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Investigating American Oystercatcher (*Haematopus palliatus*) Nest Failure on Fisherman Island National Wildlife Refuge, Virginia, USA

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Abstract.—Nest failure has often been identified as a factor affecting American Oystercatcher (*Haematopus palliatus*) survivorship. To examine causes of nest failure, small digital cameras were deployed between 6 April and 15 July 2005 on American Oystercatcher nests on Fisherman Island National Wildlife Refuge located in Northampton County, Virginia. Twenty-five attempts, representing 22 different pairs, were recorded resulting in 7,570 hr of video footage. Nest survivorship was 44% (n = 11). High tide events associated with coastal storms were the largest source of nest loss (24%, n = 6), followed by predation on eggs (16%, n = 4). Nest abandonment, unknown factors, and infertile eggs accounted for the remaining 16% (n = 4) of nests. The main predator was Fish Crows (*Corvus ossifragus*). While American Oystercatchers were incubating, 211 instances were recorded where individuals of 22 species entered the field of view of video cameras. The most common species entering included Boat-tailed Grackle (*Quiscalus major*) (22.7%), white-tailed deer (*Odocoileus virginianus*) (11.4%), Brown Pelican (*Pelecanus occidentalis*) (10.9%), Willet (*Tringa semipalmata*) (9.0%), and ghost crab (*Ocypode quadrata*) (7.1%). A wide range of responses to intruders from no reaction to permanent nest abandonment were displayed by incubating American Oystercatchers. The majority (65.9%, n = 139) of encounters were met with no reaction followed by fleeing the nest area (17.5%, n = 37), chasing the intruder (8.5%, n = 18), piping (7.6%, n = 16), and abandoning the nest (< 1.0%, n = 1). All predation events occurred when American Oystercatchers left nests unattended. *Received 14 March 2011, accepted 23 December 2012.*

Key words.—American Oystercatcher, *Haematopus palliatus*, predation, reproductive success, video monitoring, Virginia.

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The American Oystercatcher (*Haematopus palliatus*) has been designated as a species of high conservation concern in the U.S. Shorebird Conservation Plan (Brown *et al.* 2001). The Atlantic and Gulf coasts of the United States have a population size of approximately 11,000 individuals (Brown *et al.* 2005). Low fecundity has been identified as one factor responsible for population declines (Davis *et al.* 2001; American Oystercatcher Working Group *et al.* 2012). Consequently reproductive success has recently received considerable attention (Davis *et al.* 2001; Sabine *et al.* 2006; Wilke 2008). American Oystercatchers breed on coastal sandy beaches and in salt marshes. High-tide washouts and predation are reported to be the primary causes of low productivity (Davis *et al.* 2001; Wilke and Watts 2004; Sabine *et al.* 2006; American Oystercatcher Working Group *et al.* 2012). Washouts can be easy to document with regular monitoring; however, predation events are much more difficult to observe and document. Several studies have shown that nest remains are unreliable indicators of predation events and predators (Lariviere 1999; Williams and Wood 2002; Staller *et al.* 2005). Identification of the correct predator species is necessary if any predator management is to be implemented.

Virginia is considered to be a key American Oystercatcher breeding area along the east coast of the United States with the highest number of breeding pairs in any state (Wilke *et al.* 2005). Nesting success on some Virginia barrier islands has been relatively high when compared to other coastal breeding sites (Nol 1989; Davis *et al.* 2001; Sabine *et al.* 2006; Wilke 2008). However, one of these sites, Fisherman Island National Wildlife Refuge (NWR), has had a history of relatively poor hatch success and low productivity (Anderson 1988; Wilke and Watts 2004). Between 40 and 50 pairs nest there, representing 7-9% of Virginia's breeding population (Wilke *et al.* 2005). Remote cameras have been used to successfully document disturbance and predation events on American Oystercatcher nests in North Carolina and Georgia (McGowan and Simons 2006; Sa-

bine *et al.* 2006). The objectives of this study were to: 1) examine factors affecting American Oystercatcher nest failure in the egg stage using remote cameras, and 2) quantify disturbance to American Oystercatchers during nesting on Fisherman Island NWR.

