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Habitat Characteristics Associated with the Distribution and Abundance of *Histrionicus histrionicus* (Harlequin Ducks) Wintering in Southern New England

Richard A. McKinney[1,*], Scott R. McWilliams[2], and Michael A. Charpentier[3]

Abstract - *Histrionicus histrionicus* (Harlequin Ducks) that winter along the east coast of North America are listed as a population of special concern in Canada, and they use several coastal wintering sites in southern New England that are subject to varying degrees of urbanization. We studied patterns of habitat use by Harlequin Ducks at 12 known wintering sites in southern New England. An average of 327 ± 114 Harlequin Ducks were found at the sites during the winters of 2001–2003. More Harlequin Ducks wintered at sites south of Cape Cod, MA that had greater mollusk (709,133 ± 504,568 versus 97,154 ± 72,427 kcal ha^{-1}) and crustacean (27,907 ± 16,312 versus 1412 ± 1675 kcal ha^{-1}) prey energy density, and a higher index of hunting activity (2.4 ± 1.2 versus 1.4 ± 0.5) than sites to the north. We used logistic regression analysis at 12 sites inhabited by Harlequin Ducks and 12 nearby sites of similar geomorphology that did not support Harlequin Ducks to identify habitat characteristics that best explained their distribution in southern New England. Our analysis identified two habitat characteristics that affected the likelihood a site was used by Harlequin Ducks: 1) the proportion of residential, commercial, and industrial land use within a 100-m radius of the perimeter of the site; and 2) distance to the nearest Harlequin Duck wintering site. However, other factors, including those related to their extremely low population size, need to also be considered as recommendations are developed for the conservation of east coast Harlequin Ducks.

Introduction

Histrionicus histrionicus Linnaeus (Harlequin Ducks) are sea ducks that breed in remote stream reaches and frequent turbulent coastal marine habitats in winter. Two of the four populations of Harlequin Ducks are found in North America (CWS 1997), and declines were noted in the eastern Canadian population by the late 1980s. Recognition of these declines led to their being designated as endangered by the Committee on the Status of Endangered Wildlife in Canada in 1990, and subsequently down-graded to a "species of special concern" upon reevaluation in 2001. Harlequin Ducks were added to Canada's Species at Risk Act in 2003 (P. Thomas, Canadian Wildlife Service, Mount Pearl, NL, Canada, pers.

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comm.). These listings highlight the need for studies examining Harlequin Duck behavior and ecology on both their breeding and wintering grounds (Robertson and Goudie 1999).

Research priorities for the conservation of North American Harlequin Ducks include documenting the impact of human activity and disturbance near their wintering grounds (Robertson and Goudie 1999). Harlequin Ducks may be particularly vulnerable while concentrated on their wintering grounds, where even small, localized disturbances can affect substantial portions of the population (Goudie and Ankney 1986). Threats to wintering Harlequin Ducks include over-harvesting, oil spills, and, particularly in urban areas, loss of habitat caused by development. In addition to investigations into the impacts of direct human disturbance such as hunting and oil spills (Esler et al. 2000b, 2002; Lance et al. 2001), several studies have examined winter habitat use by North American Harlequin Ducks in relation to location, site morphology, and food availability (Esler et al. 2000a, Goudie and Ankney 1988, Mittlehauser et al. 2002). However, no studies have examined the impact of human activity adjacent to Harlequin Duck wintering grounds, even though significant numbers of Harlequin Ducks winter in areas that are increasingly under pressure from urbanization.

In this study, we examined patterns of habitat use by Harlequin Ducks wintering in southern New England, an area characterized by widespread coastal development that is host to about one fifth of the estimated 1800 Harlequin Ducks wintering on the east coast of North America (Mittlehauser 2000, Montevecchi et al. 1995). Our primary objective was to identify habitat characteristics that are associated with the distribution and abundance of Harlequin Ducks during winter in southern New England. We compared characteristics between sites inhabited during winter by Harlequin Ducks and nearby sites with similar geomorphology that do not support wintering Harlequin Ducks. We also compared Harlequin Duck abundance and habitat characteristics to the north and south of Cape Cod, MA, traditionally considered a dividing line for the southern New England marine environment (Roman et al. 2000). Differences in wintering-site use to the north and south of the Cape could have consequences for Harlequin Duck conservation since southern sites are often subject to increased development pressures.

