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Development and Field-testing of Survey Methods for a Continental Marsh Bird Monitoring Program in North America

Final Report

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Executive Summary

Populations of many species of secretive marsh birds are thought to be declining in North America and several species are game birds in many states and provinces. And yet, we currently lack effective monitoring programs to adequately estimate population trends of secretive marsh birds. The most commonly-used method to survey secretive marsh birds is the broadcast of recorded calls. Understanding the benefits and drawbacks associated with call-broadcast surveys is essential prior to implementing a continent-wide monitoring program. The main goal of this project was to develop a standardized monitoring protocol for secretive marsh birds that would be applicable for use throughout North America, and to have the recommended protocols field-tested by staff of numerous National Wildlife Refuges around the country. Other goals were to use the data collected by these refuges to 1) compare vocalization probability between passive and call-broadcast surveys, 2) compare temporal variation in vocalization probability between paired passive and call-broadcast surveys, 3) determine the effect of broadcasting calls of multiple marsh birds on vocalization probability of each target species, and 4) compare observer bias between passive and call-broadcast surveys. We present a protocol that includes the use of call-broadcast for surveying marsh birds throughout North America. We include the rationale behind the various components included in the protocol. This protocol is/has already being used by 194 participants representing 45 U.S. states/territories, 3 Canadian provinces, and 3 Mexican states. The data generated has been pooled into a large relational database allowing analyses to address our initial objectives. Number of birds detected was higher for call-broadcast surveys compared to passive surveys for all 8 species examined. Coefficient of variation in number of birds detected was lower for call-broadcast surveys compared to passive surveys for most species examined. We found no evidence that broadcasting calls of other species negates the benefit of conspecific call-broadcast. Moreover, our results suggest that increasing the number of minutes of conspecific call-broadcast did not further increase the number of birds detected; 30 seconds of call-broadcast was sufficient to enhance vocalization probability of all 8 species. Observer detection probability was higher on the call-broadcast segment of the surveys compared to the passive segment of the surveys for clapper rails, but didn't differ between passive and call-broadcast for the other 6 species.

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INTRODUCTION

Populations of many species of secretive marsh birds (e.g., rails and bitterns) are thought to be declining in North America (Eddleman et al. 1988, Conway et al. 1994, Ribic et al. 1999). Breeding Bird Survey (BBS) data suggests significant population declines for American bittern (*Botaurus lentiginosus*) and king rail (*Rallus elegans*; Sauer et al. 2000). Estimated BBS population trends for some other species of secretive marsh birds are not significant, but sample sizes are extremely low because the BBS does not adequately sample emergent wetlands (Bystrak 1981, Robbins et al. 1986, Gibbs and Melvin 1993). Anecdotal information suggests that many marsh bird populations in North America have declined (Conway and Gibbs 2001). Moreover, several species of marsh birds (Virginia rail, *Rallus limicola*; sora, *Porzana carolina*; clapper rail; king rail) are game species in many states and managers need estimates of population trends to set responsible harvest limits. Despite the perceived population declines and game bird status, we currently lack effective monitoring programs to adequately estimate population trends of secretive marsh birds.

Multiple federal and state management agencies have expressed interest in developing a continental marsh bird monitoring program for North America (Tacha and Braun 1994, Ribic et al. 1999). The primary goal of such a monitoring program would be to estimate population change in marsh birds, with particular emphasis on rails and bitterns. However, the sampling methods and survey protocols for such a large-scale monitoring program remain topics of debate (Ribic et al. 1999). Developing an effective monitoring protocol at the outset is essential for collection of long-term data designed to provide rigorous estimates of population change.

The most commonly-used method to determine presence and/or abundance of secretive marsh birds in local areas is the broadcast of recorded calls. Understanding the magnitude of benefits and drawbacks associated with call-broadcast surveys is essential prior to implementing a continent-wide monitoring program. One of the most important parameters to consider when making decisions regarding potential monitoring methods is detection probability. Many factors potentially affect detection probability (and variation in detection probability) that we need to identify and take into account when developing a monitoring program. Moreover, we need to compare the following component parameters associated with detection probability among potential survey methods: vocalization probability, temporal variation in vocalization probability, and observer bias. Making these comparisons using existing data is difficult due to differences in survey methods and survey duration between passive and call-broadcast surveys (Conway and Gibbs 2001; 2005). Because the number of new detections decreases with time as survey duration increases, we need to compare passive and call-broadcast surveys of equal duration on a suite of replicate study areas (Conway and Gibbs 2005).

Another potential problem with using call-broadcast surveys for a multi-species continental monitoring program is that broadcasting calls of one species may decrease the detection probability of another. Although call-broadcast has been shown to increase the number of birds detected compared to passive surveys (reviewed in Conway and Gibbs 2001), broadcasting multiple species' calls may negate any increases in detection probability obtained from broadcasting conspecific calls. Alternatively, broadcasting multiple species' calls may actually increase detection of some target species. Hence, additional research is needed to address these crucial issues before we can determine whether or not to include call-broadcast methods in a continental marsh bird monitoring program.

This project was designed to meet these needs. The primary goal was to develop protocols for conducting marsh bird surveys that were applicable across all of North America and to field-test those protocols. Another goal was to compare vocalization probability (and temporal variation in vocalization probability) among paired passive and call-broadcast surveys of the same duration. A third goal was to determine the effect of broadcasting calls of multiple marsh birds on vocalization probability of each target species by comparing number of individual birds detected among several types of surveys: call-broadcast surveys that broadcast calls of one species vs those that broadcast calls of >1 species. A fourth goal was to compare observer bias between passive and call-broadcast surveys by using two independent observers at a subset of points (Nichols et al. 2000) for both passive and call-broadcast survey methods. To ensure that the results were appropriate across a variety of regions and marsh bird communities, we worked with national wildlife refuges (and other protected areas) across North America to implement draft survey protocols (Conway 2005; Appendix 2). Participants contributed their data to a large pooled dataset which allowed us to test the issues outlined above.

OBJECTIVES

1. Produce detailed standardized survey protocols that are applicable for monitoring marsh bird populations throughout North America.
2. Work with staff at ~10 National Wildlife Refuges around the country to conduct standardized marsh bird surveys using the draft survey protocols.
3. Use the survey data produced and feedback from surveyors to improve the survey protocol.
4. Determine whether number of marsh birds detected differs between passive and call-broadcast surveys for all species of secretive marsh birds in North America.
5. Determine whether temporal variation in number of marsh birds detected differs between passive and call-broadcast surveys.
6. Examine the effects of broadcasting calls of multiple marsh bird species on detection probability of target marsh birds.
7. Determine whether observer bias differs between passive and call-broadcast surveys.

METHODS

OBJECTIVE #1-3: DEVELOPMENT AND FIELD-TESTING OF STANDARDIZED SURVEY PROTOCOL

We developed the initial draft survey protocols for monitoring marsh birds within a distinct management unit in 1999 (Conway and Gibbs 2001). These protocols were designed for use on a National Wildlife Refuge, but were applicable to any management area. We worked with regional USFWS non-game migratory bird coordinators and regional research coordinators to contact biologists at National Wildlife Refuges. Refuge biologists were encouraged to participate in the initial survey effort and provide feedback on the standardized marsh bird survey protocols. Feedback from initial participants resulted in changes and clarifications to the initial survey protocols and we have revised the protocols approximately 15 times over the past 6 years. The resultant set of survey protocols has not changed much in the past 2 years (Conway 2005; Appendix 2). Participating refuges were sent draft survey protocols and a standardized CD (cassette tapes were sent in the first 2 years) with calls of marsh birds thought to occur on their management area.

The survey protocols are described in a stand-alone document (Conway 2005; Appendix 2) that are distributed to participants across North America, and are updated periodically to include suggested improvements/clarifications provided by program participants. The survey protocols direct surveyors to count birds during both an initial passive-listening period and a subsequent period of call-broadcast. Because the suite of species that would be desirable to include in a call-broadcast sequence needs to vary from location to location throughout North America, the survey protocols provide flexibility in length of the call-broadcast period (and hence length of time spent at each point by a surveyor) and the suite of species' calls included in the broadcast sequence.

The protocols instruct participants to conduct ≥3 replicate surveys at each pre-selected survey point. Participants are encouraged to survey ≥50 survey points in each management area, although any number of survey points and any number of annual replicate surveys are helpful for estimating population trajectory at regional, national, or continental scales. The protocols recommend that surveys be conducted in all patches of emergent marshes (fresh-, brackish, or salt-water) within the management area that are >0.5 ha in total area. This recommendation is meant to focus survey attention within marshes that could support a breeding pair within a management area. The "management area" can be an entire refuge (for very small refuges) or a contiguous portion (or several disjunct portions) of a larger refuge. The protocols recommend that survey points be distributed systematically within all emergent wetlands (>0.5 ha) within the management area. Survey points or survey routes should not be placed only in areas/marshes where marsh birds are known to exist (or occur in high density) a priori. Placing points or routes based on presence or abundance is a biased sampling design that will typically lead to perceived population declines. For example, if one places samples at time *t* in areas where density is relatively high, then density at these locations will be more likely to decline over time if relative habitat quality changes over time. The location of emergent marsh vegetation within a wetland complex typically changes over time such that the most suitable areas for marsh birds in a wetland often change over time. We need a sampling design that controls for such changes in spatial variation in habitat quality over time. To account for this, the protocols recommend that participants sample "all emergent marshes within a defined area", such that observers will have to add survey points as emergent habitat increases, decreases, or shifts annually within their defined management area. Hence, participants include as many survey points as needed to cover the area of interest (i.e., the management area). The protocols provide these suggestions on how to chose survey points within a management area (i.e., a refuge) so that data collected by a refuge can possibly be used to make inferences to their entire refuge. Use of these protocols on refuges and other management areas will provide evaluation and field-testing necessary before these same (or similar) survey methods are implemented into a continental marsh bird monitoring program. However, in order to make inferences about population trajectory at regional, national, or continental scales, a continental marsh bird monitoring program must include a probabilistic approach to selecting among all possible survey points across North America.

The protocol recommends that adjacent survey points be 400 m apart along a survey route. The rationale for this recommendation is to reduce the probability that an individual bird will be detected at more than one survey point. Detecting the same individual birds at adjacent survey points makes some analyses more difficult. Data from a large-scale monitoring program typically is used to address a variety of different questions at a variety of different scales, and some analyses are best if one can assume that each point is sampling a unique set of birds. However, because some refuges (or other participants) may want to space the points closer than 400 m to address questions of local interest, the protocol suggests that participants use an increment of 400 m (i.e., 200, 100, or 50 m) so that an analyst could potentially use a subset of points at those sites to maintain 400 m spacing at all sites. Participants also record whether or not each individual bird detected is a presumed repeat from a previous survey point so that some analyses can be conducted after excluding repeats while others can be conducted using all detections.

The protocol recommends an initial 5-minute passive survey segment followed immediately by a call-broadcast segment. The call-broadcast segment includes 1-minute of survey time for each focal marsh bird species. The total duration of the call-broadcast segment depends upon the number of species of marsh birds that the participant decides to include in the call-broadcast sequence. Hence, the length of the call-broadcast segment of the survey varies among participants between 2 minutes and 12 minutes (and the time spent at each point varies among participants between 7 minutes and 17 minutes) (Table 1). The decision on how many species to include in the call-broadcast is typically based on the number of species of secretive marsh birds that breed in the particular wetland (or in the region if local information is not available at the outset of surveys). The candidate species for inclusion in the call-broadcast sequence include: black rail, least bittern, yellow rail, sora, Virginia rail, king rail, clapper rail, American bittern, common moorhen, purple gallinule, American coot, pied-billed grebe, and limpkin. This list is based on species for which the BBS provides limited information on population trends and either 1) prior evidence suggests call-broadcast substantially increases detection probability (Conway and Gibbs 2001), or 2) we lack information on the extent to which call-broadcast increases detection probability. In areas where all 13 focal species occur, some participants choose to only include a subset of these species in the call-broadcast to limit the amount of time spent at each point. Regardless of whether a species is included in the call-broadcast sequence or not, all participants are expected to record all individuals of all 13 species of secretive marsh birds during their surveys. Because participants vary in the suite of species included in their call-broadcast sequence, the number of different sequences currently being used by participants is large (Table 1).

The protocol has several aspects that allow analysts to estimate or statistically control for several components of detection probability associated with survey data. These components are important so that trends in counts can be attributed to trends in populations rather than trends in detection probability. Our rationale for including various aspects of the protocol are explained below:

1) **Recording each individual bird on a separate line or row of the datasheet and recording whether each individual bird was detected during each 1-min segment of the survey.** These two aspects go hand-in-hand and are necessary in order to effectively merge data and to effectively compare data that were collected from different locations that differ in the suite of species included in the call-broadcast sequence. For example, a survey in Arizona may include 4 species in the call-broadcast sequence (BLRA, LEBI, VIRA, COMO) and a survey in Minnesota

may include 7 species in the call-broadcast sequence (LEBI, SORA, VIRA, KIRA, AMBI, COMO, AMCO). The data produced differ in 2 regards: the duration of the survey at each point (9 and 12 minutes, respectively), and the suite of species included in the call-broadcast sequence. However, they are similar in that both included the initial 5-minute passive period and both included a minute of call-broadcast for each of 3 species: LEBI, VIRA, and COMO. By recording each bird on a separate line and recording whether each one was detected during each 1-min segment, these data can be merged to the maximum extent possible. In other words, a subset of data from both surveys can be extracted to produce the number of birds that responded during the 8 minutes of survey time that was similar at both locations (i.e., 5-min of passive, plus 1 min each of LEBI, VIRA, and COMO). This aspect allows locations across North America to use different species in their call-broadcast sequences, but the data produced will still retain the ability to compare 'apples' to 'apples' when merging or comparing data. Another example is a survey in one part of California that includes only 2 species in the call-broadcast sequence (BLRA and LEBI) and a survey in another part of California that includes 6 species in the call-broadcast sequence (BLRA, LEBI, VIRA, SORA, CLRA, and COMO). In both surveys, the first 7 minutes are identical (the initial 5 minute passive period followed by 1 min of BLRA and 1 min of LEBI calls). Recording data like this allows the analyst to truncate the data from the survey that included 6 species to what would have been detected had the surveyor used the 2 species broadcast sequence. This approach also allows analysts to compare number of birds detected and variation in numbers detected between passive and call-broadcast surveys of equal duration using paired comparisons (something not possible when the length of the passive period is not the same as the length of the call-broadcast period; Conway and Gibbs 2001, 2005).

