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An Investigation of Reproductive Failures for American Oystercatchers on Fisherman Island National Wildlife Refuge

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CENTER FOR CONSERVATION BIOLOGY
COLLEGE OF WILLIAM AND MARY

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Cover Photo: *American Oystercatcher chicks just hatching by Alex Wilke.*

The Center for Conservation Biology is an organization dedicated to discovering innovative solutions to environmental problems that are both scientifically sound and practical within today's social context. Our philosophy has been to use a general systems approach to locate critical information needs and to plot a deliberate course of action to reach what we believe are essential information endpoints.

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EXECUTIVE SUMMARY

Fisherman Island National Wildlife Refuge provides breeding habitat that is significant for the conservation of American Oystercatchers *(Haematopus palliates)*. The island supports approximately 5-10% of the Virginia breeding population. Although reproductive rates documented in recent years are comparable to other populations and to historic data from the island itself, they are considerably lower than those measured from some of the other Virginia barrier islands. Several factors may contribute to reproductive failures including tidal flooding associated with storm events, exposure to heat resulting from chronic disturbance, and predation of eggs or young from a diversity of potential predators. Our objective for this investigation was to document factors causing American Oystercatcher nest failures on Fisherman Island during the incubation period.

We used a video-monitoring approach to quantify disturbance events and causes of reproductive failure for oystercatchers breeding on Fisherman Island. We recorded 7,570 hrs of digital video footage of American Oystercatcher nests between 6 April and 15 July, 2005. We quantified the type and duration of oystercatcher reactions to 289 human and 318 non-human intrusions into breeding territories. Oystercatcher reaction to humans varied according to the type of activity and time off the nest was positively related to the duration of the activity. Non-human interactions involved 21 species. The most common species entering territories included Boat-tailed Grackle, White-tailed Deer, Brown Pelican, Willet, Ghost Crab, Marsh Rat, and American Black Duck. Oystercatcher response varied according to species and was considerably longer during the night hours.

Reproductive performance for monitored nests was relatively poor. Of 58 eggs monitored only 20 (34.5%) hatched. Of the 20 chicks that hatched only 18 (31%) survived to disperse from the nest site. Of 25 nesting attempts only 11 (44%) were successful to the dispersal phase. Pairs hatched all eggs laid and successfully moved chicks from the nest site in only 4 (16%) of 25 attempts. High tide events associated with coastal storms represented the largest source of nest loss. A total of 6 nests containing 18 eggs were lost during 3 storm events. Storms occurred on 14 April, 6 May, and 21 June. The second highest cause of loss was to predation by Fish Crows. Crows were documented to take 12 eggs during the course of 7 nesting attempts. Ghost crabs were documented to take 1 egg and 2 chicks. A Boat-tailed Grackle was observed taking a single egg on 18 May. A raccoon predated a single-egg clutch on 19 June.

BACKGROUND

Context

The American Oystercatcher *(Haematopus palliates)* belongs to the only family of shorebirds adapted to feed primarily on bivalve molluscs. This narrow feeding niche restricts nesting to a relatively small geographic area along the outer coastal fringe where preferred food is in adequate supply. Within the United States Shorebird Conservation Plan, the American Oystercatcher is listed as a species of high conservation concern (Brown et al. 2001). Within the Northern Atlantic Shorebird Plan, the American Oystercatcher has been classified as having the highest conservation priority (Clark et al. 2000). In part, these designations reflect the dependence of this species on unique coastal habitats that have received intense human pressures since the 1940's. In recent years, it has become clear that the long term success of conservation efforts on behalf of oystercatchers and other species restricted to coastal habitats will increasingly depend on providing adequate refuge lands for breeding.

Virginia plays an important and strategic role in range-wide conservation plans for American Oystercatchers. This prominent role is primarily due to the natural condition of the Virginia Barrier Islands. These islands represent the most pristine chain of barrier islands remaining along the Atlantic Coast and support at least 16% of the overall breeding population (Davis et al. 2001), as well as, one of the highest densities of wintering birds in the United States (Nol et al. 2000). However, the Virginia population has experienced dramatic population fluctuations throughout the past century. Bailey (1913) described a precipitous decline from the late 1800's through the early 1900's. He predicted that oystercatchers would be the next species to become extinct in the state due to unregulated spring hunting. Shortly after this prediction, the passage of federal protections allowed for an undocumented but apparently dramatic recovery. By the mid-1970's American Oystercatchers were once again common breeders along the island chain. Annual surveys of beach-nesting waterbirds along the barrier islands have shown that the breeding population has declined by more than 65% since the mid-1980's (Williams et al. 1990, 2000). The underlying factors causing this decline are poorly documented but are believed to include increased predation pressure.

Historically, Fisherman Island has provided important breeding habitat for American Oystercatchers. Bailey (1913) reports collecting an unusual four-egg clutch on the island in 1900. Since 1979, Fisherman has supported between 5 and 10% of the breeding population along the barrier islands (Williams unpubl. data). In the early 1980's, Anderson (1988) documented more than 50 breeding pairs on the island and suggested that the population had increased over the previous 10 years. Between 2002 and 2004 the breeding population has been between 40 and 50 pairs (Wilke 2003, Wilke and Watts 2004, Denmon pers. comm.) suggesting that it has been stable for the past 20 years.

Reproductive rates for American Oystercatchers on Fisherman Island have been lower than those reported from some of the other Virginia Barrier Islands. Between 2002 and 2004 chick production has varied between 0.1 and 0.4 chicks/breeding pair (Denmon and

Wilke, unpubl data). This level of productivity is consistent with observations made in 1981 and 1982. During these two years, Anderson (1988) recorded reproductive rates of 0.02 and 0.2 chicks/pair respectively. Although the American Oystercatcher is a long-lived species, this level of productivity does not appear adequate to maintain a stable population in the absence of regular immigration.

Several factors may contribute to reproductive failures throughout the barrier island chain. Tidal inundation has been documented to cause some failures particularly during years with successive storms and high tide events. Low feeding rates may be a factor on some territories that are situated away from good quality prey populations. Exposure and heat stress may be factors during years with several days of high temperatures particularly in locations with chronic disturbance. Predation of eggs and young has been recognized as a regular factor leading to reproductive failure in recent years. Fish Crows, Herring Gulls, snakes and mammals have all been documented to take either eggs or chicks within this system. Although the impact of tidal inundation has been relatively well documented, information on the other potential mortality factors has been more difficult to quantify.

Because Fisherman Island plays an important role in the conservation of this species and because some of these mortality factors are potentially under management control and others are clearly not, it is important to determine the relative roles of these factors in reducing reproductive rates before formulating conservation plans.

Objectives – Our single objective for this investigation was to document factors causing American Oystercatcher nest failures on Fisherman Island during the incubation period.