Methods

Study sites

Our study sites included twelve locations from Cape Ann, MA to Point Judith, RI known to regularly support at least four Harlequin Ducks during winter (Fig. 1). In order to compare characteristics of used and unused sites ,we included an additional 12 nearby sites of similar area and geomorphology at which wintering Harlequin Ducks were not regularly observed. The criteria for determining that a site was not used by Harlequin Ducks were 1) no ducks were present during surveys, and 2) there was no evidence of past use by more than 2 Harlequin Ducks during repeated observations by avian ecologists familiar with the survey areas (W. Petersen and S. Perkins, Massachusetts Audubon, Lincoln, MA, pers. comm.). The study sites consisted of rocky headlands, shallow coves, or sand beaches. In all cases, we delineated the sites using natural breaks in the topography of the site: a line drawn from shoreline to shoreline on either side of the peninsula for rocky headlands; a line drawn through the cove mouth for shallow coves; and for sandy beach areas, a line drawn perpendicular to the shoreline at a feature such as a natural or man-made jetty or rock outcropping beyond which Harlequin Ducks were not observed. All sites were similar in mean water depth (range 0.9–8.1 m [mean low water]; mean = 3.8 m), and shoreline length (range 0.4–4.8 km; mean = 1.3 km).

Waterfowl surveys

Harlequin Duck abundances for Massachusetts sites (Fig. 1) were from single surveys during the winters of 2001–2002 and 2002–2003 using a 32–60x spotting scope or through 10 x 50 binoculars from a vantage point or points from which the entire surface of the site could be viewed. Abundances

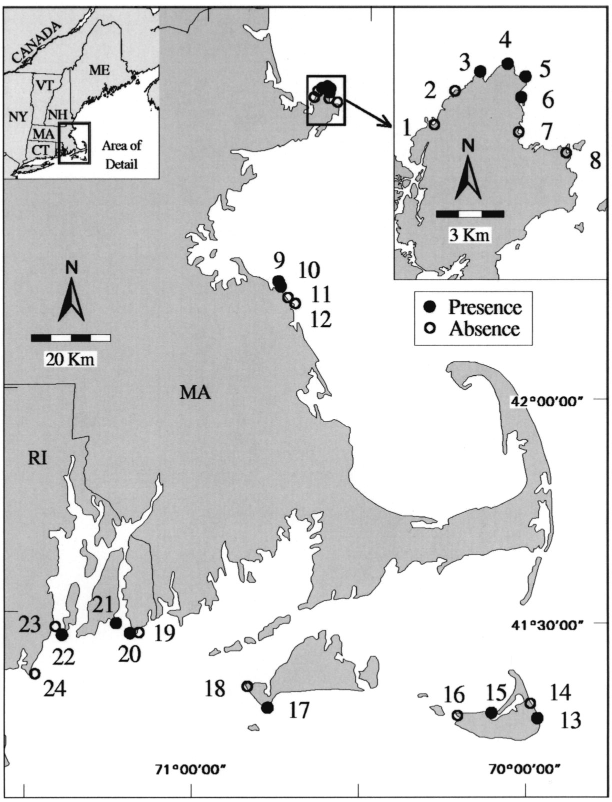

Figure 1. Location of 12 southern New England Harlequin Duck wintering sites, 2001–2003, and 12 unused sites chosen for habitat comparison. Presence and absence refer to winter use by Harlequin Ducks. 1 = Hodgkins Cove, 2 = Lanes Cove, 3 = Folly Point, 4 = Halibut Point, 5 = Andrews Point, 6 = Cathedral Ledge, 7 = Gull Point, 8 = Gap Cove, 9 = The Glades, 10 = Minot Beach, 11 = Lighthouse Point, 12 = Standish Road, 13 = Sankety Head, 14 = Squam Head, 15 = West Jetty, 16 = Eel Point, 17 = Squibnocket, 18 = Gay Head, 19 = Warren Point, 20 = Sakonnet Point, 21 = Sachuest Point, 22 = Beavertail Point, 23 = Bonnet Point, 24 = Point Judith.

for Rhode Island sites were calculated from census data collected during the winters (November through April) of 2001–2003. Bimonthly censuses at sites were performed on randomly chosen days and at randomly chosen times of day.

