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Difference in exposure of water birds to covered and uncovered float muskrat sets

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Muskrats *Ondatra zibethicus* are a popular furbearer species across much of North America. Float sets have gained popularity due to the ease of use and effectiveness of capturing muskrats. Little to no research has been conducted on muskrat float sets, especially on the impacts the float sets have on non-target animals. In North Dakota, USA, regulations allowed trappers to use float sets during the spring season, but float sets were required to have a covering made of wire mesh, wood or plastic and no opening larger than 20.32 cm (8 inches) in an effort to minimize the incidental take of non-target species. We aimed to determine if there was any non-target capture injury or mortality risk on float muskrat sets. We conducted a study to compare rates of incidental take in covered (2.54 × 2.54 cm and 15.24 × 15.24 cm wire mesh) and uncovered float sets. We trapped muskrats in fall (1191 trap nights) and spring (3054 trap nights) from 2012–2014 at four study areas in North Dakota. Over four trapping periods (two fall and two spring seasons), 490 muskrats and seven non-target species were captured. Non-target species included three black-crowned night heron *Nycticorax nycticorax*, two blue-winged teal *Anas discors* and two painted turtles *Chrysemys picta*. All avian non-target species were captured on uncovered floats. Camera trap data showed that ducks were 10.1 times less likely to be on floats than other types of water birds (e.g. herons). Covers did not negatively influence muskrat captures, but smaller mesh sizes appeared to deter birds from climbing on top of floats. All but one avian non-target capture occurred after 1 May (closing of North Dakota's spring muskrat trapping season) each year, suggesting that season dates may be an important factor to consider in attempts to reduce incidental take of protected bird species.

Muskrats *Ondatra zibethicus* are one of the most widely distributed and sought-after species of furbearer in North America (Boutin and Birkenholz 1987, Roberts and Crimmins 2010). Recently, fur prices were the highest they had been in decades, leading to more trappers being on the landscape to take advantage of the pelt price increase (Tucker 2014). Common methods for trapping muskrats include the use of footholds, body gripping traps, colony traps, and float sets. Float sets are a popular form of open water trapping equipment used during spring and fall trapping seasons. A float set usually consists of a flat wooden platform that floats just above the surface of the water with either foothold or body gripping traps placed on the top of the platform. In North Dakota, anecdotal evidence suggests an increase in use of this equipment across the state (R. Tischaefer, North Dakota Fur Hunters and Trappers Association, pers. comm.). The increase in muskrat pelt prices coupled with an increase in the use of float sets has led wildlife agencies to question whether or not float sets pose a risk for incidental capture, injury, or mortality of avian non-target species (e.g. waterfowl and other water birds).

Incidental take of non-target birds can depend on the trap design and equipment (Robinson 1943, Beasom 1974, Palmisano and Dupuie 1975, Linscombe 1976, Berchielli and Tullar 1980, Berchielli and Leubner 1981, Linhart 1981, Novak 1981). Both footholds and body gripping traps have been identified as a threat to injure or kill avian non-target species (Linscombe 1976, Parker 1983, Stocek and Cartwright 1985). In a similar study in New Brunswick, Canada, the majority of avian non-target species were captured in foothold traps (Parker 1983). A province-wide survey of New Brunswick trappers in the 1980s found that 2% of trappers reported capturing a duck (Stocek and Cartwright 1985). Gashwiler (1949) is the only published study that has evaluated avian non-target captures using uncovered float sets.

Seasonal timing of trapping activities may play a role in non-target capture rates. Wright (1954) found that spring muskrat trapping was the greatest single source of accidental mortality to nesting ducks in the northeast United States. Bailey (1976) reported that incidental capture mortality from spring muskrat trapping in Manitoba reduced the number of productive mallard *Anas platyrhynchos* hens by ten percent. Mendall (1958) considered spring muskrat trapping practices as a major cause of accidental mortality to breeding ring-necked ducks *Aythya collars* in northeastern USA. Stout (1967) analyzed the continental band recoveries from incidental waterfowl captures and attributed 69 percent of spring band recoveries to muskrat trapping related mortalities. However, no research has specifically focused on the role of fall trapping in incidental take of non-target bird species.

The goal of our study was to fill the gap related to the incidental take of non-target species using float sets. Specifically, we estimated the rate of incidental take or injury of non-target species, and we estimated exposure rates and behaviors of birds at covered and uncovered float sets to determine avian non-target species vulnerability in eastern North Dakota in the fall and spring.