METHODS

Study Area

This study was conducted on Fisherman Island National Wildlife Refuge (Figure 1). Fisherman Island is the southernmost barrier island within a chain of barriers that stretches along the seaward margin of the Delmarva Peninsula from the Virginia/Maryland state line to the mouth of the Chesapeake Bay. The island is positioned within the mouth of the Chesapeake Bay just below the southern tip of the Delmarva Peninsula. Fisherman Island is connected to the Eastern Shore mainland by the Chesapeake Bay Bridge. Fisherman Island National Wildlife Refuge was established in 1969 to protect habitat for over-wintering, migratory, and breeding birds. The island supports a diverse assemblage of habitats including small patches of upland forest on older dune lines, extensive scrub shrub, salt marsh, cat ponds, dune swale grasslands, sand and mudflats, and active beach. These habitats support a diverse bird community year round.

The primary nesting substrate for the American Oystercatcher on Fisherman Island is the active beach between the inter-tidal zone (demarcated by the wrack line) and the primary dune (Anderson 1988). Additional habitats used for nesting include the dune swale habitats within the dune complex and sandflats that occur landward of the primary dunes or on the acretionary ends of the island. The sparse vegetation in the nesting habitat is dominated by pioneering grass species which are able to withstand inundation by salt water, high soil

temperatures, xeric conditions, burial in sand, and low nutrient content in the soil (Godfrey and Godfrey 1976, Oertel 1976, Stallins 2002). The typical plant species in this zone are American beach grass (*Panicum amarulum*), salt-meadow grass (*Spartina patens*), and salt grass (*Distichlis spicata*). These species help to anchor sand and aid in dune building and stabilization.

Figure 1. Map of Fisherman Island National Wildlife Refuge.

A number of potential predators occur or have been known to occur on Fisherman Island in the recent past. Although several mammal species have the potential to reach the island, raccoons (*Procyon lotor*) and red fox (*Vulpes vulpes*) continue to pose the greatest threat. A control program conducted by USDA and refuge personnel targeting these species is ongoing. Peregrine Falcons and Great Horned Owls are capable of taking adults or chicks. Both of these species breed on or frequent the island. Herring and Great Black-backed Gulls are common on the island and may take eggs or chicks. The refuge has an ongoing program to addle Herring Gull clutches within the central portion of the colony. Fish Crows and Boat-tailed Grackles are common on the island and are well-known egg predators. Ghost crabs are abundant throughout the island where habitat is appropriate. This species is capable of taking chicks and possibly eggs. Human access to the island is highly restricted to refuge personnel and permitted researchers.

Population Monitoring

American Oystercatcher pairs on Fisherman Island were monitored by refuge personnel approximately twice weekly from late March through mid August to document breeding performance. Information collected included territorial pairs, nest location, clutch size, hatching rate, brood size, fledging success. Causes of reproductive failure were noted where known. Field protocols generally followed those outlined by Wilke and Beck (2002). Pairs were monitored for breeding activity. New nests located were coded and mapped with GPS. Nests were chosen for inclusion in video-monitoring study based on stage of nesting, potential disturbance to pair, geographic location, and access.

Video Recording

We used a video-recording system to record activities of nesting American Oystercatchers on Fisherman Island between 6 April and 15 July, 2005. Each system consisted of a color-infrared, CCTV camera (Figure 2), a color, digital video capture box (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 weather-proof box. Approximately 30 m of coaxial cable was used to connect the camera to the DVR unit.

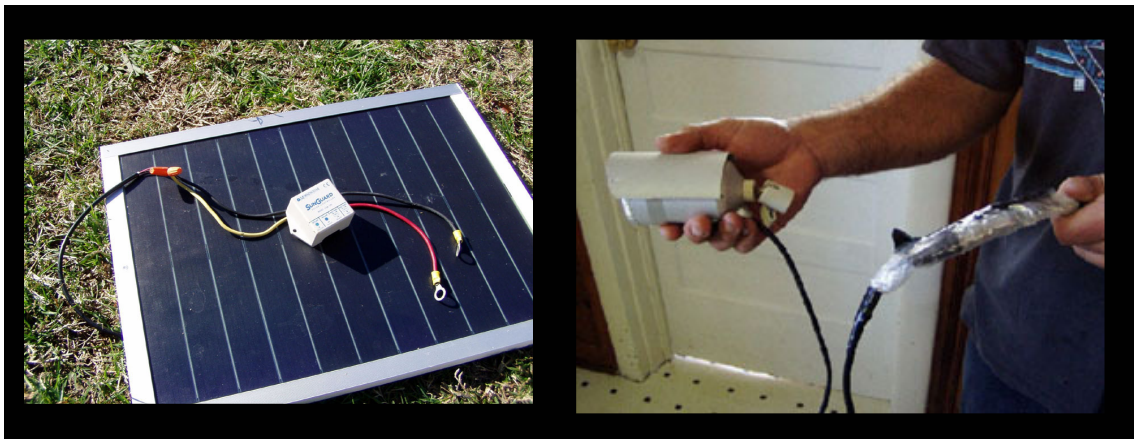

Figure 2. Images detailing the solar panel with voltage controller (left) and of the color infrared CCTV camera (right).

Video-monitoring systems were positioned such that both the details of nesting and as much as possible of the surrounding landscape could be observed. Cameras were placed on wooden posts approximately 3 - 5 m away from the nest (Figure 3). The posts were fitted with sharp objects to keep gulls, crows, owls, and other potential avian predators from using the posts as hunting perches. Posts were camouflaged with marsh plants. Video-recording equipment was positioned 15-25 m away from the nest. Video recording devices were deployed to cover the four zones of the island (Figure 4). A maximum of 10 infrared cameras were deployed on Fisherman Island at any one time. Flash cards were programmed to record an image every 5 seconds both day and night. Flash cards were exchanged on each unit every 2-3 days. Video capture systems were tested before entering any oystercatcher

territories. If video capture systems needed extensive troubleshooting, the units were switched out and troubleshooting occurred away from the breeding territory to minimize impact.

Figure 3. View of full oystercatcher camera set up. The camera is on the left side of the ridge and the digital video recording equipment is in the plastic bin on the right.

Video Review

Digital video coverage was reviewed by field personnel to quantify interactions between oystercatcher pairs and potential predators. All jpegs captured by DVRs were downloaded to PCs in the field station and reviewed using Irfinview© software. After review, images were archived on DVDs. Due to the shear 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 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 normal incubation, oystercatcher not incubating but present near nest, or oystercatcher absent from nest area. The closest distance between the potential predator and the nest was estimated in 5 m intervals. The total time of the interaction was measured in seconds. The behavior of the oystercatcher during the encounter was recorded. Behaviors included no detectable reaction to intruder, oystercatcher agitated and piping,

oystercatcher chasing intruder, 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 from the individual encounters.

