

Articles

Characteristics of Ponds Used by Breeding Mottled Ducks on the Chenier Plain of the Texas Gulf Coast

David Haukos,* Stephanie Martinez, Jeannie Heltzel

D. Haukos

U.S. Fish and Wildlife Service, Texas Tech University, MS 2125, Lubbock, Texas 79409-2125

S. Martinez, J. Heltzel

U.S. Fish and Wildlife Service, Texas Chenier Plain National Wildlife Refuge Complex, P.O. Box 278, Anahuac, Texas 77514

Abstract

Mottled ducks *Anas fulvigula* are nonmigratory and primarily depend on habitats associated with coastal marshes of the Gulf Coast for their entire life cycle. Much of remaining available coastal marsh habitats of the Texas Gulf Coast are managed by state and federal agencies. The Texas Gulf Coast breeding population of mottled ducks has recently declined dramatically. To aid in development of management plans for breeding mottled ducks, we estimated the number of potential pair ponds available on the Texas Chenier Plain National Wildlife Refuge Complex relative to marsh type (fresh, intermediate, brackish, and saline), estimated occupancy, compared habitats of used and unused pair ponds, and evaluated pair pond selection relative to marsh type during spring 2004 and 2005. Greater than 18,000 ponds were recorded in >22,400 ha of coastal marsh with >74% of potential pair ponds in the intermediate marsh type. Average pond size of 425 randomly selected ponds across marsh types was 0.09 ha. Pond occupancy was estimated as 1.3% and 2.5% in 2004 and 2005, respectively, in 634 ponds surveyed for presence of mottled duck pairs. Mottled ducks selected for ponds in fresh marsh with short surrounding vegetation associated with recent cattle grazing, but avoided recently (<3 mo prior) burned areas. Pond area was greater with shallower water depth for used compared to unused ponds. The presence and coverage of submergent and emergent vegetation did not influence use of pair ponds by mottled ducks. Development of breeding habitat (pair ponds, nesting cover, brood habitat) in fresh marsh will benefit mottled ducks. Our results indicate development of breeding habitat on the Texas Gulf Coast, and vegetation management using cattle grazing timed for disturbance in fresh marsh during mid- to late winter and early spring will further attract breeding mottled ducks.

Keywords: *Anas fulvigula*; Chenier Plain; mottled duck; National Wildlife Refuge; pair pond; Texas; waterfowl

Received: March 7, 2010; Accepted: September 23, 2010; Published Online Early: September 2010; Published: November 2010

Citation: Haukos D, Martinez S, Heltzel J. 2010. Characteristics of ponds used by breeding mottled ducks on the Chenier Plain of the Texas Gulf Coast. *Journal of Fish and Wildlife Management* 1(2):93–101; e1944-687X. doi: 10.3996/032010-JFWM-005

Copyright: All material appearing in the *Journal of Fish and Wildlife Management* is in the public domain and may be reproduced or copied without permission. Citation of the source, as given above, is requested.

The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

* Corresponding author: david.haukos@ttu.edu

Introduction

Mottled ducks *Anas fulvigula* are nonmigratory waterfowl principally dependent upon coastal marshes of the Gulf Coast for their entire life cycle (Stutzenbaker 1988; Moorman and Gray 1994). On the Texas Gulf Coast, managers of federal National Wildlife Refuges (NWRs) and state Wildlife Management Areas conserve and manage approximately 25% and 43%, respectively, of the available palustrine emergent and estuarine emergent

coastal marsh habitats critical to the life history of mottled ducks (Gulf Coast Joint Venture, unpublished data). Much of the remaining nonpublicly owned coastal marsh habitats are being subjected to a variety of anthropogenic impacts (e.g., saltwater intrusion, oil and gas exploration and processing, urbanization, and reduced freshwater inflows), most of which result in continued declines in habitat quality for mottled ducks (Stutzenbaker 1988; Moorman and Gray 1994). The recent oil spill resulting from the failure of the Deepwater



Horizon well highlights the fragility of coastal marsh and potential for devastating consequences on the marsh ecosystem. Therefore, mottled ducks in Texas will increasingly depend upon wetland and associated habitats provided and protected by NWRs and Wildlife Management Areas (Stutzenbaker 1988).

There is not currently an operational annual range-wide survey of breeding mottled ducks as there are for other North American waterfowl species. The only continuous survey (since 1986) of breeding mottled ducks for the Western Gulf Coast Population is on NWRs of the mid and upper Texas Gulf Coast. The Chenier Plain NWR Complex (Complex) on the upper Texas Gulf Coast (the region east of Houston, Texas, to the Louisiana border) historically accounted for >50% of the mottled ducks counted on Texas coastal NWRs (U.S. Fish and Wildlife Service [USFWS], unpublished data). Estimated indicated breeding pairs, based on visually corrected aerial surveys on NWRs, have declined 94% since 1986 despite a relatively large increase in the mid-1990s and remained at relatively low levels throughout the 2000s (Figure 1). Although these trends were documented on NWRs of the upper Texas Gulf Coast, other indices reveal recent declines of varying magnitude for mottled ducks throughout Texas (GCJV 2007). Johnson (2009) concluded that the trends represented by the breeding pair survey on NWRs best corresponded with the trends of estimated mottled duck population finite growth rate on the western Gulf Coast compared to other population surveys. Numerous hypotheses have been advanced as contributing to the observed decline in mottled ducks on NWRs and in Texas (GCJV 2007). These include 1) loss or degradation of reproductive habitats (e.g., pair ponds, suitable nesting cover, and brood-rearing habitats), 2) increasing predator populations (Elsey et al. 2004), 3) loss and degradation of nonbreeding habitats (i.e., winter, molt), 4) reduction of ecological disturbance (e.g., cattle and goose grazing or prescribed burning), 5) redistribution of populations (i.e., from Texas to Louisiana), and 6) continued exposure to lead from spent shot shells (Merendino et al. 2005). Concern for the status and future of mottled ducks has resulted in the USFWS declaring the species a focal species in the Migratory Bird Program Focal Species Strategy (USFWS 2005).