METHODS

Study Area

Fisherman Island NWR (37° 8' N, 75° 57' W) is located on the southern tip of the Delmarva Peninsula spanning the mouth of the Chesapeake Bay and the Atlantic Ocean (Fig. 1). Fisherman Island NWR is a 740-ha barrier island connected to the mainland via the Chesapeake Bay Bridge-Tunnel and is the southernmost island in the chain of barrier islands along the Delmarva Peninsula in Northampton County, Virginia. A detailed description of the area is given in Wilke *et al.* (2005). American Oystercatchers nest throughout the perimeter of the island's shoreline. The shoreline varies from wide sandy beaches to tidal mudflats. The site can be subjected to coastal storms which may coincide with the breeding season (Dolan *et al.* 1988) resulting in nest loss due to washovers.

The primary nesting substrate for the American Oystercatcher on Fisherman Island NWR is the beach between the inter-tidal zone and the primary dune (Anderson 1988). Additional habitats used for nesting include the dune swale habitats within the dune complex and sand flats that occur landward of the primary dunes or in areas where sand has accreted at the saltmarsh-edge. Typical plant species in this zone are American

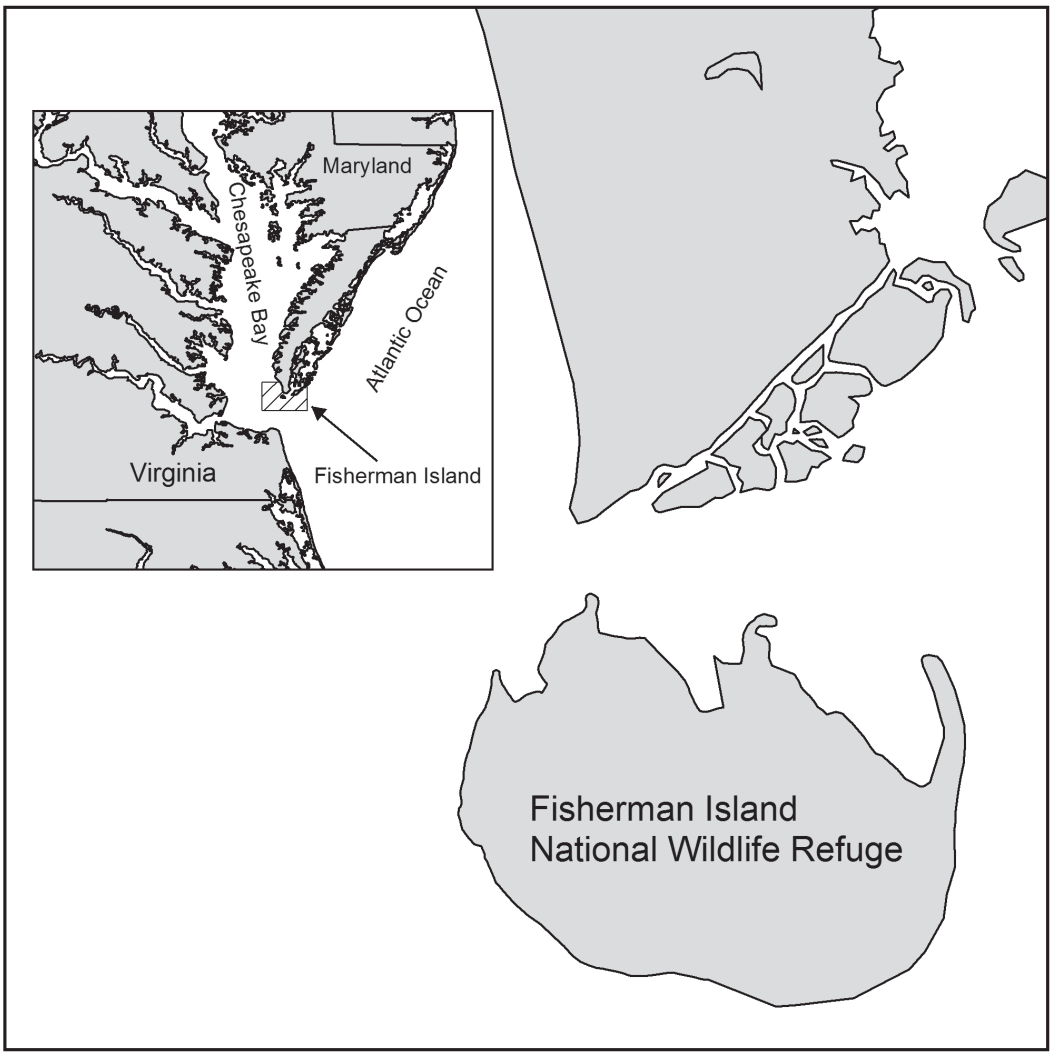

Figure 1. Location of Fisherman Island National Wildlife Refuge on the southern Delmarva Peninsula, Virginia.

beach grass (*Panicum amarulum*), salt-meadow grass (*Spartina patens*) and salt grass (*Distichlis spicata*). Other beach nesting bird species breeding on Fisherman Island NWR in this habitat include Piping Plover (*Charadrius melodus*) and Least Tern (*Sternula antillarum*).

Potential nest predators on Fisherman Island NWR include ghost crabs (*Ocypode quadrata*), various gull species, Fish Crows (*Corvus ossifragus*) and raccoons (*Procyon lotor*) (McGowan 2001; Verboven *et al.* 2001; Sabine *et al.* 2006). Human access to the island is restricted to refuge personnel and permitted researchers and is not considered a factor in low reproductive success for this site.

Video Nest Monitoring

