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Study: Buffer zone distances to protect foraging and loafing waterbirds from disturbance by personal watercraft in Florida (Study 7520)

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Abstract: Thirty-nine species of waterbirds (Pelecaniformes, Ciconiiformes, Falconiformes, Charadriiformes) were exposed to the rapid approach of a personal watercraft (PWC) and an outboard-powered boat to determine their flushing distances to these two watercraft (n=1,152 flushes). Considerable variation in the flush distances existed among individuals within the same species and between species of waterbirds to both types of vessel. The minimum and maximum flush distances ranged from 5 to 159 m, whereas the average flush distances among species ranged from 17.64 (least tern [*Sterna antillarum*]) to 57.92 m (osprey [*Pandion haliaetus*]). A comparision of the flush distances elicited by the approach of a PWC versus an outboard-powered boat indicated that only the great blue heron (*Ardea herodias*) exhibited significantly (*t*-test, $P<0.05$) larger flush distances to the approach of a PWC, whereas five species (anhinga [*Anhinga anhinga*], little blue heron [*Egretta caerulea*], caspian tern [*S. caspia*], willet [*Catoptrophorus semipalmatus*], and osprey) exhibited significantly (*t*-test, $P<0.05$) larger flush distances to the approach of an outboard-powered boat. Eleven species showed no significant (*t*-test, $P>0.05$) difference in their flush distances to the approach of either a PWC or outboard-powered boat. These preliminary data on flush distances suggest that a single buffer zone distance should be developed for both PWC and outboard-powered vessels.

Wildlife disturbance and harassment may reduce species diversity and density at the landscape or regional scale (Boyle and Samson 1985, Cole and Knight 1990). As foraging habitat becomes fragmented and human disturbances increase, more skittish species may find it difficult to secure adequate food or loafing sites (Skagen et al. 1991, Pfister et al. 1992). Conflicts arise because many aquatic habitats used by foraging waterbirds (e.g., shorelines, beaches, sandbars, and islands) also are attractive to outdoor recreationists. For example, Burger (1981) found a reduced number of shorebirds near people who were walking or jogging and about 50% of flushed birds were forced elsewhere. Boyle and Samson (1985) found wildlife observers were especially disturbing to animals because of the frequency and duration of their visits. Human disturbances can indirectly (Skagen et al. 1991, Pfister et al. 1992) or overtly (Knight and Skagen 1988, Cole and Knight 1990) disrupt wildlife community dynamics.

Several studies have suggested that the distance between human activities and wildlife was a major factor in determining if and when birds flushed and recommended not approaching wildlife or reducing the frequency of disturbances (Burger 1981, Belanger and Bedard 1989, Burger and Gochfeld 1991*a*,*b*, Grubb and King 1991, Klein 1993, Roberts and Evans 1993). Burger and Gochfeld (1991*a*) found foraging time of sanderlings (*Calidris alba*) decreased and avoidance (e.g., running, flushing) near human activities increased as the number of humans within 100 m increased. Knight and Knight (1984) suggested that flight distances of birds flushed by different types of disturbances could be used to develop zones for restricting human activities. Such buffer zones or set-back distances are one strategy to minimize the effects of human disturbance to wildlife (Erwin 1989; Rodgers and Smith 1995, 1997). Previous recommendations for buffer zones to protect waterbirds have been primarily implemented around breeding colonies and have ranged from 50 to 200 m for tern (Sterninae) species (Buckley and Buckley 1976, Erwin 1989, Rodgers and Smith 1995) and 100 to 250 m for wading bird (Ardeidae) species (Vos et al. 1985, Erwin 1989, Rodgers and Smith 1995). Although Florida began using buffer zones to protect waterbird nesting sites from human disturbances in 1976, distances for buffer zones used by natural resource personnel based on regional empirical data only recently have been developed to protect breeding colonies (Rodgers and Smith 1995) and foraging and loafing birds (Rodgers and Smith 1997) from approach of humans, motor vehicles, and outboard-powered boats.

However, there are no specific recommendations for buffer zones to reduce disturbance to waterbirds by personal watercraft (PWC). There are an estimated 1.2 million PWCs in the United States, with an additional 200,000 PWCs sold annually. The Personal Watercraft

Industry Association (1997) projects that the number of registered PWCs in the United States will be about 3.7 million by the year 2000. Because of the warm waters and climate, and abundant coastal shorelines, Florida had about 116,958 registered PWCs in 1997 (Florida Department of Highway Safety, Tallahassee), which does not include the number of PWCs brought into the state by visitors. In addition to a perceived noise factor, operators repeatedly accelerate and decelerate during typically erratic turns and maneuvers, which frequently changes loudness and pitch. This noise factor, in conjunction with the PWC's unusually large horizontal spray compared to other powerboats of similar size, has the potential to be especially disturbing to wildlife. PWCs also can travel into shallow, protected areas that are favored by foraging and loafing waterbirds.