Methods

Study areas

We trapped muskrats using covered and uncovered muskrat float sets on four study areas (Devils Lake, Arrowwood, Chase Lake and Tewaukon) across eastern North Dakota, USA in the fall (late October–November) and spring (April–May) open water trapping seasons during 2012–2014 (Fig. 1). Trapping sites within study areas were primarily on federal wildlife refuge and waterfowl production area (WPA) properties. When needed, access to private land was obtained to supplement trapping sites. The study areas (Fig. 1) were in the four counties (Nelson, Stutsman, Sargent and Richland) which in addition to continual resident trapping pressure had the highest density of nonresident muskrat trappers (Tucker 2012b) and were heavily used by migrating birds during spring and fall migrations (Reynolds et al. 2006).

The Devils Lake study area included 64 km² in northeastern North Dakota, about 39 km northeast of the town of Devils Lake, ND. Arrowwood National Wildlife Refuge (NWR) is a 64 km² area located along the James River in east–central North Dakota. The Chase Lake study area includes 134 WPAs totaling over 157 km² of land in Stutsman and Wells Counties in south–central North Dakota. Tewaukon NWR is comprised of 33 km² of land alongside the Wild Rice River in southeastern North Dakota.

Trapping

Although many float designs and cover types exist, the designs selected for this study were based upon a preliminary survey conducted by the North Dakota Fur Hunters and Trappers Association (Tischaefer 2011). Survey results suggested the most popular float design used by trappers in North Dakota is a rectangular platform with short side bumpers, a foam bottom, and a foothold trap at each end

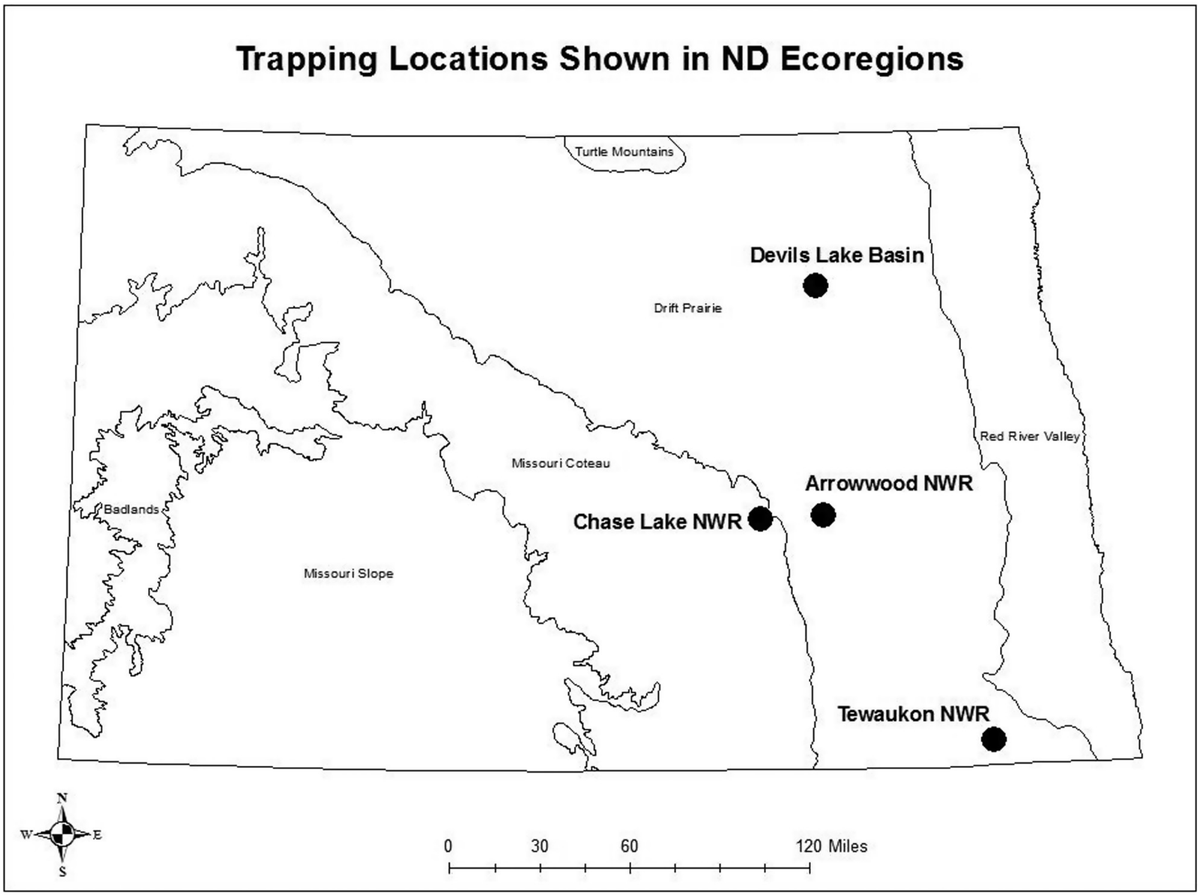

Figure 1. Major physiographic regions of North Dakota with dots marking the four study areas we used for trapping in 2012–2014. Study areas were selected because of high muskrat trapping pressure and migrating waterfowl usage.