Habitat characteristics

Habitat characteristics were developed using geographic information system (GIS) topographic databases. The GIS data (e.g., shorelines, land use, and land cover) were obtained from the Rhode Island (RIGIS) and Massachusetts (MassGIS) geographic information systems and were processed using Environmental Systems Research Institute (ESRI) ARC GIS software (Redlands, CA). Shoreline data were derived from 15-minute (1:24,000 scale) United States Geological Survey (USGS) topographic maps. Land-use and land-cover data were developed from 1995 aerial photography (1:24,000 scale) coded to Anderson modified level 3 (Anderson et al. 1976) to one-half acre minimum polygon resolution. Shoreline data were used to determine linear shoreline length. In order to calculate surrounding land use, we first delineated a 100-m buffer adjacent to a site by drawing a 100-m wide polygon parallel and upland of the shoreline, or high-water mark. We then used land-use and land-cover data from within the buffer to calculate the percent vegetated land (open land, forested, and wetland) and developed land. Developed land (DEVL) included the land-use categories residential, commercial, and industrial land. We chose a 100-m buffer because development and resultant human activity near the shoreline could potentially influence resident Harlequin Ducks. We measured the direct distance in km from the center of a site to the nearest stream mouth (NSTR) and to the center of the nearest adjacent site where Harlequin Ducks were present (NWFS). An intertidal slope estimate for each site (ITSL) was determined by first using bathymetry data for each site to generate a 2-m depth contour. The area between the shoreline of each site and the 2-m depth contour was calculated and then divided by the shoreline length. This provided a mean distance to the 2-m depth contour. By dividing the mean distance into the 2-m depth, a mean value of slope was estimated. To determine a fetch value for each site (FETC), the grid module of Arc Info was utilized. The grid module includes a visibility tool that uses an elevation model to determine what is visible from a given location. By using an elevation model of each site that included the ocean as a flat area, the open ocean area that is visible from the shoreline of each site was determined. Fetch was calculated as the area of an arc that consists of open ocean area, described by the shoreline of the site projected out to 15 km. Fetch can be considered a surrogate for potential wave exposure; greater fetch represents greater open ocean exposure and hence greater potential for wave exposure. All habitat characteristics were determined from archived data; therefore, only one measurement was made of each characteristic, and these values were used in constructing habitat models.

We used intertidal quadrat sampling to measure the abundance of benthic invertebrates that could serve as prey for Harlequin Ducks. Three 75-m transects were laid out parallel to the shoreline within the intertidal zone at each site. The transect location both horizontally (i.e., its starting point within the intertidal zone of the site) and vertically (i.e., its relative position with respect to the mean low-water and mean high-water lines) was chosen using a probability-based random sampling protocol (Paul et al. 2003). Three 1-m^2 quadrats were placed equidistant along each transect, and all invertebrates were removed by hand or with a trowel if heavily encrusted with barnacles and macroalgae. Invertebrate samples and barnacle assemblages were passed through a 0.5-mm sieve and immediately sorted, counted, and measured. Macroalgae–consisting primarily of rockweeds *Fucus* spp. and *Ascophyllum mackaii* (Linnaeus), but occasionally *Chondrus crispus* (Linnaeus) J. Stackhouse (Irish moss)–within the quadrats was sampled by first moving the macroalgae to a container partially filled with seawater. Approximately 5 drops of a 10% formalin solution was then added to the container, mixed, and allowed to settle for 2 minutes. Invertebrates, consisting mostly of amphipods and isopods that escaped from the macroalgae, were then captured by sieving and were sorted and counted as above. Biomass of available soft tissue for each was calculated using existing allometric length-weight relationships. We calculated productivity at each site using known productivity-to-biomass relationships (Robertson 1979), and used these values along with species-specific tissue-energy densities to estimate energy density (McKinney et al. 2004). Species were aggregated by phylum to calculate available crustacean energy density (PREC), available mollusk energy density (PREM), and all available prey energy density (PREY).

