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ORIGINAL PAPER

Effects of Broadcasting Conspecific and Heterospecific Calls on Detection of Marsh Birds in North America

Courtney J. Conway · Christopher P. Nadeau

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Abstract Standardized protocols that include the use of call-broadcast have recently been proposed for marsh birds in North America. We used data from point-count surveys collected across North America over eight years to evaluate the extent to which each of 13 focal marsh bird species responded to conspecific and heterospecific call-broadcast relative to passive survey methods. Surveyors detected more individuals during the 1-minute of conspecific call-broadcast compared to each of the five 1-minute passive segments and all of the 1-minute heterospecific call-broadcast segments for all species. Surveyors also detected more individuals during most of the 1-minute heterospecific call-broadcast segments compared to the 1-minute passive segments. Most birds responded to conspecific call-broadcast quickly (within 1 min), but we found some evidence for a lag time in birds' response to conspecific calls. The percent increase in the number of birds detected as a result of conspecific call-broadcast (relative to passive survey methods) varied between 14% (American bitterns *[Botaurus lentiginosus]*) to 632% (purple gallinules [*Porphyrula martinica*]). We recommend the use of point-count surveys that include both passive and call-broadcast segments for numerous marsh birds when collecting data to assess occupancy, evaluate the effects of wetland management practices, and estimate population trends of marsh birds.

Keywords Bitterns · Call-broadcast surveys · Detection probability · Marshlands · Rails · Tape playback

Introduction

The acreage of emergent wetlands in North America has declined sharply during the past century (Tiner 1984; Dahl 2006). Populations of many marsh birds that are dependent on emergent wetlands may be adversely affected by this reduction in emergent wetlands. Primary species of concern in North America include black rails (*Laterallus jamaicensis*), yellow rails (*Coturnicops noveboracensis*), soras (*Porzana carolina*), Virginia rails (*Rallus limicola*), king rails (*R. elegans*), clapper rails (*R. longirostris*), common moorhens (*Gallinula chloropus*), purple gallinules (*Porphyrula martinica*), American coots (*Fulica americana*), least bitterns (*Ixobrychus exilis*), American bitterns (*Botaurus lentiginosus*), pied-billed grebes (*Podilymbus podiceps*), and Wilson's snipe (*Gallinago delicata*). Many of these species are rare in some or all of their breeding range, and are listed on many regional and national lists of conservation concern. For example, the U.S. Fish and Wildlife Service (2002) identified black rails, yellow rails, and American bitterns as *Birds of Conservation Concern*, king rails (endangered) and least bitterns (threatened) are federally listed in Canada, California black rails and several subspecies of clapper rails are federally endangered in Mexico, and the three western subspecies of clapper rail are federally endangered in the U.S. Moreover, many of these species are game birds in many states and provinces (Tacha and Braun 1994), but

C. J. Conway (✉)
U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit,
School of Natural Resources and the Environment,
325 Biological Sciences East, University of Arizona,
Tucson, AZ 85721, USA
e-mail: cconway@usgs.gov

C. P. Nadeau
School of Natural Resources and the Environment,
325 Biological Sciences East, University of Arizona,
Tucson, AZ 85721, USA

sufficient knowledge of population status, necessary to set responsible harvest limits, is currently lacking for many species.

For these reasons, efforts have been underway during the last decade to develop continental survey protocols and a sampling design for conducting marsh bird surveys throughout North America (Ribic et al. 1999; Conway and Gibbs 2001; Conway and Timmermans 2005; Conway and Droege 2006; Johnson et al. 2009). Standardized survey protocols are now available (Conway 2008), but participants of a recent marsh bird symposium (U.S. Fish and Wildlife Service 2006) raised numerous methodological questions related to optimal survey methods. For example, some participants questioned the extent to which call-broadcast should be used, if at all, during standardized surveys throughout North America. The use of call-broadcast during marsh bird surveys has both benefits and drawbacks (Conway and Gibbs 2005). Hence, current protocols include a point-count survey with an initial 5-minute passive segment immediately followed by a call-broadcast segment, during which surveyors broadcast vocalizations of focal species into the marsh using amplified speakers. However, questions still remain as to which suite of species are most responsive to call-broadcast, and whether broadcasting one species' calls might cause detection probability of another focal species to decrease. Answers to these questions are important because they help determine whether standardized survey protocols should or should not instruct future surveyors to broadcast calls of particular species during marsh bird surveys.

Most efforts to evaluate call-broadcast have focused on the effects of conspecific calls in isolation (Conway and Gibbs 2001). A recent study conducted a meta-analysis of past studies (which differed substantially in survey methodology) to show that detection was higher during the call-broadcast segment of marsh bird surveys compared to the initial passive segments (Conway and Gibbs 2005). However, the passive and call-broadcast segments differed in duration among the disparate studies that contributed data and the data were not recorded during 1-minute segments. Because of these limitations, Conway and Gibbs (2005) were unable to: 1) provide true estimates of effect size (i.e., the extent to which 1-minute of conspecific call-broadcast increases detection relative to 1-minute of passive surveys) during a survey that includes call-broadcast for numerous focal species; 2) provide any estimate of effect size for several species of marsh birds due to the limited data available at the time; and 3) determine whether broadcasting calls of one or more focal species caused other focal species to refrain from vocalizing. Conway and Gibbs (2005) recognized these shortcomings and recommended that future studies examine the utility of call-broadcast surveys using marsh bird surveys where surveyors recorded detections during passive and call-broadcast segments of equal duration. Before the use of call-broadcast is institutionalized into a multi-species continental survey effort, more information is needed to evaluate whether broadcasting each focal species' calls affects vocalization probability for any of the other focal species. To address this need and to address the recommendations in Conway and Gibbs (2005), we used survey data collected from 117 locations across North America over eight years to evaluate the extent to which each of 13 focal marsh bird species listed above responded to conspecific and heterospecific call-broadcast relative to passive surveying methods.