To attract mottled ducks for breeding and subsequent recruitment on NWRs, managers should provide pairing, nesting, and brood-rearing habitats. During the early portion of the breeding season through mid-incubation, most duck species are territorial with females selecting pair loafing areas in wetlands, usually referred to as pair ponds, with spacing influenced by food distribution, location of nesting cover, and predator populations (Anderson and Titman 1992). Pair ponds are defended as territories because they provide access to energy and nutrition sources necessary for reproduction, ultimately influencing potential recruitment (Stutzenbaker 1988; Anderson and Titman 1992). Unfortunately, little is known about the habitat characteristics of ponds that attract paired mottled ducks for breeding efforts, which is information NWR managers need to increase recruitment of mottled ducks.

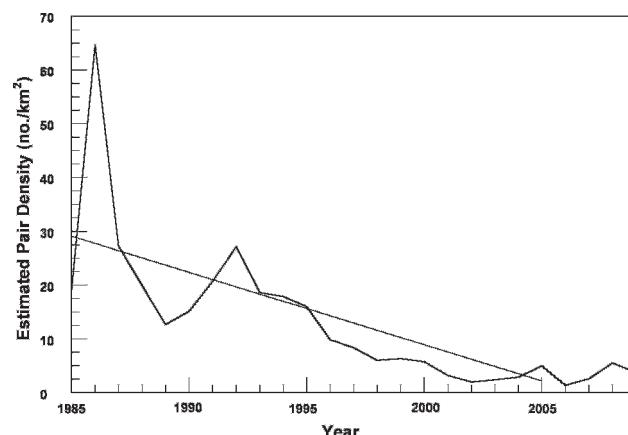


Figure 1. Estimated visibility-corrected density of breeding mottled ducks on five National Wildlife Refuges (Anahuac, San Bernard, Brazoria, Matagorda Island, Big Boggy) of the mid and upper Texas Gulf Coast from 1985 to 2008. The long-term linear trend indicates a significant decline since the late 1980s.

Mottled ducks initiate breeding activities much earlier than other North American duck species because they are nonmigratory and occupy southerly habitats. Paulus (1988) reported that 90% of females were paired by December and 100% paired by February with the peak of nest initiation in Texas and Louisiana during March and April. Territorial defense typically starts in January, with the peak of three-bird flights (territorial resident males chasing intruding pairs) occurring in March and April corresponding to the peak of the breeding season (Paulus 1988; Stutzenbaker 1988). Moorman and Gray (1994) indicated that mated pairs usually feed together in defended pair ponds prior to and during egg laying until pair bonds break during incubation. Spacing of paired mottled ducks in territorial ponds indicates foraging areas used by the pair during the breeding season (Paulus 1984), but rarely includes a nest site (Allen 1980; Baker 1983; Paulus 1984). Therefore, investigation of defended pair ponds by mottled ducks allows for evaluation of habitat characteristics that initially attract breeding pairs for reproductive activities.

From the perspective of a coastal marsh manager, habitat management for breeding mottled ducks may conflict with habitat management for wintering waterfowl. For example, managing for waterfowl preparing to migrate usually involves providing high-energy foods (e.g., seeds and tubers) for large flocks, whereas management for breeding mottled ducks focuses on provision of invertebrates rich in protein and minerals necessary for reproduction in isolated areas that provide nesting and brood-rearing habitat. In addition, common vegetation management practices (e.g., livestock grazing and prescribed fire) on NWRs may influence habitat use by breeding mottled ducks. Thus, thorough knowledge of waterfowl-habitat interactions within coastal marsh habitats is essential to the development of integrated management practices for all species. We investigated the use of pair ponds by breeding mottled ducks on the Chenier Plain NWR Complex on the upper Texas Gulf Coast. Our objectives were to 1) determine the number

of potentially available pair ponds on the Complex, 2) estimate the percentage of available ponds used by mottled ducks, 3) evaluate selection of ponds based on habitat attributes, and 4) contrast habitat characteristics between used and unused ponds.

Methods

The Chenier Plain NWR Complex is located along the Texas Gulf Coast between the city of Houston and state of Louisiana and comprised of Anahuac, McFaddin, Texas Point, and Moody NWRs. The total acquired area of the Complex was 42,762 ha; 56%, 32%, 8%, and 4% on McFaddin, Anahuac, Texas Point, and Moody NWRs, respectively (USFWS 2006). We did not sample pair ponds on Moody NWR for this study because of poor access. Mottled ducks are considered a priority species in the Comprehensive Conservation Plan of the Complex (USFWS 2006).