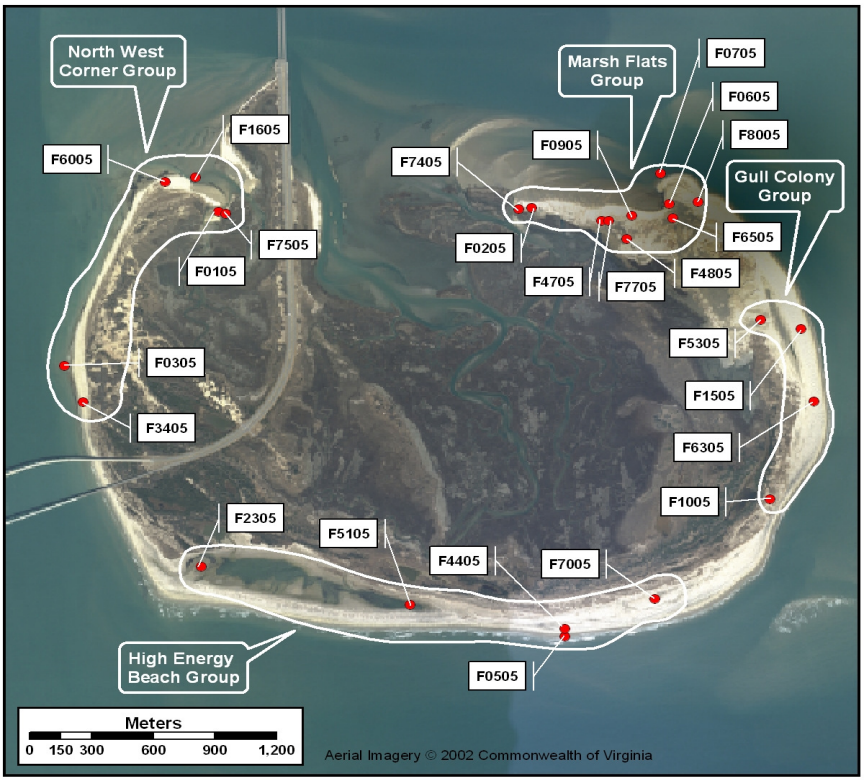

Figure 4. Nest locations and breakdown of study areas on Fisherman Island.

RESULTS

We recorded 7,570 hrs of video footage of American Oystercatcher nests between 6 April and 15 July, 2005. Twenty-five nesting attempts (representing 22 different pairs) were recorded with digital video equipment during the study period (Table 1). Video coverage per nest varied between 2 and 39 d with a mean $\pm$ standard error of 16 $\pm$ 2.1 (Table 2). Variance in coverage resulted primarily from differences in the outcome of nesting attempts. For most of the nests, coverage was initiated before or soon after clutches were completed.

Table 1. Nest identification codes for American Oystercatcher territories included in video-monitoring project on Fisherman Island during the 2005 breeding season.

Nest ID (First Nest)	Second Nest ID	Third Nest ID
F0105	F4505*	F7505
F0205	F4205*	F7305*
F0305	F7805*[#]	
F0405*	F4705[#]	
F3005*	F7705[#]	
F0505	F4405	
F0605	F6605*	
F0705	F5005*	
F0905	No re-nesting attempt	
F1005	F5805*	
F1505	No re-nesting attempt	
F1605	F6005[#]	
F1805*	F4905*	F6505
F2005*	F5505*	F7005
F2105*	F5605*	F7405
F2305	No re-nesting attempt	
F2405*	F6305	
F2605*	F5305	
F3405	No re-nesting attempt	
F3505*	F5105	
F3305*	F8005	
F4805	No re-nesting attempt	

* Denotes nesting attempts not monitored during 2005 field season.
[#] Denotes probable re-nesting attempt based on proximity to previous nest and behavioral cues.

Table 2. Details of digital video recording and associated nesting attempts for American Oystercatchers on Fisherman Island during the 2005 nesting season.

Nest ID	Clutch Completion Date	Recording Start Date	Recording End Date	Days Recorded	Recording Time (hr:min:sec)	Nest Fate
F0105	4/5/05	4/6/05	5/6/05	24	436:31:34	Washout
F0205	4/9/05	4/8/05	5/2/05	21	377:43:39	Washout
F0305	4/14/05	4/14/05	5/17/05	21	388:27:57	Hatched[1]
F0505	4/14/05	4/14/2005	4/15/2005	2	30:22:15	Washout
F0605	4/17/05	4/22/2005	5/17/2005	25	421:11:39	Hatched[2]
F0705	4/17/05	4/29/2005	5/6/2005	8	141:32:01	Washout
F0905	4/19/05	4/21/2005	4/25/2005	4	60:33:55	Abandoned[3]
F1005	4/19/05	4/20/2005	5/22/2005	33	585:00:45	Hatched[4]
F1505	4/20/05	4/27/2005	5/17/2005	21	474:24:04	Hatched
F1605	4/24/05	4/29/2005	5/6/2005	6	75:32:36	Washout
F2305	4/30/05	5/5/2005	6/5/2005	28	566:06:39	Hatched[5]
F3405	5/2/05	5/11/2005	5/15/2005	4	36:23:45	Abandoned[6]
F4405	5/20/05	5/31/2005	6/1/2005	2	24:02:48	Unknown
F4705	5/20/05	5/26/2005	5/28/2005	3	37:12:48	Predated
F4805	5/20/05	6/1/2005	6/19/2005	18	364:20:20	Predated
F5105	5/22/05	5/23/2005	6/30/2005	39	679:26:01	Hatched[7]
F5305	5/22/05	5/23/2005	6/24/2005	29	515:22:17	Hatched[8]
F6005	5/30/05	6/1/2005	6/16/2005	10	190:44:47	Predated
F6305	6/5/05	6/9/2005	7/7/2005	25	576:22:24	Hatched[9]
F6505	6/6/05	6/25/2005	7/6/2005	13	226:17:47	Hatched
F7005	6/8/2005	6/17/2005	6/20/2005	4	62:48:54	Washout
F7405	6/8/2005	6/21/2005	7/6/2005	16	293:03:25	Hatched
F7505	6/8/2005	6/23/2005	7/8/2005	16	359:53:41	Predated
F7705	6/10/05	6/23/2005	7/9/2005	15	295:52:49	Infert/addled
F8005	6/17/05	6/23/2005	7/15/2005	14	351:31:41	Hatched

[1] Nest hatched 2 of 3 eggs, other egg predated by Boat-tailed Grackle.
[2] Nest hatched 1 of 2 eggs, other egg predated by Crow.
[3] Nest abandoned, Crow predated both eggs within 3 days of abandonment.
[4] Nest hatched 1 egg, other two eggs depredated by Crow.
[5] All three eggs hatched, one chick predated by Ghost Crab, which later had a Crow take the chick away from it.
[6] Nest abandoned due to deer activity on 5/14/2005, egg predated 12 days later.
[7] Both eggs hatched, one chick predated by Ghost Crab.
[8] One egg depredated by unknown predator between 5/31/2005 and 6/3/2005. Other two eggs hatch.
[9] Nest hatched 1 of 2 eggs, other egg addled by predation attempt by Ghost Crab.