Study Area

Over 100 surveyors surveyed marsh birds at 117 locations within 35 U.S. states, three Mexican states, and one Canadian province (Fig. 1). Surveys occurred primarily on federal lands, including 71 National Wildlife Refuges. Surveyors at each location voluntarily chose to conduct surveys following the national protocol and to submit their data to the authors (we did not use a selection procedure to select any of the 117 survey sites). All surveys were conducted in wetlands that contained emergent wetland plants (e.g., cattails, bulrushes). At each location, surveyors

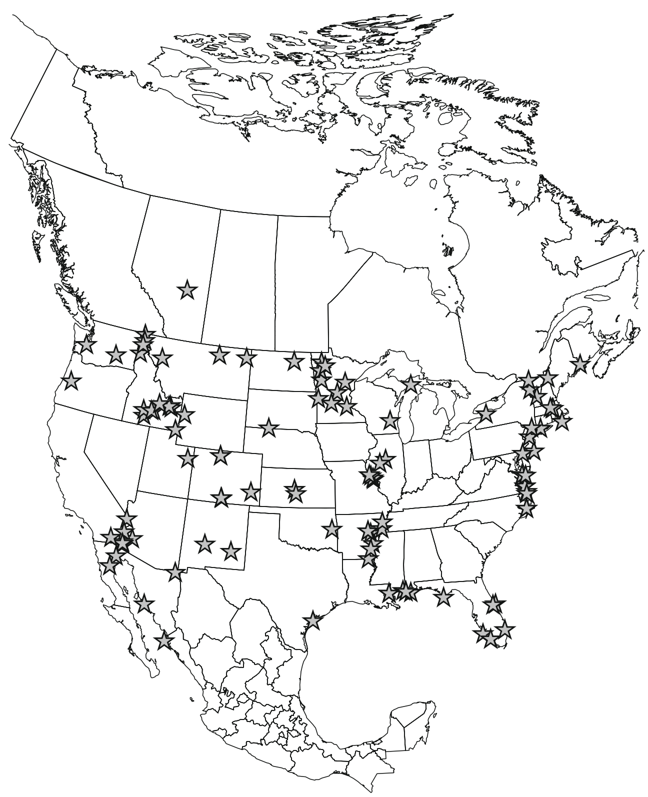

Fig. 1 We used data from 117 survey locations throughout North America to evaluate the effects of conspecific and heterospecific call-broadcast on detection probability of marsh birds

conducted point-count surveys at a series of established survey points (range = 1–294 points; $\bar{x}$ = 31 points) typically separated by at least 400 m.

Methods

We used survey data collected between 2000 and 2007 following standardized survey protocols for North America (Conway 2008). We obtained 1–5 years ($\bar{x}$ = 2 years) of survey data from each of the 117 locations. Surveyors were primarily employees of state and federal agencies. Each point-count survey consisted of an initial 5-minute passive survey segment followed by a segment that included broadcast of marsh bird vocalizations. The call-broadcast segment included a 1-minute call-broadcast period for each species thought to be a potential breeder at each location. Hence, the duration of the call-broadcast portion of the survey varied among the 117 locations because the suite of species included in the broadcast sequence varied among locations. For example, the call-broadcast segment was 4 min long at locations where surveyors included calls of four species in the call-broadcast sequence and 7 min long at locations where surveyors included calls of seven species. Each 1-minute period of the call-broadcast sequence consisted of 30 s of broadcasted calls followed by 30 s of silence. The surveyor at each location determined the number and identity of species to include in the call-broadcast sequence, based on the species considered to be potential breeders at the survey location. Surveyors generally consulted guide books and local/regional experts to determine which species bred in their area. Differences among locations in the number and identity of species included in the call-broadcast sequence are part of the current continental monitoring protocol for marsh birds and prevent surveyors from broadcasting calls for species outside their known breeding range. The continental protocol uses a standardized order in which surveyors broadcast calls across all survey locations (see Fig. 2) (e.g., black rail calls were always broadcast prior to least bittern calls if both species were broadcast at a location). The order of calls in the continental protocol was based on recommendations from a 1998 marsh bird workshop (Ribic et al. 1999). Surveyors recorded the 1-minute segment(s) during which each bird was detected during each point-count survey. The protocol directs each surveyor to record all aural and visual marsh bird detections, but most of the detections were aural because the marsh vegetation at survey sites was dense and these birds are rarely visible. We restricted our analysis to surveys conducted between March and July, and we excluded individual birds that were detected outside of the survey period (i.e., we excluded birds detected by surveyors while they were moving between points within a wetland). After these restrictions, we analyzed data from 2,976 distinct survey points at which there was ≥1 survey during ≥1 year. Surveyors surveyed each point 1–6 times per year between March and July, but in most (83%) cases surveyors surveyed each point 1–3 times per year. We used a different subset of this large dataset to evaluate the effectiveness of call-broadcast for each of the 13 focal species because a different subset of the 2,976 points was within the breeding range of each focal species. For each focal species, we only analyzed the surveys where the surveyor included that species' calls in the broadcast sequence and where the species was known to be present (i.e., was detected during ≥1 1-minute survey segment). We calculated the proportion of birds detected during each 1-minute survey segment for each species using the following ratio:

$$\frac{\text{Number of individuals detected during 1-minute segment}}{\text{Total number of individuals detected}}$$

We used contingency table analysis for each species to test the null hypothesis that the proportion of birds present that were detected did not vary among the 18 1-minute survey segments (five passive segments, one conspecific segment, and 12 heterospecific segments). We also used the following formula to calculate the percent increase in the number of individuals of a focal species detected during its 1-minute conspecific call-broadcast segment relative to 1-minute of passive surveying:

$$\left(n_{x,c} - n_{x,p}\right)/n_{x,p}$$

where $n_{x,c}$ = the number of individuals of species x detected during its 1-minute conspecific call-broadcast segment, and $n_{x,p}$ = the number of individuals of species x detected during a 1-minute passive segment (average among the five passive segments).