Surveys were conducted two to three times a week to locate breeding pairs and nests during the breeding season (April-August) of 2005 on Fisherman Island NWR. Surveys were conducted by vehicle and on foot. Nest locations were recorded with a GPS and nests were marked with a paint stick approximately 10 m east of the nest and several inches above the ground (Wilke 2008). Nests were chosen for inclusion in the video-monitoring study based on stage of nesting, potential disturbance to pair, geographic location, and access. Cameras were deployed after incubation began (after two eggs were laid or after 2 days if maximum clutch size was one egg; American Oystercatcher Working Group *et al.* 2012); deployment ranged between 0-19 days of clutch completion. We used a video-recording system to record nesting activities between 6 April and 15 July 2005. Each system consisted of a color-infrared, CCTV camera, with a 4.0 mm lens, a color, digital video capture recorder (DVR), a 1-gigabite memory card, an 11-watt Unisolar solar panel attached to a 4.5 amp charge controller, and a 12-volt, deep cycle marine battery. The power and recording portion of the system was housed in a weatherproof box. Approximately 30 m of coaxial cable was used to connect the camera to the DVR unit. Cameras had a viewable distance range of 100 m and a horizontal range of 6 m across the nest site.

Cameras were placed on wooden posts approximately 3-5 m away from the nest and 0.5 m above the ground. The posts were fitted with inverted nails to prevent potential avian predators from using the posts as hunting perches. Posts were camouflaged with marsh plants or wrack, and cameras were spray painted to blend with either sand or vegetation. Video-recording equipment was positioned at least 15 m away from the nest depending on the amount of available cover. A maximum of 10 infrared cameras were deployed on Fisherman Island NWR at any one time. Recording equipment was programmed to record an image every 5 seconds both day and night. Flash cards were exchanged on each unit every 2 to 3 days to minimize nest disturbance. During each card change, nest contents were checked. Video capture systems were tested before entering any American Oystercatcher territories. Systems took an average of 13.4 min (SE = 1.2) to set up at the nest site. We would not leave cameras in place unless resumed incubation could be confirmed. Cameras were widely distributed on nests throughout the island. However, they were not randomly assigned to nests and were located on nests that appeared not especially susceptible to washouts. Nests without cameras were monitored every 2 to 3 days so that productivity could be determined for all nests during the season.