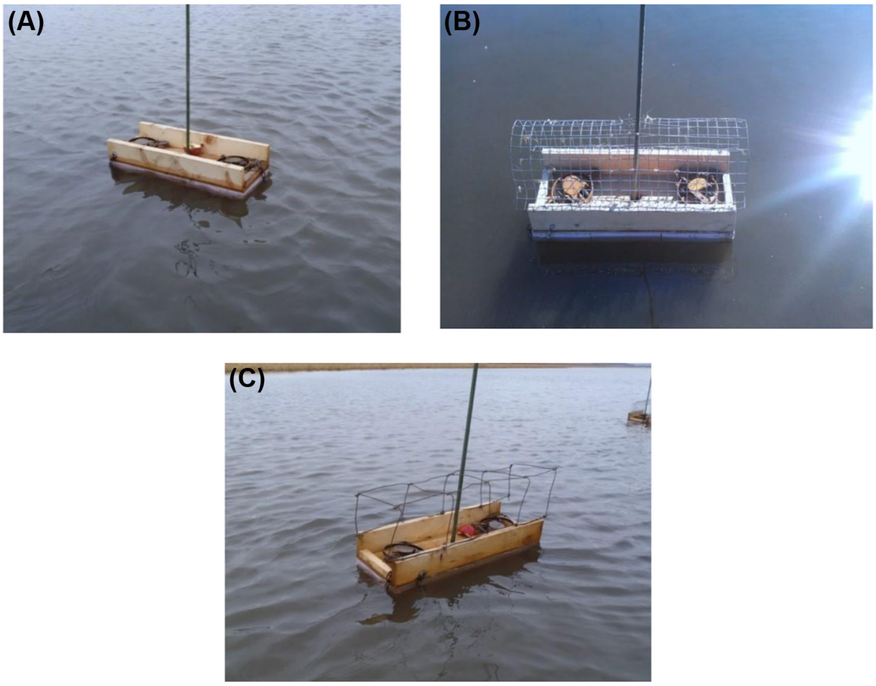

Figure 2. Rectangular float set used to capture muskrats in North Dakota, 2012–2014, with three types of coverings: (A) uncovered float set, (B) float set using 2.54×2.54 cm (1×1 in) metal wire mesh cover, and (C) float set using 15.24×15.24 cm (6×6 in) wire mesh cover type. Photos courtesy of Stephanie Tucker, North Dakota Game and Fish Department.

of the float (Fig. 2). An additional survey indicated popular cover types included wire mesh, PVC pipe, drain tile tubes, and plastic mesh (Tucker 2012a). From the most popular float covers, we selected 2.54×2.54 cm wire mesh (hereafter: 1×1) and 15.24×15.24 cm wire mesh (hereafter: 6×6) coverings in addition to a float that would have no cover (hereafter: uncovered). Also, we selected No. 1-1/2 coil spring foothold traps (Duke Company, West Point, MS) to be used at each end of our float sets.

We trapped muskrats by placing three float sets, one of each cover type, approximately 10 meters away from each other, in wetlands that were being used by water birds and had muskrat sign (e.g. presence of tracks, scat, huts and/or feeding sign). We staked float sets in place with rebar driven into the wetland substrate and baited them with apples. We classified wetlands using the system developed by Stewart and Kantrud (1971) to classify natural lakes and ponds in the glaciated prairie region. Based on their system, a seasonal pond or lake is a type III, a semi-permanent pond or lake is a type IV, and a permanent pond or lake is a type V (Stewart and Kantrud 1971). Intermediate streams (IS) were also used as a classification for road-ditch type wetlands, which are commonly used by trappers due to easy accessibility (Supplementary material Appendix 1).