The number of individual birds exposed to heterospecific call-broadcast was often less than the number of individual birds exposed to conspecific call-broadcast (or to the five 1-minute passive survey periods) because the suite of species included in the broadcast sequence was not the same at each survey location. For example, our analysis included data from 5,726 least bitterns detected, but only 171 of those detections occurred at survey locations where yellow rail calls were included in the broadcast sequence because least bitterns occur in many locations outside the breeding range of yellow rails. It made no sense for surveyors to broadcast yellow rail calls at locations where yellow rails did not occur. Hence, differences in the proportion of birds detected during heterospecific and conspecific call-broadcast segments may be due (at least partly) to regional differences in many factors (e.g., density, response rate, surveyor abilities, number and identity of other species included in the broadcast sequence). The potential for regional bias is greater in comparisons that involved greater disparity in sample sizes between the heterospecific call segments and the conspecific and passive segments. To address this issue, we also tested the null hypothesis that the proportion of birds present that were detected did not vary among 1-minute segments for each of 4–5 broadcast sequences used most commonly by surveyors in 4–5 regions of the United States. Sample sizes for these regional comparisons were the same for all 1-minute segments, unlike the continent-wide analyses described above, and the data for each sample was from similar regions of the United States. We conducted these regional comparisons on three of our focal species, which are among those of the greatest conservation concern: least bitterns, king rails, and clapper rails. Similar to the continental-scale analysis, we used contingency table analyses to compare the proportion of birds that responded during the various 1-minute survey segments.

In all of our analyses, we used the individual bird detections as our sampling unit because we were interested in the extent to which conspecific and heterospecific call-broadcast increased an individual bird's probability of vocalizing compared to passive surveys. Individual birds may not be independent; the vocal behavior of one individual bird might influence the vocal behavior of another bird. All common approaches for estimating detection probability assume that the probability of detection of one individual is independent of that of others in the same population despite the fact that this assumption is likely violated in most surveys. This issue is likely to be less of a problem for secretive marsh birds than for other species because they occur at relatively low breeding densities and our modal number of individuals detected at a survey point was one. We conducted 31 contingency table analyses and so we were concerned about experimentwise error. Hence, we used a conservative alpha level (α=0.001) and report the actual *P*-values so that readers can make their own decisions regarding which differences are biologically significant. Moreover, we were more interested in the effect sizes rather than specific *P*-values.

Results

For all 13 focal species, the proportion of birds detected differed among the 1-minute survey segments (all *P*-values $\leq$ 0.001) (Figs. 2 and 3). The percent increase in the number of birds detected as a result of conspecific call-broadcast (compared to the average of the 1-minute passive segments) varied among species: 101% for black rails, 36% for least bitterns, 112% for yellow rails, 217% for soras, 439% for Virginia rails, 302% for king rails, 111% for clapper rails, 78% for common moorhens, 632% for purple gallinules, 58% for American coots, 14% for American bitterns, 124% for pied-billed grebes, and 18% for Wilson's snipe. Surveyors also detected more birds during the 1-minute of conspecific call-broadcast than during any of the 1-minute heterospecific call-broadcast segments for all 13 species (Figs. 2 and 3). However, surveyors detected more birds during most (but not all) of the heterospecific call-broadcast segments compared to passive segments in most of the 13 focal species. For example, surveyors detected more black rails during each of the three 1-minute heterospecific call-broadcast segments than during any of the 1-minute passive segments (Fig. 2a).

We found similar patterns when we examined data separately for the 4–5 most commonly used broadcast sequences for three of our focal species. For all three species examined (least bitterns, king rails, and clapper rails), individuals were equally or more likely to be detected during the 1-minute conspecific call-broadcast segments than during any of the 1-minute passive segments (Figs. 4, 5 and 6). King rails and clapper rails were also more likely to be detected during many of the 1-minute heterospecific segments compared to the 1-minute passive segments, even some of the heterospecific segments that occurred prior to the conspecific segment (Figs. 5 and 6). The extent to which conspecific call-broadcast increased detection probability varied considerably among regions. For example, the proportion of clapper rails detected during the 1-minute conspecific call-broadcast segment was 61% in Alabama, but only 20% in Florida (Fig. 6). Many of our analyses indicated that increasingly more birds were detected as the 5-minute passive period progressed (Figs. 2b, c, 3a, b, e, g, 4b–d, 6a), whereas others indicated a spike during the first minute, a reduction during the second minute, and then a steady increase over the final 3 min of the passive period (Figs. 3c, 5a, c, 6b).

Discussion

Conspecific call-broadcast increased detection probability of all 13 species of marsh birds relative to passive segments of the survey, but the magnitude of the increase varied greatly among species. Conspecific call-broadcast was most effective at increasing detection probability (relative to passive survey segments) for purple gallinules and all six species of rails. Other studies have also reported that call-broadcast dramatically increases detection probability for many of these species (Johnson and Dinsmore 1986; Manci and Rusch 1988; Conway and Gibbs 2001; Erwin et al. 2002; Conway et al. 2004; Conway and Gibbs 2005; Conway and Nadeau 2006). Our results suggested a relatively small increase in detection probability for least bitterns, American bitterns, and Wilson's