Digital video coverage was reviewed to quantify interactions between American Oystercatcher pairs and potential predators. All images were downloaded at the field station and reviewed using Irfinview software (Skiljan 2005). After review, images were archived on DVDs. Due to the quantity of video coverage, only encounters with intruders were reviewed in detail. An encounter was considered to be any time an intruder (all animals except the focal pair of American Oystercatchers) entered the field of view. Encounters with potential predators were characterized in several ways. The behavior of American Oystercatchers prior to the interaction was recorded. Behaviors recorded prior to the encounter included incubation, American Oystercatcher not incubating but present near nest, or American Oystercatcher absent from nest area. The closest distance between the potential predator and the nest was estimated in 5 m intervals. The time of the interaction was measured in seconds. The behavior of the American Oystercatcher during the encounter was recorded. Behaviors were categorized as no detectable reaction to intruder, American Oystercatcher agitated and piping, American Oystercatcher chasing intruder, American Oystercatcher fleeing the nest area, and nest abandoned. Nests were considered to be abandoned if birds were never observed to return to the nest site. The total number of encounters, total duration of encounters, and the total time off the nest were compiled for each pair that was recorded. We compared productivity (number of chicks fledged per pair) between nests with cameras and nests without cameras to determine whether there was a negative or positive "camera" effect on productivity that could affect the results (Richardson *et al.* 2009).

RESULTS

Reproductive Success

Twenty-five attempts, from 22 American Oystercatcher pairs, were recorded with digital video equipment (Table 1) resulting in 7,570 hr of video footage. Video coverage per nest varied between 2 and 39 days with a mean and standard error of 16 ± 2.1 days. Variance in coverage resulted primarily from differences in the outcome of nesting attempts. Of 25 recorded nesting attempts, 44% (n = 11) were successful in hatching and dispersing at least one American Oystercatcher chick from the nest. Pairs

Table 1. Details of digital video recording and associated nesting attempts for American Oystercatchers on Fisherman Island National Wildlife Refuge, Virginia, during the 2005 nesting season.

Nest ID	Clutch Size	No. Eggs Hatched	No. Chicks Dispersed	Days Recorded	Nest Fate	Comments
F0105	5	0	0	24	Washout	A 2 female and 1 male trio
F0205	3	0	0	21	Washout	
F0305	3	2	2	21	Hatched	Nest hatched 2 of 3 eggs, other egg predated by Boat-tailed Grackle
F0505	3	0	0	2	Washout	
F0605	2	1	1	25	Hatched	Nest hatched 1 of 2 eggs, other egg predated by Fish Crow
F0705	3	0	0	8	Washout	
F0905	2	0	0	4	Abandoned	Nest abandoned, Fish Crow predated both eggs within 3 days of abandonment
F1005	3	1	1	33	Hatched	Nest hatched 1 egg, other 2 eggs predated by Fish Crow
F1505	2	2	2	21	Hatched	
F1605	2	0	0	6	Washout	
F2305	3	3	2	28	Hatched	All 3 eggs hatched, 1 chick predated by ghost crab, Fish Crow later took chick away from crab
F3405	2	0	0	4	Abandoned	Nest abandoned due to deer activity on 5/14/2005, egg predated 12 days later by Fish Crow
F4405	2	0	0	2	Unknown	
F4705	3	0	0	3	Predated-Fish Crow	
F4805	1	0	0	18	Predated-raccoon	
F5105	2	2	1	39	Hatched	Both eggs hatched, 1chick predated by ghost crab
F5305	3	2	2	29	Hatched	One egg predated by unknown predator between 5/31/2005 and 6/3/2005; other 2 eggs hatched
F6005	1	0	0	10	Predated-Fish Crow	
F6305	2	1	1	25	Hatched	Nest hatched 1 of 2 eggs, other egg addled by ghost crab predation attempt
F6505	2	2	2	13	Hatched	
F7005	2	0	0	4	Washout	
F7405	2	unknown	unknown	16	Hatched	At least 1 egg hatched, but then equipment was removed due to weather
F7505	4	0	0	16	Predated	Nest had 2 eggs predated by Fish Crow; 2 eggs taken by unknown predator between 7/4/2005 and 7/7/2005; a 2 female and 1 male trio
F7705	1	0	0	15	Infertile/addled	
F8005	2	2	2	14	Hatched	