We trapped a combination of approximately twenty small 'pothole' type wetlands, larger semi-permanent wetlands, and intermediate streams in each study area to replicate the typical activity of muskrat trappers in North Dakota during the open trapping season (25 October – 30 April). These types of wetlands were representative of the region of North Dakota where trapping was conducted within the Prairie Pothole Region with mostly seasonal and semi-permanent wetlands. We began trapping each spring after ice started to melt from wetlands at our southern-most study area (Tewaukon) and continued for approximately 1–2 weeks following ice-out. Then, we moved northward as spring-thaw occurred, and trapped for approximately 1–2 weeks, repeating this process until we trapped all study areas. This resulted in approximately six weeks of intensive trapping across the four study locations, some of which extended beyond the current open trapping season dates. This was done to determine if the current season dates influenced non-target species captures. We conducted fall trapping in the reverse order, starting with the northern study area (Devils Lake) and moving south as wetlands began to freeze, which coincided with peak fall migration and current and historic trapping season dates. We performed daily trap checks to remove any captures and replenished bait as needed. Within each study area, we trapped each wetland for approximately 5–7 days before moving our float sets to another wetland. Therefore, we trapped a study area for 1–2 weeks (depending on ice conditions), but individual wetlands for 5–7 days in order to emulate commonly used trapping practices, where trappers deploy traps for a week or less at a wetland and then move their traps once success begins to decline to another wetland.

When a non-target species was captured, we recorded the species, sex, date, location and extent of injuries (mortality, broken leg, etc.). If an animal (muskrat or non-target) was significantly wounded and recovery was not possible, we followed proper permit protocols from the US Fish and Wildlife Service (permit no: MB80456-1), University of North Dakota IACUC protocols (Office of Laboratory Animal Welfare No. A3917-01, Protocol No. 1208-1), and North Dakota Game and Fish Department Scientific Collecting Permits (GNF03201382, GNF03308880, and GNF03538895) for euthanasia and further necropsy of the animal to examine injuries. We reported non-target mortalities to North Dakota Game and Fish Department and the Migratory Bird Permit Office. We disposed of or donated all migratory birds to the University of North Dakota (UND) Vertebrate Museum (physical address: Biology Department, 10 Cornell Street, Stop 9019, Grand Forks, ND 58202-9019) for teaching and research specimens. We donated the majority of muskrats to the North Dakota Cooperative Fur Harvester Education Program, while a few were donated to the UND Vertebrate Museum for educational specimens.

To estimate rates of incidental take or injury, determine exposure rates at covered and uncovered muskrat float sets, and evaluate behaviors of water birds, we deployed one trail camera (Covert Extreme Red 40, Lewisburg, KY) at each float set. We placed each camera approximately 5 m from the float set and camouflaged it in nearby vegetation (e.g. cattails). We set the cameras to record video for one minute when activated by motion (high sensitivity) in the camera viewing area with a 30 s delay between videos. We defined an exposure as anytime a water bird or muskrat came into the field of view of the camera (approximately 2 m on each side of the float). To evaluate vulnerability of water birds to being trapped in a float set, we classified behaviors of water birds during exposures as either a swim by/fly by, contacting the float (such as bumping the sides, spinning the float, etc.), or on float/trapped. We defined vulnerability using two dependent variables: 1) daily exposure rates of coming within 2 m of a muskrat float set (to understand bird interactions relative to trapping effort), and 2) the frequency of contacts birds had with a float (to determine how often they might actually have a chance of capture).

Data analysis

We calculated muskrat and water bird captures per trap night, water bird daily exposure, and behaviors of water birds using video footage recorded from trail cameras placed at float sets. We also explored how covariates of trap cover type, wetland class, season, wetland site, study area, year, and bird group influenced water bird exposures and behaviors and muskrat capture efficiency by constructing regression models using SAS software (SAS Inst.). We hypothesized that exposure in the spring would be higher at semi-permanent wetlands than at larger permanent wetlands because water birds use these for breeding. We hypothesized that wetland use might differ seasonally, among bird groups (e.g. puddle ducks, diving ducks, coots, herons), or between migratory flocks as opposed to nesting pairs.

Water bird exposure at float

We used the sum of the number of detections as a measure of exposure, and analyzed this by using the number of days as an offset (see analysis details below). Note that this method does not discern among individual birds and represents total overall exposure time (not exposures per individual). We modeled exposure of water birds using a generalized linear mixed model with residual pseudo-likelihood estimation in SAS (PROC GLIMMIX) assuming a Poisson distribution, log-link, total encounters as the response variable, and log-transformed number of trap-nights as an offset. We report the inverse link of the model estimates on the data scale, which, given the offset, represent water bird exposures per float set per trap night. We included effects of trap cover type, season, wetland class, and the interaction of season and trap cover type as the fixed effects; random variables included location and wetland within a location as G-side effects (to account for non-independence of the three float types within a single wetland across the study area) and time as a residual R-side effect (with wetland as subject). We hypothesized that the interaction of season and cover type would influence the exposure rate of water birds, especially the interaction of a 1×1 cover in the spring trapping season due to the fact that the 1×1 float covering has a similar appearance to nesting structures used in North Dakota. We used an alpha value of 0.05 to evaluate statistical significance of the predictor variables.

