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Abundance, Distribution, and Geographic Origin of Non-breeding American Oystercatchers (*Haematopus palliatus*) in North Carolina, USA

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Abstract.—American Oystercatchers (*Haematopus palliatus*) are present in North Carolina, USA, year-round. About 6-7% of the total Western Atlantic population winters in North Carolina. To estimate numbers of American Oystercatchers present during the non-breeding season, four major concentration areas were surveyed in North Carolina, each with multiple roost sites, from 2008-2013. Abundance of American Oystercatchers remained generally stable during the study period. The Lower Cape Fear River area had the greatest number of American Oystercatchers in all seasons. Mean peak abundance was greatest during winter at all concentration areas. Peak winter abundance was 158 at Ocracoke Inlet, 265 in Back Sound, 187 in Masonboro Sound, and 470 on the Lower Cape Fear River. Fall abundance was generally greater than spring abundance at all concentration areas except Masonboro Sound. Most banded individuals observed were marked in North Carolina as chicks or nesting adults, and they exhibited fidelity to concentration areas. About 15% of American Oystercatchers used wooden docks as roost sites; the rest used natural substrates and a man-made rock wall. At sites where roost habitat is a limiting factor, fabricated structures might be a useful substitute. Most roost sites receive no protection during the non-breeding season, and we observed sources of potential disturbance on 2.8-50.6% of surveys. Pedestrians and boats were the most common sources of potential disturbance. *Received 2 August 2015, accepted 14 July 2016.*

Key words.—American Oystercatcher, distribution, disturbance, habitat selection, *Haematopus palliatus*, non-breeding, North Carolina, roost site, winter.

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The American Oystercatcher (*Haematopus palliatus*) is a conspicuous shorebird found throughout coastal areas from Nova Scotia, Canada, to Texas, USA, in its Western Atlantic and Gulf Coast range. American Oystercatchers breed as far north as Maine, USA, and winter as far north as New Jersey, USA. Breeding typically occurs from March or April to August (American Oystercatcher Working Group *et al.* 2012). During the 6-9 month non-breeding season, adults and subadults may remain at or near their summer site or migrate south, congregating at large roost sites throughout the Southeast USA from South Carolina to Florida (Brown *et al.* 2005). Resights of banded individuals reveal that some American Oystercatchers remain in North Carolina year-round, often near their natal sites or breeding territories, while others originating from northern breeding grounds stop or overwinter in the state (American Oystercatcher Working Group 2015).

American Oystercatchers generally forage at low tide when shellfish beds or mudflats are exposed, then congregate in communal high-tide roosts during the non-breeding season (American Oystercatcher Working Group *et al.* 2012), making roost site surveys conducive to winter population assessments. In Virginia and Maryland, USA, coastal bays and barrier islands of the Delmarva Peninsula support between 1,500 and 2,265 wintering individuals (Wilke *et al.* 2007). In South Carolina, USA, winter surveys found between 3,000 and 4,000 American Oystercatchers, primarily in the Cape Romain area (Sanders *et al.* 2004). Results

from a rangewide aerial survey of wintering American Oystercatchers conducted during November 2002-February 2003 estimated 10,971 ± 298 individuals in the United States Western Atlantic population (Brown *et al.* 2005). In North Carolina, the survey detected 575 American Oystercatchers and estimated a winter population of 647. In 2013, a second aerial survey of wintering American Oystercatchers estimated 11,285 ± 313 individuals along the Gulf and Atlantic coasts and 799 in North Carolina (S. A. Schulte, unpubl. data). The aerial surveys, as well as previous ground-based observations of American Oystercatchers, identified four main concentrations in North Carolina: Ocracoke Inlet and Back Sound in Carteret County, Masonboro Sound in New Hanover County, and the Lower Cape Fear River in New Hanover and Brunswick Counties. Ground-based assessments of these concentration areas had not been performed previously.