hatched all eggs laid and successfully moved chicks from the nest site in only four of the 25 attempts. The causes of partial or complete nest failures were captured on digital video (Table 1). High tide events associated with coastal storms represented the largest source of nest loss. A total of 24% of all attempts photographed (n = 6) were lost during three storm events. Avian predation was the predominant biological cause of clutch losses for nests under video surveillance. Fish Crows were the primary species involved with predation events and were documented taking 12 eggs in 28% (n = 7) of the nesting attempts. A Boat-tailed Grackle (*Quiscalus major*) was observed taking a single egg and filmed rolling an egg out of an unattended nest away from the area on two separate nests. A Herring Gull (*Larus argentatus*) was observed inserting its bill into a nest but no predation was observed. Ghost crabs were documented taking one egg and two chicks. In both cases where ghost crabs ate American Oystercatcher chicks, the chicks appeared to be listless and near death and were left in the nest by the adult prior to the event. The chicks were still in their nests when predation occurred. In addition to these predation events, ghost crabs were observed attempting to move eggs out of the nest on two occasions and were chased by adult American Oystercatchers on one of these occasions. A raccoon was filmed eating a single-egg clutch.

Some American Oystercatcher pairs were away from nests for extended periods of time, many of which were 90 min or longer with the longest period approaching 11 hr and often occurring at night. For example, nest F5105 had 13 disturbance events that lasted over 90 min and parents remained off the nest for more than 104 hr but still hatched both eggs in the clutch. However, it took these eggs at least 38 days to hatch rather than the average 27-29 days (American Oystercatcher Working Group *et al.* 2012). This was also one of the chicks left in the nest in poor condition that was subsequently eaten by a ghost crab.

Overall productivity on Fisherman Island NWR in 2005 was 0.13 chicks fledged per pair with 22 nests hatching from 82 known attempts. Productivity among nests with cameras was 0.09 and productivity among nests without cameras was 0.16. We found no significant differences in productivity (t = 0.591, P = 0.28). Eleven of the camera nests had at least one egg hatch (44.0%) and 11 non-camera nests had at least one egg hatch (19.3%). The washout rate for non-camera nests was 47.4%, whereas the washout rate for nests with cameras was 24%. Three nests with cameras (12%) had at least one egg predated (but not the entire clutch); six nests without cameras had at least one egg predated (10.5%).

Species Interactions

We recorded 211 instances where individuals of 22 species entered the field of view of video cameras while American Oystercatchers were incubating. The majority of these observations involved individuals that came in close contact with the nest with more than 80% occurring within 10 m. The most common species entering territories included ghost crab, American Black Duck (*Anas rubripes*), Brown Pelican (*Pelecanus occidentalis*), Willet (*Tringa semipalmata*), Boat-tailed Grackle, marsh rice rat (*Oryzomys palustris*), and white-tailed deer (*Odocoileus virginianus*) (Table 2). These seven species accounted for 71.7% (n = 152) of all observations.

Incubating American Oystercatchers showed a wide range of responses to intruders from no reaction to permanent nest abandonment. The majority (65.9%, n = 139) of encounters were met with no reaction followed by fleeing the nest area (17.5%, n = 37), chasing the intruder (8.5%, n = 18), piping (7.6%, n = 16), and abandoning the nest (< 1.0%, n = 1). Response varied according to intruder species. For most (11 of 22 species elicited reactions < 10% of the time) species entering the territory, American Oystercatchers showed no reaction (Table 2).

American Oystercatchers continued to incubate in 72% of the instances when an intruder came to within 1 or 2 m of a nest. Eight out of 22 species elicited aggression or a fleeing response by nesting

Table 2. Reactions of nesting American Oystercatchers to intruder species captured by digital video recorders on Fisherman Island National Wildlife Refuge, Virginia, during the 2005 nesting season. Median times and ranges are in minutes. Median distances and ranges are in meters.