Geographic Comparisons

Video coverage and parameters measured did not differ between pairs located within the four geographic areas of Fisherman Island that were studied (Table 3). Although there were more nesting attempts covered in the marsh flats (9) compared to the other 3 geographic areas (6, 5 and 4 for high energy beach, northwest corner, and gull colony respectively), the number of disturbance events, time of interaction, and time off the nest did not differ with geography when standardized by video coverage. This finding suggests that there was no

systematic shift in disturbance with geography. For this reason, observations were pooled in remaining analyses.

Table 3. Results of Kruskal-Wallis comparisons of video coverage and disturbance parameters for American Oystercatcher nests between geographic areas on Fisherman Island.

Parameter	df	H	P
Hours of Video Coverage	3, 24	7.13	>0.05
Disturbance Events/Video Coverage	3, 24	5.77	>0.05
Interaction Time/Video Coverage	3, 24	6.68	>0.05
Time off Nest/Video Overage	3, 24	5.60	>0.05

Human Disturbance

We recorded 289 instances of human intrusions into oystercatcher territories that were under video surveillance. These included field vehicles driving down the beach (63), field biologists conducting surveys (19), biologists changing memory cards in video systems (173), and biologists setting up or maintaining video systems (33). Oystercatcher response varied according to the type and proximity of intrusion. Birds seemed to respond the least to field vehicles driving down the beach. On 16 (25.4%) occasions, the vehicle did not flush incubating birds. On 2 of these occasions, birds did not flush even though the vehicle was estimated to be within 20 m of the nest. All other types of human intrusions involved field biologists on the ground in close proximity to nests and resulted in incubating birds leaving the nest (Table 4).

Table 4. Summary of reactions by American Oystercatchers to human intrusions on Fisherman Island during the 2005 breeding season.

Human Interactions	*N*	Reaction				
		No RXN	Flee Nest Area	Chase Predator	Piping/ Agitated	Abandon nest
Field Vehicle	63	16 (25.4%)	45 (71.4%)	--	2 (3.1%)	--
Field Biologist/Nest Check	19	--	19 (100%)	--	--	--
Compact Flash Card Change	174	--	174 (100%)	--	--	--
System Deployment/maintenance	33	--	32 (97%)	--	--	1 (3%)
Total Human Disturbance	**289**	**16 (5.5%)**	**270 (93.4%)**	**--**	**2 (0.7%)**	**1 (0.4%)**

The length of human disturbance events varied according to the type of activity being performed (Table 5). The time that intruders were near the nest and interacting with oystercatchers varied significantly according to activity type (Kruskal-Wallis, $H = 110.0_{(3, 260)}$, $P < 0.001$). In terms of activity length, establishing and maintaining video systems was the highest followed by changing video cards, surveying by field biologists, and field vehicles driving down the beach. A further pair-wise examination of these differences showed that all of these activities were different from one another with respect to time of interaction except system establishment and card changing (Table 6).

Table 5. Summary statistics for human interactions with American Oystercatcher pairs on Fisherman Island during the 2005 breeding season. Presented are median values and ranges () in minutes. Distances ± standard deviations are in meters.

Source of Disturbance	N	Time of Interaction	Time off Nest	Closest Distance
Field Vehicle	63	0.58 (0.17-6.33)	6.91 (0.67-33.27)	47.2±18.9
Field Biologist	19	6.43 (1.75-13.0)	11.34 (2.83-37.62)	22.6±28.8
Compact Flash Card Change	174	5.0 (0.17-25)	9.8 (2.6-51.33)	4
System Deployment/maintenance	33	10.5 (3.0-37.0)	23.91 (7.5-654.28)	9.6±2.0
Total Human Disturbance	**289**	**5.0 (0.17-37.0)**	**8.98 (7.5-654.28)**	**6.2±9.7**

Table 6. Results of pair-wise comparisons of different sources of human disturbance. Comparisons are for the length of disturbance events. Values presented are Z-values from Mann-Whitney U tests. Significance values are *P< 0.05, **P< 0.01, ***P< 0.001.

Intrusion	Card Change	Field Vehicle	Biologist Survey	System Maintenance
Card Change	-------			
Field Vehicle	9.61^{***}	-------		
Biologist Survey	3.93^{***}	6.90^{***}	-------	
System Maintenance	0.10	5.84^{***}	2.54^{*}	-------

There is a significant relationship between the duration of a human-related disturbance event and the length of time oystercatchers were away from the nest (Figure 5). However, this relationship is driven primarily by the duration of the event itself rather than any proportional increase in time off the nest with increasing interaction time. The length of disturbance is not a good predictor of residual time off the nest (i.e. time off the nest after human left the territory) ($R^2 = 0.11$, $F = 3.9_{1, 252}$, $P > 0.05$). The distribution of residual time values is normally distributed with a mean ± standard deviation of 5.7 ± 6.93 minutes. As with duration of the event itself, the residual time away from a nest was influenced by activity type (Kruskal-Wallis, $H = 17.4_{(3, 260)}$, $P < 0.001$). A further pair-wise examination of these differences showed that system establishment and maintenance caused birds to be off the nest for a significantly longer time period compared to the other disturbance categories (Table 7).

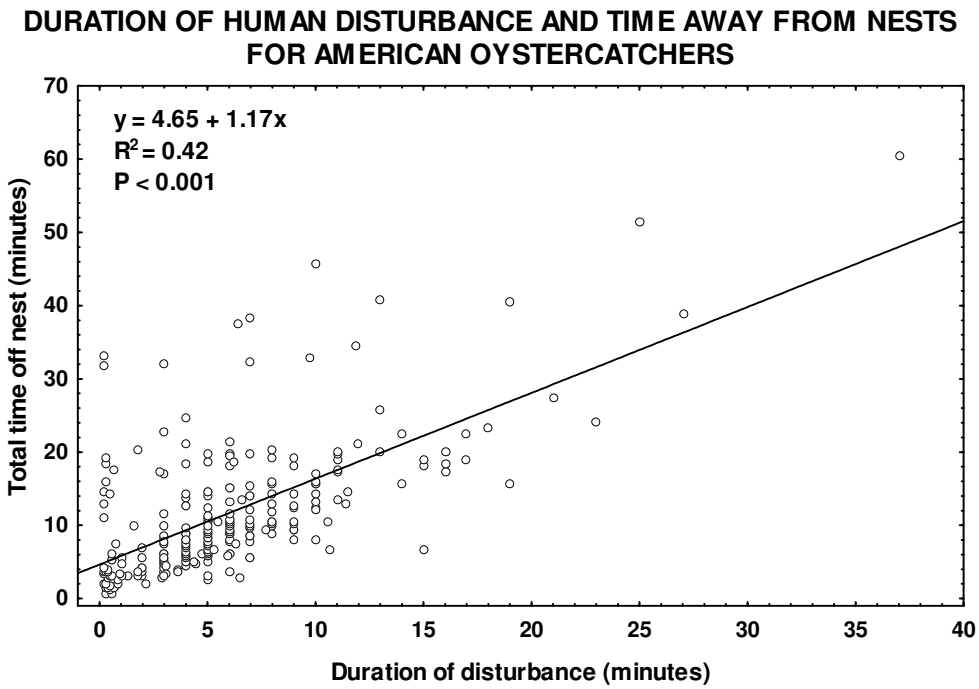

Figure 5. Relationship between the duration of interactions between oystercatchers and humans and the time American Oystercatchers were off the nests during the breeding season of 2005 on Fisherman Island.