We used 2002 aerial photography digitized in ArcMap (Environmental Systems Research Institute, Redlands, CA) and field measurements of salinity gradients during that same year to characterize availability of ponds in the coastal marsh. We recognize that salinity gradients may have shifted between 2002 and initiation of the study, but all field salinity measurements during the study corresponded to the initial 2002 classification of marsh type. To determine the number of ponds available for breeding mottled ducks, we used ArcMap to count all open water bodies (i.e., ponds) that were $\geq 9.29 \text{ m}^2$ in the four different coastal marsh types (fresh [0–0.5 parts per thousand {ppt} salinity], intermediate [0.5–3.5 ppt], brackish [3.5–10 ppt], and saline [$>10 \text{ ppt}$]) on the Complex. Bodies of water in prairies, ditches, canals, bayous, and manmade ponds or reservoirs were excluded from this study except when water levels of canals or ditches exceeded banks enough to be 9.29 m^2 in area in adjacent coastal marsh. When a pond appeared to be divided by vegetation, each division was marked as an individual pond when sites were visually isolated (vegetation was $\geq 1 \text{ m}$ tall and at $\geq 75\%$ of the separated surface area was bordered by vegetation). For large marsh areas of intermixed water and vegetation without obvious borders, individual ponds were delineated based on visually defined isolated areas of open water. Because there were $>18,000$ marked as potentially available, we measured the area of 425 randomly selected ponds stratified by marsh type (2% of total ponds), calculated the average area by marsh type, and multiplied those averages by the number of marked ponds per marsh type for each refuge to estimate total surface area of identified ponds.

Once locations of all potential ponds were determined, we assigned a number to each pond with ArcMap, and then used a random number generator to randomly choose numbers and corresponding ponds stratified by marsh type and refuge. To estimate the percentage of available ponds breeding mottled ducks used, we randomly chose ponds in each marsh type to determine pond occupancy by pairs. Each randomly selected pond was visited once by airboat, truck, all-terrain vehicle, or

foot from 3 March to 9 April 2004, and 25 February to 6 April 2005, from sunrise to 3 h after sunrise or from 3 h before sunset to sunset to determine the presence or absence of a breeding mottled duck pair. These dates and time periods correspond to presence of feeding by pairs in selected territorial pair or loafing ponds (Paulus 1984; Stutzenbaker 1988). We used the area of each marsh type on each refuge to stratify pond sampling across marsh types and individual refuges. Our objective was to sample 100 fresh, 150 intermediate, 125 brackish, and 100 saline marsh potential pair ponds for occupancy across the entire Complex each year of the study (2004, 2005). We downloaded coordinates of each randomly selected pond (ponds were randomly selected each year) into a Global Positioning System (Garmin 765T), which we used to locate each pond (accuracy $\pm 3 \text{ m}$) in the field.

If mottled ducks were flushed from a randomly selected pond, we recorded whether it was a pair or a lone bird. We never flushed greater than two birds from a selected pond. When an indicated breeding pair (pair or lone male) was recorded on a random pond, the pond was designated as a "random/used" pond, and if no birds were present, the pond was designated as "random/unused." If a marked pond no longer existed (i.e., was overgrown with cattail *Typha* spp., dried up, etc.), we randomly selected another pond from those available within the proper stratification.

At each randomly selected pond, we measured water salinity, water depth, and pond area; evaluated height of surrounding vegetation; estimated the percent coverage of emergent vegetation; and determined the presence or absence of submergent plant communities to characterize general habitats the ponds provided. The presence of recently (within previous 3 mo) burned or grazed vegetation surrounding each pond was also recorded and verified with prescribed-fire or cattle-grazing records. Vegetation structure surrounding the pond was categorized by estimating the height of the dominant vegetation. Categories of surrounding vegetation were "short" ($<0.6 \text{ m}$; e.g., *Paspalum vaginatum*, *Distichlis spicata*, and *Sagittaria* spp.), "medium" (0.6–1.3 m; e.g., *Spartina patens*, *Schoenoplectus americanus*, and *Schoenoplectus robustus*), and "tall" ($>1.3 \text{ m}$; e.g., *Typha* spp., *Phragmites australis*, and *Schoenoplectus californicus*).

We measured salinity by submersing a salinity meter (YSI, Models 30 and 63) to the bottom of the pond in undisturbed areas and recording two to three readings (ppt) in different areas of each pond. If there was a difference $>1.0 \text{ ppt}$ among readings, we noted the high, low, and average values. Otherwise, we only recorded the average. We measured water depth (mm) at three random locations with a meter stick. The stick was held vertically in the water and allowed to fall to the bottom of the pond using its own weight. If there was a difference $>100 \text{ mm}$ in the depth readings, we recorded the high, low, and average measurements. To estimate the surface area for small ponds ($<30 \text{ m}^2$), we used a meter stick or tape measure to physically measure pond perimeter and then surface area was calculated; for medium-sized ponds (30–2,000 m^2), the pond edge was



Table 1. Total area (ha) of coastal marsh categorized by marsh type available in 2002 (Available area), percent total area represented by marsh type (%), and area sampled for presence of ponds used by breeding pairs of mottled ducks *Anas fulvigula* (Sampled area) in 2004 and 2005 on Anahuac, McFaddin, and Texas Point National Wildlife Refuges comprising the Chenier Plain National Wildlife Refuge Complex (Complex) of the upper Texas Gulf Coast.