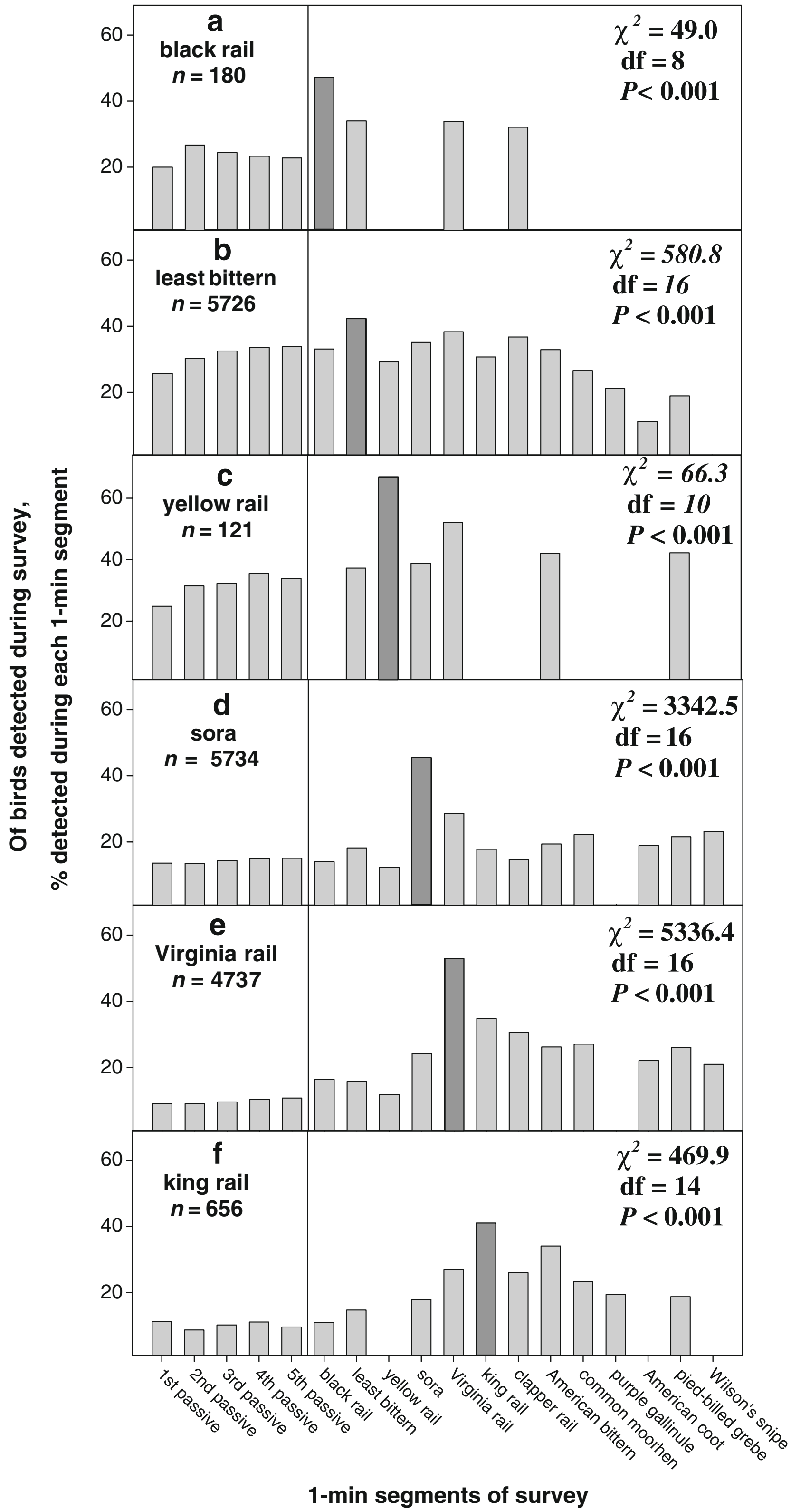

Fig. 2 The percentage of birds detected varied among 1-minute segments of marsh bird surveys throughout North America from 2000–2007 for black rails, least bitterns, yellow rails, soras, Virginia rails, and king rails. Each *bar* on the x-axis corresponds to a 1-minute survey segment that either involved no call-broadcast (the five *bars* on the left side of each graph) or call-broadcast (the *bars* on the right side of each graph). Number of birds detected for the 13 *bars* on the right side of each panel are: black rails (180, 162, 0, 0, 177, 0, 162, 0, 0, 0, 0, 0, 0); least bitterns (5512, 5726, 171, 1124, 5280, 638, 5320, 709, 662, 433, 215, 423, 0); yellow rails (0, 121, 121, 121, 121, 0, 0, 121, 0, 0, 0, 116, 0); soras (2224, 3221, 2358, 5734, 5734, 1483, 258, 5337, 594, 0, 1033, 4964, 1038); Virginia rails (1813, 2728, 992, 3938, 4737, 850, 963, 3764, 783, 0, 856, 3517, 1017); king rails (440, 619, 0, 234, 476, 656, 415, 85, 386, 211, 0, 138, 0). We did not report proportions for any 1-minute call-broadcast segments for which we had <60 detections (indicated by the lack of a *bar* in the graph). The conspecific call-broadcast segment is highlighted in *dark grey*. Each *bar* indicates the percentage of individuals detected that were detected during that particular 1-minute segment (e.g., of the 162 black rails detected sometime during the survey in locations where both black rail and least bittern calls were broadcast, 34% of those 162 birds vocalized during the 1-minute least bittern broadcast segment)

snipe, which corroborates results for these species from several past studies (see Cashen 1998, Conway and Gibbs 2005, Conway and Nadeau 2006), but other studies have reported a more substantive effect of call-broadcast for these species (Swift et al. 1988; Gibbs and Melvin 1993; Bogner and Baldassarre 2002; Lor and Malecki 2002; Allen et al. 2004). Differences across studies in the effectiveness of call-broadcast at increasing detection probability may be caused