Table 7. Results of pair-wise comparisons of residual time off nests related to different sources of human disturbance. Values presented are Z-values from Mann-Whitney U tests. Significance values are *P< 0.05, **P< 0.01, ***P< 0.001.

Intrusion	Card Change	Field Vehicle	Biologist Survey	System Maintenance
Card Change	-------			
Field Vehicle	0.47	-------		
Biologist Survey	1.29	1.10	-------	
System Maintenance	3.99***	3.31***	2.65**	-------

Non-human Interactions

We recorded 212 instances where individuals of 21 species other than humans entered the field of view of video cameras while oystercatchers were incubating. The majority of these observations involved individuals that came in close contact with the nest (Figure 6) with more than 80% moving to within 10 m. The most common species entering territories included Boat-tailed Grackle, White-tailed Deer, Brown Pelican, Willet, Ghost Crab, Marsh Rat, and American Black Duck (Table 8). These 7 species accounted for 152 (71.7%) of all observations.

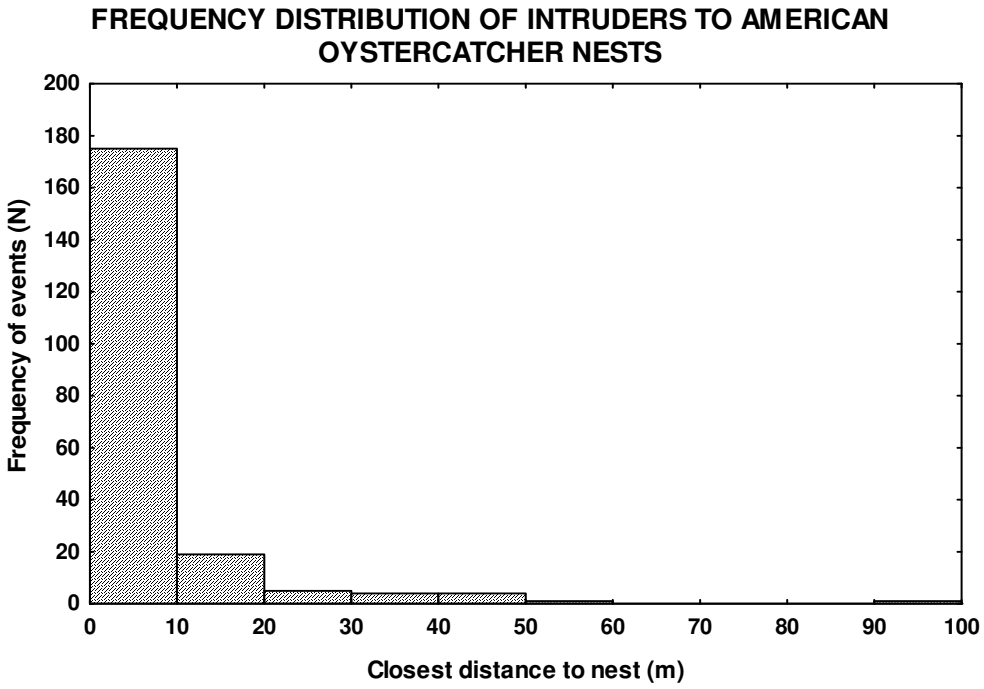

Figure 6. Frequency distribution of the closest distance American Oystercatcher nests were approached by non-human intruders during the breeding season of 2005 on Fisherman Island.

Incubating oystercatchers showed a wide range of responses to intruders from no reaction to nest abandonment. The majority (65.5%) of encounters were met with no reaction followed by fleeing the nest area (17.4%), piping (9.0%), chasing the intruder (8.0%), and abandoning the nest (<1.0%). Response varied according to intruder species. For most (11 of 21 species elicited reactions <10% of the time) species entering the territory, oystercatchers showed no reaction (Table 8). In many encounters oystercatchers continued to incubate even though intruders came to within 1 or 2 m of the nest. For only a few intruders, the dominant response was either aggressive to the intruder (e.g. American Oystercatcher, American Black Duck, Herring Gull) or fleeing the territory (e.g. Great Horned Owl, White-tailed Deer). Among all of the intruder species documented, white-tailed deer seemed to elicit the greatest response with all encounters resulting in birds leaving the territory and in one instance abandoning the nest. The length of response of oystercatchers to Great Horned Owls, White-tailed Deer, and American Black Ducks was much longer than of the other species. Most of the interactions with the owls and deer occurred during the night hours and this may have contributed to the long periods off the nest. An extended interaction between one oystercatcher pair and a black duck appeared to have been a dispute over a nesting location. The black duck appeared to have wanted to nest close to the oystercatcher nest and this caused the oystercatchers to become agitated.

Table 8. Reaction of incubating American Oystercatchers to species entering territories during the breeding season of 2005 on Fisherman Island.

Intruder Species	N	Reaction				
		No RXN	Fled	Chase	Piping/ Agitated	Abandon
Boat-tailed Grackle	48	35 (70.8%)	3 (6.25%)	4 (8.3%)	6 (12.5%)	--
White-tailed Deer	24	--	23 (95.8%)	--	--	1 (4.2%)
Brown Pelican	23	22 (95.7%)	--	1 (4.3%)	--	--
Willet	19	17 (89.5%)	--	2 (10.5%)	--	--
Ghost Crab	15	13 (86.7%)	1 (6.7%)	1 (6.7%)	--	--
Marsh Rat	13	13 (100%)	--	--	--	--
American Black Duck	10	3 (30%)	--	2 (20%)	5 (50%)	--
Unidentified Bird	8	6 (75%)	1 (12.5%)	--	1 (12.5%)	--
Fish Crow	7	4 (57.1%)	1 (14.3%)	1 (14.3%)	1 (14.3%)	--
Unidentified Animal	7	2 (28.6%)	1 (14.3%)	1 (14.3%)	3 (42.9%)	--
Canada Goose	6	3 (50%)	2 (33.3%)	1 (16.7%)	--	--
Great Horned Owl	6	3 (50%)	3 (50%)	--	--	--
American Oystercatcher	4	1 (25%)	--	2 (50%)	1 (25%)	--
Herring Gull	4	1 (25%)	--	2 (50%)	1 (25%)	--
Clapper Rail	3	2 (66.7%)	--	--	1 (33.3%)	--
Black Skimmer	2	2 (100%)	--	--	--	--
Black-bellied Plover	2	2 (100%)	--	--	--	--
Diamondback Terrapin	2	2 (100%)	--	--	--	--
Laughing Gull	2	2 (100%)	--	--	--	--
Unidentified Gull	2	2 (100%)	--	--	--	--
Great Black-backed Gull	1	--	1 (100%)	--	--	--
Great Egret	1	1 (100%)	--	--	--	--
Tri-Colored Heron	1	1 (100%)	--	--	--	--
Snowy Egret	1	--	1 (100%)	--	--	--
Total Animal Disturbance	**211**	**138 (65.4%)**	**37 (17.5%)**	**17 (8.1%)**	**19 (9.0%)**	**1 (0.0%)**