Marsh type ^a	Anahuac		McFaddin		Texas Point		Complex	
	Available area (%)	Sampled area						
Fresh	472 (5.5)	472	2,608 (11.0)	453	0 (0.0)	0	3,081 (8.6)	925
Intermediate	5,892 (68.6)	5,892	19,762 (83.4)	10,258	552 (16.0)	551	26,204 (73.3)	16,701
Brackish	1,942 (22.6)	1,942	1,333 (5.6)	1,333	930 (27.0)	877	4,206 (11.8)	4,152
Saline	278 (3.2)	278	0 (0.0)	0	1,968 (57.0)	398	2,247 (6.3)	676
Total	8,584	8,584	23,703	12,044	3,450	1,826	35,738	22,454

^a Fresh = 0–0.5 parts per thousand (ppt); intermediate = 0.5–3.5 ppt; brackish = 3.5–10 ppt; and saline = >10 ppt.

walked using a Global Positioning System to map the perimeter, then the area was calculated using ArcMap; and for large ponds (>2,000 m²), an airboat was driven around the pond and a Global Positioning System was used to map the pond perimeter, then pond area was calculated using ArcMap.

Only a small proportion of random ponds were used by breeding mottled ducks. During the study, we recorded locations of all ponds used by pairs found during daily refuge management activities (i.e., established salinity transects across all units and habitat types of each refuge), systematic evaluation of habitat condition of the refuges using air boats throughout the breeding season, and while traveling to and from sampled random ponds on each refuge. Pair ponds used by breeding mottled ducks during the same daily time periods as for random pond visits were considered used ponds and combined with the randomly used ponds to constitute the used pond data set. These ponds were revisited and habitat data were collected in the same manner as at random ponds.

Statistical analyses

We evaluated habitat selection based on the Neu et al. (1974) method, which is appropriate for these data (Alldredge and Griswold 2006). This approach compares the 95% confidence interval associated with the proportion of locations among habitat types with the proportional availability each habitat type within the study area. We compared use versus availability of ponds among marsh type (fresh, intermediate, brackish, and saline) and surrounding vegetation height (i.e., surrounding structure; short, medium, and tall). We compared percent of used versus available ponds containing submergent and emergent vegetation. Finally, we assessed the influence of cattle grazing and prescribed fire disturbances on the proportion of ponds used associated with these events versus the proportion for all available ponds.

We used a 2-way factorial analysis of variance (ANOVA) to compare measured habitat features of pond area (ha), water depth (mm), water salinity (ppt), and pond coverage by emergent vegetation (%) between used and unused ponds and marsh type (fresh, intermediate, brackish, and saline). Following a significant ($P < 0.05$)

ANOVA, a least significant difference test was used to compare means among marsh types.

Results

In 2002, the total area of coastal marsh on the Chenier Plain NWR Complex was estimated to be 35,738 ha (Table 1). Intermediate marsh represented the highest percentage of marsh type available on the Complex, followed by brackish, fresh, and saline. Of the total marsh area, we sampled 22,454 ha for pair ponds, which represented 63% of the total marsh available on the Complex (Table 1). The sampled area excluded inaccessible areas of intermediate and fresh marsh of McFaddin NWR and portions of saline and brackish marsh of Texas Point NWR. Sampled marsh area was representative of the entire Complex; intermediate marsh represented the highest percentage (74%), followed by brackish (18%), fresh (4%) and saline (3%; Table 1).

We identified 18,830 ponds in the sampled area of the four marsh types on the Complex; the area of these ponds constituted 7.4% of the available sampled marsh area on the Complex (Table 2). Anahuac NWR had the greatest number of ponds in fresh, brackish, and saline marsh types, whereas McFaddin NWR had the greatest number of ponds in the intermediate marsh type. Overall, McFaddin NWR had the greatest number of identified ponds by a small margin (Table 2). Ranking, by marsh type, of pond numbers and area was intermediate, brackish, saline, and fresh (Table 2). Average (SE) pond size, by marsh type, was 0.03 (0.01) ha in fresh marsh, 0.13 (0.06) ha in intermediate, 0.06 (0.02) ha in brackish, and 0.06 (0.03) ha in saline. Across marsh types, average pond size was 0.09 (0.03) ha.

In 2004 and 2005, we surveyed 634 randomly selected ponds (317 ponds/y) or 3.4% of the 18,830 identified ponds. Because of logistical constraints in 2004, the original objective of visiting 425 randomly chosen ponds was not achieved. To ensure a consistent sampling effort between years, we visited the same number of ponds on each refuge and in each marsh type in both 2004 and 2005. Of these, 8.8% occurred in fresh marsh, 45.7% in intermediate marsh, 38.8% in brackish marsh, and 6.6% in saline marsh (Table 2). Sampled ponds were distrib-



Table 2. Total area (ha) and number of available ponds (Available) and total area (ha) and number of randomly selected ponds visited (Sampled) by marsh type to determine the pond occupancy of mottled ducks *Anas fulvigula* breeding on the upper Texas Gulf Coast on Anahuac, McFaddin, and Texas Point National Wildlife Refuges comprising the Chenier Plain National Wildlife Refuge Complex (Complex) in spring 2004 and 2005.