A secondary benefit is that analysts can use 2 different methods to estimate 2 different components of detection probability. Data collected in this way are similar to a 'capture history' and can be analyzed using a removal model or capture-recapture modeling methods to estimate vocalization probability (Farnsworth et al. 2002, Moore et al. 2004, Kirkpatrick et al. 2006). Moreover, data collected in this way by multiple observers at the same point can be used to estimate observer bias (Nichols et al. 2000, Conway and Simon 2003, Conway et al. 2004, Moore et al. 2004).

A third benefit of this aspect is that by recording each bird on a separate line, surveyors can estimate distance to each individual bird which allows analysts to: 1) use distance sampling as a way to estimate changes in detection probability over time, and 2) only use detections within some distance (i.e., 50m, 100m, 200m, etc) in order to compare relative densities of species between locations. Distance estimates have substantial error associated with them, but each person or analyst can make their own decision as to whether the distance estimates are useful or not (see #3 below).

A fourth benefit of this aspect is that it facilitates training surveyors. When training surveyors, recording data in this fashion helps the instructor determine which individual birds the surveyor miss-identified or failed to detect (see "Training" section below).

2) **Estimating distance to each bird**. The protocol recommends that surveyors estimate the distance to each individual bird detected. At the 1998 workshop, participants had considerable debate on the value of, and potential bias associated with, estimating distance to each bird. This remains a contentious issue. There are those who are outspoken fans of distance estimation and

the things those estimates provide (Diefenbach et al. 2003, Ellingson and Lukacs 2003, Norvell et al. 2003, Royle et al. 2004), and there are those who are outspoken critics of distance estimation and believe it has no (or little) value (Hutto and Young 2002). We chose to recommend the least contentious path. If we don't include distance estimation in a continental marsh bird survey program, we turn our backs on those who believe that distance estimation adds value or rigor to the survey data produced. If we include distance estimation in a continental protocol, we don't really turn our backs on anyone. Those who are fans can use the distance data as they like (hopefully acknowledging the assumptions and potential biases those data include), and those who are critics of the value of distance estimation can analyze the survey data without using those estimates.

Although estimating distance to each bird has substantial error associated with those estimates (especially when most birds are heard and not seen), this recommendation is based on the following benefits associated with estimating distance:

1) allows analysts to estimate components of detection probability using distance sampling. Those who believe that distance sampling does not yield useful information can simply ignore distance estimates in their analysis of the pooled data. Those who believe that estimates should be put into distance bins rather than actual estimates can create bins prior to analysis (this even allows analysts who prefer this approach to create as many different distance bins as the data will allow or the same number used in some previous study). Hence, having participants estimate distance to each individual bird allows the greatest flexibility and the most analytical options.
2) allows surveyors to more easily determine which individual was detected during which 1-minute segment of the survey. For example, if a surveyor detects 4 Virginia Rails during the initial minute of a survey, recording the estimated distance to each bird makes it easier for the surveyor to determine which of those 4 individuals called again during the 8th minute of the survey (or whether the call represents a new individual).
3) allows analysts to partially control for differences in observer bias across years by having the option of limiting data to only those birds detected within '*x*' m of the observer.

A potential alternative to estimating distance to each bird is to have surveyors place each bird detected into 'distance bins' that are created a priori (e.g., 0-50m, 50-100m, and >100m). This may provide the surveyor with a higher level of comfort (i.e., not having to generate a single number for distance to each bird, but the data generated now has 2 levels of error that the analyst must account for: 1) one generated by the inherent error associated with estimating how far away a bird actually is, and 2) one generated by the pooling of birds from different distances into one distance bin (i.e., a bird that is very obviously <10m away essentially gets the same distance estimate as one that is thought to be 49m away). Moreover, the number and cut-offs for each distance bin would be a matter of debate. Each of the target species of secretive marsh birds is going to differ in the typical distance detected. Many surveys will be conducted from the adjacent upland some distance from the edge of the marsh and black rails tend to use the wetland-upland interface of marshlands whereas pied-billed grebes, American coots, and common moorhens typically use areas near the interior of marshlands. For example, data from the past 5 years indicate that most (59%) black rails are detected within 50m of the surveyor whereas only 15% of pied-billed grebes were detected within 50m of the surveyor (Table 2). Hence, the optimal number and width of distance bins would differ among the species that are the target of this survey effort. Estimating distance to each bird allows the analyst to create distance bins a posteriori and the number and width of these bins can differ to account for differences among species in their distance-detection functions. The optimum number of distance bins is also correlated with the amount of data available to the analyst; as more data accumulates, an analyst can split the data into more bins a posteriori.

4) **Recording the type of call given by each bird**. This aspect was included to account for variation in ability to identify calls across observers and the fact that the probability of detection differs among different call types. We believe that including this as a variable may greatly improve our ability to estimate population trends across time and to better account for variation in observers' ability to identify species' calls. Each focal species of secretive marsh bird has 2-5 common calls. Some of these calls are loud, raucous, easy to learn, and unique (easy to hear at a great distance and difficult to confuse with other calls). Others are soft and/or easy to confuse with other species' calls. For example, the 2 most common black rail calls differ in the distance at which birds giving these calls are typically detected (Table 3). Hence, the observer detection probability for a particular species likely differs depending on the type of call given. Recording the call(s) given by each bird allows observers to estimate population trends of a particular species in several ways: 1) using all detections regardless of call given, 2) restricting the analysis to include only birds that gave the most common call for that species, or 3) restricting the analysis to include only birds that gave the most distinguishable call for that species, etc. Data on calls given by each species can also help deal with the potential bias associated with long-term surveys if the timing of the breeding season changes over time. Many marsh birds have particular calls (i.e., the Virginia rail's *ticket*, the clapper rail's *kek*) that are only given during the pairing and early mating season. The proportion of these calls relative to calls given by mated pairs (i.e., the Virginia rail's *grunt*, the clapper rail's *clatter*) can provide a basis for testing whether the timing of the breeding season has changed over time and whether or not surveys were conducted during the same stage of the breeding cycle in different locations. These data can also be used to refine the seasonal survey windows in the continental protocol so that surveys are conducted during the same stage of the breeding cycle in each region of North America (to the extent possible). Recording this (and other) covariates is more of an option in a continental marsh bird survey program (more so than in a program like BBS) because the number of focal species is relatively small and the number of individuals detected on a typical point is few.

5) **Recording whether each bird is a repeat from a previous survey point.** This aspect is important if survey points are close enough where the same individual bird(s) might be detected at more than one point. Counting the same bird twice is potentially problematic for some ways in which analysts would like to analyze these data. Many people conducting marsh bird surveys want their survey points to be relatively close together (i.e., 50-100m apart) so that they don't miss rare birds (i.e., black rails or king rails) within the survey area. Even if adjacent points are separated by some set distance (currently, the protocol suggests that adjacent points be $\geq$400m apart), some of the focal marsh bird species can be detected at great distances (e.g., 37% of the

pied-billed grebes in our database were detected >200m from the surveyor; Table 2). Many survey protocols attempt to get around this issue by telling surveyors to "ignore birds that were counted at a previous survey point". However, our multiple-observer surveys using technicians that we trained ourselves over the past 5 years have convinced us that surveyors vary in how conservative or liberal they are in assigning a particular bird as a new detection or one that was detected at a previous point. This variation among observers infuses variation in the counts. By recording whether each bird was or was not a repeat, an analyst can estimate population trends including all birds detected at all points (regardless of whether or not a bird was thought to be a repeat from a previous point). This may provide the best estimate of population trend because it does not rely on the subjective opinion of each surveyor as to whether or not each bird was or was not a repeat. However, other analyses associated with other questions of interest may not want to include suspected repeats (e.g., how many king rails are there in a particular state?).

6) **Conducting periodic multiple-observer surveys.** As the protocol is currently written, this is an optional component. Consequently, other than ourselves, only 2 or 3 other participants conducted multiple-observer surveys over the past 5 years. The benefit of multiple-observer surveys is that they provide estimates of one component of detection probability: observer detection probability (i.e., observer bias) (Nichols et al. 2000, Conway et al. 2004). In other words, multiple-observer surveys allow the analyst to identify observers that have hearing loss or are unable to identify the calls of certain focal species. Multiple-observer surveys are something that obviously wouldn't be a component of every survey route, but some annual or bi-annual effort to conduct multiple-observer surveys at a subset of survey points in some coordinated systematic fashion would allow analysts to refute (or perhaps support) the potential criticism that any trend in number of birds counted could be due to a trend over time in observer bias rather than an actual trend in abundance. Hence, the fact that multiple-observer surveys do not provide estimates of true detection probability is not important (the method estimates observer detection probability, which is one component of detection probability), only that they allow the analyst to refute or support the alternative explanation that a trend in count is due to a trend in observer bias.

OBJECTIVE #4: NUMBER OF BIRDS DETECTED WITH PASSIVE AND CALL-BROADCAST SURVEYS

We used two approaches to compare the number of birds detected between passive and call-broadcast surveys. The first was a paired approach where we compared the number of birds detected per minute during the initial 5 minute passive period with the number of birds detected per minute during the subsequent call-broadcast period. This paired approach allowed us to use all of the data from the pooled dataset from across North America, and also allowed us to control for daily variation in calling behavior which is often very high with secretive marsh birds (Conway and Gibbs 2001). The second was also a paired approach at a subset of survey routes in Arizona and southern California where a surveyor conducted a completely passive survey one day and then the same surveyor conducted a call-broadcast survey the following day on the same survey route.

Approach #1: Number of birds detected on passive vs subsequent call-broadcast segments

For this first approach, we compared the number of birds detected during one minute of the initial 5-minute passive segment of a survey and the number of birds detected during the one minute when that species' calls were being broadcast during the subsequent call-broadcast segment of the same survey. Hence, this was a paired analytical approach. The sample sizes differed for each species because for each species we only included data from surveys that included calls of that species in the broadcast sequence. The pooled dataset already has approximately 115,000 lines of data (i.e., individual bird detections) from marsh bird surveys across North America and only 38% of the data received has been merged (Table 4). Approximately half of the data in the pooled database (Table 4) was collected in southern Arizona and southern California by our field crew at the University of Arizona. We used paired *t*-tests to evaluate whether call-broadcast increased number of birds detected per minute compared to passive surveys.

Approach #2: Passive vs call-broadcast surveys conducted on separate days

For this second approach, we alternated which of the two types of surveys (passive or call-broadcast) was conducted first. We also used two different broadcast sequences when comparing completely passive surveys with call-broadcast surveys: one that included only black rail calls and the other that included only clapper rail calls.

OBJECTIVE #5: TEMPORAL VARIATION ASSOCIATED WITH PASSIVE AND CALL-BROADCAST SURVEYS

We used paired *t*-tests to evaluate whether or not coefficient of variation in number of birds detected differed between passive and call-broadcast segments of the surveys. We estimated the coefficient of variation in the number of birds detected among replicate surveys within the same year using only data from the initial 5 minute passive period of each survey and compared that to the coefficient of variation in number of birds detected only during the first 5 minutes of the call-broadcast segment of each survey. Because the length of the call-broadcast segment varied among participants, we only used those surveys which included a call-broadcast sequence that was $\geq$5 minutes long and for which calls of the species of interest were within the first 5 minutes of the broadcast sequence. We used paired *t*-tests to determine whether the coefficient of variation in number of birds detected differed between 5 minutes of passive survey and 5 minutes of call-broadcast survey for each of 12 species of secretive marsh birds.

OBJECTIVE #6: EFFECTS OF BROADCASTING CALLS OF MULTIPLE SPECIES

Numerous studies have examined whether broadcasting conspecific calls increases vocalization probability of marsh birds by comparing number of birds detected during passive vs call-broadcast surveys (reviewed in Conway and Gibbs 2001). However, the majority of these studies have examined the usefulness of call-broadcast for one species in isolation (e.g., the effect of broadcasting clapper rail calls on vocalization probability of clapper rails). Not surprisingly, most of these studies have found that call-broadcast increases the number of birds detected. However, few studies have examined whether broadcasting the calls of multiple species during a single survey increases detection probability. For example, call-broadcast may increase detection probability when a species' calls are broadcast in isolation, but might be less effective when a species' calls are just one of many species' calls broadcast during a 10-minute survey period. This is an important distinction because any national or continental marsh bird monitoring program that includes call-broadcast would seemingly have to include calls of multiple species at each point, and yet broadcasting calls of one species (i.e., a larger-bodied species) may decrease vocalization probability of another species and even negate increases in detection probability usually gained by broadcasting conspecific calls. To examine the effects of broadcasting calls of multiple species during marsh bird surveys, we compared detection probability of black rails and clapper rails during 3 different 9-min survey protocols: 1) 3 minutes of silence, followed by 6 minutes of clapper rail calls, 2) 3 minutes of silence, followed by 3 minutes of black rail and 3 minutes of clapper rail calls, and 3) 3 minutes of silence followed by 1 minute each of black rail, least bittern, sora, Virginia rail, clapper rail, and pied-billed grebe calls. If broadcasting calls of certain species adversely affects detection probability of other species, we expected the number of black rails and clapper rails detected to be different among the 3 protocols. We conducted paired surveys in Arizona and southern California where the number of species included in the broadcast sequence differed but the length of the survey was the same. These paired surveys allowed us to compare the number of individual birds detected among call-broadcast surveys that broadcast calls of one species, two species, and six species. We conducted separate paired *t*-tests for each of 8 species (black rail, least bittern, sora, Virginia rail, clapper rail, and pied-billed grebe calls). Likewise, we used paired *t*-tests to evaluate whether the number of detections differed between call-broadcast surveys with 3 minutes each of black rail and clapper rail calls and those with 1 minute of each of to compare number detected between 1-species and 2-species broadcast sequences, and between 2-species and 6-species broadcast sequences.