Events that resulted in a reaction by an incubating oystercatcher differed from those that did not with respect to length of interaction and closest distance to nest (Tables 9 and 10). The duration of the encounter was longer for encounters that resulted in a response compared to those that did not (median time = 8.47 and 4.13 for reaction, no reaction respectively) (Mann-Whitney U statistic = 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 and 4.5 m for no reaction, reaction respectively) (Mann-Whitney U statistic = 4157, $P < 0.01$).

We recorded 107 instances where individuals of 11 species entered the field of view of video cameras while oystercatchers were absent and the nest was unattended (Table 11). 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 Ghost Crabs, Fish Crows, Boat-tailed Grackles, and raccoons. For all but the ghost crab, a high proportion (9 of 13) of the intrusions that occurred when nests were unattended resulted in predation events.

Table 9. Summary of interactions with intruders where the oystercatchers showed no behavioral response. Median interaction times and ranges are in minutes. Median distances and ranges are in meters.

Disturbance Type	N	Time of Interaction	Closest Distance
Boat-tailed Grackle	35	1.13 (0.08-35.77)	2 (1-20)
Brown Pelican	22	1.33 (0.17-52.85)	3 (1-8)
Willet	19	0.33 (0.17-7.88)	4 (1-10)
Marsh Rat	13	0.25 (0.08-5.73)	1 (1-2)
Ghost Crab	13	1.33 (0.25-15.17)	1 (0-2)
Unidentified Bird	7	0.75 (0.17-3.07)	10 (2-20)
Unidentified Animal	4	0.99 (0.25-3.90)	4 (1-20)
Crow	4	2.44 (1.08-4.83)	2 (1-30)
Canada Goose	3	0.57 (0.08-1.42)	5 (1-15)
Great Horned Owl	3	1.50 (0.83-2.07)	6 (3-20)
Black Duck	3	39.02 (8.55-76.98)	2 (1-10)
Clapper Rail	2	0.25 (0.17-0.33)	1
Laughing Gull	2	0.92 (0.17-1.67)	3 (2-4)
Black-bellied Plover	2	0.50 (0.25-0.75)	1
American Oystercatcher	2	4.88 (0.33-9.43)	7 (3-10)
Unidentified Gull	2	0.58 (0.42-0.75)	5
Herring Gull	2	0.67 (0.50-0.83)	1
Diamondback Terrapin	2	1.08 (0.75-1.40)	18 (15-18)
Black Skimmer	2	37.43	1
Tri-Colored Heron	1	0.25	6
Snowy Egret	1	0.50	25
Great Egret	1	0.75	4
Total AMOY No RXN	**148**	**0.87 (0.08-76.98)**	**2 (0-30)**

Table 10. Summary of interactions with intruders where the oystercatchers showed a behavioral response. Median times and ranges are in minutes. Median distances and ranges are in meters.

Disturbance Type	N	Time of Interaction	Time off Nest	Closest Distance
Deer	24	5.08 (0.25-35.13)	11.88 (3.08-573.07)	13 (0-60)
Boat-tailed Grackle	10	3.46 (0.17-21.38)	3.08 (0.33-654.28)	1 (1-20)
Black Duck	7	42.42 (1.4-89.77)	1.92 (1.0-539.17)	2 (2-8)
Unidentified Animal	3	0.17 (0.17-3.23)	4.15 (0.07-7.98)	30 (10-100)
Crow	3	1.33 (0.42-1.92)	2.0 (0.42-2.25)	1 (0-10)
Canada Goose	3	3.60 (2.67-68.3)	9.72 (3.85-19.87)	15 (5-40)
Great Horned Owl	3	3.73 (0.83-88.97)	69.03 (3.37-489.9)	5 (1-6)
Ghost Crab	2	3.73 (1.25-6.2)	2.57 (0.25-4.88)	1 (0-2)
Herring Gull	2	0.91 (0.42-1.4)	0.71 (0.42-1.0)	8 (6-10)
American Oystercatcher	2	2.15 (0.07-4.23)	4.69 (4.48-4.90)	1 (0-2)
Brown Pelican	1	0.85	0.25	1
Unidentified Bird	1	2.75	3.67	15
Great Black-backed Gull	1	6.47	5.65	0
Clapper Rail	1	0.17	0.32	1
Total AMOY Reactions	**63**	**3.23 (0.07-89.77)**	**5.65 (0.25-654.28)**	**5 (0-100)**

Table 11. Summary of intrusions that occurred during periods when oystercatcher nests were unattended during the 2005 breeding season on Fisherman Island. Median times and ranges are in minutes. Median distances and ranges are in meters.

Species/Nest Interactions	N	Time of interaction	Distance of interaction	Total Predation Events
Ghost Crab	63	1.58 (0.17-16.43)	1.0 (0-2.0)	3
Crow	11	0.42 (.08-2.0)	1.0 (0)	7
Deer	9	0.17 (0.02-3.88)	0.0 (0-40.0)	--
Great Horned Owl	8	2.67 (0.02-15.12)	5.0 (1.0-3.0)	--
Canada Goose	4	3.86 (0.67-29.27)	1.0 (0-6.0)	--
Willet	4	0.58 (0.17-1.33)	0.5 (1.0-5.0)	--
Marsh Rat	2	1.83 (0.25-3.4)	3.5 (1.0)	--
Diamondback Terrapin	2	0.5 (0.25-0.75)	1.0 (1.0)	--
Boat-tailed Grackle	1	4.33	1.0	1
Unidentified Animal	1	0.17	0.0	--
Raccoon	1	2.0	1.0	1
Black-crowned Night Heron	1	0.17	0.0	--
Totals With AMOY Not Incubating	**107**	**1.08 (0.02-29.27)**	**1.0 (0-40.0)**	**12**

Reproductive Performance

For the nests monitored with video-recording equipment, reproductive performance to hatching was relatively poor. Of 58 eggs monitored with video recording equipment, only 20 (34.5%) hatched (Table 12). Of the 20 chicks that hatched only 18 (31%) survived to disperse from the nest site. Of 25 nesting attempts only 11 (44%) were successful to the dispersal phase. Pairs hatched all eggs laid and successfully moved chicks from the nest site in only 4 (16%) of 25 attempts.