Marsh type ^a	Anahuac				McFaddin				Texas Point				Complex			
	Available		Sampled		Available		Sampled		Available		Sampled		Available		Sampled	
	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.
Fresh	4.5	114	1.3	42	3.8	97	1.0	14	0.0	0	0.0	0	8.3	211	2.3	56
Intermediate	431.0	4,589	6.5	108	595.1	6,636	30.2	172	69.7	742	0.6	10	1,095.8	11,667	37.3	290
Brackish	304.5	3,783	2.8	112	190.3	2,364	1.0	78	39.9	496	11.2	56	534.7	6,643	15.0	246
Saline	17.9	184	0.4	26	0.0	0	0.0	0	12.2	125	1.9	16	30.1	309	2.3	42
Total	757.9	8,670	11.0	288	789.2	9,097	32.2	264	121.8	1,363	13.7	82	1,668.9	18,830	56.9	634

^a Fresh = 0–0.5 parts per thousand (ppt); intermediate = 0.5–3.5 ppt; brackish = 3.5–10 ppt; and saline = >10 ppt.

uted across the Complex: 45% on Anahuac, 42% on McFaddin, and 13% on Texas Point NWRs. In 2004, a total pond area of 26.64 ha was sampled on the Complex, representing 1.6% of the potential pond area in the sampled portion of the Complex. In 2005, a total pond area of 30.23 ha was sampled, representing 1.8% of the potential pond area on the Complex.

Mottled duck pairs were present on four randomly selected ponds (1.3% occupancy) in 2004: one brackish pond with short surrounding vegetation, one intermediate pond with short vegetation, one intermediate pond with medium vegetation, and one fresh pond with medium vegetation (*Supplemental Material*, Table S1, <http://dx.doi.org/10.3996/032010-JFWM-005.S1>). In 2005, mottled ducks were present on eight randomly surveyed ponds (2.5% occupancy): three brackish ponds with short surrounding vegetation, two brackish ponds with medium vegetation, one intermediate pond with short vegetation, one intermediate pond with medium vegetation, and one saline pond with medium vegetation. In 2004, using the pond occupancy rate of 1.3%, we estimated that 245 pairs of mottled ducks were in the sampled area of the Complex. In 2005, based on the pond occupancy rate of 2.5%, we estimated that 471 pairs of mottled ducks were on the sampled area of the Complex.

In 2004, of the estimated 245 pairs of mottled ducks using the sampled area of the Complex, assuming all pair sightings were independent due to establishment of territories, locations of 4 pairs in random ponds and 89 additional pairs observed during the search periods were

recorded (37.9% of estimated total number of pairs); 17 pairs used habitats other than delineated ponds (e.g., prairies, reservoirs, and bayous/ditches). Therefore, the final 2004 data set was based on 76 “used” ponds (4 from random/used ponds and 72 other recorded used ponds) and 313 “unused” ponds. Of these 76 pairs, 54% occurred at Anahuac NWR, 30% at McFaddin NWR, and 16% at Texas Point. In 2005, of the estimated 471 pairs of mottled ducks occurring in the sampled area of the Complex, locations of 8 pairs on randomly searched ponds and locations of an additional 127 pairs were recorded during the search periods (28.7% of estimated total number of pairs). Twenty-six pairs used habitats other than delineated ponds; thus, 101 ponds were included in the data set for habitat use–availability comparisons (8 from random/used ponds and 93 other recorded used ponds). Of these 101 pairs, 52% occurred at Anahuac NWR, 36% at McFaddin NWR, and 12% at Texas Point NWR.

In 2004, pairs of mottled ducks settled most frequently in intermediate marsh (65.8%), followed by brackish (23.6%), fresh (7.9%), and saline (2.6%) marsh types. In 2005, intermediate marsh was again used most frequently (43.6%), followed by brackish (33.7%), fresh (13.9%), and saline (8.9%) marsh. However, pond occupancy was not in proportion to pond availability within marsh type across years ($\chi^2_3 = 178.02, P < 0.001$). Across both years, mottled ducks selected ponds in fresh marsh (1.1% availability versus 11.3% used), but used ponds in all other marsh types in proportion to availability (Table 3). Furthermore, selection of habitat structure surrounding

Table 3. Percent occurrence by breeding mottled ducks *Anas fulvigula* (Used) relative to availability of ponds (Available) by coastal marsh type on the Chenier Plain National Wildlife Refuge Complex in spring 2004 and 2005.

Marsh type ^a	Available		Used		95% CI
	n	%	n	%	
Fresh	211	1.1	20	11.3	5.4–17.3
Intermediate	11,667	61.9	94	53.1	43.7–62.5
Brackish	6,643	35.3	52	29.4	20.8–37.5
Saline	309	1.6	11	6.2	1.6–10.8
Total	18,830		177		

^a Fresh = 0–0.5 parts per thousand (ppt); intermediate = 0.5–3.5 ppt; brackish = 3.5–10 ppt; and saline = >10 ppt.



Table 4. Percent occurrence by breeding mottled ducks *Anas fulvigula* (Used) in coastal marsh ponds relative to availability of ponds (Available) based on surrounding vegetation structure on the Chenier Plain National Wildlife Refuge Complex in spring 2004 and 2005.