OBJECTIVE #7: OBSERVER BIAS ASSOCIATED WITH PASSIVE AND CALL-BROADCAST SURVEYS

One component of detection probability is the ability of observers to detect a bird that calls during the survey period (observer detection probability; Conway and Simon 2003, Conway et al. 2004). Call-broadcast could potentially increase observer detection probability (i.e., decrease observer bias) because hearing the calls of target species broadcast at each point may help observers learn calls and help ensure that less common calls are not missed. Alternatively, call-broadcast could decrease observer detection probability if the noise of the broadcast itself causes some observers (but not all) to miss calling birds. We examined the effect of call-broadcast on observer detection probability using the double-observer method (Nichols et al. 2000). We compared observer bias between passive and call-broadcast surveys by using two independent observers at a subset of points at several locations in Arizona and southern California for both passive and call-broadcast survey methods. These data allowed us to estimate observer detection probability (Conway and Simon 2003; Kirkpatrick et al. 2006) for each of 8 species for a variety of different surveyors. Observers conducted surveys side-by-side without comparing notes and recorded distance to each bird detected. At the end of the season, we compared survey data from each observer in a pair to determine the number of birds detected by observer #1 that were not detected by observer #2 (x_{12}), the number of birds detected by observer #2 that were not detected by observer #1 (x_{21}), the total number of birds detected by observer #1 (x_{11}), and the total number of birds detected by observer #2 (x_{22}). Equations for calculating observer detection probability for each observer are provided in Conway and Simon (2003). We used 2 approaches for examining whether observer detection probability differed between passive surveys and call-broadcast surveys. For the first approach, we estimated observer detection probability for 11 observers for each of 7 species of secretive marsh birds. We then averaged across the 11 observers to obtain an average observer detection probability for each species for both the passive segment of our surveys and the call-broadcast segment of our surveys. We then compared observer detection probability between passive and call-broadcast segments using paired *t*-tests. For each species, we only included data from observer pairs from which x_{11}, x_{12}, x_{21}, and x_{22} were all >1 in our analyses. For the second approach, we summed the data across all observers to calculate one estimate of observer detection probability for both the passive segment and the call-broadcast segment for each of the 7 species. This approach allowed us to use all data (i.e., we didn't have to discard data from pairs of observers that only conducted a few double-observer surveys together) and effectively weighted each observer pair based on the amount of data contributed.

TRAINING. Similar to any other monitoring programs, formal training of surveyors will dramatically help improve the quality of survey data produced. Over the past 3 years, we have given training workshops in mid-March in Yuma, Arizona for those involved with marsh bird monitoring. This is a good location for training surveyors from many parts of North America because 8 of the focal species in the national protocols are common in the area (black rails, least bitterns, soras, Virginia rails, clapper rails, common moorhens, American coots, and pied-billed grebes). We have given 4 workshops attended by a total of 100 biologists from a variety of state and federal agencies conducting (or planning to conduct) marsh bird surveys. All of the aspects listed above [recording each bird on a separate line, recording whether each bird is detected during each 1-min segment, estimating distance to each bird, and recording the call type(s) given by each bird] makes training much more effective and efficient. And conducting double- or multiple-observer surveys is the method by which training is most effectively accomplished. We are currently exploring the possibility of developing training modules over the internet so that surveyors can learn all the common calls of all the focal species, and tests can be taken on-line to determine competency of all surveyors.

RESULTS

OBJECTIVE #1: DETAILED SURVEY PROTOCOLS APPLICABLE ACROSS NORTH AMERICA

We developed survey protocols based on information from the following sources: 1) verbal and written (Ribic et al. 1999) comments from the 1998 workshop on marsh bird monitoring held at Patuxent Wildlife Research Center in Laurel, Maryland; 2) personal knowledge of marsh bird vocalization behavior and dynamics of emergent wetlands; 3) comments and recommendations from Dr. James Gibbs and other colleagues who have worked extensively on secretive marsh birds; and 4) feedback from NWRs conducting marsh bird surveys in a variety of wetlands across North America (see Objective #2 below). Widespread use of these protocols lead to the development of a standardized marsh bird monitoring program for North America (www.ag.arizona.edu/srnr/research/coop/azfwru/NMBMP/). The resultant protocols (Conway 2005; Appendix 2) are available on this website. This program has grown rapidly during the past 5 years (Fig. 1). Recently, we have worked with researchers and managers working on salt-marsh passerines to make these protocols useable for those working on any species of marsh bird in a unified monitoring and research program (Conway and Droege, in press).

OBJECTIVE #2: WORK WITH ~10 NWRS TO BETA-TEST DRAFT SURVEY PROTOCOLS

Use of the standardized survey protocols began with a few refuges in 1999, and the number of refuges and other participants using the draft protocols increased linearly each year (Table 4; Fig. 1). By the end of 2005, we had 194 participants that had been involved in the standardized survey effort representing 45 U.S. states/territories, 3 Canadian provinces, and 3 Mexican states (Tables 5-7; Fig. 2). Comments and feedback via telephone and email from refuges during 2000-2002 helped to improve/refine protocols. The current survey protocols are the culmination of ~15 revisions that incorporated comments from refuge biologists and others that helped field-test the initial versions. Data has been submitted by participants in a variety of formats. Over half of the survey data collected by participants between 1999-2005 was submitted as paper copies of raw survey sheets. Data that was submitted electronically, was submitted using a variety of spreadsheet and database programs. In 2004, we created a standardized spreadsheet (available in either EXCEL or ACCESS) that we distributed to participants so that data would be entered using a standard format. We are currently working with representatives of the USFWS Office of Migratory Birds and USGS Patuxent Wildlife Research Center to develop an on-line data entry module on the internet that will allow participants to the program to enter their data over the internet and the data will be immediately added to the pooled database. The website will also include the ability to access data and site summaries for each participant. We had a 2-day meeting in Tucson in early January 2006 with Bruce Peterjohn, Mark Wimer, and Soch Lor to determine the structure of the database and the on-line entry formats.

OBJECTIVE #3: EVALUATE PROBLEMS WITH RECOMMENDED METHODS AND REVISE PROTOCOLS

Initial participants that helped field-test the initial survey protocol and/or provided useful discussion of survey methodology included: Debra Kimbrell-Anderson, Marian Bailey, Karla Brandt, David Brownlie, Jennifer Casey, Pam Denmon, Sam Droege, Marc Epstein, Charles Francis, William Gates, Diane Granfors, Helen Hands, Chuck Hunter, David Klute, Stephanie Koch, Soch Lor, Debbie Melvin, Laura Mitchell, Mike Norton, Mike Rule, Marshall Sasser, Eric Soehren, Sandy Spencer, Janith Taylor, Matt Whitbeck, Linda Ziemba, and many others. Most of these initial participants provided feedback on how to improve and standardize survey methods and how to make the written protocol document less ambiguous. Some of the issues that received substantial debate included how to estimate distance to each bird, the benefits (and drawbacks) of having participants estimate distance to each bird as opposed to using distance categories (or bins) into which each individual was assigned, and how to measure habitat features (and which habitat features to measure) associated with each survey point.

OBJECTIVE #4: NUMBER OF BIRDS DETECTED WITH PASSIVE AND CALL-BROADCAST SURVEYS

Approach #1: Number of birds detected on passive vs subsequent call-broadcast segments

Call-broadcast increased the number of birds detected relative to passive surveys for all species (Fig. 3). The effectiveness of call-broadcast at increasing the number of detections was less pronounced for least bitterns and American bitterns compared to the other species. Also see results presented under Objective #5.

Approach #2: Passive vs call-broadcast surveys conducted on separate days

We did not detect a difference between the number of black rails detected between completely passive surveys and those that included the broadcast of black rail calls (Fig. 4A). The power to detect differences was small because black rails were detected on only 11 of these 32 survey routes and the number detected on those 11 routes was typically only one bird. As expected, we also did not detect differences in the number of birds detected for any of the other 7 species of secretive marsh birds whose calls were not included in the call-broadcast sequence (Fig. 4A). Likewise, we did not detect a difference between the number of clapper rails detected between completely passive surveys and those that included the broadcast of clapper rail calls (Fig. 4B). And as expected, we also did not detect differences in the number of birds detected for any of the other 5 species of secretive marsh birds whose calls were not included in the call-broadcast sequence (Fig. 4B); we did not detect any black rails or soras on these 18 survey routes. The power to detect differences was small because clapper rails were detected on only 5 of these 18 survey routes.

OBJECTIVE #5: TEMPORAL VARIATION ASSOCIATED WITH PASSIVE AND CALL-BROADCAST SURVEYS

When we compare a 5-minute passive survey to 5 minutes of call-broadcast, the mean number of individuals detected was higher and the coefficient of variation in number detected was lower for the call-broadcast portion of the survey (Fig. 5). The extent to which call-broadcast increases the number of birds detected was greatest for the true rails and less pronounced for the 2 bitterns, American coots, and pied-billed grebes (Fig. 6). Similarly, the extent to which call-broadcast reduces the coefficient of variation in number of birds detected was greatest for the true rails and less pronounced for American bitterns and coots. Call-broadcast surveys actually had higher coefficient of variation than passive surveys for pied-billed grebes (Fig. 6). Call-broadcast surveys also had lower coefficient of variation in number of marsh birds detected compared to passive surveys in previous studies (Conway et al. 2004, Conway and Gibbs 2005).

OBJECTIVE #6: EFFECTS OF BROADCASTING CALLS OF MULTIPLE SPECIES

The number of clapper rails detected did not differ ($t = 0.6$, $P = 0.555$) between 9-minute call-broadcast surveys that only included clapper rail calls and 9-minute call-broadcast surveys that included both black rail and clapper rail calls (Fig. 7A). Hence, playing black rail calls in addition to clapper rail calls did not negate the effectiveness of broadcasting clapper rail calls to increase detection probability of clapper rails. As one would expect, the number of black rails detected was higher ($t = 2.9$, $P = 0.010$) on surveys that included three 30-second segments of both black rail and clapper rail calls relative to those that included six 30-second segments of clapper rail calls (Fig. 7A). Moreover, the number of black rails and the number of clapper rails detected did not differ ($t = 0.2$, $P = 0.812$ and $t = 0.3$, $P = 0.772$, respectively) between surveys with three 30-second segments each of black rail and clapper rail calls and those with only one 30-second segment of their calls (Fig. 7B). As one would expect, the number of soras ($t = 3.5$, $P = 0.001$), Virginia rails ($t = 4.4$, $P < 0.001$), least bitterns ($t = 2.4$, $P = 0.017$), and pied-billed grebes ($t = 3.5$, $P = 0.001$) detected were all higher on surveys that included one 30-second segment of their calls relative to those that included only black rail and clapper rail calls (Fig. 7B). Hence, broadcasting calls of multiple species increases vocalization probability of all species on the broadcast sequence and the effectiveness of call-broadcast at increasing vocalization probability for any one species is not compromised by including one short broadcast segment of many species rather than repeated broadcast segments of that one species.

OBJECTIVE #7: OBSERVER BIAS ASSOCIATED WITH PASSIVE AND CALL-BROADCAST SURVEYS

We estimated observer detection probability for 7 species of secretive marsh birds based on 11 different surveyors using 20 different combinations of two surveyors conducting double-observer surveys at a total of 492 survey points. The number of double-observer surveys conducted by each combination of observers varied from 1-7 survey routes ($\bar{x} = 3.4$ survey routes). During the passive segment of the surveys, observer detection probability was highest for Virginia rails and lowest for soras (Fig. 8). During the call-broadcast segment of the surveys, observer detection probability was highest for clapper rails and lowest for least bitterns (Fig. 8). Observer detection probability was higher ($t = 3.4$, df = 6, $P = 0.015$) on the call-broadcast segment of the surveys compared to the passive segment of the surveys for clapper rails, but didn't differ between passive and call-broadcast for the other 6 species (Fig. 8). Observer detection probability varied more among species during the passive segment of the survey compared to the call-broadcast segment of the survey (Fig. 8).

PRODUCTS

This project has generated many products (Appendix 1) and the products generated will increase now that a large amount of the data has been entered, proofed, and merged into a pooled database.

DISCUSSION

The protocol recommended here is suitable for use throughout North America. The protocol has several aspects that allow analysts to estimate or statistically control for several components of detection probability associated with survey data. These components are important so that trends in counts can be attributed to trends in populations rather than trends in detection probability. The protocol currently suggests that calls of 13 species be considered as possibilities for inclusion in the call-broadcast sequence at each site. The number of species' calls that actually do get included in the call-broadcast sequence is allowed to vary among sites (i.e., any combination of the 13 primary species) and will always include a subset of these 13 possible species. The 13 species listed here are not set in stone; some may be deleted and/or other species added as more information becomes available or needs change. Species in addition to the 13 for which participants have requested including in their call-broadcast sequence include: **least grebe**, red-necked grebe, yellow-breasted crake, Carribean coot, sandhill crane, black tern, **Wilson's snipe**, **green heron**, West Indian ruddy duck, sedge wren, Nelson's sharp-tailed sparrow, swamp sparrow, and **seaside sparrow**. Species listed above in bold print are currently being included in the call-broadcast sequence at one site using this protocol (Table 1) and hence data may be available to examine the extent to which call-broadcast increases detection probability for these species. Many of the species listed above have a restricted range in the U.S. and are of regional concern in the areas where they do occur.

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Table 1. Number of participants using each of 104 different call-broadcast sequences. Sequences lacking entry in final column are those for which ≥1 participant requested that sequence and we burned and mailed a CD, but data with these sequences are not currently in the pooled database.