The causes of partial or complete nest failures were captured on digital video (Table 12). High tide events associated with coastal storms represented the largest source of nest loss. A total of 6 nests containing 18 eggs were lost during 3 storm events. Storms occurred on 14 April, 6 May, and 21 June. The greatest losses occurred during the major storm on 6 May. The second highest cause of loss was to Fish Crow predation on eggs. Crows were documented to take 12 eggs during the course of 7 nesting attempts. Ghost crabs were documented to take 1 egg and 2 chicks. In addition to these predation events, ghost crabs were observed attempting to move eggs out of nest on two occasions and were chased by adult oystercatchers on one occasion. A Boat-tailed Grackle was observed taking a single egg on 18 May. A raccoon predated a single-egg clutch on 19 June.

Table 12. Fate of American Oystercatcher eggs on Fisherman Island during the breeding season of 2005.

Nest ID	Clutch Size	Number of Eggs Hatched	Number of Predated Eggs or Chicks	Predator Species	Washout Date	Predation Date
F0105	5	0	--	--	5/6/05	--
F0205	3	0	--	---	5/6/05	--
F0305	3	2	1 egg	Grackle		5/18/05
F0505	3	0	--	--	~4/14/05 to 4/16/05	--
F0605	2	1	1egg	Crow		4/25/05
F0705	3	0	--	--	5/6/05	
F0905	2	0	2 eggs	Crow	--	4/23/2005 and 4/24/2005
F1005	3	1	2 eggs	Crow	--	5/19/05
F1505	2	2	--	--	--	--
F1605	2	0	---	--	5/6/05	--
F2305	3	3	1 chick	Ghost Crab	--	6/4/05
F3405	2	0	2 abandoned	Crow	--	5/26/05
F4405	2	0	2 eggs	--	--	Unknown/removed camera system
F4705	1	0	1 egg	Crow	--	5/28/05
F4805	1	0	1 egg	Raccoon	--	6/19/05
F5105	2	2	1 chick	Ghost Crab	--	6/29/05
F5305	3	2	1 egg	--	--	Between 5/31 and 6/3/2005
F6005	1	0	1 egg	Crow	--	6/15/05
F6305	2	1	1 egg	Ghost Crab	--	6/28/05
F6505	2	2	--	--	--	--
F7005	2	0	--	--	6/21/05	--
F7405	2	2	--	--	--	--
F7505	4	0	4 eggs	3 Crow 1Unknown	--	7/4, 7/6 [2eggs], between 7/8-7/10
F7705	1	0/addled	--	Ghost Crab possibly addled egg	--	--
F8005	2	2	--	--	--	--
Totals	**58**	**20 (34.5 %)**	**17 eggs (29.3%)**	**4 species**	**18 eggs (31.0%)**	**Between 4/23 and 7/10/2005**

Some oystercatcher pairs were away from nests for extended periods of time with many having periods of absence of 90 minutes or greater with the longest period being nearly 11 hours. However, the impact of these disturbance events on productivity is not clear. Several nests with the most disturbance and the greatest overall time away from nests were productive (Table 13). For example, nest F5105 had 13 disturbance events that lasted more than 90 min and an overall time off the nest due to disturbance of more than 104 hours but hatched both eggs in the clutch. Nest F7405 experienced long periods off the nest totaling more than 39 hrs and was able to hatch the entire clutch. In contrast, nest F4805 was predated by a raccoon while adults were away from the nest for more than 7 hrs. Given that all of the predation events occurred while nests were unattended it seems likely that disturbances that keep adults away from the nest may result in a higher likelihood of a nest being predated.

Table 13. Summary of documented disturbance events that were greater than 1.5 hrs in length for American Oystercatcher nests on Fisherman Island during the breeding season of 2005.

Nest ID	Number of Bouts >1.5 hours	Total Time Off Nest (hours)	Nest Fate
F0105	2	8.67	Washout
F0205	3	12.98	Washout
F0305	2	11.51	Hatched 2 of 3 eggs, other egg depredated in an unrelated event.
F0605	1	2.87	Nest hatched 1 of 2 eggs, other egg depredated by crow in wind related event.
F0905	1	0.00	Abandoned
F1005	1	2.65	Nest hatched 1 of 3 eggs, other two eggs depredated by crow in unrelated event.
F4805	6	46.15	Nest depredated by raccoon while AMOY was off nest for over 7 hours.
F5105	13	104.33	Both eggs hatched, one chick predated by ghost crab.
F5305	3	21.99	Nest hatched 2 of 3 eggs, other egg depredated by unknown predator in unrelated event.
F6005	1	9.38	Nest depredated by crow in unrelated event.
F6305	1	6.13	One of two eggs hatched, other egg was possibly addled in unrelated event.
F6505	1	10.90	Nest hatched both eggs.
F7405	5	39.61	Eggs hatched.
F7505	1	6.61	Two eggs depredated in unrelated event.
F7705	2	11.33	Nest infertile/addled, possibly due to event.
F8005	*3*	*21.57*	Nest hatched two eggs.

DISCUSSION

Fisherman Island is an important location for the conservation of American Oystercatchers. In 2003, the island supported approximately 8% of the Virginia population (Wilke 2003). This population has been identified as the largest breeding population supported by a single state (Wilke et al. 2005). Although Fishman Island is a relatively small island with limited habitat, it supports a dense breeding population that appears to have remained stable since the early 1980s (Anderson 1988, Wilke and Beck 2002).

Despite the apparent stability of the breeding population of American Oystercatchers on Fisherman Island, reproductive rates have been consistently low. During 1981 and 1982, Anderson (1988) recorded reproductive rates of 0.02 and 0.2 chicks respectively. Between 2002 and 2004 chick production has varied between 0.1 and 0.4 chicks/breeding pair (Wilke and Beck 2002, Denmon and Wilke, unpubl data). These reproductive rates are similar to other populations along the Atlantic Coast (Nol 1989, Davis et al. 2001, Sabine et al. 2006). Low reproductive rates have long been considered to be "normal" for American Oystercatchers and have been believed to be offset by longevity. However, these rates are low compared to many other locations within the same barrier island system (Wilke 2005).

Storm overwash and predation have been identified as the dominant causes of reproductive failure in intensively studied populations of American Oystercatchers (Nol et al. 1984, Davis et al. 2001, Sabine et al. 2006). Nol et al. (1984) documented the repeated loss of nests to severe storms during the seasons of 1981 and 1982 within field sites on Chincoteague, Wallops, and Assawoman Islands in Virginia. Overwash was responsible for 22% of clutch losses on Cape Lookout National Seashore between 1997 and 1999 (Davis et al. 2001). Storm events have been a significant source of clutch losses in low-lying areas of the Delmarva seaside in both the lagoon system and on barrier islands. In some years, losses within marshes of the lagoon system have been more than 90% (Wilke 2005). Storm events were responsible for the largest number of clutch losses for nests under video surveillance on Fisherman Island. Storms that caused failures occurred on 14 April, 6 May, and 21 June, 2005.