Vegetation structure	Available		Used		95% CI
	n	%	n	%	
Short (<0.6 m)	158	25.1	105	59.3	51.5–67.2
Medium (0.6–1.3 m)	375	59.6	57	32.2	24.7–39.7
Tall (>1.3)	96	15.3	5	2.8	0.2–5.5

used pair ponds was also found ($\chi^2_2 = 110.09, P < 0.0001$). Mottled duck pairs exhibited a preference for ponds with short surrounding habitat structure across both years (<0.6 m; 25.1% availability versus 59.3% used). They avoided ponds with medium and tall surrounding vegetation (Table 4). However, used ponds containing submergent ($\chi^2_1 = 1.13, P = 0.29$; 25.9% availability versus 29.7% used [95% CI on use = 22.0–37.4]) and emergent vegetation ($\chi^2_1 = 3.30, P = 0.08$; 45.8% availability versus 54.5% used [95% CI on use = 47.5–63.3]) were used in proportion to availability.

The type of surrounding disturbance influenced pair pond selection by mottled ducks. Selection for ponds associated with cattle grazing was apparent ($\chi^2_1 = 60.84, P < 0.001$; 12.3% availability versus 31.5% used [95% CI on use = 23.7–37.4]). However, paired mottled ducks avoided ponds that were associated with recent prescribed burns ($\chi^2_1 = 5.01, P = 0.02$; 19.3% availability versus 10.4% used [95% CI on use = 5.3–15.5]).

There was no interaction between pond use categories and marsh type for any of the four measured habitat variables (pond area: $F_{3,802} = 1.43, P = 0.23$; water depth: $F_{3,810} = 0.36, P = 0.78$; water salinity: $F_{3,812} = 1.37, P = 0.25$; or percent emergent coverage: $F_{3,811} = 2.25, P = 0.08$). Pond area increased across habitat types from fresh to saline marsh ($F_{3,802} = 2.67, P = 0.04$; Table 5) and was nearly three times greater for used than unused ponds ($F_{1,802} = 5.95, P = 0.02$; Table 6). Water depth of ponds did not differ among marsh type ($F_{3,810} = 1.12, P = 0.34$; Table 5); however, used ponds had shallower water depth than unused ponds ($F_{1,810} = 6.70, P = 0.01$; Table 6). Percent emergent vegetation was greater in fresh marsh compared to the other marsh types ($F_{3,811} = 62.89, P < 0.001$; Table 5). However, percent emergent vegetation did not differ between used and unused ponds ($F_{1,811} = 1.59, P = 0.21$; Table 6). There was no difference in

average water salinity between used and unused ponds ($F_{1,812} = .011, P = 0.74$; Table 6).

Discussion

Although recognized as an important part of the reproductive activity of waterfowl (Anderson and Titman 1992) there have been few descriptions of habitats used by paired mottled ducks during the nesting season compared to most other species of ducks. Stutzenbaker (1988) reported that male mottled ducks defended ponds formed by temporary open water sites in prairie habitats, especially those surrounded by sienna bean *Sesbania drummondii*. However, these sites have become relatively rare since the 1980s. Durham and Afton (2006) concluded that flooded rice fields were important loafing and feeding habitat for mottled ducks nesting in agricultural lands of former coastal prairie in Louisiana, especially during drought. White and James (1978) reported that mottled duck foraging habitat was typically <30 cm in depth. Weeks (1969) reported that estimated loafing area size ranged from 10 to 130 ha, but was usually <40 ha. However, there are no detailed descriptions of habitats used by paired mottled ducks in coastal marsh habitats.

The sheer number of potentially available ponds and low occupancy rate (e.g., 0.8 ponds/ha and 1.9%, respectively, on the Chenier Plain NWR Complex) likely leads to an assumption that these habitats are not limiting to mottled duck populations in coastal marsh. Such an assumption may hinder management for breeding mottled ducks because it is quite apparent that certain features of ponds attract paired mottled ducks. Therefore, managers should include consideration of pair habitats, in addition to nesting and brood-rearing habitats, in management plans for breeding mottled ducks in coastal marsh.

Table 5. Average mean and standard error (SE) surface area, water depth, and percent cover by emergent vegetation of ponds sampled for the presence of breeding mottled ducks *Anas fulvigula* among four coastal marsh types on Anahuac, McFaddin, and Texas Point National Wildlife Refuges of the upper Texas Gulf Coast during spring 2004 and 2005.

Marsh type ^a	Surface area (ha)		Water depth (mm)		Emergent vegetation (%)	
	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE
Fresh	0.02A ^b	0.03	114.1A	14.9	51.6A	2.7
Intermediate	0.06A	0.01	134.9A	6.9	21.2B	1.3
Brackish	0.10B	0.02	126.6A	7.9	6.2C	1.4
Saline	0.15B	0.04	98.2A	18.6	7.7C	3.4

^a Fresh = 0–0.5 parts per thousand (ppt); intermediate = 0.5–3.5 ppt; brackish = 3.5–10 ppt; and saline = >10 ppt.

^b Means with the same letter do not differ ($P > 0.05$) among marsh type within each habitat variable.

Table 6. Average mean and standard error (SE) pond area, water depth, emergent vegetation, and water salinity (parts per thousand [ppt]) for ponds used and unused by breeding mottled ducks *Anas fulvigula* on Anahuac, McFaddin, and Texas Point National Wildlife Refuges of the upper Texas Gulf Coast during spring 2004 and 2005.

Usage	Habitat variable							
	Pond area (ha)		Water depth (mm)		Emergent vegetation (%)		Salinity (ppt)	
	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE
Used	0.12 ^a	0.02	99.0 ^a	9.6	19.9	1.7	2.81	0.12
Unused	0.05	0.01	137.9	5.4	23.4	0.9	2.74	0.07

^a Means with the same letter differed ($P < 0.05$) between used and unused ponds.