Species	Scientific Name	*n*	Number of Reactions	Fled	Chase	Piping/ Agitated	Abandon	Time of Interaction	Time off Nest	Closest Distance
Ghost Crab	*Ocypode quadrata*	15	13 (86.7%)	1 (6.7%)	1 (6.7%)	0	0	3.73 (1.25-6.20)	2.57 (0.25-4.88)	1 (0-2)
Diamond-backed Terrapin	*Malaclemys terrapin*	2	2 (100%)	0	0	0	0			
Canada Goose	*Branta canadensis*	6	3 (50.0%)	2 (33.3%)	1 (16.7%)	0	0	3.60 (2.67-68.30)	9.72 (3.85-19.87)	15 (5-40)
American Black Duck	*Anas rubripes*	10	3 (30.0%)	0	2 (20.0%)	5 (50.0%)	0	42.42 (1.40-89.77)	1.25 (0.0-539.17)	2 (2-8)
Brown Pelican	*Pelecanus occidentalis*	23	21 (91.3%)	0	2 (8.7%)	0	0	1.05 (0.85-1.25)	0.45 (0.25-0.65)	1
Great Egret	*Ardea alba*	1	1 (100%)	0	0	0	0			
Snowy Egret	*Egretta thula*	1	1 (100%)	0	0	0	0			
Tri-colored Heron	*Egretta tricolor*	1	1 (100%)	0	0	0	0			
Clapper Rail	*Rallus longirostris*	3	2 (66.7%)	0	0	1 (33.3%)	0	0.17	0.32	1
Herring Gull	*Larus argentatus*	4	1 (25.0%)	0	2 (50.0%)	1 (25.0%)	0	0.50 (0.42-1.40)	0.42 (0.00-1.00)	6 (1-10)
Great Black-backed Gull	*Larus marinus*	1	0	1 (100%)	0	0	0	6.47	5.65	0
Laughing Gull	*Leucophaeus atricilla*	2	2 (100%)	0	0	0	0			
Unidentified Gull		2	2 (100%)	0	0	0	0			
Black Skimmer	*Rynchops niger*	1	1 (100%)	0	0	0	0			
Black-bellied Plover	*Pluvialis squatarola*	2	2 (100%)	0	0	0	0			
American Oystercatcher	*Haematopus palliatus*	4	1 (25.0%)	0	2 (50.0%)	1 (25.0%)	0	0.33 (0.07-4.23)	4.48 (0.0-4.90)	2 (0-10)
Willet	*Tringa semipalmata*	19	17 (89.5%)	0	2 (10.5%)	0	0	0.29 (0.25-0.33)	0	7 (4-10)
Great Horned Owl	*Bubo virginianus*	6	3 (50.0%)	3 (50.0%)	0	0	0	3.73 (0.83-88.97)	69.03 (3.37-489.90)	5 (1-6)
Fish Crow	*Corvus ossifragus*	7	5 (71.4%)	1 (14.3%)	1 (14.3%)	0	0	0.96 (0.42-1.92)	2.0 (0.42-2.25)	1 (0-10)
Boat-tailed Grackle	*Quiscalus major*	48	35 (72.9%)	3(6.3%)	4 (8.3%)	6 (12.5%)	0	2.23 (0.33-21.38)	3.08 (0.00-4.82)	2 (1-20)
Unidentified Bird		8	6 (75.0%)	1 (12.5%)	0	1 (12.5%)	0	1.46 (0.17-2.75)	1.84 (0.00-3.67)	9 (2-15)
Marsh Rice Rat	*Oryzomys palustris*	13	13 (100%)	0	0	0	0			
Raccoon	*Procyon lotor*	1	0	1 (100%)	0	0	0	0.01	396.65	0
White-tailed Deer	*Odocoileus virginianus*	24	0	23 (95.8%)	0	0	1 (4.2%)	5.08 (0.25-35.13)	12.33 (3.08-abandon)	13 (0-60)
Unidentified		7	4 (57.1%)	1 (14.3%)	1 (14.3%)	1 (14.3%)	0	0.17 (0.17-3.23)	4.15 (0.67-7.98)	30 (10-100)
Total Disturbance		211	139 (65.9%)	37 (17.5%)	18 (8.5%)	16 (7.6%)	1 (0.5%)			