The ultimate goal of this study is to recommend buffer distances that will minimize PWC disturbance to foraging and loafing waterbirds in Florida. Florida is an important area for providing resident waterbird habitat, winter shorebird refugia, and staging areas for migrating species along both coasts. Using a technique previously developed for recommending buffer zones for waterbirds in Florida (Rodgers and Smith 1995, 1997), the objectives of this study are to collect data on the distances to birds flushed by PWCs at multiple sites and calculate appropriate buffer zones for foraging and loafing waterbirds in response to PWC disturbances.

METHODS

Eleven sites along the east and west coasts of Florida were visited with a mixture of low, moderate, and high amounts of human activity to avoid the problems of habituation and autocorrelation in the response by birds. Care was taken to conduct the flushing of waterbirds out of view of the public to avoid a negative image. As a control, I decided to compare the flushing distances in response to the rapid approach of a PWC with a outboard-powered boat. Two types of watercraft were used to flush birds: a 14-foot jonboat (length=4.42 m, width=1.75 m) with a 30 horse-powered Mercury outboard motor and Sea•Doo model GTX (length=3.20 m, width=1.22 m). Specific data regarding the noise generated by each vessel in the water are given in Table 1.

Data was collected during September–November 1998 and April–June 1999 on the flush distances of birds in response to watercraft approach for several species of waterbirds (Pelecaniformes spp., Ciconiiformes spp., Charadriiformes spp., Falconiformes sp.). For both practical and biological reasons, experimental birds were flushed while they are engaged in foraging and loafing behaviors, as opposed to nesting activities. Based on a previous study (Rodgers and Smith 1995), it is difficult to flush a single species in a colony and the flushing event causes considerable disturbance to the nesting birds. In addition, 5 of 9 species comparisons exhibited significantly greater flushing distances while foraging or loafing compared to flushing distances while nesting (Rodgers and Smith 1997). Grubb and King (1991) also found that bald eagles (*Haliaeetus leucocephalus*) more often flushed from perches than nests and more easily flushed while foraging than while nesting. Thus, buffer zone distances derived from non-breeding birds should be adequate to protect nesting birds. In a study of Canada geese (*Branta canadensis*), Belanger and Bedard (1990) found that human disturbance increased energy expenditure by the birds (via flight and alertness) and reduced their energy intake (via lower feeding rates). Access by birds to disturbance-free foraging areas to secure food for nestlings may be as important as disturbance-free breeding sites and suitable nesting substrate in determining the stability of a colony (Rodgers and Smith 1997).

Because it is difficult to quantify the initial alert response distance to a disturbance, I used the more readily detected and easily measured flushing distance as an index of watercraft disturbance. Flushing distance is defined as the distance from the observer to the bird at the moment it actually begins movement away from the approaching watercraft. When approaching a group of birds, distance was measured from the first bird in the group that flushed to the watercraft. The distance between the watercraft and the bird's location was measured in meters using a Bushnell Yardage Pro® laser range finder with calibrated accuracy of ± 1 m.

Each approach towards an experimental bird employed two people and a standardized approach technique for both types of watercraft. A lead observer on one PWC located the subject bird from a distance of at least 250 meters and approached in a direct, but irregular path at moderate speed of 25-35 km/hr. At the instant the bird began to move from its foraging or loafing location, a marker buoy was dropped into the water. The second observer on another PWC idled at the marker buoy and measured the straight-line distance to the former location of the flushed bird in the water or on shore. The use of with the jonboat was different in that but both people were in the boat but the approach towards the bird, marking the flushing point, and measuring the flush distance were similar.

Data collection was restricted to between 0700-1600 hours on clear to partly cloudy days, with wind conditions <15 km/h. To reduce the effect of autocorrelation between the first bird flushed and subsequent flushing events and to minimize impacts on avian activities, I limited the number of disturbances to one or two events/species at each site within 1000 m of one another. Flushing distances for individual birds or flocks were measured only once. Because of these restrictions, sample sizes often were unbalanced among species, age, and site classes (i.e., not all combinations will be represented by sample sizes ≥ 10).

The empirical quantiles versus the quantiles of a standard normal distribution and histograms for untransformed flushing distances for species with ≥ 10 observations were plotted using the UNIVARIATE procedure (SAS Institute, Inc. 1990*a*). The Shapiro-Wilk statistic was used to test whether the data were normally distributed for each species x age, species x site, and species x age x site. Residuals from an ANOVA model plotted against the predicted values also were used to examine for a random scatter that suggested homogeneity of variance and the appropriate transformation of the flushing distances. Analysis of the data indicated the distances often exhibited a right-skewed distribution (i.e., data were positive skewed or smaller distances were more frequent than larger distances) and required a log transformation to normalize the data when appropriate. ANOVA/Fisher's protected least-significant difference test (SAS Institute, Inc. 1990*b,c*) were used on subsets (i.e., species x age, species x site, species x age x site, species x species) to test for the null hypothesis that no significant ($P>0.05$) differences existed in the flushing distances among and within species and sites.

