence in the dunes not only resulted in nest failure, but also caused the incubating adult to temporarily abandon the nest, exposing eggs and chicks to temperature extremes and greater risk of predation. One nest, located in an area of frequent pedestrian traffic, was abandoned after 35 days of incubation. Examination of the eggs following abandonment revealed partially developed embryos. Frequently, adults were observed off the nest when pedestrians were nearby. The cause of failure is unknown; however, it is suspected that the nest failed because of thermal stress to eggs caused by a lack of incubation, likely induced by human disturbance. While regulations to keep people out of the dunes may not be effective by themselves, creating educational programs on American Oystercatchers and other beach-nesting birds and their needs during the breeding season may be helpful in reducing human disturbances.

Overwash rarely caused nest failure at CINS. Although it was documented previously as a primary contributor to nest failure in Georgia, overwash occurs primarily on sandbars and marshes (George 2002). Overwash on barrier island beaches was rare (14 of 69 nests, George 2002). Several researchers documented flooding as the primary cause of nest failure on low-elevation sand spits or marsh habitats (Kilham 1979; Nol 1989; Corbat 1990). Nesting at higher elevations reduces the probability of overwash and, after hatching, the dunes provide refuge from predators and high tides (Lauro and Burger 1989). The abundance of high elevation nesting habitat in the well-developed dune system at CINS provided ample nesting habitat out of reach of high tides.

Nest failure due to trampling by horses was previously undocumented. Horse activity on the beach as well as multiple near tramplings were observed (J. B. Sabine, pers. obs.), suggesting that this is a regular source of nest failure from year to year. As much as 23.5% (N = 17) of nest failures on Little St. Simons Island resulted from trampling by cattle (Corbat 1990). Feral horses, found on several barrier islands along the East Coast, can be detrimental to the sensitive dune complex. Horses graze dune-forming vegetation and trample dunes, which results in destabilization and erosion of the dune complex (Johnson *et al.* 1974) and potentially destroys nests of several species of ground nesting shorebirds.

Chick loss was a major source of reproductive failure at CINS, but only one loss was documented on videotape. Gulls and other oystercatchers were observed attacking and stabbing chicks (J. B. Sabine, pers. obs.). A Laughing Gull (*L. atricilla*) killed a chick in North Carolina (McGowan 2004). Radio tracking chicks may be an effective technique to document causes of chick loss.

In areas with high predation rates, predator control increases reproductive success (McGowan 2004); however, this management tool is labor intensive, long-term, and often very expensive. Additionally, in areas of frequent human activity, predator control is difficult to implement safely. Perhaps conservation funds would be better-spent protecting areas that have been documented as areas with high reproductive success, such as the North End of CINS and Egg Island Bar, at the mouth of the Altamaha River in Georgia (George 2002). Further research is required to monitor annual American Oystercatcher reproduction in these important areas and to identify other areas of high reproductive success for conservation and protection. Use of areas with high reproductive success for recreational purposes may attract predators and disrupt nesting activities, so plans should be made to protect these areas from human disturbance.

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