Our objectives were to: 1) estimate numbers of American Oystercatchers at the four major North Carolina concentration areas during non-breeding seasons; 2) determine geographic origin and estimate site fidelity of banded individuals; 3) describe roost habitat selected; and 4) identify sources of potential disturbance.

Methods

Study Area

The four major non-breeding concentration areas were at Ocracoke Inlet, Back Sound, Masonboro Sound, and the Lower Cape Fear River, North Carolina, USA (Fig. 1). Each included multiple roost sites and regularly hosted ≥ 50 American Oystercatchers. Ocracoke Inlet (surveyed 2009-2013) is a large inlet between North Core Banks and Ocracoke Island. Roost sites in this area include Beacon Island, a natural marsh island; Shell Castle Island, composed of three long, narrow shell rakes (natural accumulations of loose oyster [*Crassostrea virginica*] shells) and one shell and rock mound; and North Rock Island, composed of about six small marsh and shell islands. These islands are adjacent to shallow sand shoals and oyster beds. All sites in Ocracoke Inlet are only accessible by boat.

Roost sites in Back Sound (surveyed 2008-2011) included Phillips Island, a natural island in the Newport River; other natural islands (Bird Shoal and smaller associated shoals, Horse Island, and Carrot Island); and various shell rakes around Bottle Run Point. All sites in Back Sound are only accessible by boat.

Masonboro Sound (surveyed 2009-2013) is between Masonboro Island, which is only accessible by boat, and the mainland. Masonboro Sound includes an extensive marsh system with multiple large, shallow bays and oyster beds. The western edge of the marsh is adjoined by the Atlantic Intracoastal Waterway (AIWW). The western shore of the AIWW is thoroughly developed with residential neighborhoods. Many waterfront houses have long docks projecting into the AIWW that host flocks of roosting shorebirds, including American Oystercatchers. The docks and the east and west banks of the AIWW were surveyed.

Within the Lower Cape Fear River (surveyed 2009-2013), the primary roost sites are Shellbed Island, a marsh and shell island, and the Fort Fisher Rocks, a 4.5-km long fabricated rock dike constructed during the 1870s-1890s, extending north and south of Zeke's Island. Other roost sites are three dredged-material islands (South Pelican Island, Ferry Slip Island, Battery Island), Striking Island (a natural island), and unnamed shell rakes. East of the Fort Fisher Rocks is an extensive estuary of smooth cordgrass (*Spartina alterniflora*) marsh, oyster beds, and mudflats. The northern portion of the Fort Fisher Rocks and Zeke's Island may be accessed by foot at low tide. All other sites are only accessible by boat.

Survey Methods

Surveys conducted at Ocracoke Inlet, Masonboro Sound, and the Lower Cape Fear River occurred weekly and at least twice a month at Back Sound. We considered spring migration to be March-May, fall migration to be August-October, and winter to be November-February (American Oystercatcher Working Group *et al.* 2012). Years given for winters indicate the year the season began (i.e., the survey period from November 2009 to February 2010 is winter 2009).

We visited each roost site in a concentration area within 2 hr of high tide, except for Ocracoke Inlet, which transitioned to primarily a mid- and low-tide foraging site during the study and was therefore visited at various tidal stages to find birds. American Oystercatchers were primarily roosting at high tide; thus, aggregation at roost sites increased the probability that counts included most of the birds using the area.

Flock sizes and engraved color band codes were recorded using binoculars, 20-60x spotting scopes, and/or a camera with an 80-400 mm telephoto lens. When possible, the boat was anchored and observers walked or waded close to the roosting birds without flushing them, but at some sites observations were made entirely from a boat. Observers remained at each roost site as long as necessary to count all birds present. Surveys were not conducted during rain, thunderstorms, high winds (> 32 kmph), or in low light conditions (dawn, dusk, night).