Recommend buffer distances for individual species will ultimately be calculated using the mean and standard deviation of the sampled populations (Rodgers and Smith 1995, 1997). Because of concurrent activity of other birds or reactions to prey while the bird foraged, it was not always possible to determine when the bird under observation first exhibited an alert response to the approach of the watercraft. However, the mean difference between when a bird exhibited alert behavior and flushed was 19.34±11.56 m (range=4–62 m, n=169 flushes). The estimated upper limit for the 95th percentile of the alert distance prior to flushing is 38.11 m. This agrees closely with previous observations from blinds when single birds approached by a person became alert 25–40 m prior to flushing (Rodgers and Smith 1995). The addition of 40 m to the flushing distances of sampled populations is a conservative strategy to minimize agonistic responses by birds and take into consideration the suggestion by Thompson and Thompson (1985) that mixed species assemblages are more vigilant and skittish than single species groups.

Buffer distances will be derived in the following manner. For a given species, let X_i represent the observed flushing distance for an individual approach i, and $Y_i = \ln(X_i)$. It is assumed that the X_i are independent, identically distributed and followed a lognormal distribution with parameters μ and σ such that $\mu = E(Y_i)$ and $\sigma^2 = \mathrm{var}(Y_i)$. The desired buffer distance will be defined as the upper limit of an approximate 95th percentile of a one-sided confidence interval for $E(X)$ plus 40 m. That is

$$\text{buffer distance} = \exp(\hat{\mu} + Z_{0.95}\,\hat{\sigma}) + 40 \text{ m},$$

where $\hat{\mu}$ and $\hat{\sigma}$ are the sample mean and standard deviation for the observed values of $Y_i = \ln(X_i)$, $i = 1, \ldots, n$, and $Z_{0.95}$ is the 0.95 quantile of a standard normal variable (i.e., $Z_{0.95}=1.6495$). I believe the 95th percentile criterion provides a sufficiently conservative margin in the establishment of buffer zones for waterbirds.

RESULTS

Thirty-nine species of waterbirds (Pelecaniformes, Ciconiiformes, Falconiformes, Charadriiformes) were exposed to the rapid approach of a personal watercraft and an outboard-powered boat (n= total of 1,152 flushing distances). The following narrative only concerns those species for which the number of data ≥10 flushes.

PWC flush distances

Considerable variation in the flush distances existed among individuals within the same species and significant (ANOVA/Fisher's lsd test, $P<0.05$) differences occurred among species of waterbirds to the approach of a PWC (Table 2). Extreme distances ranged from 5 to 159 m, whereas the average distances among species ranged from 17.64 (least tern [*Sterna antillarum*]) to 48.80 m (great blue heron [*Ardea herodias*]). In general, larger species exhibited greater average flushing distances suggesting larger species may require longer take-off times (*cf.* smaller shorebirds with larger herons). Surprisingly, the brown pelican (*Pelecanus occidentalis*) exhibited one of the larger average flush distances despite its close association with and known habituation to boating activities along the coast.

Outboard-powered boat distances

Considerable variation in the flush distances also existed among individuals within the same species and significant (ANOVA/Fisher's lsd test, $P<0.05$) differences occurred among species of waterbirds to the approach of an outboard-powered boat (Table 3). Extreme flush distances ranged from 8 to 156 m, whereas the average distances among species ranged from 22.31 (forsters tern [*S. forsteri*]) to 57.92 m (osprey [*Pandion haliaetus*]). As with the PWC, larger species generally exhibited greater average flushing distances (*cf.* smaller shorebirds with larger herons). Once again, the brown pelican exhibited one of the larger average flush distances.

PWC versus Outboard-Powered Boat

A comparision of the flush distances elicited by the approach of a PWC versus an outboard-powered boat indicated that only the great blue heron exhibited significantly (*t*-test,

$P<0.05$) larger flush distances to the approach of a PWC, whereas five species (anhinga [*Anhinga anhinga*], little blue heron [*Egretta caerulea*], caspian tern [*S. caspia*], willet [*Catoptrophorus semipalmatus*], and osprey) exhibited significantly (*t*-test, $P<0.05$) larger flush distances to the approach of an outboard-powered boat (Table 4). Eleven species showed no significant (*t*-test, $P>0.05$) difference in their flush distances to the approach of either a PWC or outboard-powered boat.