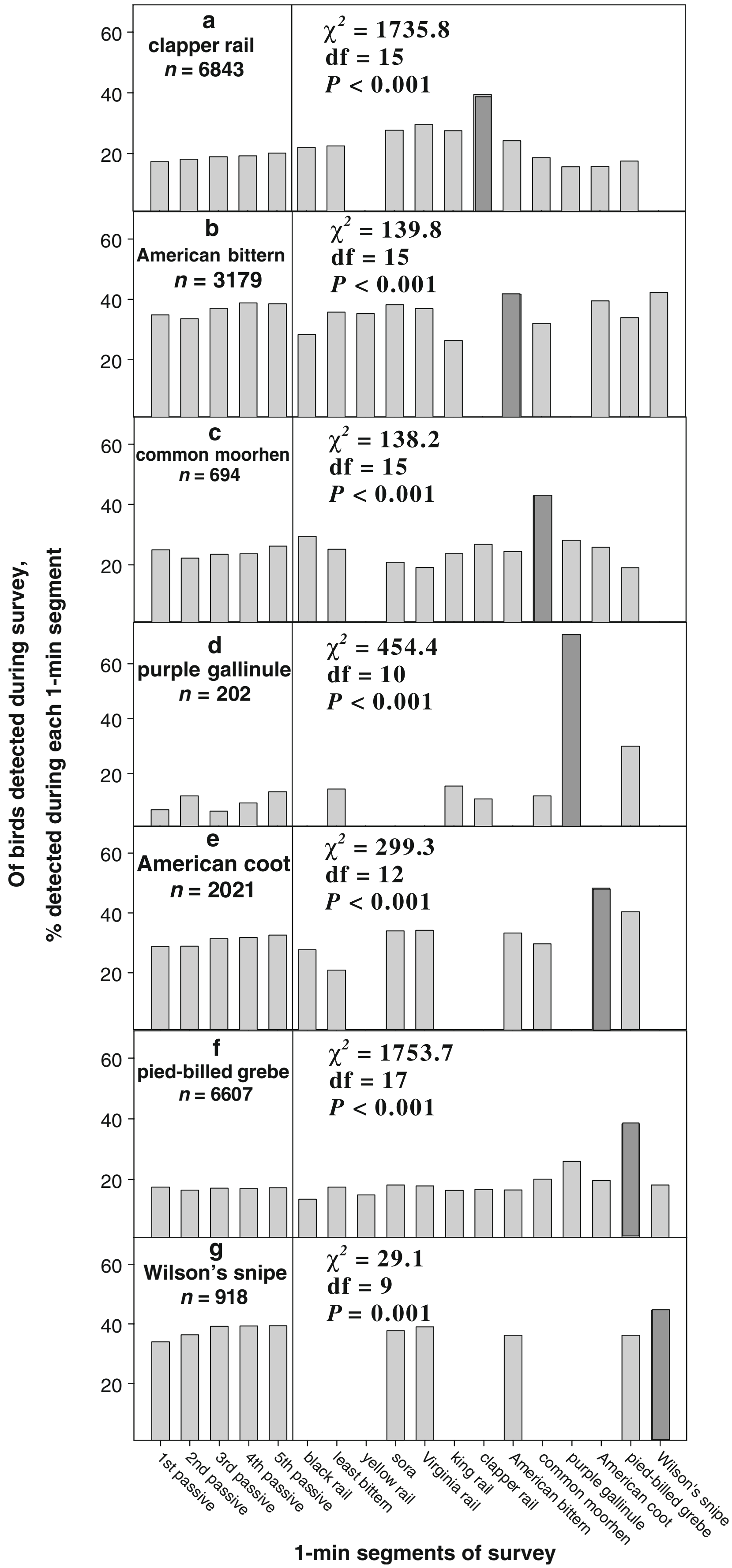

Fig. 3 The percentage of birds detected varied among 1-minute segments of marsh bird surveys throughout North America from 2000–2007 for clapper rails, American bitterns, common moorhens, purple gallinules, American coots, pied-billed grebes, and Wilson's snipe. Each *bar* on the x-axis corresponds to a 1-minute survey segment that either involved no call-broadcast (the five *bars* on the left side of each graph) or call-broadcast (the *bars* on the right side of each graph). Number of birds detected for the 13 *bars* on the right side of each panel are: clapper rails (6690, 5889, 0, 2404, 3609, 2791, 6843, 591, 1894, 1856, 1378, 1431, 0); American bitterns (980, 1583, 1206, 3177, 3179, 348, 0, 3179, 225, 0, 608, 2885, 886); common moorhens (326, 665, 0, 317, 377, 342, 522, 254, 694, 335, 240, 252, 0); purple gallinules (0, 201, 0, 0, 0, 193, 186, 0, 159, 202, 0, 60, 0); American coots (94, 211, 0, 2013, 2021, 0, 0, 2021, 212, 0, 2021, 1972, 0); pied-billed grebes (1597, 2682, 1760, 6470, 6584, 956, 168, 6306, 1475, 131, 1587, 6607, 2327); Wilson's snipe (0, 0, 0, 918, 918, 0, 0, 918, 0, 0, 0, 918, 918). We did not report proportions for any 1-minute call-broadcast segments for which we had <60 detections (indicated by the lack of a *bar* in the graph). The conspecific call-broadcast segment is highlighted in *dark grey*. Each *bar* indicates the percentage of individuals detected that were detected during that particular 1-minute segment (e.g., of the 1,856 clapper rails detected sometime during the survey in locations where both clapper rail and purple gallinule calls were broadcast, 16% of those 1,856 birds vocalized during the 1-minute purple gallinule broadcast segment)