At each site, we scanned flocks for bands and recorded band color and alpha-numeric code. From 5

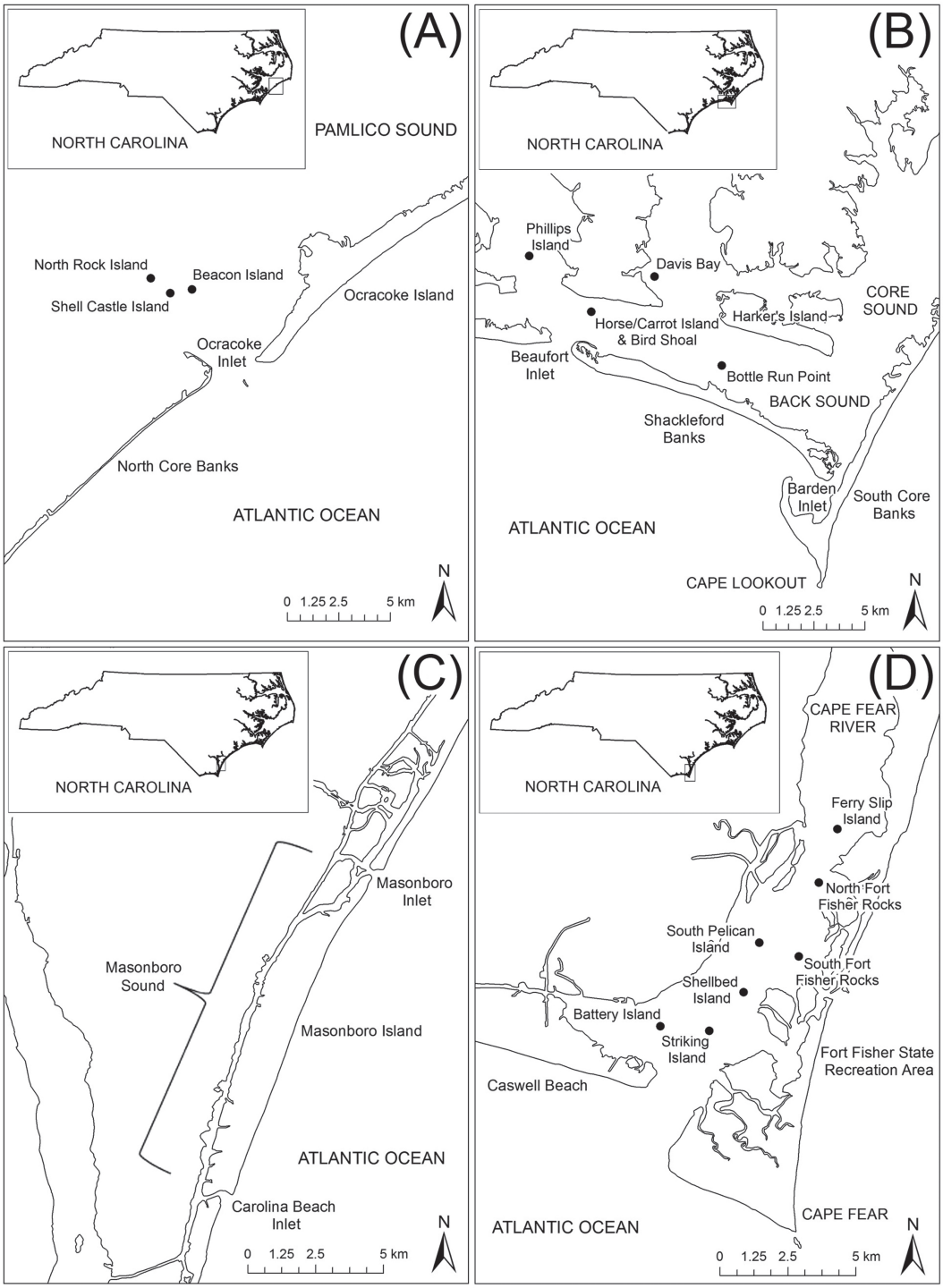

Figure 1. Major non-breeding American Oystercatcher roost concentration areas within North Carolina, USA. (A) Ocracoke Inlet; (B) Back Sound; (C) Masonboro Sound; (D) Lower Cape Fear River.