An index of waterfowl hunting (HUNT; range: 1–5) was developed for each of the sites using the best available data on hunting trends for the Rhode Island sites (C. Allin, Rhode Island Division of Fish and Wildlife, West Kingston, RI, pers. comm.), observations made during sampling events, and input from avian ecologists familiar with the survey areas (W. Petersen and S. Perkins, pers. comm.). Sites at which waterfowl hunting was prohibited by state waterfowl hunting regulations were assigned an index value of 1. Those at which hunting was allowed, but which had only occasional hunting activity documented, were assigned a value of 3. Sites where hunting was allowed and regular hunting activity had been documented and observed during waterfowl census events were assigned a value of 5. Other sites were assigned intermediate values depending on the level and documentation of hunting activity.

Statistical analysis and model development

We used logistic regression analysis (Hosmer and Lemeshow 2000) to determine which habitat characteristics were most important in explaining distribution of Harlequin Ducks. For logistic regression analysis, we used a case-control sampling design that included the 12 known Harlequin Duck winter habitats and an additional 12 nearby sites of similar area and geomorphology that did not support Harlequin Ducks (Keating and Cherry 2005). The following variables were used for this analysis: nearest Harlequin Duck site (NWFS), fetch (FETC), intertidal slope (ITSL), prey density (PREY), distance to the nearest stream mouth (NSTR), and proportion of residential, commercial, and industrial land use within a 100-m radius of the perimeter of the site (DEVL). Since we were using logistic regression as an exploratory technique to try to identify habitat characteristics that might be important in determining harlequin distribution, we relaxed the significance criteria for entry of variables into the model to $\alpha = 0.1$. Results were reported only for variables that entered the model.

Analysis of variance (ANOVA) and Student's t-tests were used to test for differences in harlequin abundance between northern and southern sites. For this analysis, we used mollusk and crustacean prey energy density (PREM, PREC), the index of waterfowl hunting (HUNT), nearest Harlequin Duck site (NWFS), and intertidal slope (ITSL) as independent variables, and Harlequin Duck abundance as the dependent variable. Harlequin abundance and prey energy densities are reported as means ± standard deviation. Statistical analyses were performed with SAS for Windows ver. 6.12 (Carey, NC).

Results

We observed on average 327 Harlequin Ducks per year at our study sites during the winters of 2001–2004 (Table 1). More Harlequin Ducks were found at sites south of Cape Cod (196 ± 61 ducks per site per year) than at those north of the Cape (130 ± 53 ducks per site per year; $t_5 = 2.02$, P = 0.027). Southern sites had both the highest (Squibnocket, 79.9 ± 15.2 ducks per site per year) and lowest (Sakonnet Point, 5.4 ± 5.5 ducks per site per year) mean abundance.

Table 1. Abundance (number of ducks per site per year ± SD) of Harlequin Ducks at southern New England wintering sites, 2001–2003.

		Harlequin Duck abundance		
Site	Location	2001–2002	2002–2003	Mean 2001–2003
Folly Point[A]	North	6	12	8.9 ± 4.1
Halibut Point[A]	North	67	51	59.0 ± 11.3
Andrews Point[A]	North	11	7	9.1 ± 2.8
Cathedral Ledge[A]	North	34	14	24.0 ± 14.1
The Glades[A]	North	13	17	15.0 ± 2.8
Minot Beach[A]	North	19	9	14.0 ± 7.1
Sankety Head[A]	South	19	35	27.1 ± 11.3
West Jetty[A]	South	12	29	20.5 ± 12.0
Squibnocket[A]	South	69	91	79.9 ± 15.6
Sakonnet Point[B]	South	6.8 ± 11.0	4.0 ± 4.2	5.4 ± 5.5
Sachuest Point[B]	South	47.0 ± 12.9	51.9 ± 9.0	49.4 ± 11.0
Beavertail Point[A]	South	1	20	10.5 ± 13.4
Total all sites				327.0 ± 114