Water bird behaviors at floats

From the camera data, we classified water bird behaviors observed at the floats as either swim by/fly by, contact float, or on float/trapped. The two contact behaviors (contact, on float/trapped) provided opportunities to evaluate potential captures based on birds coming in direct contact with the float in any way. Since a float may have already captured a muskrat or a trap may not always trigger, we wanted to determine factors influencing the probability of capture or injuries that would result from direct interactions with the float; therefore, it is a reflection of potential captures and not actual captures.

Although we classified the behaviors into separate categories, we estimated the influence of covariates on any contact by water birds at float sets using a logistic regression since most birds that contacted the float got on top of it or were captured. Thus, we examined which covariates had an impact on whether or not a water bird contacted a float in any way. Birds were divided into groups 1) puddle ducks, 2) diving ducks, and 3) other water birds (e.g. herons, coots, pelicans, etc.). We used the behavior of contacting a float as the dependent variable. Predictor variables for both regressions included cover type, season, and bird groups (other water birds compared to puddle and diving ducks combined). We did not separate out types of ducks since management questions were focused on any ducks, and due to the fact that no diving duck ever got onto to a float during our observations resulting in quasi-complete separation for this group. Year was not used due to quasi-complete separation (i.e. some years we did not have any of the behaviors exhibited by certain bird groups) during analysis. We estimated individual covariate coefficients of the global models. We transformed coefficient estimates to their respective odds ratio (OR) for interpretation. An odds ratio confidence interval including 1.0 was not considered statistically significant.

Muskrat capture efficiency

We defined muskrat trapping efficiency as the number of muskrats captured per trap night on the float sets. We modeled muskrat trapping efficiency using a generalized linear mixed model with residual pseudo-likelihood estimation in SAS (PROC GLIMMIX) using the same details as with bird encounter rates but with trapped muskrats as the response variable (assuming Poisson distribution, log-link, log-transformed trap-nights as offset, cover type, season, wetland class and the interaction of season and cover type as fixed effects, location and wetland within location as G-side random

Table 1. Summary statistics of muskrat trapping and incidental capture rates by cover type and season in eastern North Dakota, 2012–2014.

Trapping season and cover type	Trap nights	No. non-targets	No. muskrats	No. muskrats/trap night	No. non-targets/trap night
Season					
Fall 2012	273	0	22	0.081	0.000
Spring 2013	1314	1	72	0.055	0.0007
Fall 2013	918	0	165	0.179	0.000
Spring 2014	1740	6	231	0.133	0.003
Cover type					
Uncovered	1415	5	159	0.112	0.004
1×1	1415	1	125	0.088	0.001
6×6	1415	1	204	0.144	0.001
Total	4245	7	490	0.115	0.002

effects, and time with wetland as subject as residual R-side random effects). We examined the coefficient estimates to determine what impact individual covariates had on daily capture rates of muskrats at float sets. We report the inverse link of the model estimates on the data scale, which given the offset, represent muskrat captures per float set per trap night.

Results

Trapping

We captured seven non-target animals over 4245 trap nights (i.e. capture rate of 0.002 for non-target species/trap night) on 112 wetlands (55 type III, 33 type IV, 5 type V and 19 IS) during fall and spring trapping seasons over the two year study period (Table 1). Non-target species captured included three unknown sex black-crowned night herons *Nycticorax nycticorax*, two female blue-winged teal *Anas discors*, and two unknown sex painted turtles *Chrysemys picta* (Table 2). The non-target captures all occurred during the spring season on different wetlands. All avian non-target species that were captured occurred on uncovered float sets and were fatal. The turtles were captured on a 1×1 and a 6×6 float set, but neither was fatal and turtles were released alive. Three of the incidental captures (two painted turtles and a black-crowned night heron) occurred during the open muskrat trapping season (25 October – 30 April), while the other four captures (two blue-winged teal and two black-crowned night herons) came after the closing date of the season (Table 2).