American Oystercatchers in at least 50% of their encounters (Table 2). In three of the six recorded Great Horned Owl (*Bubo virginianus*) encounters, American Oystercatchers had no response, while they fled the area in the other three encounters. Among all intruder species documented, white-tailed deer seemed to elicit the greatest response with all encounters (n = 24) resulting in birds leaving the territory and in one instance abandoning the nest. The length of American Oystercatcher response to American Black Ducks, Great Horned Owls, and white-tailed deer combined was significantly longer (median time off nest = 9.45 min for these species and 0.0 min for other species) (Mann-Whitney U = 721, P < .001) than that of all the other species combined (Table 2). An extended interaction between an American Oystercatcher pair and an American Black Duck appeared to have been a dispute over a nesting location. The American Black Duck attempted to nest inside the American Oystercatcher pair's territory and this caused the American Oystercatchers to become agitated.

The duration of the encounter was longer for encounters that resulted in a response compared to those that did not (median time = 8.47 min and 4.13 min for reaction, no reaction respectively) (Mann-Whitney U = 4175, P < 0.01). The closest distance to the nest during the encounter was significantly shorter for encounters that did not result in a reaction compared to those that did (median distance = 2.0 m for no reaction, and 4.5 m for a reaction) (Mann-Whitney U = 4157, P < 0.01).

We recorded 107 instances where individuals of 11 species entered the field of view of video cameras while American Oystercatchers were absent and the nest was unattended. The majority of these intruders approached within 2 m of the nest. Twelve (11.2%) of the 107 intrusions documented resulted in a predation event. Predators included Fish Crows with seven predation events, ghost crabs with three predation events, and Boat-tailed Grackles and raccoons with one predation event each.

DISCUSSION

Causes of nest failure for American Oystercatchers on Fisherman Island NWR were similar to what has been reported in other studies. Coastal storms and avian predation have been documented at other sites within the breeding range; however, in our study mammalian predation on Fisherman Island NWR was not as important as has been reported for other sites.

Fish Crows were the most abundant nest predators on Fisherman Island NWR, but the impact of that species on American Oystercatcher reproductive success in other parts of the breeding range may vary (Davis *et al.* 2001; Sabine *et al.* 2006; Schulte 2012). On Cape Lookout National Seashore, avian predation was not a significant cause of nest failures with known outcomes (Davis *et al.* 2001). Sabine *et al.* (2006) documented only a single predation event on video involving an American Crow (*Corvus brachyrhynchos*) on Cumberland Island in Georgia. Schulte (2012) speculated that Fish Crow predation was higher for American Oystercatcher chicks than nests on the Outer Banks of North Carolina. Anderson (1988) observed over 300 Fish Crows on Fisherman Island NWR during the breeding season of 1981 with two instances of direct predation by Fish Crows involving an American Oystercatcher egg and a small chick.

Prior to the construction of the Chesapeake Bay Bridge-Tunnel in the early 1960s, Fisherman Island NWR was isolated from the Delmarva mainland by a channel that is more than 1 km wide. The construction of the bridge-tunnel may have increased colonization of the island by ground predators through providing greater access. As recently as 1998, Fisherman Island NWR was considered raccoon free (Erwin *et al.* 2001), but in recent years observations of raccoons on Fisherman Island NWR have increased (P. Denmon, pers. obs.). However, only one nest was predated by a raccoon during this study. Mammalian predation is most often reported as the most consistent source of both clutch and brood loss for American Oystercatchers throughout their range

(American Oystercatcher Working Group *et al.* 2012). Within Cape Lookout National Seashore, predators accounted for 77% of documented losses (Davis *et al.* 2001) with raccoons implicated in 79% (n = 42) of those cases where predators could be identified. On Cumberland Island, 72% (n = 18) of clutch losses were attributed to mammals (n = 12) (Sabine *et al.* 2006). Along the Virginia barrier islands, an increase in reproductive rates has been attributed to the removal of mammalian predators on selected islands (Wilke *et al.* 2005).