[A]n = 1 census per year
[B]n = 12 censuses per year

Sites to the south of Cape Cod had greater prey energy density of mollusks (392,260 ± 251,998 versus 87,868 ± 76,424 kcal ha^{-1}; ANOVA: df = 1, F = 8.50, p = 0.02) and crustaceans (31,605 ± 20,304 versus 512 ± 7819 kcal ha^{-1}; ANOVA: df = 1, F = 14.1, p = 0.003), and a higher index of hunting activity (2.3 ± 1.4 versus 1.3 ± 0.5; ANOVA: df = 1, F = 4.56, p = 0.04) than sites to the north (Table 2). Also, southern sites had greater distances to nearest Harlequin Duck sites (4.35 ± 2.39 versus 0.31 ± 0.80 km; ANOVA:df = 1, F = 17.0, p = 0.002). Northern sites had higher mean intertidal slopes than southern sites (0.051 ± 0.021 versus 0.024 ± 0.024; ANOVA: df = 1, F = 4.05, p = 0.07).

Most habitat characteristics used in the logistic regression analysis were quite variable (Table 3), and only two characteristics were significantly related to presence/absence of Harlequin Ducks and so entered into the model (Table 4): DEVL (proportion of residential, commercial, and industrial land use within a 100-m radius of the perimeter of the site), and NWFS (distance to the nearest Harlequin Duck wintering site in km). Wintering sites with Harlequin Ducks were on average closer to other sites with Harlequin Ducks (2.33 ± 2.66 km) and had less developed land nearby (38.6 ± 28.1%) than wintering sites without Harlequin Ducks (3.40 ± 3.49 km, 67.2 ± 31.6%, respectively) (Table 3).

Discussion

Along the northeast coast of the US, Cape Cod has traditionally been considered a dividing line for the marine environment, with different distributions of benthic and pelagic species often reported north and south of the Cape (Roman et al. 2000). Within our southern New England study area (i.e., from Cape Ann, MA to Narragansett Bay, RI), we found that more

Table 2. Habitat and landscape characteristics for wintering sites used by Harlequin Ducks to the north and south of Cape Cod, MA in southern New England during 2001–2003. Location = whether the site is to the north (N) or south (S) of Cape Cod; PREM = energetic content of invertebrate mollusk prey in kcal per hectare; PREC = energetic content of invertebrate crustacean prey in kcal per hectare; HUNT = index of hunting activity; NWFS = nearest Harlequin Duck wintering site; ITSL = intertidal slope (%). Values for PREM and PREC are means ± SD.

Site	Location	PREM	PREC	HUNT	NWFS	ITSL
Folly Point	N	38,995 ± 17,745	227 ± 163	2.0	0.010	0.073
Halibut Point	N	76,447 ± 50,509	445 ± 180	2.0	0.010	0.049
Andrews Point	N	71,739 ± 34,434	418 ± 178	1.0	0.208	0.065
Cathedral Ledge	N	154,686 ± 98,063	901 ± 454	1.0	0.419	0.063
The Glades	N	58,623 ± 23,003	341 ± 204	1.0	0.591	0.036
Minot Beach	N	126,719 ± 69,695	738 ± 310	1.0	0.590	0.017
Sankety Head	S	762,368 ± 71,668	61,425 ± 3482	2.0	3.689	0.066
West Jetty	S	630,239 ± 23,409	50,779 ± 2234	2.0	7.567	0.002
Squibnocket	S	298,102 ± 141,382	24,018 ± 1014	2.0	6.838	0.012
Sakonnet Point	S	323,805 ± 150,216	26,089 ± 1278	5.0	1.700	0.019
Sachuest Point	S	94,941 ± 45,571	7649 ± 3400	1.0	4.081	0.020
Beavertail Point	S	244,104 ± 23,409	19,668 ± 2234	2.0	2.242	0.020