May 1999 to 1 January 2014, 3,585 American Oystercatchers were banded from Texas to Massachusetts, USA, most with duplicate two- or three-character field-readable bands (American Oystercatcher Working Group 2015). Presence and type (dogs, pedestrians, etc.) of potential sources of anthropogenic disturbance

near roost sites were recorded on all surveys except at Back Sound where disturbance was noted only during August 2009-February 2010.

We used Google Earth (Google, Inc. 2015) to estimate the length of docks used by roosting American Oystercatchers. We calculated the mean of the peak counts in each season across all years (mean peak count) for each concentration area to estimate the proportion of American Oystercatchers using each area in spring, fall, and winter. A one-way analysis of variance, or a Kruskal-Wallis one-way analysis of variance for results that failed normality or equal variance tests, was used to detect differences in peak abundance among survey-years for each concentration area, for each season. A one-way analysis of variance or a Kruskall-Wallis one-way analysis of variance was used to compare seasonal means for each year at each of the four concentration areas. A Tukey Test or Dunn's Method was used to determine which seasons were different. Our *a priori* level of significance was $P \leq 0.05$ (Systat Software, Inc. 2006).

RESULTS

American Oystercatcher abundance at all four concentration areas remained generally stable during the survey period. However, at the Lower Cape Fear River, winter abundance increased ($F = 4.311$, $P = 0.010$) and at Masonboro Sound, fall abundance was different ($H = 8.276$, $P = 0.041$) between 2011 and 2012 (Table 1). There were no differences in seasonal abundances among years at other areas.

Mean and peak abundance were greatest during winter at all four major concentration areas in each year, except at the Lower Cape Fear River where peak fall counts equaled or exceeded winter counts on two surveys (Table 1). Mean and peak abundance were more frequently greater during fall migration than spring migration at all major concentration areas except at Masonboro Sound, where mean and peak abundance were always greater during spring than fall migration. Across all survey-years, counts were greatest during winter at Back Sound and the Lower Cape Fear River (Table 2). For all other sites, spring and fall migration numbers were not

Table 1. Non-breeding American Oystercatchers at four major concentration areas in North Carolina, USA, 2008-2013. "–" indicates no mean or SE available ($n = 1$).

	Spring Migration				Fall Migration				Winter			
Location	Peak	Mean	*n*	SE	Peak	Mean	*n*	SE	Peak	Mean	*n*	SE
Ocracoke Inlet												
2009					57	42	2	15	69	47	2	22
2010					53	36	7	8	105	101	2	5
2011	63	–	1	–	57	31	14	4	158	84	16	9
2012	42	–	1	–	91	34	16	8	116	40	6	17
2013					45	21	11	4	35	–	1	–
Back Sound												
2008									265	205	7	17
2009					199	132	8	16	233	201	6	9
2010	104	82	2	23	248	130	10	19	242	174	5	20
2011					134	106	5	9	194	157	2	38
Masonboro Sound												
2009					93	39	10	8	187	66	9	14
2010	79	33	5	14	26	22	2	5	143	58	6	24
2011	132	68	7	15	32	20	10	3	134	68	8	16
2012	74	51	6	11	60	41	6	6	115	83	5	10
2013									176	150	3	24
Cape Fear River												
2009					315	135	5	50	277	184	8	20
2010	238	137	6	28	368	126	6	53	416	182	7	50
2011	256	150	7	26	399	216	10	45	399	316	8	28
2012	251	195	7	15	373	242	6	42	382	337	5	21
2013									470	324	2	146

Table 2. Mean number of non-breeding American Oystercatchers by season at four major concentration areas in North Carolina, USA, 2008-2013. Means within each row with different letters are different at P ≤ 0.05.