Mottled ducks selected for ponds in freshwater marsh. Although ponds were used in proportion to availability in the other three marsh types based on habitat selection ratios (Manly et al. 2002), mottled ducks were 11.7, 12.2, and 2.6 times more likely to select ponds available in fresh marsh than those in intermediate, brackish, and saline marsh types, respectively, on the Chenier Plain NWR complex. Considering the relatively low availability of freshwater marsh on the Complex, such definitive selection ratios indicate that it is critical to concentrate management efforts for breeding mottled ducks on freshwater marsh.

The relatively smaller selection ratio of saline marsh was due to inclusion of Texas Point NWR, where saline marsh was the predominant marsh type. Excluding Texas Point NWR data, the freshwater : saline marsh type selection ratio increased to 4.6. Use of saline habitats by breeding mottled ducks appears to be more than expected considering the perceived negative factors associated with breeding attempts in these habitats (e.g., Moorman et al. 1991). However, breeding pairs of mottled ducks are frequently observed feeding in saline marsh habitats, especially those habitats dominated by *Ruppia maritima*. On the Chenier Plain NWR Complex, saline marsh is frequently separated from adjacent intermediate marsh by salt prairie ridges, facilitating easy movements among habitat types (P. Walther and M. Whitbeck, USFWS, personal observation). Further evaluation is needed to determine resources provided by saline marsh habitats for breeding mottled ducks and whether females preferentially move to areas of fresher marsh for nesting.

Structure of the vegetation community surrounding ponds had a greater influence on pond use than the presence of submergent and emergent vegetation. Mottled duck pairs selected for ponds that were surrounded by relatively short vegetation (<0.6m) and habitats influenced by livestock grazing. These conditions are complementary, with 60% of all ponds with short surrounding vegetation being grazed, whereas 28% of the ponds that were not being grazed were represented by short surrounding vegetation. For used ponds only, 73% of grazed ponds had short surrounding vegetation.

Disturbance by grazing herbivores is a natural component of the coastal marsh ecosystem (Bhattacharjee et al. 2007). Management of the Chenier Plain NWR Complex includes prescribed burning, cattle grazing, and

increasing opportunity for grazing by snow geese *Chen caerulescens* to replicate historical natural disturbance (USFWS 2006). Moderate grazing following burns in marshes also prolongs the availability of new grass shoots, a valuable food for snow geese (Gosselink et al. 1979). The current cattle-grazing management program is quite flexible to take advantage of varying quantity and quality of forage, availability of fresh groundwater to provide watering sites within all marsh types, and unit-specific management objectives (USFWS 2006). Grazing pressure and timing is used to create conditions that allow for the germination, growth, and reproduction of species adapted to frequent disturbance (i.e., early successional sere) by alternation of species composition of plant communities (Valentine 1961; USFWS 2006).

Mottled duck pair avoidance of recently burned but not grazed areas indicates that pond selection includes factors in addition to the structure of surrounding vegetation because the distribution of height of surrounding vegetation was similar between burned and grazed ponds (short grazed = 59.9% burned = 63.8%; medium grazed = 34.3% burned = 31.2%; tall grazed = 5.8% burned = 5.0%). Apparently, the physical disturbance from cattle grazing is creating additional conditions that attract paired mottled ducks. Comparisons of invertebrate populations between grazed and burned ponds may provide insight into the attractiveness of grazing-disturbed habitats to paired mottled ducks.

It is unlikely that pair-pond habitats would be used by female mottled ducks for brood rearing (Rigby 2008) or by birds during molt (Stutzenbaker 1988). Therefore, it is recommended for managers of coastal marsh to provide different habitats to attract and sustain breeding mottled ducks. However, mottled duck broods have greater survival in fresh compared to saline conditions, so management of breeding mottled ducks should concentrate on fresh marsh (Moorman et al. 1991). Use of vegetation disturbance, especially cattle grazing, is useful for management of mottled ducks in coastal marsh. Further, prescribed fire can be used to focus and distribute cattle grazing within fresher areas of coastal marsh to create pair-pond habitats attractive to mottled ducks. Grazing management is also used to create nesting cover desired by mottled ducks on the Chenier Plain NWR Complex (USFWS 2006). Our results indicate development of adaptive grazing management plans in fresh and intermediate coastal marsh will be beneficial to breeding mottled ducks.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author.

Table S1. Mottled duck presence and habitat measurements of coastal marsh ponds, 2004–2005.

Found at DOI: 10.3996/032010-JFWM-005.S1 (251 KB XLS).

Acknowledgments

We greatly appreciate the assistance of biologists and staff of the Chenier Plain National Wildlife Refuge Complex during the study. In particular, we would like to thank J. Neaville, P. Walther, M. Whitbeck, A. Loranger, and K. McDowell for their support. P. Walther, M. Whitbeck, J. Moon, J. Haskins, and M. Brasher reviewed earlier drafts of the manuscript. Comments provided by W. Conway, an anonymous reviewer and the Subject Editor helped to improve this manuscript.

Funding for the study was provided by the U.S. Fish and Wildlife Service, Region 2, Migratory Bird Office and administered by the Texas Cooperative Fish and Wildlife Research Unit at Texas Tech University.