Sequence #	species #1	species #2	species #3	species #4	species #5	species #6	species #7	species #8	species #9	species #10	species# 11	species #12	# of sites using
9	BLRA	CLRA											3
88	BLRA	CLRA	AMBI										
65	BLRA	KIRA											1
36	BLRA	KIRA	CLRA										
122	BLRA	LEBI	CLRA	YERA	SORA	VIRA	KIRA	AMBI	COMO	AMCO	LIMP		2
64	BLRA	LEBI	KIRA										1
82	BLRA	LEBI	KIRA	AMBI	PUGA								1
45	BLRA	LEBI	KIRA	CLRA									1
8	BLRA	LEBI	KIRA	CLRA	AMBI	COMO	PUGA	AMCO	PBGR				1
35	BLRA	LEBI	KIRA	CLRA	COMO	PUGA	AMCO	PBGR					3
6	BLRA	LEBI	KIRA	COMO	PBGR								2
68	BLRA	LEBI	KIRA	COMO	PUGA	AMCO	PBGR						1
93	BLRA	LEBI	KIRA	PUGA	AMCO	PBGR							
116	BLRA	LEBI	SORA	VIRA	CLRA								
33	BLRA	LEBI	SORA	VIRA	CLRA	AMBI							4
31	BLRA	LEBI	SORA	VIRA	CLRA	AMBI	COMO	AMCO	PBGR				3
11	BLRA	LEBI	SORA	VIRA	KIRA								8
60	BLRA	LEBI	SORA	VIRA	KIRA	AMBI							1
39	BLRA	LEBI	SORA	VIRA	KIRA	AMBI	COMO						2
20	BLRA	LEBI	SORA	VIRA	KIRA	AMBI	COMO	AMCO					1
18	BLRA	LEBI	SORA	VIRA	KIRA	AMBI	COMO	AMCO	PBGR				2
2	BLRA	LEBI	SORA	VIRA	KIRA	AMBI	COMO	PBGR					1
61	BLRA	LEBI	SORA	VIRA	KIRA	AMBI	COMO	PBGR	EAGR				1
80	BLRA	LEBI	SORA	VIRA	KIRA	CLRA							2
73	BLRA	LEBI	SORA	VIRA	KIRA	CLRA	AMBI	PBGR					
51	BLRA	LEBI	SORA	VIRA	KIRA	CLRA	PBGR						1
111	BLRA	LEBI	SORA	VIRA	KIRA	CLRA	YERA	COMO	PBGR				
124	BLRA	LEBI	SORA	VIRA	KIRA	PBGR							
121	BLRA	LEBI	VIRA	CLRA									
32	BLRA	LEBI	VIRA	CLRA	AMBI								2
76	BLRA	LEBI	VIRA	KIRA	CLRA								1
15	BLRA	LEBI	VIRA	KIRA	CLRA	COMO							1
54	BLRA	LEBI	YERA	KIRA	CLRA	AMBI	COMO	PUGA	PBGR				1
48	BLRA	LEBI	YERA	SORA	KIRA	CLRA	AMBI						
38	BLRA	LEBI	YERA	SORA	VIRA	AMBI	PBGR						
120	BLRA	LEBI	YERA	SORA	VIRA	CLRA	AMBI	COMO	PBGR				3
119	BLRA	LEBI	YERA	SORA	VIRA	KIRA	AMBI						2
7	BLRA	LEBI	YERA	SORA	VIRA	KIRA	AMBI	COMO					3
123	BLRA	LEBI	YERA	SORA	VIRA	KIRA	AMBI	COMO	AMCO	PBGR			1
50	BLRA	LEBI	YERA	SORA	VIRA	KIRA	AMBI	COMO	PBGR				2
70	BLRA	LEBI	YERA	SORA	VIRA	KIRA	AMBI	COMO	PUGA	PBGR			1
3	BLRA	LEBI	YERA	SORA	VIRA	KIRA	AMBI	PBGR					2
81	BLRA	LEBI	YERA	SORA	VIRA	KIRA	AMBI	PUGA					1
103	BLRA	LEBI	YERA	SORA	VIRA	KIRA	CLRA	AMBI	COMO	PUGA	AMCO	LIMP	
83	BLRA	LEBI	YERA	SORA	VIRA	KIRA	CLRA	AMBI	PUGA	LEGR	PBGR		1
74	BLRA	LEBI	YERA	SORA	VIRA	KIRA	CLRA	AMBI	PUGA	PBGR			1
1	BLRA	LEBI	YERA	VIRA	KIRA	AMBI	COMO	PBGR					2
55	BLRA	LEBI	YERA	VIRA	KIRA	AMBI	COMO	PUGA	PBGR				1
41	BLRA	SORA	VIRA	AMBI	PBGR								2
66	BLRA	VIRA	KIRA	CLRA									1
16	BLRA	YERA	SORA	VIRA	KIRA	AMBI	PBGR						1
24	BLRA	YERA	VIRA	KIRA									

Table 1. Continued.

125	CLRA	BLRA									1
37	KIRA	CLRA	COMO	PUGA							
53	LEBI	CLRA	SORA	VIRA	KIRA	AMBI	COMO	AMCO	PBGR		1
23	LEBI	KIRA									1
87	LEBI	KIRA	CLRA	COMO							
46	LEBI	KIRA	CLRA	COMO	PUGA						1
19	LEBI	KIRA	CLRA	PUGA	PBGR						
21	LEBI	KIRA	CLRA	PUGA	PBGR	LIMP					1
84	LEBI	SORA	KIRA	AMBI	COMO	PBGR					
59	LEBI	SORA	VIRA								3
63	LEBI	SORA	VIRA	AMBI							1
28	LEBI	SORA	VIRA	AMBI	AMCO	PBGR					2
17	LEBI	SORA	VIRA	AMBI	COMO	AMCO	PBGR				6
43	LEBI	SORA	VIRA	AMBI	COMO	PBGR					1
14	LEBI	SORA	VIRA	AMBI	PBGR						5
118	LEBI	SORA	VIRA	CLRA	AMBI	COMO	AMCO	PBGR			
67	LEBI	SORA	VIRA	COMO	PBGR						1
75	LEBI	SORA	VIRA	KIRA							1
25	LEBI	SORA	VIRA	KIRA	AMBI						2
56	LEBI	SORA	VIRA	KIRA	AMBI	COMO					1
72	LEBI	SORA	VIRA	KIRA	AMBI	COMO	AMCO	PBGR			2
34	LEBI	SORA	VIRA	KIRA	AMBI	COMO	PBGR				6
78	LEBI	SORA	VIRA	KIRA	AMBI	COMO	PUGA	AMCO	PBGR		1
71	LEBI	SORA	VIRA	KIRA	AMBI	PBGR					2
44	LEBI	SORA	VIRA	KIRA	CLRA						1
27	LEBI	SORA	VIRA	KIRA	CLRA	AMBI	COMO	AMCO			1
102	LEBI	SORA	VIRA	KIRA	CLRA	AMBI	PBGR				
107	LEBI	SORA	VIRA	KIRA	CLRA	PBGR					
98	LEBI	SORA	VIRA	KIRA	COMO	PBGR					
30	LEBI	SORA	VIRA	YERA	COMO	PBGR					6
85	LEBI	VIRA	KIRA	AMBI	AMCO	AMCO	PBGR				
69	LEBI	VIRA	KIRA	COMO	PBGR						1
62	LEBI	YERA	SORA	AMBI							1
29	LEBI	YERA	SORA	VIRA	AMBI	AMCO	PBGR				1
26	LEBI	YERA	SORA	VIRA	AMBI	COMO	PBGR				1
22	LEBI	YERA	SORA	VIRA	AMBI	PBGR					3
10	LEBI	YERA	SORA	VIRA	COMO	PBGR					1
47	LEBI	YERA	SORA	VIRA	KIRA	AMBI					2
13	LEBI	YERA	SORA	VIRA	KIRA	AMBI	COMO	AMCO	PBGR		
79	LEBI	YERA	SORA	VIRA	KIRA	AMBI	COMO	PUGA	AMCO	PBGR	1
49	LEBI	YERA	VIRA	KIRA	CLRA	AMBI	COMO				
57	SESP	BLRA	LEBI	PUGA	COMO	AMCO	CLRA				1
12	SORA	VIRA									
5	SORA	VIRA	AMBI	AMCO	PBGR						20
40	SORA	VIRA	AMBI	AMCO	PBGR	GBHE	WISN				1
42	SORA	VIRA	AMBI	PBGR							4
58	VIRA	SORA	AMBI	LEBI							1
52	VIRA	SORA	LEBI	COMO	PBGR						2
86	YERA	AMBI									
112	YERA	PBGR									
4	YERA	SORA	VIRA	AMBI	AMCO	PBGR					4
77	YERA	SORA	VIRA	AMBI	PBGR						5

Table 2. Percent of all detected birds (those for which distance estimates were recorded) within each of 3 distances for each of 12 species of secretive marsh birds. The number of detections with distance estimates for yellow rail, purple gallinule, and limpkin were too small (<20) to make reporting percentages here meaningful.

Species	% detections within			
	50m	100m	200m	*n*
black rail	59	90	99	4071
black tern	57	81	99	115
least bittern	35	69	93	12251
sora	47	80	97	3039
Virginia rail	42	76	97	6998
king rail	36	69	89	418
clapper rail	33	78	96	8833
American bittern	26	56	82	697
common moorhen	46	80	96	8416
American coot	59	87	97	4651
pied-billed grebe	15	36	63	12516
Wilson's snipe	28	55	88	193

Table 3. Percent of black rails giving each of 2 common calls (*kic-kic-kerr* and *grr*) that were recorded within each of 3 distance categories.

Call given	% detections within			
	50m	100m	150m	*n*
kic-kic-kerr	47	85	95	2530
grr	84	99	100	853

Table 4. Number of participants using the standardized marsh bird survey protocols in each year, 1999-2005.

	Year							
	1999	2000	2001	2002	2003	2004	2005	**Total[3]**
# participants	7	31	32	55	82	103	89	**194**
# states/provinces	7	16	18	30	37	41	34	**51**
% merged[1]	29%	55%	56%	67%	65%	17%	5%	**38%**
# survey routes[2]	40	158	83	165	219	112	71	**464**
# survey points[2]	192	1868	871	1618	2175	1264	807	**4543**
# replicate surveys[2]	562	3439	1935	4415	7909	7012	4933	**30205**

[1]percent of participants whose data has been received, entered, proofed, and merged into the pooled database.
[2]only includes data that has been merged into the pooled database.
[3]Totals do not equal the sum across years because many of the same participants, routes, and points were included in multiple years.

Table 5 Number of detections for each of 13 species of secretive marsh birds recorded each year at each location within the pooled marsh bird database.

Location	Year	AMBI	AMCO	BLRA	CLRA	COMO	KIRA	LEBI	LIMP	PBGR	PUGA	SORA	VIRA	YERA	Other
Agassiz NWR	2000	96	2	0	0	0	0	8	0	146	0	148	54	0	0
	2001	76	0	0	0	0	0	13	0	77	0	75	43	0	0
	2002	114	54	0	0	0	0	4	0	99	0	149	33	0	93
AL Gulf Coast/Bon Secour NWR	2003	0	0	0	184	6	15	9	0	0	19	0	0	0	479
Alamosa NWR	2001	7	48	0	0	0	0	0	0	13	0	18	2	0	59
	2002	8	79	0	0	0	0	0	0	12	0	18	9	0	62
Alberta BCR11	2002	2	366	0	0	0	0	0	0	4	0	157	0	0	689
Anahuac NWR	2003	0	0	0	2	0	0	0	0	0	0	0	0	0	35
Assabet River NWR	2002	0	0	0	0	0	0	0	0	0	0	0	7	0	490
	2003	1	0	0	0	0	0	3	0	0	0	0	10	0	2750
AZGFD Phoenix area	2003	0	24	0	43	27	0	24	0	12	0	6	4	0	232
	2004	1	68	0	75	84	0	55	0	105	0	2	23	0	4
AZGFD-Lower Colorado River	2003	0	0	19	222	0	0	47	0	0	0	34	132	0	0
	2004	0	0	40	162	0	0	48	0	0	0	42	116	0	0
Back Bay NWR	2000	0	14	0	0	1	25	5	0	18	0	1	0	0	1644
	2001	2	2	0	0	1	27	21	0	0	0	10	1	0	1655
	2002	0	0	0	0	0	25	31	0	0	0	0	1	0	2342
	2003	0	0	0	0	0	30	5	0	11	0	15	2	0	0
Back Bay NWR	2004	0	1	0	0	0	24	34	0	6	0	0	0	0	3201
Baja/Sonora/Sinaloa/Colorado River Delta	2003	65	0	12	752	0	0	392	0	0	0	75	160	0	0
Bald Knob NWR	2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bill Williams NWR	2000	0	0	18	0	0	0	0	0	0	0	0	5	0	0
Bitter Lake NWR	2003	0	0	0	0	0	0	0	0	0	0	0	64	0	0
Bowdoin NWR	2002	0	8	0	0	0	0	0	0	1	0	14	0	0	364
Cape Cod National Seashore	1999	2	0	0	0	0	2	0	0	2	0	1	2	0	90
	2000	3	0	0	0	0	1	2	0	17	0	13	8	0	476
Cedar Island NWR	2003	0	0	1	121	0	0	0	0	0	0	0	1	0	0
Cheyenne Bottoms Wildl. Area	2003	4	0	0	0	10	0	7	0	0	0	8	50	0	0
Cibola NWR	2000	0	0	0	8	0	0	28	0	0	0	0	0	0	0
Clarence Cannon NWR	2002	1	0	3	0	0	3	20	0	0	0	1	2	2	0
	2003	44	0	0	0	0	14	41	0	58	0	64	15	1	0
	2004	28	0	0	0	0	12	10	0	0	0	149	28	4	0
Columbia NWR	2003	28	1	0	0	0	0	0	0	67	0	5	64	0	117
Confed. Salish/Kootenai Tribes	2003	0	145	0	0	0	0	0	0	18	0	111	23	0	2626
Delair Div of Great River NWR	2002	0	0	0	0	0	0	7	0	0	0	1	0	0	0
	2003	0	0	0	0	0	0	0	0	0	0	19	0	2	0
Eastern Shore of Virginia/Fisherman Island NWR	2001	0	0	0	91	0	6	0	0	0	0	0	0	0	0
	2002	0	0	0	140	0	0	0	0	0	0	0	0	0	0
	2003	0	0	0	219	0	0	0	0	0	0	0	0	0	0
	2004	0	0	0	230	0	0	0	0	0	0	0	0	0	2
Edwin B. Forsythe NWR	2004	0	0	0	23	0	0	0	0	0	0	0	0	0	563
Fern Ridge Lake (CORPS/ODFW)	2003	24	59	0	0	0	0	0	0	7	0	22	19	0	126
Great Bay NWR	2001	0	0	0	0	0	0	1	0	0	0	0	6	0	320
	2002	1	0	0	0	1	1	3	0	1	0	2	8	0	561
	2003	0	0	0	0	0	0	0	0	0	0	0	3	0	427
Great Meadows NWR	2002	1	0	0	0	0	0	1	0	0	0	1	6	0	702
	2003	0	2	0	0	0	0	0	0	6	0	11	40	0	5915

Table 5. Continued.