Susceptibility to overwash is determined by elevation and exposure (Lauro and Burger 1989). 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 (Nol and Humphrey 1994). In practice, this option requires that nests be in close proximity to higher ground. On Fisherman Island, nests within some areas are in close enough proximity to dune complexes to consider this management option. However, many of the associated dune complexes are currently occupied by large gull colonies which in some cases may have displaced oystercatchers to lower nesting sites. Opportunistic application of this approach on a trial basis may be warranted to investigate its value in improving hatching rates.

Predation is likely the most consistent source of both clutch and brood loss for American Oystercatchers throughout their range. Within Cape Lookout National Seashore

predators accounted for 76% of documented losses (Davis et al. 2001). Raccoons were implicated in all of the events where predators could be identified. On Cumberland Island 13 of 18 (72%) clutch losses documented on video were attributed to predators (Sabine et al. 2006). These included 9 events involving raccoons, 3 events involving bobcats, and 1 event involving an American Crow. This study also documented 1 chick lost to a ghost crab. Along the Virginia barrier islands, an increase in reproductive rates has been attributed to the removal of mammalian predators on selected islands (Wilke 2005). In 2005, the reproductive rate on Metompkin Island was 1.14 chicks/pair with only 10 predation events documented from 80 breeding attempts. Events were attributed to raccoons (5), avian (1), unknown (2), and ghost crabs (2).

Prior to the construction of the Chesapeake Bay Bridge in the early 1960s, Fisherman Island was isolated from the Delmarva mainland by a channel that is more than 1 km wide. The construction of the bridge may have increased colonization of the island by ground predators by providing greater access. Periodic observations of mammals have been made over the years. Anderson (1988) noted the remains of a red fox on the island in the early 1980s. However, in recent years observations of mammals and depredation of nests have increased leading to a management program designed to control predator populations. In 2005, only one of over twenty nests monitored by video was predated by a raccoon. It is unclear whether or not this is representative of loss rates over a broader time period. Predation by raccoons may be episodic and catastrophic. Although ground predators do not appear to be the primary cause of low reproductive rates for oystercatchers in recent years, a continued effort to remove mammalian predators from Fisherman Island is clearly warranted.

Avian predation was the primary biological cause of clutch losses for nests under video surveillance. Fish Crows were the primary species involved with predation events. A Boat-tailed Grackle was detected rolling an egg out of an unattended nest and away from the area on 19 May. A Herring Gull was observed inserting its bill into a nest but no predation was observed. On two different occasions, a Great Horned Owl was observed standing over a nest but did not prey on its contents. On Cape Lookout National Seashore Davie et al. (2001) did not believe that avian predation was a significant cause of reproductive failures. Sabine et al. (2006) documented only a single predation event involving what was suggested to be an American Crow.

Due to its position relative to the lower Delmarva mainland large numbers of Fish Crows are known to fly back and forth between Fisherman Island and the mainland. During the fall months, thousands of crows fly out to communal roosts on the island and then back to the mainland in the morning (Watts, pers. Obs.). Anderson (1988) observed over 300 Fish Crows on the island during the breeding season of 1981 and suggested that crows were the dominant cause of reproductive failure. He observed crows regularly flying low over oystercatcher territories apparently searching for unguarded eggs and young. He observed two instances of direct predation by crows involving an egg and a small chick. Fish Crows are accomplished egg predators and due to the geographic position of Fisherman Island and the habitat composition on the lower mainland, control of crow predation represents a difficult problem to manage.

Beach-nesting birds that breed on the barrier islands often share their territories with populations of ghost crabs. This species forages widely throughout the active beach zone and is known to feed on a wide range of food items. On the Virginia barrier islands the species has been documented to take Piping Plover chicks (Cross 1996) and on one occasion to take a plover clutch (Watts and Bradshaw 1995). Sabine et al. (2006) documented a ghost crab taking a chick shortly after hatching on Cumberland Island. On Fisherman Island, we documented ghost crabs taking chicks from two different territories and interacting with unattended clutches. In both cases where crabs ate chicks, the chicks appeared to be in poor condition and were left at the nest by the adult prior to the event. On two occasions crabs were in separate nests and attempted to move eggs away from the nest. These attempts were unsuccessful.

American Oystercatchers are shy around humans and human disturbance has been implicated as a source of reproductive failure on both Cumberland Island (Sabine et al. 2006) and Cape Lookout National Seashore (Davis et al. 2001). The impact of humans is either direct through nest destruction or indirect through either keeping birds away from nests or feeding areas. All of these impacts have been implicated in other populations. Fisherman Island is closed to the public such that the only humans present on the island are permitted researchers and/or management personnel. We documented dramatic and consistent responses to humans on foot by pairs under video surveillance. These responses were proportional to the duration of the disturbance. By contrast, the response to vehicular traffic in the beach zone was limited. The refuge currently utilizes vehicles on the beach where necessary and greatly limits the amount and duration of foot traffic near nesting areas. This is an appropriate policy and is consistent with minimizing indirect impacts to nesting pairs.

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Appendix I. List of common and scientific names for species detected during video coverage.

Intruder Common Name	Genus	Species	Confirmed Predation
American Oystercatcher	*Haematopus*	*palliatus*	--
American Black Duck	*Anas*	*rubripes*	--
Black Skimmer	*Rynchops*	*niger*	--
Black-bellied Plover	*Pluvialis*	*squatarola*	--
Black-crowned Night Heron	*Nycticorax*	*nycticorax*	--
Boat-tailed Grackle	*Quiscalus*	*major*	yes
Brown Pelican	*Pelicanus*	*occidentalis*	--
Canada Goose	*Branta*	*canadensis*	--
Clapper Rail	*Rallus*	*longirostrus*	--
Diamondback Terrapin	*Melaclemys*	*terrapin*	--
Fish Crow	*Corvus*	*ossifragus*	yes
Ghost Crab	*Ocypode*	*quadrata*	yes
Great Black-backed Gull	*Larus*	*marinus*	--
Great Egret	*Ardea*	*alba*	--
Great Horned Owl	*Bubo*	*virginianus*	--
Herring Gull	*Larus*	*argentatus*	--
Laughing Gull	*Larus*	*atricilla*	--
Marsh Rat	*Oryzomys*	*palustris*	--
Raccoon	*Procyon*	*lotor*	yes
Snowy Egret	*Egretta*	*thula*	--
Tri-colored Heron	*Egretta*	*tricolor*	--
White-tailed Deer	*Odocoileus*	*virginianus*	--
Willet	Catoptrophorus	semipalmatus	--