DISCUSSION

Eleven of 17 species comparisons (64.7%) showed no significant difference in the flush distance between the approach of a PWC and an outboard-powered boat. Despite their reputation for noise and wildlife disturbance, the direct approach of a PWC rarely elicited a greater flush distance. Rather, when there was a significant difference in the flush distance, the conventional outboard-powered boat most often exhibited the larger flush distance (5 of 6 comparisons or 83.3%).

A major difference in the operation of a PWC and an outboard-powered boat is the ability of the former vessel to be operated at fast speeds and in shallow water. These two features are often cited as a cause of waterbird disturbance. However, with the advent of jet-foot and jack-plate devices, outboard-powered boats also can be operated at fast speeds and in shallow water. Thus, both PWC and outboard-powered vessels have the potential to disturb foraging and loafing waterbirds. The preliminary data collected during this study on flush distances suggest that a single buffer zone distance should be developed for both PWC and outboard-powered vessels.

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Table 1. Sound energy (decibels) recordings of water vessels used in the flushing of waterbirds.

Distance	Jonboat	Personal watercraft
10 meters	87	83
20 meters	82	77
30 meters	76	72
40 meters	71	69
50 meters	66	64

Table 2. Flush distances in meters of waterbirds (minimum of 10 flushes) to the rapid approach of a personal watercraft.

Species	Number	Minimum	Maximum	Mean	SD
Anhinga	60	19	115	44.09	20.06
Brown pelican	70	5	130	47.01	31.95
Double-crested cormorant	85	5	111	48.47	25.42
Great blue heron	122	8	120	48.80	22.11
Great egret	125	10	130	45.53	18.72
Little blue heron	56	16	92	33.94	11.71
Reddish egret	17	19	70	42.93	14.70
Snowy egret	50	5	85	30.39	16.31
Tricolored heron	37	11	91	39.85	19.44
White ibis	35	5	112	37.43	23.22
Wood stork	10	20	69	36.32	13.81
Caspian tern	18	10	50	29.13	10.12
Royal tern	48	11	138	35.68	22.99
Forsters tern	26	9	51	21.50	8.65
Least tern	13	5	46	17.64	9.60
Laughing gull	57	5	64	27.82	14.57
Ring-billed gull	10	19	88	41.76	21.37
Black-bellied plover	46	9	68	23.88	10.12
Willet	52	7	65	24.47	10.99
Oystercatcher	48	5	80	29.12	13.76
Long-billed dowitcher	20	9	42	19.45	8.01
Osprey	68	20	159	48.42	20.74

Table 3. Flush distances in meters of waterbirds (minimum of 10 flushes) to the rapid approach of a outboard-powered boat.

Species	Number	Minimum	Maximum	Mean	SD
Anhinga	55	11	135	53.16	23.06
Brown pelican	76	20	134	52.80	22.70
Double-crested cormorant	73	15	129	42.76	19.94
Great blue heron	91	10	137	41.95	20.33
Great egret	90	16	156	50.99	22.64
Little blue heron	50	16	108	49.48	22.49
Snowy egret	67	9	97	31.78	15.29
Tricolored heron	42	10	98	44.36	22.28
White ibis	50	9	81	36.54	17.60
Caspian tern	10	22	121	50.83	28.34
Royal tern	23	10	71	29.06	14.44
Forsters tern	26	8	52	22.31	8.23
Laughing gull	47	11	56	27.74	10.70
Willet	62	17	82	31.48	10.32
Black-bellied plover	41	11	48	22.92	9.06
Oystercatcher	37	11	59	30.27	11.48
Osprey	56	30	140	57.92	22.40

Table 4. Comparison of flush distances of waterbirds to the rapid approach of a personal watercraft and outboard-powered boat.

Species	Mean flushing distance (m)		
	PWC	Jonboat	Difference[a]
Anhinga	44.09	53.16	$P<0.04$
Brown pelican	47.01	52.80	n.s.
Double-crested cormorant	48.47	42.76	n.s.
Great blue heron	48.80	41.95	$P<0.02$
Great egret	45.53	50.99	n.s.
Little blue heron	33.94	49.48	$P<0.01$
Snowy egret	30.39	31.78	n.s.
Tricolored heron	39.85	44.36	n.s.
White ibis	37.43	36.54	n.s.
Caspian tern	29.13	50.83	$P<0.01$
Royal tern	35.68	29.06	n.s.
Forsters tern	21.50	22.31	n.s.
Laughing gull	27.82	27.74	n.s.
Willet	24.47	31.48	$P<0.01$
Black-bellied plover	23.88	22.92	n.s.
Oystercatcher	29.12	30.27	n.s.
Osprey	48.42	57.92	$P<0.04$

[a] *t*-test performed on log-transformed data.