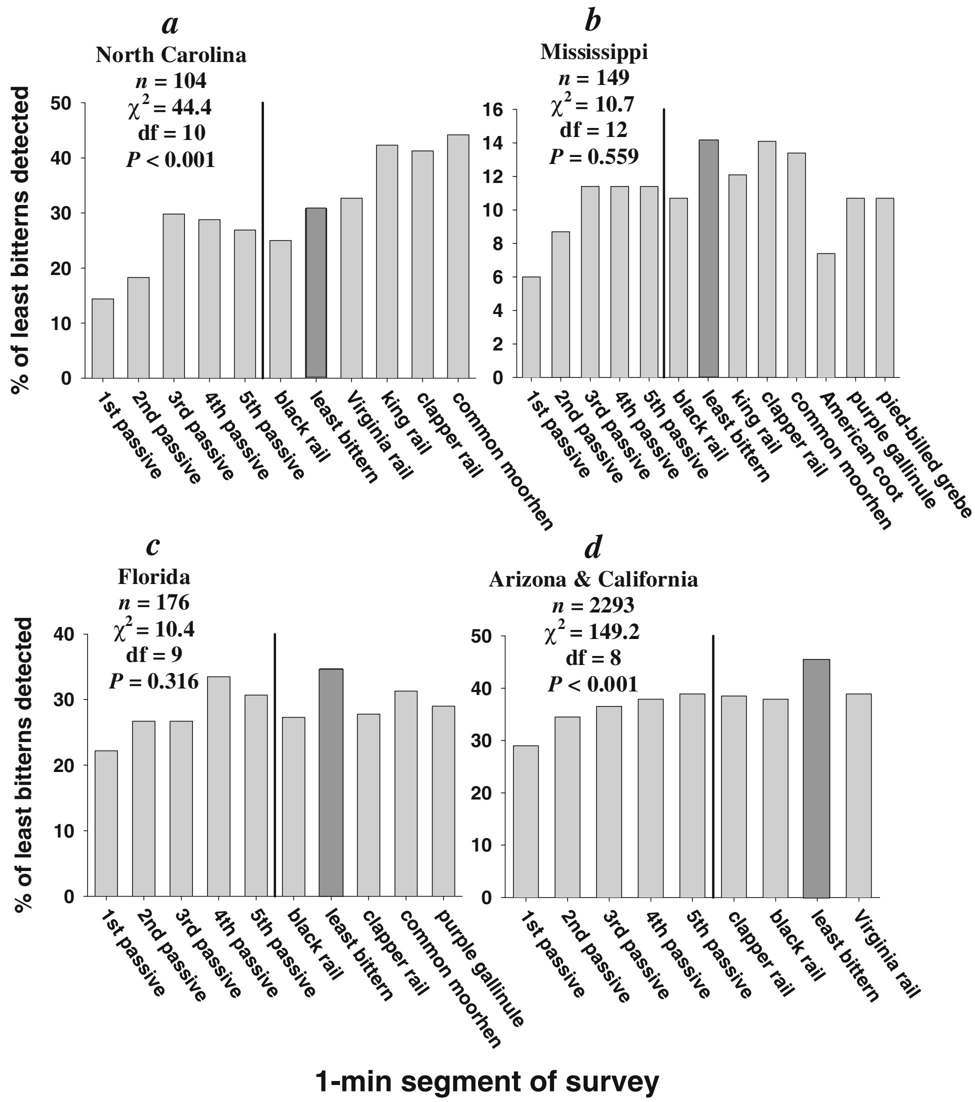

Fig. 4 The percentage of least bitterns detected varied among 1-minute survey segments for the four call-broadcast sequences used in North America from 2000–2007 during surveys where surveyors detected the most least bitterns. Each call-broadcast sequence consisted of a distinct suite of species' calls (displayed on the x-axis). Each *bar* on the x-axis corresponds to a 1-minute survey segment that either involved no call-broadcast (the five *bars* on the left side of each graph) or call-broadcast (the *bars* on the right side of each graph). The sample size (*n*) refers to the number of birds detected using that call-broadcast sequence. The conspecific call-broadcast segment is highlighted in *dark grey*

by differences in the proximity of birds to the surveyor (Lor and Malecki 2002; Conway et al. 2008) or the stage of the nesting cycle when surveys are conducted (Kaufmann 1971, 1988; Conway et al. 1993; Legare et al. 1999; Bogner and Baldassarre 2002). The percent increase in numbers detected as a result of call-broadcast may have been even higher had we taken these issues into account in our analyses.

Our estimates of relative effectiveness of call-broadcast (the percent increase in the number of individuals of a focal species detected during its 1-minute conspecific call-broadcast segment relative to 1-minute of passive surveying) were identical to that in Conway and Gibbs (2005) for common moorhen, but were substantially different for the other species. The estimates provided here are more reliable because we were able to compare a 1-minute passive survey segment to a 1-minute segment of conspecific call-broadcast. Moreover, we were able to provide estimates for less-common species for which Conway and Gibbs (2005) did not have sufficient data (black rail, yellow rail, clapper rail, purple gallinule, and Wilson's snipe).

Our results were similar to those of numerous past studies that have reported that marsh birds vocalize more frequently in response to conspecific compared to heterospecific call-broadcast (Tacha 1975; Johnson and Dinsmore 1986; Gibbs and Melvin 1993; Allen et al. 2004; Conway and Nadeau 2006; Pierluissi 2006). In contrast, several authors have reported that some marsh birds respond as readily to broadcasted calls of closely related species as they do to their own (Glahn 1974; Irish 1974; Kaufmann 1983; Johnson and Dinsmore 1986; Allen et al. 2004). Fewer studies have examined specifically whether the inclusion of heterospecific calls (in addition to conspecific calls) in broadcast sequences increases detection probability of focal marsh birds. Those that have, reported that inclusion of heterospecific calls either did not affect (Swift et al. 1988) or increased (Todd 1980; Tango et al. 1997;