Water bird exposure rates at floats

We evaluated 8207 water bird encounters with float sets over the two year study period from 311 377 one-minute video recordings collected by trail cameras placed at each float set (Table 3). Avian non-target species had a daily exposure rate of 1.93 exposures per day (Table 3). Puddle ducks (47.5%) were observed most frequently around float sets followed by other water birds (33.0%) and diving ducks (9.5%) (Table 3). Puddle ducks were exposed to float sets 1.74 times more frequently than other water birds and 6.17 times more frequently than diving ducks (Table 3).

Although we could not insure complete independence among individuals (i.e. no marked individuals) from our camera data, we examined time between camera triggers where a non-target species was observed to determine how often we may be having the same individual triggering the camera. We found that 76.8% of events did not occur on the same day, have the same species or have the same number of individuals in consecutive observations. Of the consecutive observations that occurred with the same species and number of individuals, only 8.5% occurred within 20 min of one another and only 3.1% occurred within 5 min of one another. We interpret this to mean two things: 1) the number of exposure events that occurred within the 30 s delay of our cameras was small, and therefore unlikely to bias our 'per day' estimates of exposure rates, and 2) any repeat visits by the same individual to the same float set generally occurred greater than 5–20 min apart and could thus be reasonable interpreted as a unique exposure event. Thus, we decided to include all camera observations in order to examine encounters reflecting encounter rates of non-target species to float sets.

From our global-mixed model for non-target exposures, we found cover type of the float had a significant influence (Table 4) on whether an avian non-target was exposed to a float set with higher exposures occurring at floats without covers (Fig. 3). Season influenced daily exposure rates at each float set with 1.7314 fewer avian non-target species exposures per day in the fall as compared to spring (Fig. 3). Although not statistically significant (Table 4), we found

Table 2. Incidental captures from muskrat float sets in North Dakota (2012–2014).

Species	Date	Cover type	Wetland class	Mortality	Study area
Black-crowned night heron	27 April 2013	none	4	yes	Tewaukon
Black-crowned night heron	14 May 2014	none	4	yes	Chase Lake
Blue-winged teal	10 May 2014	none	3	yes	Chase Lake
Black-crowned night heron	22 May 2014	none	4	yes	Devils Lake
Blue-winged teal	21 May 2014	none	4	yes	Devils Lake
Painted turtle	22 April 2014	1×1	3	no (released)	Tewaukon
Painted turtle	21 April 2014	6×6	3	no (released)	Tewaukon

Table 3. Summary statistics of the number of observed exposures of water birds and muskrats from trail camera videos collected over 4245 trap nights during fall and spring trapping season in eastern North Dakota, 2012–2014.

Species	Swim by or fly-by	Contact float	On float or trapped	Any contact or exposure	Total	No. exposures day^{-1}
Muskrat	520	168	461	0.547	1149	0.27
Puddle duck	4709	1	13	0.003	4723	1.11
Diving duck	774	0	0	0.000	774	0.18
Other water birds	2665	4	41	0.017	2710	0.64
Total birds	8148	5	54	0.007	8207	1.93

a trend for higher daily exposure rates at more permanent wetlands (type IV and V) as compared to the smaller semi-permanent type wetlands (type III, and IS) with 1.547 fewer daily exposures at floats located in type IS wetlands than class V wetlands.

Water bird behaviors at floats

The most common type of water bird behavior observed at float sets was a swim by / fly by (99.3%). Other less common behaviors included contact float (0.1%) and on float/trapped (0.3%; Table 3). We found that regardless of bird group, avian non-target species were on average 2.3 times (1/0.432) less likely to contact a float set with a 1×1 cover as compared to an uncovered float set, but 6×6 covers had similar probabilities of contact as uncovered (Table 5). Avian non-target species were 7.5 times (1 / 0.133) less likely to contact a float set in the fall as compared to the spring season (Table 5). Other, non-duck water birds showed the greatest vulnerability to float sets and were 10.1 times more likely to contact a float set as compared to puddle and diving ducks collectively (Table 5). In fact, no diving duck ever contacted a float during this study.

Black-crowned night herons and blue-winged teal were the most common non-target species to climb onto float sets. Black-crowned night herons encountered float sets 13 times, with eight of those resulting in a night heron climbing onto a float set (61.5% of total behaviors observed for this species). Blue-winged teal climbed onto float sets during 13 of the 3578 encounters observed at float sets (0.4% of total behaviors observed for this species).

Table 4. F-values for type III tests of fixed effects (A) and least-squares means (B) of bird exposure rates and muskrat capture rates for three types of covers on muskrat float sets in fall and spring and at different wetland classes.