Great Swamp NWR	2002	0	0	0	0	0	0	2	0	0	0	4	22	0	640
Hamden Slough NWR	2003	31	104	0	0	0	0	4	0	110	0	54	73	0	2075
Havasu NWR	2000	0	0	0	22	0	0	5	0	0	0	2	19	0	0
	2001	0	57	0	60	0	0	147	0	23	0	0	79	0	626
	2002	0	638	0	16	37	0	524	0	291	0	0	63	0	121
	2003	0	356	0	63	410	0	573	0	468	0	0	113	0	2
	2004	0	0	0	125	875	0	599	0	514	0	18	127	0	0
	2005	1	0	2	166	817	0	693	0	252	0	31	247	0	0
Horicon NWR	2001	4	0	0	0	0	0	3	0	0	0	77	17	0	231
	2002	11	0	0	0	0	1	1	0	0	0	113	36	0	242
	2003	1	0	0	0	0	0	2	0	0	0	20	5	0	102
Illinois River NWFR	2003	0	330	0	0	0	0	2	0	3	0	2	1	0	125
Imperial NWR	2000	3	0	6	14	0	0	74	0	0	0	21	13	0	0
	2001	0	19	3	38	0	0	99	0	0	0	2	3	0	66
	2002	1	375	6	72	13	0	226	0	133	0	2	1	0	1187
	2003	0	753	25	184	117	0	595	0	419	0	14	20	0	538
	2004	3	0	55	209	514	0	998	0	1187	0	89	6	0	1
	2005	3	0	116	229	345	0	887	0	831	0	77	27	0	1
Iroquois NWR	2000	4	51	0	0	32	0	2	0	42	0	4	19	0	152
	2002	7	4	0	0	7	0	1	0	16	0	3	9	0	5
	2003	4	23	0	0	0	0	0	0	11	0	7	11	0	11
	2004	1	14	0	0	11	0	1	0	20	0	6	3	0	60
J.N. Ding Darling NWR	2003	0	3	0	3	18	1	0	0	0	0	5	0	0	0
	2004	1	10	0	6	119	4	2	0	0	0	9	0	0	3
Lake Alice NWR/Devils Lake WMD	2002	9	630	0	0	0	0	2	0	78	0	21	15	0	3138
Lake Umbagog NWR	2000	10	0	0	0	0	0	0	0	0	0	3	20	0	259
	2001	9	0	0	0	0	0	0	0	1	0	1	17	0	430
	2002	2	0	0	0	0	0	0	0	0	0	2	7	0	603
	2003	10	0	0	0	0	0	0	0	0	0	1	9	0	634
Litchfield WMD	2002	1	0	0	0	0	0	2	0	62	0	44	11	0	0
	2003	8	0	0	0	0	0	11	0	77	0	55	41	0	0
Lower Colorado River	2000	1	0	551	383	0	0	462	0	0	0	97	687	0	16
	2001	0	0	85	143	0	0	83	0	0	0	29	226	0	5
	2002	0	810	137	488	81	0	321	0	340	0	52	610	0	2387
	2003	0	1021	679	592	713	0	684	0	589	0	84	868	0	70
	2004	6	1	789	870	1110	0	963	0	884	0	219	869	0	5
	2005	0	0	905	621	823	0	1055	0	597	0	167	697	0	0
Loxahatchee NWR	2003	1	0	0	0	14	7	6	10	1	0	0	0	1	60
Mackay Island NWR	2002	2	0	0	6	0	36	14	0	9	0	9	13	0	328
	2003	16	0	1	0	0	90	33	0	1	0	0	16	0	1
	2004	6	0	0	1	12	101	64	0	16	0	0	8	0	1
Mattamuskeet NWR	2003	1	0	0	0	0	37	19	0	0	0	18	6	0	0
Medecine Lake NWR	2002	49	739	0	0	0	0	0	0	137	0	112	29	0	426
Merrit Island NWR	2003	0	0	0	0	30	0	2	0	0	0	0	0	0	3
Minnesota Valley NWR	2003	0	0	0	0	0	0	1	0	1	0	3	17	0	225
Missisquoi NWR	2000	6	0	0	0	23	0	1	0	44	0	11	13	0	98
	2003	12	0	0	0	36	0	0	0	64	0	0	0	0	292
Monte Vista NWR	2001	10	38	0	0	0	0	0	0	8	0	42	3	0	25
	2002	8	52	0	0	0	0	0	0	1	0	13	4	0	969
Moosehorn NWR	1999	13	0	0	0	0	0	0	0	6	0	18	59	0	137
	2000	1	0	0	0	0	0	0	0	3	0	32	30	0	172
	2001	8	0	0	0	0	0	0	0	7	0	31	34	0	2204
	2002	2	0	0	0	0	0	0	0	7	0	32	29	0	2190
	2003	14	0	0	0	0	0	1	0	2	0	24	31	0	2044
	2004	11	0	0	0	0	0	0	0	6	0	47	40	0	0
Morris WMD	2003	14	0	0	0	0	0	2	0	46	0	9	3	0	16

Table 5. Continued.

National Elk Refuge	2002	0	0	0	0	0	0	0	0	0	0	4	0	0	0
	2003	0	1	0	0	0	0	0	0	0	0	29	0	0	85
Nisqually NWR Complex	2003	14	5	0	0	0	0	0	0	3	0	3	20	0	593
Nomans Land Island NWR	2003	0	0	0	0	0	0	0	0	0	0	0	15	0	2
	2004	0	0	0	0	0	0	0	0	0	0	0	15	0	282
Ouray NWR	2001	38	994	0	0	0	0	0	0	64	0	3	1	0	107
	2002	14	104	0	0	0	0	0	0	43	0	1	5	0	284
Oxbow NWR	2002	0	0	0	0	0	0	0	0	0	0	0	6	0	1050
	2003	0	0	0	0	0	0	0	0	2	0	0	0	0	5
	2004	0	0	0	0	0	0	0	0	0	0	1	2	0	46
Prairie Potholes Region	2002	27	0	0	0	0	1	3	0	2	0	224	44	1	534
	2003	56	0	0	0	0	0	1	0	99	0	152	110	3	313
Red Lake Band of Chippewa	2002	60	102	0	0	0	0	1	0	69	0	96	10	11	256
	2003	26	6	0	0	0	0	11	0	62	0	48	25	0	0
San Bernardino/Leslie Canyon NWR	2003	0	12	0	0	0	0	0	0	0	0	2	0	0	0
Seney NWR	2003	16	0	0	0	0	0	0	0	3	0	23	3	0	0
Silvio O. Conte NFWR	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	45
S. Bonno-Salton Sea NWR	2000	10	0	0	239	0	0	39	0	0	0	0	10	0	13
	2004	12	0	0	1240	486	0	171	0	141	0	65	17	0	0
	2005	7	0	11	1140	460	0	201	0	284	0	90	15	0	0
Southern California Coast	2000	0	0	0	5	0	0	3	0	0	0	0	22	0	0
	2001	0	0	8	0	0	0	0	0	0	0	2	9	0	0
St Johns NWR	2002	0	0	1	2	2	6	0	0	0	0	0	0	0	8
	2003	0	0	2	0	0	0	0	0	0	0	0	0	0	0
St Vincent NWR	2002	0	0	0	5	2	0	1	0	0	0	0	0	0	516
Stewart B McKinney NWR	2000	0	0	0	37	0	1	1	0	0	0	0	9	0	87
	2001	0	0	0	15	0	0	0	0	0	0	0	6	0	0
	2002	0	0	0	19	0	0	0	0	0	0	0	1	0	318
	2003	0	0	0	20	0	2	4	0	0	0	0	5	0	8
Supawna Meadows NWR	2002	0	0	0	33	0	0	1	0	0	0	0	0	0	273
	2003	0	0	0	122	0	38	21	0	0	0	6	6	0	0
Ted Shanks Conserv. Area	2002	0	0	0	0	0	0	5	0	0	0	0	0	0	183
Ten Thousand Islands NWR	2003	0	0	0	2	6	6	0	1	0	0	0	0	0	265
Tishomingo NWR	2003	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total		1093	8126	3475	9462	7243	516	10448	11	8759	19	3657	6623	25	54223

Table 6. Location and primary contact for each site where participants have requested protocols for standardized marsh bird surveys over the past 6 years.

FWS Region	State/ Prov.	Participating Location	Current Contact	Survey Years
1	CA	Elkhorn Slough National Est. Res. Reserve	Rikke Kvist Preisler	2004
1	CA	La Jolla Band Luiseno Indians San Diego Co.	Chris Greeff	2004
1	CA	Sacramento/San Francisco	John Martin	2004
1	CA	San Francisco Bay NWR	Joy Albertson	
1	CA	Sonny Bonno-Salton Sea NWR	Courtney Conway	2000-05
1	CA	Southern CA Coast	Courtney Conway	2000-01
1	ID	Bear Lake	Colleen Moulton	2005
1	ID	Boundary Creek	Colleen Moulton	2005
1	ID	Camas NWR	Colleen Moulton	2005
1	ID	Camas Prairie Centennial Marsh	Colleen Moulton	2004-05
1	ID	Carey Lake	Colleen Moulton	2005
1	ID	Coeur d'Alene WMA	Colleen Moulton	2005
1	ID	MacArthur Lake	Colleen Moulton	2005
1	ID	Market Lake WMA	Colleen Moulton	2005
1	ID	Mud Lake WMA	Colleen Moulton	2005
1	ID	Silver Creek Preserve - IBA	Colleen Moulton	2004-05
1	ID	Sterling WMA	Colleen Moulton	2005
1	ID	Teton Valley, Idaho	Robert Cavallaro	2004
1	ID	Westmond Lake	Colleen Moulton	2005
1	OR	Fern Ridge Lake (CORPS/ODFW)	Kat Beal	2003-04
1	WA	Black River Unit of Nisqually NWR	Hillary Naught	
1	WA	Columbia NWR	Randy Hill	2003-04
1	WA	Nisqually NWR Complex	Marian M. Bailey	2003-05
1	WA	Turnbull NWR	Mike Rule	1999-05
2		Cyndee Baker	Cyndee Baker	2005
2	AZ	AGFD Phoenix area	Bill Burger	2003-05
2	AZ	Arlington Ponds	Mark Stewart	2004
2	AZ	Bill Williams NWR	Courtney Conway	2000
2	AZ	Cibola NWR	Courtney Conway	2000-02
2	AZ	Goodyear Butte	Diane Lausch	2004
2	AZ	Havasu NWR	Courtney Conway	2000-05
2	AZ	Imperial NWR	Courtney Conway	2000-05
2	AZ	Lower Colorado River	Courtney Conway	2000-05
2	AZ	Mittry Lake State Mgmt Area	Lin Piest	2003-04
2	AZ	Patagonia area marshes	Tim Snow	2004
2	AZ	San Bernardino/Leslie Canyon NWR	Nina King	2003
2	NM	Bitter Lake NWR	Gordon Warrick	2003-05
2	NM	Bosque del Apache NWR	Colin Lee	2004
2	NM	Maxwell NWR	Rick Gooch	2003
2	OK	Salt Plains NWR	Ron Shepperd	2005
2	OK	Sequoyah NWR	Jeffrey Sanchez	2005
2	OK	Tishomingo NWR	Kris Patton	2003
2	TX	Anahuac NWR	Andy Loranger	2003-04
2	TX	Aransas NWR	Darrin Welchert	2005
2	TX	Mcfaddin NWR	Patrick Walther	2004

Table 6. Continued.

2	TX	Texas Point NWR	Patrick Walther	2004
2	TX	Trinity River NWR	Michael Blessington	2004
3	IA	DeSoto NWR	Bob Barry	2003
3	IA	Driftless Area NWR	Clyde Male	1993-03
3	IA	Port Louisa NWR	Karen Harvey	2004
3	IL	central IL CREP wetlands	Ben O'Neal	2005
3	IL	Delair Div of Great River NWR	Candy Chambers	2002-02
3	IL	Illinois River NWFR	Gwen Kolb	2003
3	IL	Illinois River Valley	Joshua Stafford	2005
3	IN	Indiana Dunes National Monument	Ralph Grundel	2002
3	IN	Patoka River NWR	Bob Dodd	2004
3	MI	Michigan Natural Features Inventory	Michael Monfils	2005
3	MI	Seney NWR	Dave Olson	2001-05
3	MI	Shiawassee NWR	Jim Dastyck	2002-05
3	MN	Agassiz NWR	Soch Lor	2000-05
3	MN	Big Stone NWR	Kim Bousquet	2004
3	MN	Crane Meadows NWR	Jeanne Holler	2003-04
3	MN	Hamden Slough NWR	Mike Murphy	2003-05
3	MN	Leech Lake Band of Chippewa Indians	Steve Mortensen	
3	MN	Litchfield WMD	Mary Soler	2002-04
3	MN	Minnesota Valley NWR	Vicki Sherry	2003-04
3	MN	Morris WMD	Sara Vacek	2003-04
3	MN	Natural Resources Research Institute	JoAnn Hanowski	2003
3	MN	Prairie Potholes Region	Diane Granfors	2002-05
3	MN	Red Lake Band of Chippewa Indians	Dave Price	2002-04
3	MN	Rice Lake NWR	Michelle McDowell	2004-05
3	MN	Sherburne NWR	Jeanne Holler	1999-05
3	MN	throughout MN	Randy Frederickson	2004
3	MN	Upper Mississippi River NW&FR	Vickie Hirschboeck	2003-05
3	MO	2600 ac south of Clarence Canon NWR	Brian Loges	2004
3	MO	B.K. Leach CA	Brian Loges	2005
3	MO	Clarence Cannon NWR	Candy Chambers	2002-05
3	MO	Squaw Creek NWR	Frank Durbian	2003
3	MO	Ted Shanks Conservation Area	Eileen Kirsch	2002
3	SD	entire state of SD	Nancy Drilling	2005
3	WI	Bad River Band of Lake Superior Chippewa	Tommy Doolittle	
3	WI	Horicon NWR	Wendy Woyczik	1999-04
3	WI	Leopold WMD	Jim Lutz	2005
3	WI	Northeastern WI	Bob Fisher	2003
3	WI	Whittlesey Creek NWR	Pam Dryer	2000-02
3	WI	WI DNR peatlands	Sumner Matteson	2005
3	WI	WMA in Northeastern WI	Larry Riedinger	2004
4	AL	AL Gulf Coast/Bon Secour NWR	Eric C. Soehren	2003-04
4	AL	Wheeler NWR	William R. Gates	2005
4	AR	Bald Knob NWR	Tom Edwards	2002
4	AR	Delta region of AR	Andrea Green	2004
4	AR	Mississippi River Delta	Jason Phillips	2003
4	AR	Nora Schubert	Nora Schubert	2002
4	AR	Southern AR	Karen Rowe	

Table 6. Continued.