Table 3. Habitat and landscape characteristics used in logistic regression analysis of winter-site use by Harlequin Ducks in southern New England during 2001–2003. LENG = linear shoreline length in km; DEPT = water depth (mean low water) in m; NWFS = distance to nearest Harlequin Duck wintering site in km; FETC = fetch in km^2; ITSL = intertidal slope (%); PREY = energetic content of invertebrate prey in kcal per hectare; NSTR = distance to nearest freshwater stream mouth in km; DEVL = proportion of residential, commercial, and industrial land use within a 100-m radius of the perimeter of the site. Sites are listed in order from north to south corresponding to Figure 1. Values for PREY and for sites where Harlequin Ducks were present (P) and absent (A) are means ± SD.

Site	LENG	Presence/ absence	NWFS	FETC	ITSL	PREY	NSTR	DEVL
Hodgkins Cove	1.68	A	0.668	178	0.040	79,438 ± 39,293	0.000	0.506
Lanes Cove	1.60	A	0.013	253	0.045	32,102 ± 18,379	0.683	0.845
Folly Point	2.21	P	0.010	307	0.073	39,222 ± 18,563	0.000	0.620
Halibut Point	1.50	P	0.010	377	0.049	76,892 ± 34,522	0.240	0.044
Andrews Point	1.55	P	0.208	370	0.065	72,156 ± 44,573	1.013	0.306
Cathedral Ledge	1.52	P	0.419	221	0.063	155,587 ± 90,240	1.448	0.484
Gull Point	1.61	A	1.179	97	0.091	88,910 ± 61,266	0.562	0.978
Gap Cove	1.32	A	2.102	281	0.076	97,788 ± 53,783	0.658	0.969
The Glades	1.41	P	0.591	310	0.036	58,964 ± 30,661	2.493	0.216
Minot Beach	1.06	P	0.590	216	0.017	127,457 ± 54,362	2.579	0.944
Lighthouse Point	1.74	A	1.600	110	0.010	29,371 ± 12,923	1.376	0.663
Standish Road	1.25	A	1.600	287	0.010	106,519 ± 54,249	2.722	0.955
Sankety Head	1.12	P	3.689	311	0.066	823,793 ± 353,595	4.604	0.432
Squam Head	1.14	A	3.689	299	0.054	1,391,701 ± 859,691	3.260	0.847
West Jetty	1.70	P	7.567	256	0.002	681,017 ± 493,972	3.099	0.726
Eel Point	2.09	A	7.567	275	0.012	316,938 ± 229,889	10.948	0.159
Squibnocket	2.04	P	6.838	381	0.012	322,121 ± 193,272	0.000	0.056
Gay Head	1.85	A	6.838	449	0.011	591,371 ± 286,121	0.279	0.270
Warren Point	1.14	A	1.700	337	0.019	1,811,075 ± 923,648	0.378	0.686
Sakonnet Point	2.01	P	1.700	322	0.007	349,894 ± 164,450	1.323	0.425
Sachuest Point	2.51	P	4.081	277	0.020	102,590 ± 55,799	0.127	0.059
Beavertail Point	2.59	P	2.242	282	0.039	263,772 ± 134,337	1.991	0.325
Bonnet Point	1.39	A	2.242	114	0.029	910,619 ± 427,991	1.717	0.985
Point Judith	1.67	A	11.651	494	0.016	859,493 ± 403,880	3.647	0.199
Present	1.77 ± 0.50		2.329 ± 2.664	303 ± 56	0.037 ± 0.026	256,122 ± 255,505	1.576 ± 1.438	0.386 ± 0.281
Absent	1.54 ± 0.30		3.404 ± 3.485	288 ± 121	0.034 ± 0.027	526,277 ± 599,117	2.185 ± 3.017	0.672 ± 0.316

Harlequin Ducks wintered at sites south of Cape Cod and that these sites had greater prey energy density and lower intertidal slopes, which may make the benthic prey more accessible to foraging Harlequin Ducks. Thus, availability of good-quality foraging areas may in part explain the large-scale patterns of Harlequin Duck abundance in southern New England. However, we also found that sites south of Cape Cod had increased hunting activity, and greater distances between wintering sites. It is possible that Harlequin Ducks are enduring the costs (e.g., increased migration, higher disturbance) of wintering at more southerly sites in order to take advantage of more abundant and accessible prey.