References

- Alldredge JR, Griswold J. 2006. Design and analysis of resource selection studies for categorical resource variables. *Journal of Wildlife Management* 70:337–346.
- Allen JA. 1980. Nesting and productivity of mottled ducks in marshlands of southwest Louisiana. Master's thesis. Baton Rouge: Louisiana State University.
- Anderson MG, Titman RD. 1992. Spacing patterns. Pages 251–289 in Batt BDJ, Afton AD, Anderson MG, Ankney CD, Johnson DH, Kadlec JA, Krapu GL, editors. *Ecology and management of breeding waterfowl*. Minneapolis, Minnesota: University of Minnesota Press.
- Baker OE III. 1983. Nesting and brood rearing habits of the mottled duck in the coastal marsh of Cameron Parish, Louisiana. Master's thesis. Baton Rouge: Louisiana State University.
- Bhattacharjee J, Haukos DA, Neaville J. 2007. Vegetation response to disturbance in a coastal marsh in Texas. *Community Ecology* 8:15–24.
- Durham RS, Afton AD. 2006. Breeding biology of mottled ducks on agricultural lands in southwestern Louisiana. *Southeastern Naturalist* 5:311–316.
- Elsey RM, Trosclair PL, Linscombe JT. 2004. The American alligator as a predator of mottled ducks. *Southeastern Naturalist* 3:381–390.
- [GCJV] Gulf Coast Joint Venture. 2007. Mottled duck conservation plan. Lafayette, Louisiana. Available: <http://www.gcjv.org/docs/GCJV%20MODU%20Cons%20Plan.pdf> (September 2010).
- Gosselink JG, Curves CL, Parsons JW. 1979. An ecological characterization study of the Chenier Plain coastal ecosystem of Louisiana and Texas. Volume 1. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-78/9.
- Johnson FA. 2009. Variation in population growth rates of mottled ducks in Texas and Louisiana. Reston, Virginia: Administrative Report to U.S. Fish and Wildlife Service. Available: <http://www.fws.gov/migratorybirds/NewReportsPublications/SpecialTopics/BySpecies/Johnson.Mottled%20Ducks%20Admin%20Report.Final.pdf> (September 2010).
- Manly BFJ, McDonald LL, Thomas DL, McDonald TL, Erickson WP. 2002. Resource selection by animals: statistical design and analysis for field studies. 2nd edition. Dordrecht, The Netherlands: Kluwer Academic.
- Merendino MT, Lobpries DS, Neaville JE, Ortego JD, Johnson WP. 2005. Regional differences and long-term trends in lead exposure in mottled ducks. *Wildlife Society Bulletin* 33:1002–1008.
- Moorman AM, Moorman TE, Baldassarre GA, and Richard DR. 1991. Effects of saline water on growth and survival of mottled duck ducklings in Louisiana. *Journal of Wildlife Management* 55:471–476.
- Moorman TE, Gray PN. 1994. Mottled duck. Account 81 in Poole A, Gill F, editors. *The birds of North America*. Philadelphia, Pennsylvania: The Academy of Natural Sciences, and Washington, D.C.: American Ornithologists' Union.
- Neu CW, Byers CR, Peek JM. 1974. A technique for analysis of utilization-availability data. *Journal of Wildlife Management* 38:541–545.
- Paulus SL. 1984. Behavioral ecology of mottled ducks in Louisiana. Doctoral dissertation. Auburn, Alabama: Auburn University.
- Paulus SL. 1988. Social behavior and pairing chronology of mottled ducks during autumn and winter in Louisiana. Pages 59–70 in Weller MW, editor. *Waterfowl in winter*. Minneapolis, Minnesota: University of Minnesota Press.
- Rigby EA. 2008. Recruitment of mottled ducks (*Anas fulvigula*) on the upper Texas Gulf Coast. Master's thesis. Lubbock: Texas Tech University. Available: http://etd.lib.ttu.edu/theses/available/etd-10312008-151830/unrestricted/Rigby_Elizabeth_Thesis.pdf (September 2010).
- Stutzenbaker CD. 1988. The mottled duck—its life history, ecology, and management. Austin, Texas: Texas Parks and Wildlife Department.
- [USFWS] U.S. Fish and Wildlife Service. 2005. The U.S. Fish and Wildlife Service's focal species strategy for migratory birds: measuring success in bird conservation. Washington, D.C.: U.S. Fish and Wildlife Service, Division of Migratory Birds. Available: <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Management/FocalSpecies/The%20Focal%20Species%20Fact%20Sheet%20and%20Table.pdf> (September 2010).
- [USFWS] U.S. Fish and Wildlife Service. 2006. Texas Chenier Plain refuge complex: environmental impact statement, comprehensive conservation plan, and land protection plan. Albuquerque, New Mexico: U.S. Fish and Wildlife Service, National Wildlife Refuge System, Southwest Region, Division of Planning. Available:



- able: <http://www.fws.gov/southwest/refuges/plan/docs/TableOfContents.pdf> (September 2010).
- Valentine JM. 1961. Grazing on the Sabine National Wildlife Refuge. Lafayette, Louisiana: Bureau of Sport Fisheries and Wildlife. Unpublished report. Available from corresponding author upon request.
- Weeks JL. 1969. Breeding behavior of mottled ducks in Louisiana. Master's thesis. Baton Rouge: Louisiana State University.
- White DH, James D. 1978. Differential use of freshwater environments by wintering waterfowl of coastal Texas. *Wilson Bulletin* 90:99–111.