4	FL	Florida Panther NWR	Larry Richardson	2003
4	FL	J.N. Ding Darling NWR	Kendra Pednault-Willett	2003-04
4	FL	Lake Woodruff NWR	Kristina Sorensen	2005
4	FL	Lower Suwannee NWR	Steve Barlow	2004
4	FL	Loxahatchee NWR	Stefani Melvin	2003-04
4	FL	Merrit Island NWR	Marc Epstein	2003-04
4	FL	Okefenokee NWR	Sara Aicher	2004
4	FL	St Johns NWR	Marc Epstein	2002-04
4	FL	St Marks NWR	Joe Reinman	2005
4	FL	St Vincent NWR	Thom Lewis	2002
4	FL	Ten Thousand Islands NWR	Terry Doyle	2003-05
4	KY	Ballard WMA	Elizabeth Ciuzio	2004-05
4	KY	WMA - western KY	Elizabeth Ciuzio	
4	LA	Bayou Sauvage NWR	Charlotte Parker	2005
4	LA	Big Branch Marsh NWR	Charlotte Parker	2005
4	LA	Cameron Prairie NWR	Sammy King	2004
4	LA	central LA	Nicholas Winstead	2004
4	LA	Grand Bay National Est. Research Reserve	Mark S. Woodrey	2004-05
4	LA	Grand Bay NWR	Mark S. Woodrey	2004-05
4	LA	Rockefeller Wildlife Refuge	Sammy King	2004
4	LA	Southwestern LA	Sergio Pierluissi	2004-05
4	LA	Spring Bayou WMA; Marksville, LA	Lorrie Laliberte	2004
4	MS	Lower Pascagoula River Coastal Reserve	Mark S. Woodrey	2005
4	MS	Mississippi Sandhill Crane NWR	Scott Hereford	2004-05
4	NC	Cedar Island NWR	Michael Legare	2002-04
4	NC	Mackay Island NWR	Kendall Smith	2002-04
4	NC	Mattamuskeet NWR	Michael Legare	2003-04
4	PR	Laguna Cartagena NWR	Stephen Earsom	2003-04
4	SC	ACE Basin NWR	Sara Schweitzer	2005
4	SC	Cape Romain NWR	Marshall Craig Sasser	2003
4	SC	Nemours Wildlife Foundation	Sara Schweitzer	2005
4	SC	North Inlet-Winyah Bay Ntl. Est. Res. Reserve	Anna Toline	2006
4	SC	Waccamaw NWR	Gary M. Phillips	2005
4	TN	Reelfoot Lake, nw TN	Nicholas Winstead	2003
4	TN	Wolf River, w Tennessee	Shelton Whittington	2004
5	CT	Stewart B McKinney NWR	Sara Williams	2000-03
5	MA	Assabet River NWR	Stephanie Koch	2002-04
5	MA	Cape Cod National Seashore	Bob Cook	1999-00
5	MA	Great Meadows NWR	Stephanie Koch	2002-04
5	MA	Great Pond, Hatfield, MA	Mitch Hartley	2005
5	MA	Nomans Land Island NWR	Stephanie Koch	2003-04
5	MA	Oxbow NWR	Stephanie Koch	2002-04
5	MA	Silvio O. Conte NFWR	Michelle Babione	2000
5	MA	wetlands throughout MA	Brian Tavernia	2005
5	MD	Blackwater NWR Chesapeake Mshlds Complex	Dixie Birch	2000-05
5	MD	Eastern Shore of MD	Sherry Daugherty	2005
5	MD	entire state of MD	Ashley Traut	2005
5	MD	Martin NWR, Chesapeake Mshlds Complex	Dixie Birch	2000-05
5	ME	Moosehorn NWR	Maurry Mills	1999-05

Table 6. Continued.

5	ME	University of Maine	Jed Hayden	2005
5	NH	Great Bay NWR	Debra Kimbrell-Anderson	2000-03
5	NH	Lake Umbagog NWR	Laurie Wunder	1999-05
5	NJ	Edwin B. Forsythe NWR	Jorge Coppen	2004-05
5	NJ	Gateway National Recreation Area	Sara Stevens	2005
5	NJ	Great Swamp NWR	Steve Byland	2002
5	NJ	Supawna Meadows NWR	Linda Chorba Ziemba	2002-05
5	NY	Iona Island	Chuck Neider	2005
5	NY	Iroquois NWR	Paul Hess	2000-04
5	NY	New York, NYSDEC	Dave Adams	2004
5	NY	West Point Military Academy	Chris Pray	2003
5	PA	All of PA	Michael Lanzone	2004
5	PA	John Heinz NWR	Brendalee Phillips	2005
5	PA	private wetland in PA	Rick Mellon	2005
5	VA	Back Bay NWR	John Gallegos	2000-05
5	VA	E. Shore of Virginia/Fisherman Island NWR	Pamela Denmon	2001-05
5	VA	entire state of VA	Mike Wilson	2004
5	VA	Mockhorn WMA - atlantic coast	Gary Costanzo	2005
5	VA	Rappahannock River Valley NWR	Sandy Spencer	2002-04
5	VA	Saxis WMA - Chesapeake Bay	Ruth Boettcher	2004-05
5	VT	Missisquoi NWR	Al (Robert) Zelley	2000-04
5	VT	VT Audubon (3 IBAs)	Regan Brooks	2003
6	CO	Alamosa NWR	Rich Levad	2001-05
6	CO	Blanca Wetlands	Rich Levad	2005
6	CO	Brown's Park	Suzanne Beauchaine	2005
6	CO	John Martin Res/Ft. Lyon SWA	Rich Levad	2003-05
6	CO	Monte Vista NWR	Rich Levad	2001-05
6	CO	Russell Lakes SWA	Rich Levad	2005
6	CO	throughout CO	Rich Levad	
6	KS	All of KS	Helen Hands	2005
6	KS	Cheyenne Bottoms Wildlife Area	Helen Hands	2003-04
6	KS	Quivira NWR	Helen Hands	2004
6	MN	Rydell NWR	Dave Bennett	2004-05
6	MT	Bowdoin NWR	Fritz Prellwitz	2002
6	MT	Confed. Salish/Kootenai Tribes	Janene Lichtenberg	2002-04
6	MT	Medecine Lake NWR	Beth Madden	2002
6	MT	Waterfowl Production Areas in NE Montana	Allison J. Puchniak	2004
6	ND	Lake Alice NWR/Devils Lake WMD	Cami Dixon	2002
6	ND	Northern Prairie	Mark Sherfy	2004
6	SD	Lacreek NWR	Shilo Comeau	2003-05
6	UT	Ouray NWR	Diane Penttila	2001-05
6	WY	National Elk Refuge	Eric Cole	2002-03
n/a	Alberta	Alberta BCR11	Mike Norton	2002
n/a	Alberta	Northeastern Alberta	Julienne Morissette	2004-05
n/a	Manit.	The Duck Mountains of Manitoba	Julienne Morissette	
n/a	Mexico	Baja	Osvel Hinojosa	2003-04
n/a	Mexico	Coloardo River Delta	Osvel Hinojosa	2003-04
n/a	Mexico	Sinaloa	Osvel Hinojosa	2003-04
n/a	Mexico	Sonora	Osvel Hinojosa	2003-04
n/a	Rota	Rota	Paul Wenninger	2004
n/a	Sask.	Weyerhaeuser Prince Albert Forest Mgmt Area	Julienne Morissette	

Table 7. Number of survey points and the number of replicate surveys conducted each year at each location that has contributed data to the pooled database (only includes data that has been entered, proofed, and merged as of November 2005).

Location	1999		2000		2001		2002		2003		2004		2005	
	# Points	# Repl.	# Points	# Repl.	# Points	# Repl.	# Points	# Repl.	# Points	# Repl.	# Points	# Repl.	# Points	# Repl.
Agassiz NWR	0	0	47	3	43	3	42	3	0	0	0	0	0	0
AGFD Phoenix area	0	0	0	0	0	0	0	0	41	4	57	3	0	0
AL Gulf Coast/Bon Secour NWR	0	0	0	0	0	0	0	0	125	1	0	0	0	0
Alamosa NWR	0	0	0	0	14	3	13	2	0	0	0	0	0	0
Alberta BCR11	0	0	0	0	0	0	320	1	0	0	0	0	0	0
Anahuac NWR	0	0	0	0	0	0	0	0	6	1	0	0	0	0
Assabet River NWR	0	0	0	0	0	0	13	3	14	5	0	0	0	0
Lower Colorado River	0	0	0	0	0	0	0	0	58	2	50	4	0	0
Back Bay NWR	0	0	18	4	32	3	33	3	33	3	33	3	0	0
Baja/Sonora/Sinaloa	0	0	0	0	0	0	0	0	81	2	0	0	0	0
Bald Knob NWR	0	0	0	0	0	0	13	2	0	0	0	0	0	0
Bill Williams NWR	0	0	64	1	0	0	0	0	0	0	0	0	0	0
Bitter Lake NWR	0	0	0	0	0	0	0	0	20	3	0	0	0	0
Bowdoin NWR	0	0	0	0	0	0	16	1	0	0	0	0	0	0
Cape Cod National Seashore	97	5	37	7	0	0	0	0	0	0	0	0	0	0
Cedar Island NWR	0	0	0	0	0	0	0	0	19	3	0	0	0	0
Cheyenne Bottoms Wildl. Area	0	0	0	0	0	0	0	0	44	4	0	0	0	0
Cibola NWR	0	0	44	1	0	0	1	1	0	0	0	0	0	0
Clarence Cannon NWR	0	0	0	0	0	0	23	7	29	9	30	9	0	0
Columbia NWR	0	0	0	0	0	0	0	0	46	3	0	0	0	0
Confed. Salish/Kootenai Tribes	0	0	0	0	0	0	0	0	53	3	0	0	0	0
Great River NWR	0	0	0	0	0	0	6	2	6	4	0	0	0	0
E. Shore of Virginia Fisherman Island NWR	0	0	0	0	14	3	16	3	18	3	17	3	0	0
Edwin B. Forsythe NWR	0	0	0	0	0	0	0	0	0	0	36	2	0	0
Fern Ridge Lake (ODFW)	0	0	0	0	0	0	0	0	17	3	0	0	0	0
Great Bay NWR	0	0	0	0	13	3	13	3	13	3	0	0	0	0
Great Meadows NWR	0	0	0	0	0	0	16	3	41	5	0	0	0	0
Great Swamp NWR	0	0	0	0	0	0	17	3	0	0	0	0	0	0
Hamden Slough NWR	0	0	0	0	0	0	0	0	19	0	0	0	0	0
Havasu NWR	0	0	90	1	95	4	95	3	95	4	95	4	95	4
Horicon NWR	0	0	0	0	14	4	21	3	15	3	0	0	0	0
Illinois River NWFR	0	0	0	0	0	0	0	0	10	3	0	0	0	0
Imperial NWR	0	0	172	2	68	3	129	3	225	5	201	6	192	5
Iroquois NWR	0	0	36	1	0	0	36	2	36	1	36	1	0	0
J.N. Ding Darling NWR	0	0	0	0	0	0	0	0	18	1	19	9	0	0
Lake Alice NWR/Devils Lake	0	0	0	0	0	0	22	3	0	0	0	0	0	0
Lake Umbagog NWR	0	0	24	3	24	3	24	3	24	3	0	0	0	0
Litchfield WMD	0	0	0	0	0	0	31	3	31	3	0	0	0	0
Lower Colorado River	0	0	918	9	341	4	345	5	434	5	444	6	437	5
Loxahatchee NWR	0	0	0	0	0	0	0	0	15	2	0	0	0	0

Mackay Island NWR	0	0	0	0	0	0	12	4	26	3	26	3	0	0
Mattamuskeet NWR	0	0	0	0	0	0	0	0	18	4	0	0	0	0
Medecine Lake NWR	0	0	0	0	0	0	29	3	0	0	0	0	0	0
Merrit Island NWR	0	0	0	0	0	0	0	0	10	3	0	0	0	0
Minnesota Valley NWR	0	0	0	0	0	0	0	0	12	4	0	0	0	0
Missisquoi NWR	0	0	21	2	0	0	0	0	20	0	0	0	0	0
Monte Vista NWR	0	0	0	0	21	3	14	2	0	0	0	0	0	0
Moosehorn NWR	95	3	89	3	89	3	109	3	102	3	90	3	0	0
Morris WMD	0	0	0	0	0	0	0	0	40	3	0	0	0	0
National Elk Refuge	0	0	0	0	0	0	17	2	25	3	0	0	0	0
Nisqually NWR Complex	0	0	0	0	0	0	0	0	18	6	0	0	0	0
Nomans Land Island NWR	0	0	0	0	0	0	0	0	19	2	17	2	0	0
Ouray NWR	0	0	0	0	26	3	25	3	0	0	0	0	0	0
Oxbow NWR	0	0	0	0	0	0	8	3	10	5	9	2	0	0
Prairie Potholes Region	0	0	0	0	0	0	103	4	160	3	0	0	0	0
Red Lake Band of Chippewa Indians	0	0	0	0	0	0	34	3	38	3	0	0	0	0
San Bernardino/Leslie Canyon NWR	0	0	0	0	0	0	0	0	7	3	0	0	0	0
Seney NWR	0	0	0	0	0	0	0	0	18	3	0	0	0	0
Silvio O. Conte NFWR	0	0	3	2	0	0	0	0	0	0	0	0	0	0
Sonny Bonno-Salton Sea NWR	0	0	281	2	0	0	0	0	0	0	118	5	94	6
Southern California Coast	0	0	31	2	68	3	0	0	0	0	0	0	0	0
St Johns NWR	0	0	0	0	0	0	17	3	11	3	0	0	0	0
St Vincent NWR	0	0	0	0	0	0	14	1	0	0	0	0	0	0
Stewart B McKinney NWR	0	0	12	3	10	2	12	2	12	3	0	0	0	0
Supawna Meadows NWR	0	0	0	0	0	0	16	3	40	3	0	0	0	0
Ted Shanks Conserv. Area	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Ten Thousand Islands NWR	0	0	0	0	0	0	0	0	12	1	0	0	0	0
Tishomingo NWR	0	0	0	0	0	0	0	0	5	4	0	0	0	0
Total # points Average # replicates	192	4	1887	3	872	3	1664	3	2189		1278	3	818	5

Figure 1. Number of participants using the standardized North American marsh bird survey protocols and submitting their data to the pooled dataset during each of the past 6 years.

Figure 2. Locations in North America where participants are conducting marsh bird surveys using the standardized survey protocols. Yellow stars indicate participating NWRs and red stars indicate participants that are not associated with NWRs.

Figure 3. Proportion of all birds detected that were detected during each 1-min segment during surveys for each of 11 species. The first 5 minutes of each survey did not include call-broadcast, and each subsequent minute included the broadcast of common calls of a different species. We only included species for which >200 detections were available from the pooled database. Segments on the graph lacking a bar indicate that we lack data for surveys that included that species in the broadcast sequence on which the species of interest was detected (all surveys included the initial 5 minutes of silence, but the species included in the broadcast sequence varied among participants). The red bar in each panel highlights the proportion of birds detected during the one minute of conspecific calls for that species.

Figure 4. Mean (± SE) number of birds detected per survey route between completely passive surveys (circles with black error bars) and those during which calls of A) black rails, and B) clapper rails were broadcast (triangles with gray error bars). Sample sizes were: A) 32 paired survey routes, and B) 18 paired survey routes.