The cumulative abundance of Harlequin Ducks reported at the 12 southern New England coastal wintering sites in our study (213–441 birds per year) comprised 12–25% of the estimated population of 1800 ducks wintering along the east coast of North America (Mittelhauser et al. 2002, Vickery 1988). Sites where Harlequin Ducks were present in southern New England averaged 38.6% developed land within a 100-m radius of the shoreline, and the amount of developed land significantly influenced the distribution of Harlequin Ducks. Several recent studies examined the effects of increasing urbanization on breeding-bird species diversity and species composition (Jokimaki and Kaisanlahti- Jokimaki 2003, Melles et al. 2003, Salvati 2003); however, few studies have examined the effects of urbanization on waterfowl abundance. In our study, we used adjacent land use as a surrogate for urbanization and human disturbance, with the expectation that as urban land use increases, the potential for human disturbance (e.g., boat traffic, humans and pets walking the shoreline) in close proximity to wintering Harlequin Ducks also increases at a given site. We found that the presence of Harlequin Ducks at a given site was negatively influenced by the extent of developed land within a 100-m radius of the site. Thus, Harlequin Ducks that winter in southern New England are exposed and apparently respond to impacts from human disturbance.

In southern New England, Harlequin Ducks appear to exclusively use narrowly defined winter habitats year after year, a phenomena that may be related to the extremely high rates of site fidelity or philopatry shown to wintering and breeding sites by this species (Iverson et al. 2004; Robertson et al. 1999, 2000). We found relatively similar numbers of Harlequin Ducks

Table 4. Results of logistic regression analysis of Harlequin Duck abundance at southern New England wintering sites and adjacent sites with similar geomorphology using presence/absence as the dependent variables and additional habitat and landscape characteristics from Table 3. NWFS = distance to nearest Harlequin Duck wintering site in km; DEVL = proportion of residential, commercial, and industrial land use within a 100-m radius of the perimeter of the site.

Site	dF	Estimate	Standard error	Wald chi-square	Prob > chi-square	Odds-ratio estimate	95% Wald confidence limits	
Intercept	1	3.70	1.63	5.20	0.022	—	—	—
NWFS	1	-0.364	0.206	3.12	0.077	0.69	0.46	1.04
DEVL	1	-0.498	0.209	5.65	0.017	0.61	0.40	0.92

between years at each site, although our analysis also showed that the likelihood of Harlequin Ducks being present at a site decreased with distance to the nearest occupied Harlequin Duck wintering site. This indicates that wintering Harlequin Ducks may prefer sites that are near other sites with Harlequin Ducks. Other birds are attracted to conspecifics, although this may lead to increased intra-specific competition (Davoren et al. 2003, Reed and Dobson 1993, Silverman et al. 2004). If true for Harlequin Ducks, then they may use conspecifics as indicators of habitat quality and so are attracted to wintering sites with other ducks, only to be displaced through intraspecific competition to nearby sites of suitable but lower quality habitat (Alonso et al. 2004).

Our findings have several implications for the management and conservation of wintering Harlequin Ducks in southern New England. First, given the negative effect of development on the presence of Harlequin Ducks at wintering sites, further development near currently used wintering sites should be limited. Second, our finding that proximity to nearby occupied sites may be influencing habitat selection of Harlequin Ducks during winter suggests that maintaining nearby clusters of suitable coastal wintering sites is important. Given the difficulty of accurately assessing habitat selection of small populations such as the east coast Harlequin Ducks (Greene and Stamps 2001), we encourage further studies to determine if these patterns are also evident when and where Harlequin Duck populations are more dense.

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