Beach-nesting birds that breed on the barrier islands often share their territories with populations of ghost crabs. Ghost crabs forage widely throughout the active beach zone and are known to feed on a wide range of food items (Wolcott 1978; Branco *et al.* 2010). On the Virginia barrier islands, this species has been documented to take Piping Plover chicks (Loegering *et al.* 1995) and on one occasion to take a Piping Plover clutch (Watts and Bradshaw 1995). Sabine *et al.* (2006) documented a ghost crab taking an American Oystercatcher chick shortly after hatching on Cumberland Island. On Fisherman Island NWR, we documented ghost crabs taking American Oystercatcher chicks from two different territories and interacting with unattended clutches.

In our study, 95.8% of all video encounters with white-tailed deer resulted in American Oystercatchers fleeing an incubating nest with one pair permanently abandoning the nest after the encounter, although the precise cause of the abandonment is unknown. Sheep (*Ovis aries*; Moore and Reid 2009), horses (*Equus caballus*; Sabine *et al.* 2006) and deer (P. Denmon, pers. obs.) have resulted in oystercatcher nests being trampled. In areas with ungulate overabundance and high predation pressures, this could be a factor overlooked in nest success.

Our video recorded a high number of interspecies interactions. Even though most interactions did not flush American Oystercatchers from nests, all predation events occurred when nests were unattended. Therefore, it seems likely that disturbances that keep adults away from the nest may result in a higher likelihood of a nest being predated. However, several nests with the greatest amount of disturbance and the greatest overall time away from nests hatched. McGowan and Simons (2006) found that birds that made fewer trips away from the nest but with longer absences had higher nest survival rates and speculated that this was possibly an adaptation to high predation pressures. Smith *et al.* (2007) speculated that increased incubation recesses may decrease nest success in some shorebird species. Disturbance resulting in American Oystercatchers flushing from nests would appear to be more problematic during the day, especially in the presence of diurnal avian predators. It is unclear whether nocturnal predators, primarily mammals, are able to detect attended and unattended nests with equal proficiency. However, unattended nests may lead to longer incubation periods (Nisbet and Welton 1984; Nuechterlein and Buitron 2002), thus exposing eggs to predators and washouts for longer periods than necessary.

The three recorded nesting attempts with partial clutch loss were a result of avian predation. Partial clutch predation in ground-nesting birds is frequently reported in nest fate studies (Maxson and Oring 1978; Lauro and Tanacredi 2002; Staller *et al.* 2005). In some years this is a relatively common event on Fisherman Island with up to 20% of observed American Oystercatcher nests affected (P. Denmon, pers. obs.). Partial clutch predation may occur opportunistically when nests are left momentarily unattended or when parental attendance may be able to stop the predation event (e.g., chasing the predator away) before the entire clutch can be predated. Most studies focus on human disturbance affecting avian reproductive success; however, our study showed that disturbance may be the result of interspecific disturbance.

During 2005 notable high tides caused an inordinate amount of nest washouts. Storm overwash has been identified as one of the dominant causes of reproduc-

tive failure in intensively studied populations of American Oystercatchers (Nol *et al.* 1984; Davis *et al.* 2001). Storm events were responsible for the largest number of clutch losses for nests under video surveillance on Fisherman Island NWR even though attempts were made to place cameras on nests that appeared least susceptible to inundation. Increasing the elevation of nests in place or moving nests to higher ground have both been suggested as management options to reduce losses in low-lying areas and have been used successfully in limited cases (Moore and Reid 2009; American Oystercatcher Working Group *et al.* 2012). On Fisherman Island NWR, some breeding territories are close enough to dunes to consider this management option. Opportunistic application of this approach on a trial basis may be warranted to investigate its value in improving hatching rates.

Our results show the importance of obtaining site-specific information when managing for predators. On sites where predator management is conducted, the use of cameras may be important to target the correct species. The equipment is continually becoming easier to use and less costly and may warrant the time and expense necessary to manage for predation of nesting oystercatchers. Our findings were limited by the number of coastal storms that occurred in 2005. Further examination with cameras should determine if our results are representative of typical oystercatcher nesting seasons on Fisherman Island NWR.

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