	Spring Migration			Fall Migration			Winter		
Location	Mean	N	SE	Mean	n	SE	Mean	n	SE
Ocracoke Inlet	53^{AB}	2	11	31^{B}	50	3	71^{A}	27	8
Back Sound	82^{B}	2	23	125^{B}	23	10	178^{A}	18	9
Masonboro Sound	52^{AB}	19	8	31^{B}	31	3	76^{A}	31	9
Cape Fear River	162^{B}	20	14	184^{AB}	29	24	248^{A}	29	20

different. Although survey-years overlapped, they were not the same among the four major concentration areas. During fall and winter 2009-2011, when surveys took place at all four concentration areas, mean peak counts on the Lower Cape Fear River accounted for 35.3-57.9% of observations, followed by Back Sound (25.1-41.4%), Ocracoke Inlet (8.3-19.6%), and Masonboro Sound (5.4-13.3%).

We recorded 222 banded American Oystercatchers in the four concentration areas, representing nine States of banding origin (Table 3). Most banded American Oystercatchers (54.3-88.9%) were banded as chicks or breeding adults in North Carolina. Ocracoke Inlet had the greatest proportion of North Carolina-banded individuals. Birds banded in Virginia comprised the next-highest proportion of birds (5.6-20.0%) at Ocracoke Inlet, Back Sound, and the Lower Cape Fear River. Oystercatchers marked in Virginia and New Jersey each comprised 10.4% of birds using roost sites in Masonboro Sound.

Most of the banded individuals (54.2%) at Ocracoke Inlet were seen during migration only (Table 4). At the other concentration areas, about one third (29.2-31.4%) of banded American Oystercatchers was seen during migration only. Thirty-three of the total 222 banded individuals (14.7%) were seen at multiple concentration areas within North Carolina, 31 at two areas, and two at three areas. Multiple sightings occurred most often at areas closest to one another: at Ocracoke Inlet and Back Sound ($n = 14$) and at the Lower Cape Fear River and Masonboro Sound ($n = 11$).

Most American Oystercatchers in North Carolina roosted on natural habitats (shell rakes or sandy shorelines of natural estuarine islands) and the Fort Fisher Rocks (Fig. 2); however, docks without railings also were used for roosting habitat. Most observations (96.5%) of American Oystercatchers found in Masonboro Sound were on docks. Eighteen of 160 docks in the survey area were used at least once by roosting American Oystercatchers; nine were used regularly (> 10 observations of flocks or single birds). All but one of the docks that American Oystercatchers used extended ≥ 60 m over water and all lacked railings and posts that were visually similar to railings.

At Ocracoke Inlet, one or more sources of potential anthropogenic disturbance were observed on 6.7% of surveys ($n = 75$). Types of potential disturbance observed were boats and pedestrians. At Back Sound, one or more sources of potential disturbance were observed on 2.8% of surveys ($n = 18$). Types of potential disturbance observed

Table 3. Number of banded American Oystercatchers observed during non-breeding surveys by the State (USA) in which birds were banded, 2008-2013. Includes individuals seen at multiple sites.

Location	Massachusetts	Rhode Island	New Jersey	Delaware	Virginia	North Carolina	South Carolina	Georgia	Florida	Total
Ocracoke Inlet	1	1	0	0	4	64[a]	1	1	0	72
Back Sound	12	0	3	0	14	38	0	3	0	70
Masonboro Sound	4	0	5	1	5	27	1	4	1	48
Cape Fear River	5	0	5	0	7	48[b]	1	1	0	67

[a]Includes six individuals that also nested on roost sites within the concentration area.
[b]Includes three individuals that also nested on roost sites within the concentration area.

Table 4. Number of banded American Oystercatchers seen during migration only and during winter at four major concentration areas in North Carolina, USA 2008-2013. Includes individuals seen at multiple sites.