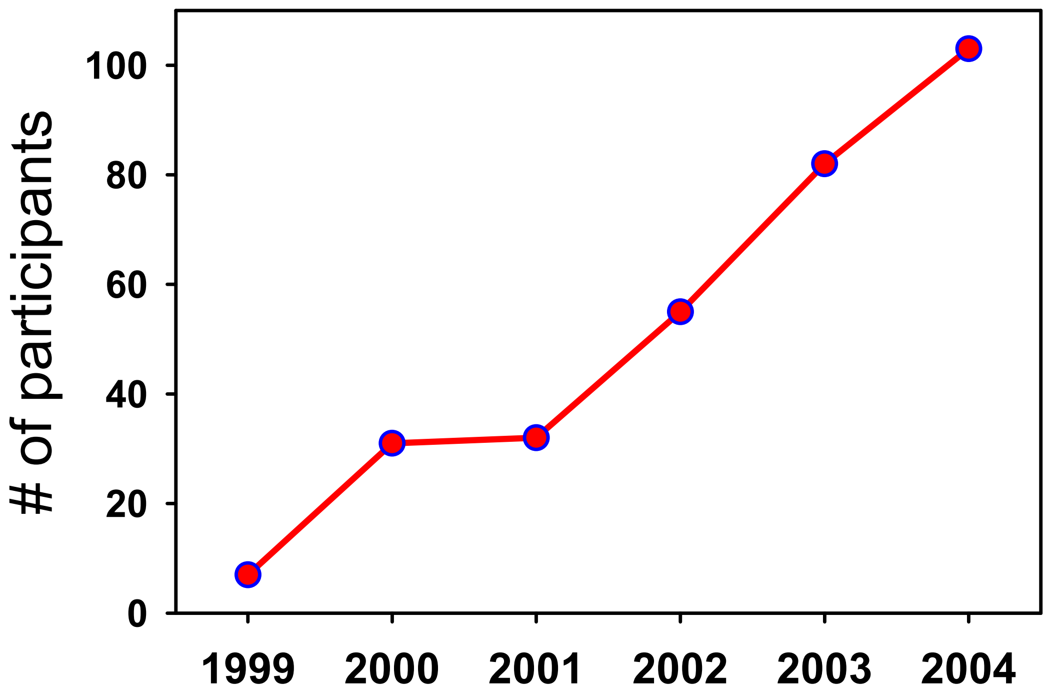
Figure 5. Mean (± SE) and coefficient of variation in number of birds detected per point during the initial passive period (either 3 or 5 minutes in duration) and the subsequent call-broadcast period after the call-broadcast period was truncated to the same duration of the passive period (i.e., birds detected during the first 3 or 5 minutes of the call-broadcast period). For each species, we restricted the analysis to only those survey points at which that species was included within the first 3 or 5 minutes of the call-broadcast period. For each species, means (A) only include points at which ≥1 bird was detected on ≥1 replicate survey. Coefficient of variation within points (B) only includes points at which ≥1 bird was detected on ≥1 replicate survey during both the passive segment and the call-broadcast segment.

Figure 6. Percent increase in the number of birds detected as a result of call-broadcast (A), and percent decrease in the coefficient of variation in number of birds detected as a results of call-broadcast (B).

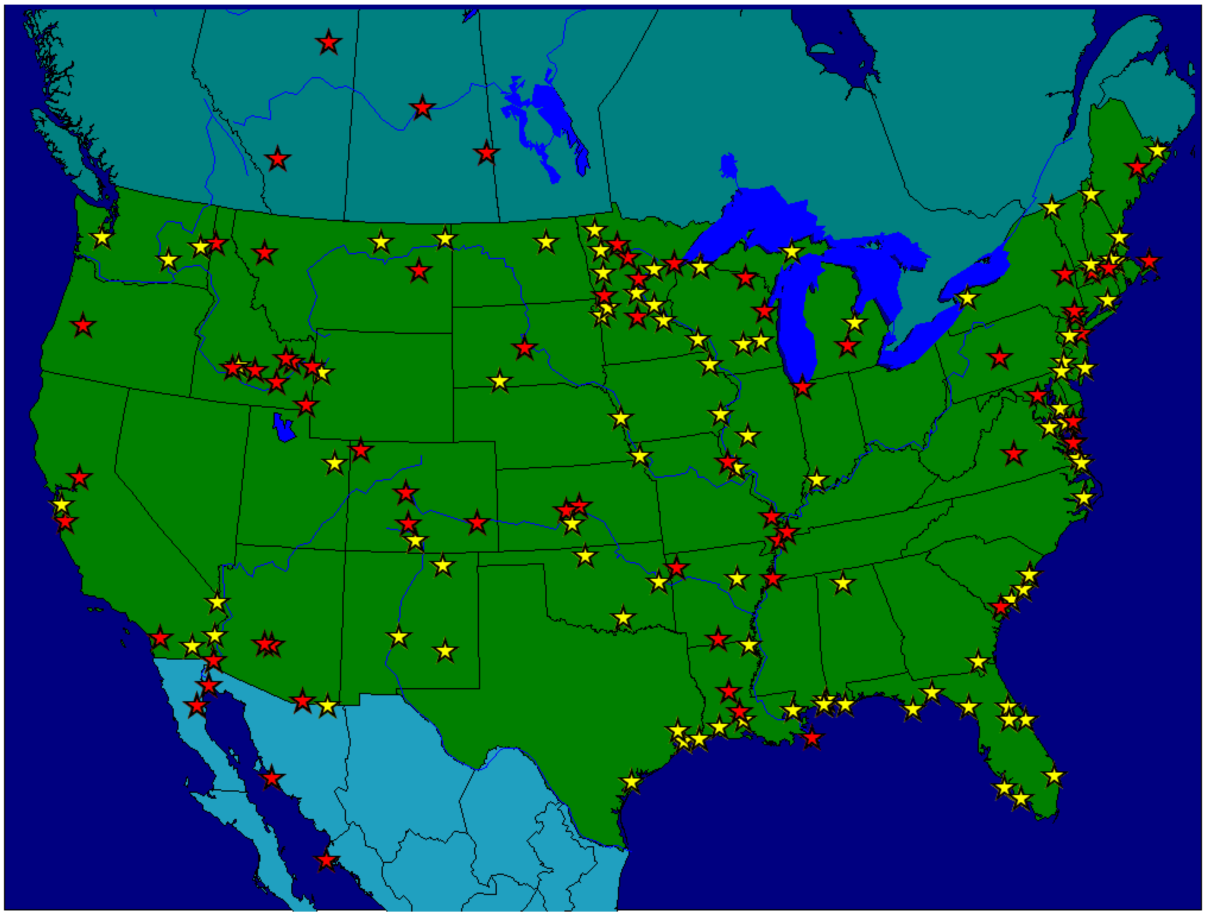
Figure 7. Effects of broadcasting multiple species' calls on number of secretive marsh birds detected. A) Mean (± SE) number of birds detected for each of 8 species of secretive marsh birds on 9-minute surveys that included six 30-second segments of clapper rail calls (circles with black error bars) and those that included three 30-second segments each of black rail and clapper rail calls (triangles with gray error bars); $n = 19$ survey routes. B) Mean (± SE) number of birds detected for each of 8 species of

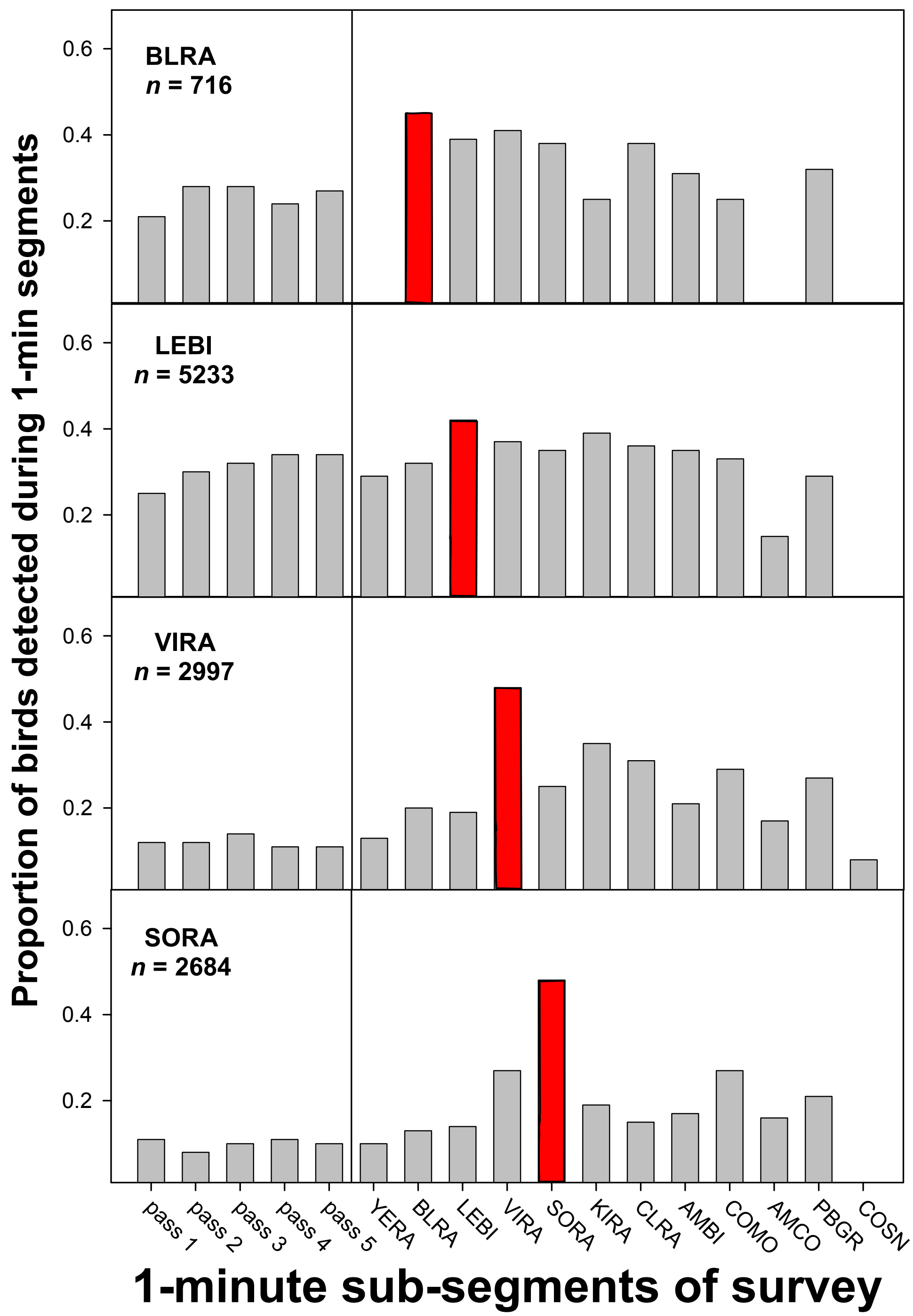
secretive marsh birds on 9-minute surveys that included three 30-second segments each of black rail and clapper rail calls (circles with black error bars) and those that included one 30-second segment of each of 6 species' calls (black rail, least bittern, sora, Virginia rail, clapper rail, pied-billed grebe) (triangles with gray error bars); *n* = 78 survey routes. The dotted reference line in each graph separates the species for which calls were broadcast during at least one of the two survey protocols (left of the dotted line) and those for which calls were not broadcast during either of the two survey protocols (right of the dotted line).

Figure 8. A) Mean (± SE) of observer detection probability for each of 7 species of secretive marsh birds averaged across 11 observers during both the passive segment of the survey and the call-broadcast segment of the survey. We only included data from observer pairs from which x_{11}, x_{12}, x_{21}, and x_{22} were all >1. There was insufficient data for any of the observer pairs to estimate observer detection probability for soras during the passive segment of the surveys. B) Observer detection probability for each of 7 species of secretive marsh birds during both the passive segment of the survey and the call-broadcast segment of the survey summing data across all 11 observers.