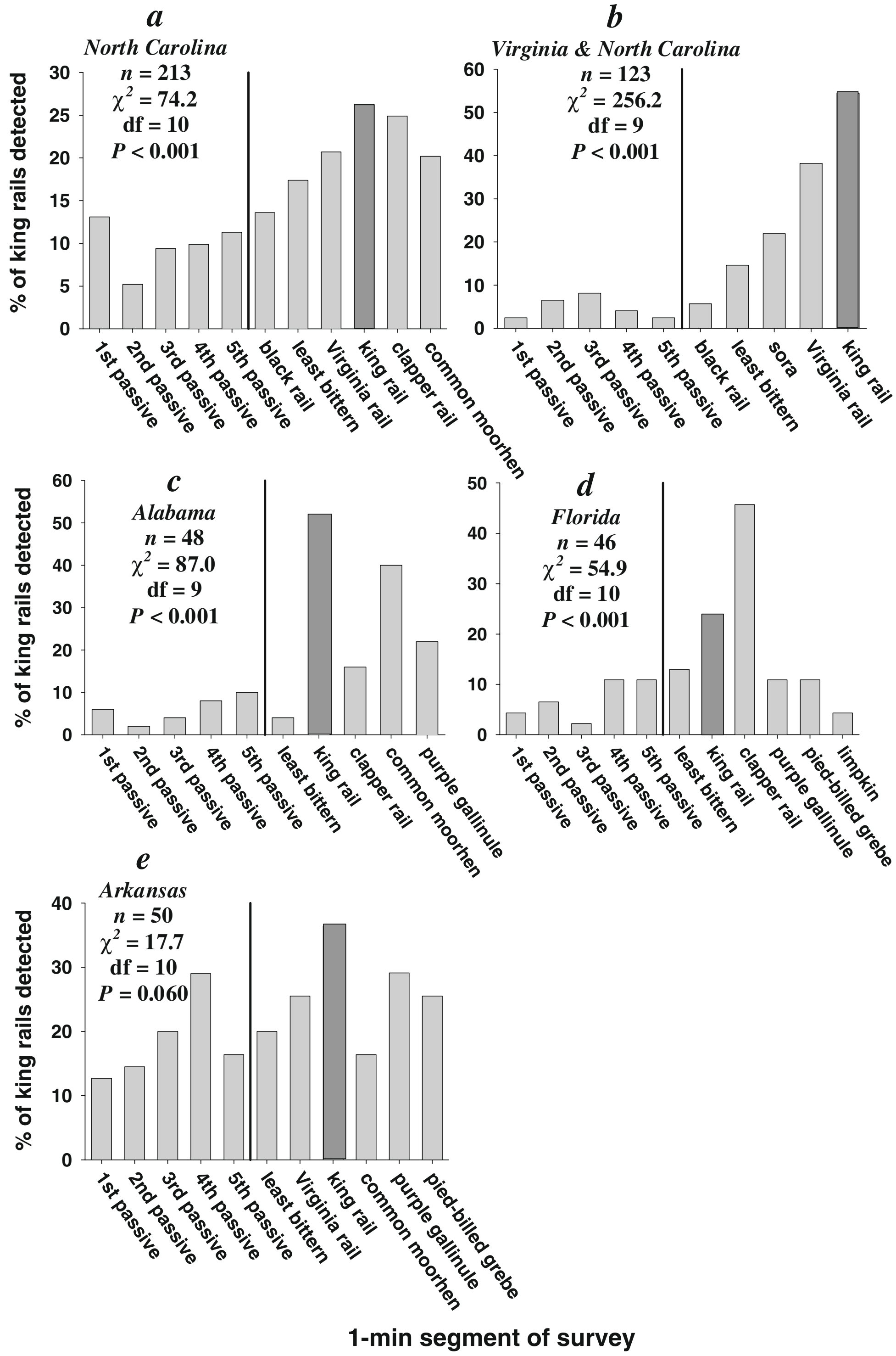

Fig. 5 The percentage of king rails detected varied among 1-minute survey segments for the five call-broadcast sequences used in North America from 2000–2007 during surveys where surveyors detected the most king rails. Each call-broadcast sequence consisted of a distinct suite of species' calls (displayed on the x-axis). Some surveyors in North Carolina used the broadcast sequence in 7a and some used the sequence in 7b. Each *bar* on the x-axis corresponds to a 1-minute survey segment that either involved no call-broadcast (the five *bars* on the left side of each graph) or call-broadcast (the *bars* on the right side of each graph). The sample size (*n*) refers to the number of birds detected using that call-broadcast sequence. The conspecific call-broadcast segment is highlighted in *dark grey*

Conway and Nadeau 2006) detection probability of focal marsh birds relative to only using conspecific calls. Furthermore, Conway and Gibbs (2005) presented data showing that the variance in the number of birds detected is lower during call-broadcast surveys relative to passive surveys. Hence, other studies support our finding that broadcasting calls of numerous species during standardized marsh bird surveys facilitates (rather than hinders) detection of secretive marsh birds. Our ability to examine whether broadcasting heterospecific calls in any way dampens the effectiveness of conspecific call-broadcast was limited because we standardized the chronological order in which surveyors broadcasted species' calls (i.e., black rail calls were always broadcast prior to sora calls). But even if