Location	Migration Only	Winter
Ocracoke Inlet	39	33
Back Sound	22	48
Masonboro Sound	14	34
Cape Fear River	20	47

were boats, wild ponies (*Equus ferus*), pedestrians, and dogs (*Canis lupus familiaris*). In Masonboro Sound, one or more sources of potential disturbance were observed on 8.6% of surveys ($n = 81$ surveys). Types of potential disturbance were boats, pedestrians, dogs, and fireworks. On the Lower Cape Fear River, one or more sources of potential disturbance were noted on 50.6% of surveys ($n = 77$ surveys). Types of potential disturbance were pedestrians, boats, and dogs.

Discussion

Numbers of migrating and wintering American Oystercatchers at major concentration areas in North Carolina remained generally stable during the study years, and specific roost sites were regularly used except where erosion occurred at Ocracoke Inlet. These areas may be attractive to American Oystercatchers due to proximity of quality foraging and roosting habitat, making trips between them less energetically costly (Rogers *et al.* 2006). Similar consistent use of roost sites has been noted elsewhere in the American Oystercatcher's winter range (Sanders *et al.* 2004) and is found in other shorebirds such as the Western Sandpiper (*Calidris mauri*; Warnock and Takekawa 1996). Variation in peak counts may have been caused by differences in tidal amplitudes or weather conditions that affected roost site selection (Peters and Otis 2007). The increase detected in the number of wintering American Oystercatchers on the Lower Cape Fear River may have been due to sub-optimal tidal conditions on several 2009 and 2010 surveys. Differences between fall abundance in Masonboro Sound were likely due to low sample size in 2010.

To increase the accuracy of migration and winter counts of American Oystercatch-

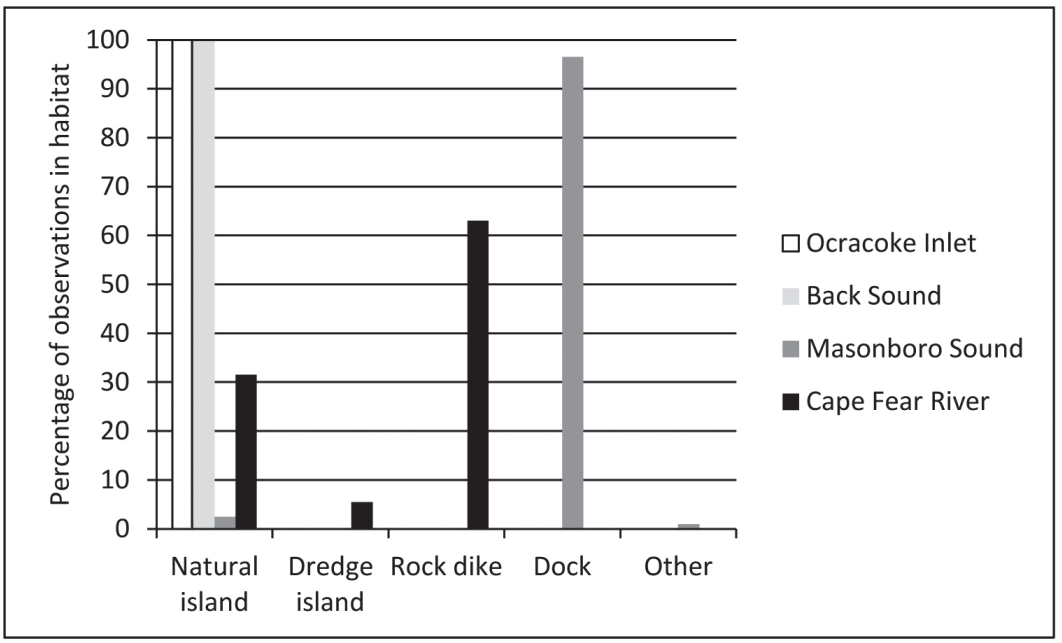

Figure 2. Habitat types used by non-breeding American Oystercatchers at four major non-breeding concentration areas in North Carolina, USA, 2008-2013. Birds in "other" habitat types were flying or on rip rap.

ers at key roost sites, surveys should be conducted within 1 hr of high tide (Hostetter *et al.* 2015) with multiple observers, thus obtaining estimates of observer bias, and with band resight data, estimates of detection probability.