Effect	Numerator df	Bird encounters	Muskrat captures
Fixed effects (Denominator df)		(467)	(450)
Cover type	2	5.06**	6.88**
Season	1	51.05***	4.78*
Cover type × Season	2	1.95	5.23*
Wetland class	3	1.87	0.90
Cover type means			
1 × 1		1.19	0.06
6 × 6		1.00	0.10
none		1.79	0.08
Season means			
Fall		0.69	0.09
Spring		2.42	0.07
Wetland class			
IS		0.67	0.11
3		1.24	0.07
4		1.52	0.06
5		2.21	0.08

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Muskrat capture efficiency

We captured 490 muskrats (all fatal captures) over 4245 trap nights during fall and spring seasons at all trapping locations over the two year study period (Table 1). The use of covers on float sets did not negatively impact trapping efficiency; in fact, float sets with a 6×6 cover had the highest captures per day, with this most noticeable in the spring season (Fig. 4). Wetland class did not have an impact on trapping efficiency (Table 4). Trapping efficiency was higher on average (Table 4) during the fall trapping season compared to the spring, but an interaction between float set cover type and season (Table 4) suggested that seasonal differences in trapping efficiency may vary by float set cover type (Fig. 4).

Discussion

Our results suggest that water birds are vulnerable to incidental capture or injury from the use of uncovered muskrat float sets, but that covers are effective at eliminating non-target captures of avian species during both spring and fall trapping seasons without affecting trapping efficiency for muskrats. These results are consistent with past research that have found that muskrat trapping and the equipment used (e.g. footholds, body grippers, etc.) may negatively impact non-target animals through incidental take or injury (Gashwiler 1949, Wright 1954, Mendall 1958, Stout 1967, Bailey 1976, Linscombe 1976, Parker 1983, Stocek and Cartwright 1985).

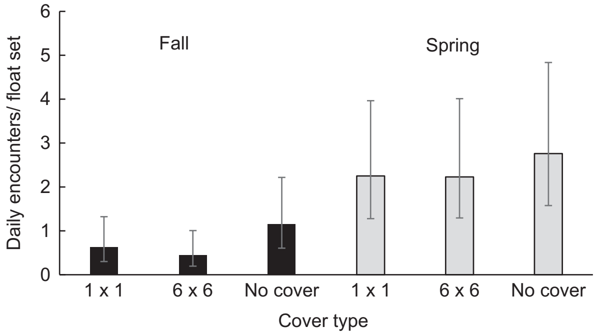

Figure 3. Daily bird encounters at muskrat float sets with 1×1 inch covering, 6×6 in cover, and no covering during the fall and spring muskrat trapping seasons in eastern North Dakota (2012–2014).

Table 5. Covariate coefficient estimates examining whether or not a water bird contacted a float set after an exposure (i.e. coming within 2 m of float). Associated odds ratios (OR) are also calculated for result interpretation.

Parameter	Estimate	SE	Odds ratio	OR LCI	OR UCI
Intercept	–5.5078	0.3554			
1 × 1	–0.8399	0.4123	0.432	0.192	0.969
6 × 6	0.1822	0.2973	1.200	0.670	2.149
Season[a]	–2.0148	1.0123	0.133	0.018	0.970
Bird group[b]	2.3141	0.3515	10.116	5.079	20.147

[a]Spring (compared to fall) was used as the baseline for season analysis. [b]Other water birds were compared to ducks (baseline) in analysis of bird group.

Most studies focus on the vulnerability of waterfowl to muskrat trapping practices and do not include other common water birds. To our knowledge only a few studies have looked at water bird vulnerability during the spring seasons, and no studies have focused on the fall season (Gashwiler 1949, Wright 1954, Mendall 1958, Stout 1967, Bailey 1976).

Gashwiler (1949) reported capture of one duck for every 14.7 muskrats captured, and estimated a total of 1945 mortalities and another 2220 injuries to ducks during the 1946 spring muskrat trapping season in Maine. By comparison, we caught one water bird for every 98 muskrats captured or 0.002 bird / trap night. The difference in magnitude of water bird captures could be due to the difference in habitat and species of birds present in North Dakota and Maine. Gashwiler (1949) showed that 43 percent of waterfowl captured were American black ducks *Anas rubripes*, which are not common in North Dakota.

We also demonstrate that water birds are vulnerable in the fall, which has previously not been demonstrated, but we observed very few captures overall. Birds were more likely to contact and even sit on top of a float during the spring. This is likely due to the breeding behaviors displayed in the spring, such as using floating structures for nesting sites, as compared to fall.