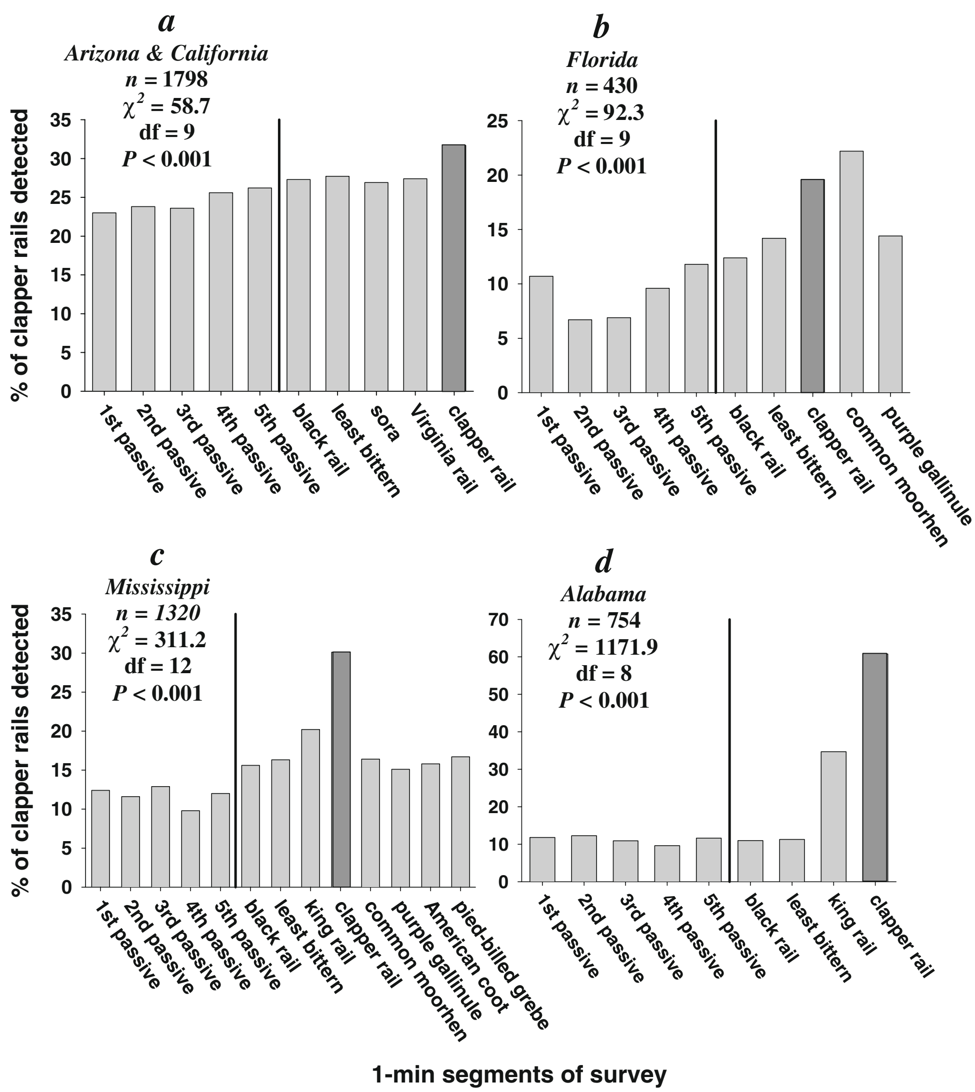

Fig. 6 The percentage of clapper rails detected varied among 1-minute survey segments for the four call-broadcast sequences used in North America from 2000–2007 during surveys where surveyors detected the most clapper rails. Each call-broadcast sequence consisted of a distinct suite of species' calls (displayed on the x-axis). Each *bar* on the x-axis corresponds to a 1-minute survey segment that either involved no call-broadcast (the five *bars* on the left side of each graph) or call-broadcast (the *bars* on the right side of each graph). The sample size (*n*) refers to the number of birds detected using that call-broadcast sequence. The conspecific call-broadcast segment is highlighted in *dark grey*

broadcasting heterospecific calls dampens the effectiveness of conspecific calls to some extent (i.e., perhaps the responsiveness during the 1-minute conspecific segment would have been even higher if we hadn't included heterospecific segments), our results suggest that this effect is not sufficient to avoid the inclusion of multiple species' calls in a standardized continental monitoring effort.

We detected more birds during many of the 1-minute heterospecific segments than the five 1-minute passive segments, even some of the heterospecific segments that occurred prior to the conspecific segment. These results suggest that increased calling during heterospecific call-broadcast segments is not merely due to a lag in the time it takes birds to respond to conspecific call-broadcast. If birds often waited to respond to conspecific call-broadcast, we would have expected: 1) a large number of individuals detected during the heterospecific call-broadcast segment that immediately follows the broadcast of conspecific calls, and 2) a gradual decline in number of birds detected with each passing minute after the broadcast of conspecific calls until the number detected was similar to the number detected during the heterospecific segments prior to the segment with conspecific calls. We observed some evidence of these patterns in a few cases (Figs. 5a, 6b), but not in most cases (Figs. 4b–d, 5e, 6c).

The proportion of birds detected during each of the 1-minute passive segments was not constant (as one might expect); more birds were often detected with each passing minute of the 5-minute passive period. Potential explanations for this steady increase in numbers detected with each passing minute of the passive period include: 1) birds may hesitate to vocalize during the first minute or two of a survey because they were disturbed by the surveyor approaching the survey point, 2) some surveyors may not record a bird until they hear numerous calls and become confident of the presence or identity of the bird, or 3) surveyors' ability to hear birds may increase during the first few minutes of a survey because it takes awhile for them to get settled and to start hearing subtle calls. Indeed, the pattern of increasing numbers detected across the passive period appeared to be more common (or more pronounced) in species that have very subtle or quiet vocalizations (least bitterns and yellow rails; Figs. 2b–c, 4b–d).

The effectiveness of conspecific call-broadcast varied among regions, but different broadcast sequences were used in different regions of North America by different surveyors, so these differences are likely due to one or more of the following reasons: 1) regional differences in the effectiveness of call-broadcast due to regional dialects, 2) regional differences in the effectiveness of call-broadcast due to regional differences in timing of surveys relative to the nesting cycle, 3) differences among surveyors in their ability to identify or detect subtle calls, or 4) differences in effectiveness of conspecific call-broadcast based on identity of other species in the call-broadcast sequence. We do not believe that the latter explanation was responsible for the observed differences because some of the call-broadcast sequences that showed the largest positive effects of conspecific calls were very similar (as far as the suite of species included in the sequence) to others that showed little effects of conspecific calls (e.g., Fig. 5c versus d). Moreover, the extent to which call-broadcast increased detection probability relative to passive segments appeared to be unrelated to the location of the conspecific call in the broadcast sequence (Figs. 4, 5 and 6). Regional differences in call dialects is an important issue for standardization of call-broadcast surveys if calls recorded in one region do not increase detection probability of populations of that same species in a different region. To aid the development of optimal marsh bird survey protocols for North America, we suggest further research into: 1) the effects of broadcasting different or non-local dialects on birds' response to call-broadcast, 2) the optimal timing of call-broadcast surveys in each region of North America, 3) the extent of surveyor bias in detection of each call type for each species of secretive marsh bird, and 4) experimental studies designed to examine the extent to which the broadcast sequence (i.e., the identity and chronological order of species' calls included in the broadcast sequence) affects detection probability during call-broadcast surveys. Better information on these four issues will enhance design of continental survey protocols and rigorous analysis of existing marsh bird data.

Recommendations

We recommend that both passive and call-broadcast segments continue to be included in marsh bird surveys because this approach will increase detection probability and thereby help evaluate the effects of common wetland management actions (e.g., burning, disking, drawdowns) and the effects of broad-scale environmental changes (e.g., sea level rise) on marsh bird populations. Including multiple species' calls during call-broadcast surveys provides higher detection probability for all focal species compared to passive surveys; the use of multiple species' calls during call-broadcast surveys does not obfuscate the effectiveness of conspecific call-broadcast. More research is needed to determine whether broadcasting calls during surveys is warranted for the two species for which we found only minor benefits of call-broadcast: American bitterns and Wilson's snipe. Our data show that call-broadcast significantly alters vocalization of breeding marsh birds, suggesting that other behavioral responses may also occur. Thus, we recommend caution in using this technique outside of standardized research and monitoring efforts.

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