Band resight data showed migratory connectivity with Florida, Georgia, and South Carolina to the south and, to the north, all States in which American Oystercatchers have been banded except New York. However, only seven American Oystercatchers had been banded in New York at the time of this study (American Oystercatcher Working Group 2015). During migration and winter seasons, the four concentration areas also were used by American Oystercatchers that had nested or hatched in North Carolina, revealing the non-migratory nature of some individuals. Because some banded American Oystercatchers were seen only during spring or fall migration, it appears some birds use these areas, particularly Ocracoke Inlet, as stopovers or staging areas during migration.

The consistency with which American Oystercatchers used concentration areas and specific roost sites indicates these places are important to American Oystercatchers in North Carolina during migration and winter. However, the concentration areas do not receive protection from human disturbance or other management during the non-breeding months.

Disturbance factors were present at all four major concentration areas. Experimentally presenting types of disturbance to roosting American Oystercatchers (e.g., Sabine *et al.* 2008) would provide better knowledge of their response than recording the presence/absence of uncontrolled disturbance factors that occur during surveys. Although flushing is an obvious effect of disturbance, shorebirds, including American Oystercatchers, also respond in other ways, including displacement from or abandonment of a site (Burger 1981; Pfister *et al.* 1992), increased vigilance behavior (Peters and Otis 2005), reduction in time spent resting or foraging (Thomas *et al.* 2003; Tarr *et al.* 2010), reduced foraging success (Coleman *et al.* 2003), and physiologically (Borneman *et al.* 2014). Avoidance of disturbed areas has been observed in other roosting shorebird species (Pfister *et al.* 1992; Kirby *et al.* 1993; Navedo and Herrera 2012), but avoidance or abandonment of a site may not be noticed if monitoring is not consistent and long-term. Further, flushing or abandonment of a site may not be the best indicator of impacts to shorebirds because decisions to leave a disturbed area are influenced by other factors such as availability and quality of alternative habitat (Gill *et al.* 2001).

Habitat alteration or loss is another threat to American Oystercatchers. The docks within Masonboro Sound are privately owned and may be lost to removal or disrepair, new disturbance regimes (e.g., increased use by owners and pets), or incompatible alterations such as the addition of railings. Railings on docks appeared to deter American Oystercatchers from roosting on docks. This may be because rails obstruct birds' fields of view and flight paths.

In the longer term, climate change and associated rises in sea level and storm frequency, as well as increased erosion and land subsidence, will impact coastal habitats in North Carolina (Karl *et al.* 2009). Back Sound and Ocracoke Inlet are located in areas identified as high to very high risk of physical changes to the shoreline as sea level rises, and Masonboro Sound and the Lower Cape Fear River are located in areas identified as moderate to very high risk (Hammar-Klose and Thieler 2001). Roost sites in Ocracoke Inlet were mostly lost during this study. Such changes will continue to affect marshes and estuarine islands that non-breeding American Oystercatchers use (Erwin *et al.* 2006, 2011).

American Oystercatchers roosting in North Carolina occupied artificial habitat in greater proportion than reported elsewhere (Sanders *et al.* 2004; Brown *et al.* 2005). Should roost sites be lost, it may be possible to replace them in some locations with artificial structures (Burton *et al.* 1996), such as dock-like structures, deposits of oyster shells, or elongate rocks. This

conservation strategy may become necessary if changes due to sea level rise and subsidence impede the natural formation of new roosting habitat or if human population growth increases disturbance. Our observations of Black-bellied Plover (*Pluvialis squatarola*), Dunlin (*C. alpina*), Western Sandpiper, and Short-billed Dowitcher (*Limnodromus griseus*) roosting with American Oystercatchers on fabricated structures suggest conserving or creating such habitat would have potential benefits for multiple species of shorebirds.

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