The most vulnerable bird group was the other water bird category (e.g. coots, grebes, herons, etc.), which were >10 times more likely to contact a float as compared to duck species. Also, herons were more likely to be captured in a float set compared to duck species. It is worth noting, that we never observed a diving duck on top of a float, only puddle ducks. We captured 3/8 herons that contacted the float sets, as compared to 2/13 puddle ducks. This may be in part due to the breeding and feeding behavior of some water bird species to nest or perch on floating vegetation or structures in the springtime (Baldassarre and Bolen 2006). Also, muskrat float sets resemble some artificial nesting structures (e.g. hen houses) that are widely used by waterfowl in wetlands in eastern North Dakota, and this may make female ducks that are prospecting for nest sites particularly vulnerable to incidental take during spring muskrat trapping seasons.

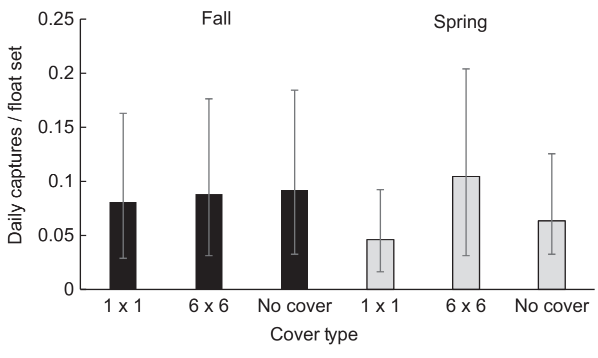

Figure 4. Daily captures of muskrats per float set at covered and uncovered float sets during fall and spring trapping seasons in eastern North Dakota (2012–2014).

Cover type did influence exposures of water birds to float sets, but perhaps more importantly cover type played an important role in whether or not a float set was contacted or if the bird was trapped. Our results suggest that muskrat trapping efficiency is not really decreased by the use of 1 × 1 and 6 × 6 wire mesh coverings on float sets. In fact, we captured the most muskrats on a 6 × 6 wire mesh covered float set (42.7%). These results show that covers on float sets do not negatively impact muskrat captures as compared to uncovered float sets, and a covered float set does not deter a muskrat from encountering it.

The application of our research are not limited to eastern North Dakota because surrounding states have also observed an increase in the use of muskrat float sets, and South Dakota, Nebraska and parts of Alaska have spring trapping seasons. The original cover requirement by North Dakota Game and Fish for muskrat float sets was to have a covering made of wire mesh, wood or plastic and no opening larger than 20.32 cm (8 in). This may result in floats that have sides and sit higher in the water than other designs used in areas not having cover requirements. Float set designs that sit lower in the water and are uncovered have been reported to catch non-target water birds at potentially higher rates (South Dakota Game Fish and Parks, pers. comm., September 2013). We believe this is due to the fact that these floats would be easier to climb onto by birds and other non-target species than our float design. Our float design was difficult for water birds to get onto and also to stay on. Videos collected during the study showed that when a water bird attempted to get onto a float set, they needed to flap their wings just to get far enough out of the water and get onto the float set. When the water bird would get onto the float set, the floats were unstable and would 'wobble' in the water which most of the time forced the water bird to exit the float set. In contrast, a float set design without sides to attach a cover would sit lower in the water and be more stable for a water bird to go onto. We believe that our design is less appealing to non-target water bird capture by being higher in the water and creating an unstable perch for water birds. Further research is needed on the effect float set height in the water has on non-target water bird injury or take to confirm if this is correct.

Management implications

Although only a few migratory birds were taken during this study, any incidental take of migratory birds is illegal under federal law in the United States. Therefore, unless/until incidental take by trappers is specifically permitted or exempted under the migratory bird regulations in North America, we recommend the use of trap covers during any open water trapping seasons or high risk exposure periods for migratory birds. This requirement would have the added benefit of protecting trappers from violating federal laws associated with incidental take of migratory birds. Based on our research, current float cover regulations and season dates (25 October – 30 April) on muskrat float sets in North Dakota are efficient in limiting incidental non-target water bird take or injury through the requirement of float set coverings during peak waterfowl migration in the spring trapping season. Continued research on this subject will ultimately help to understand float designs and timing of seasons that mitigate impacts on local ecosystems.

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Supplementary material (available online as Appendix wlb-00308 at <www.wildlifebiology.org/appendix/wlb-00308>). Appendix 1.