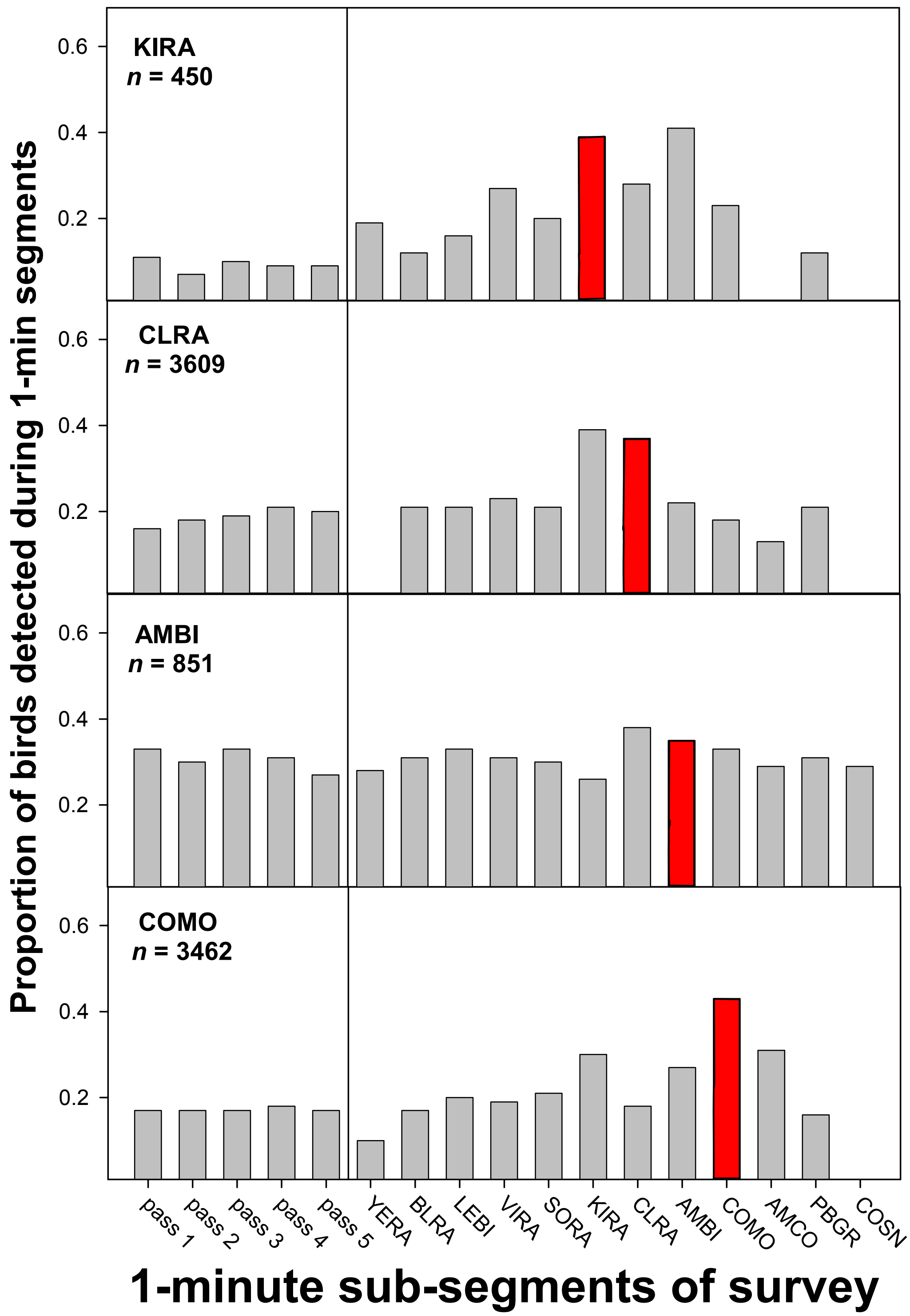


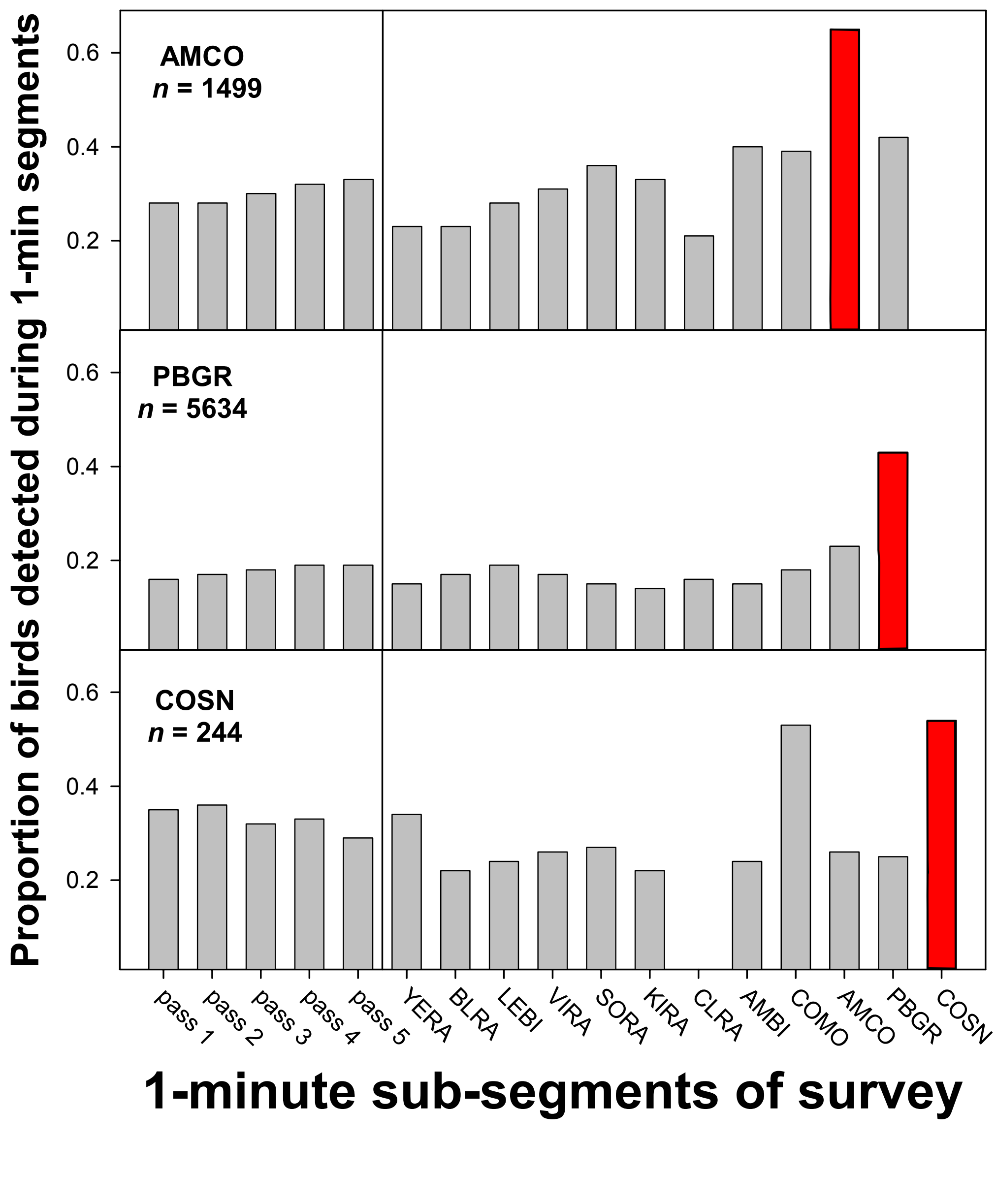
# of participants
100
80
60
40
20
0
1999
2000
2001
2002
2003
2004



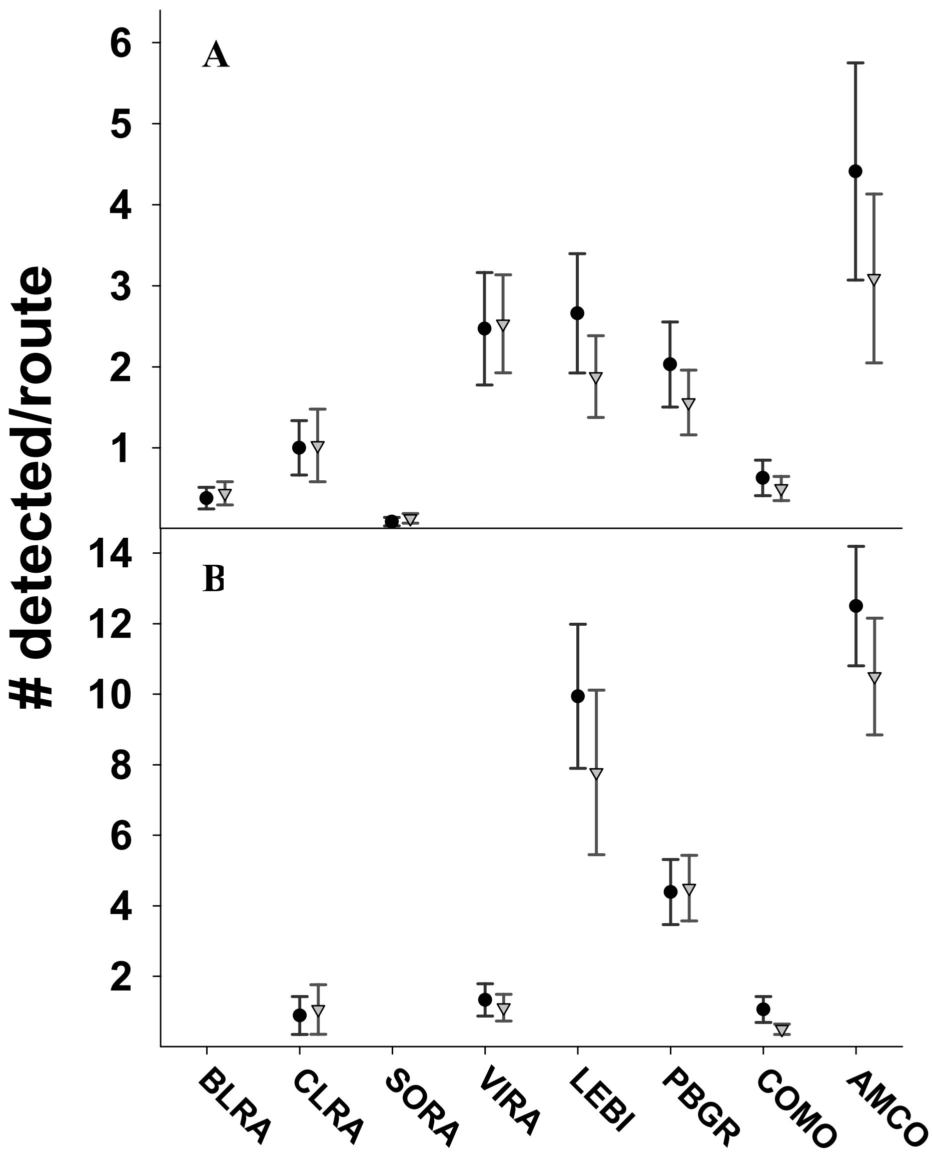


BLRA
n = 716
LEBI
n = 5233
VIRA
n = 2997
SORA
n = 2684
0.6
0.4
0.2
Proportion of birds detected during 1-min segments
pass 1
pass 2
pass 3
pass 4
pass 5
YERA
BLRA
LEBI
VIRA
SORA
KIRA
CLRA
AMBI
COMO
AMCO
PBGR
COSN
1-minute sub-segments of survey

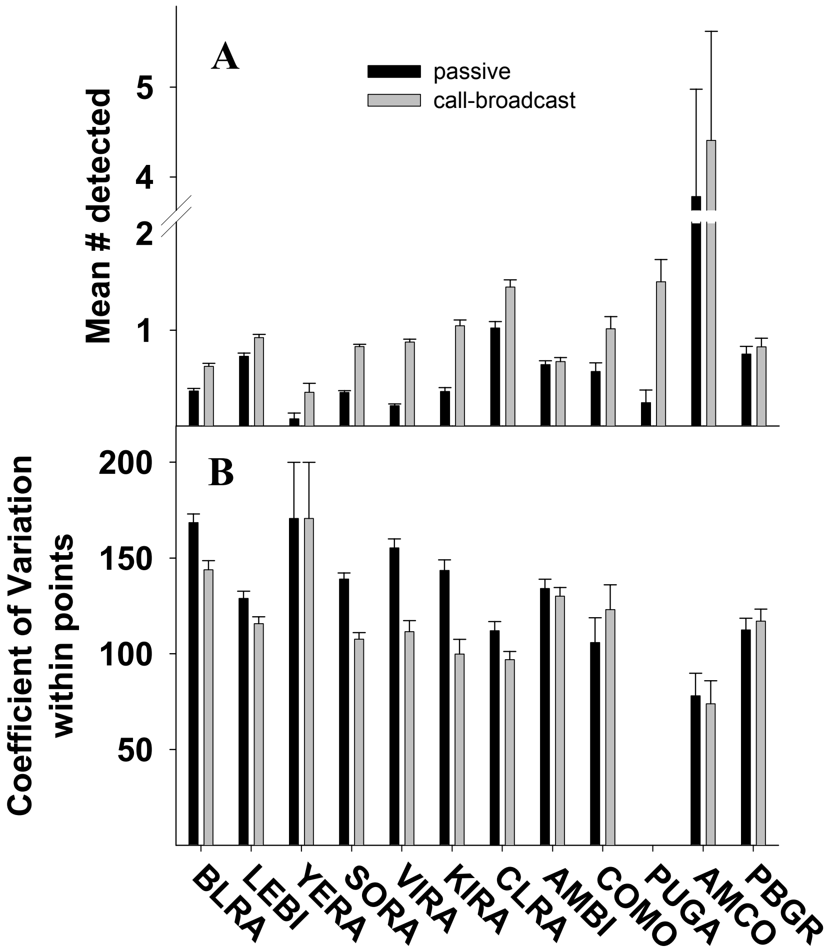

KIRA
n = 450
CLRA
n = 3609
AMBI
n = 851
COMO
n = 3462
0.6
0.4
0.2
Proportion of birds detected during 1-min segments
pass 1
pass 2
pass 3
pass 4
pass 5
YERA
BLRA
LEBI
VIRA
SORA
KIRA
CLRA
AMBI
COMO
AMCO
PBGR
COSN
1-minute sub-segments of survey

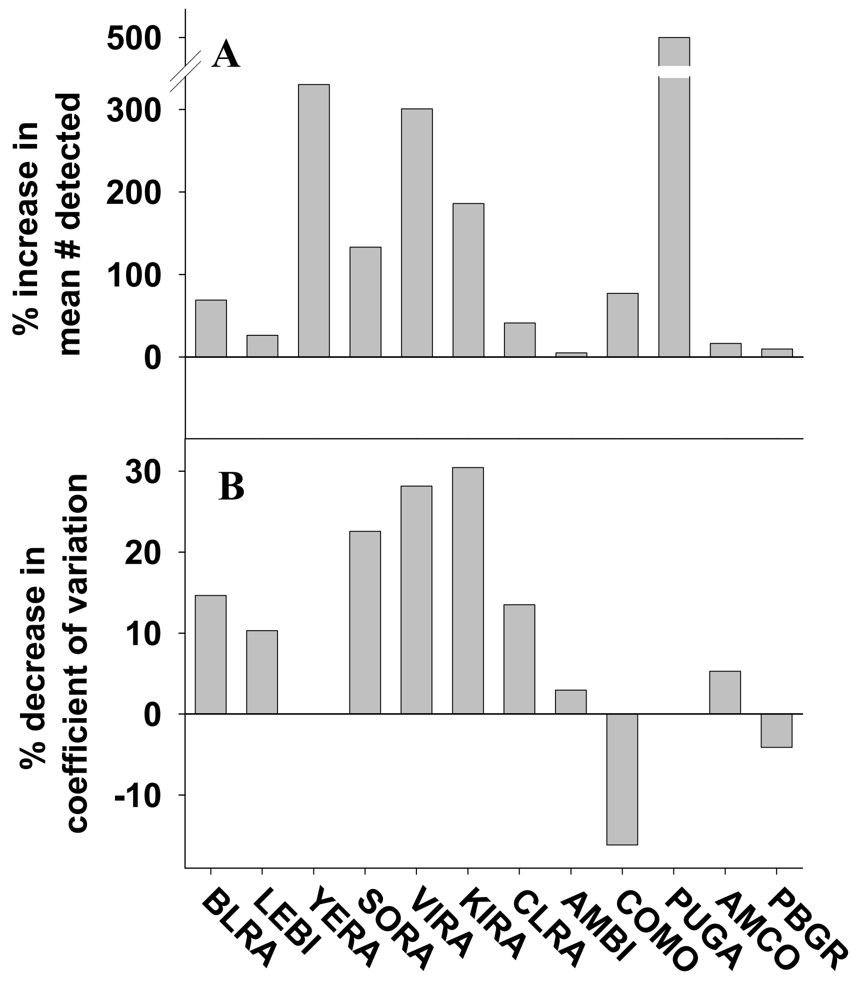


AMCO
n = 1499
PBGR
n = 5634
COSN
n = 244
0.6
0.4
0.2
pass 1
pass 2
pass 3
pass 4
pass 5
YERA
BLRA
LEBI
VIRA
SORA
KIRA
CLRA
AMBI
COMO
AMCO
PBGR
COSN
Proportion of birds detected during 1-min segments
1-minute sub-segments of survey

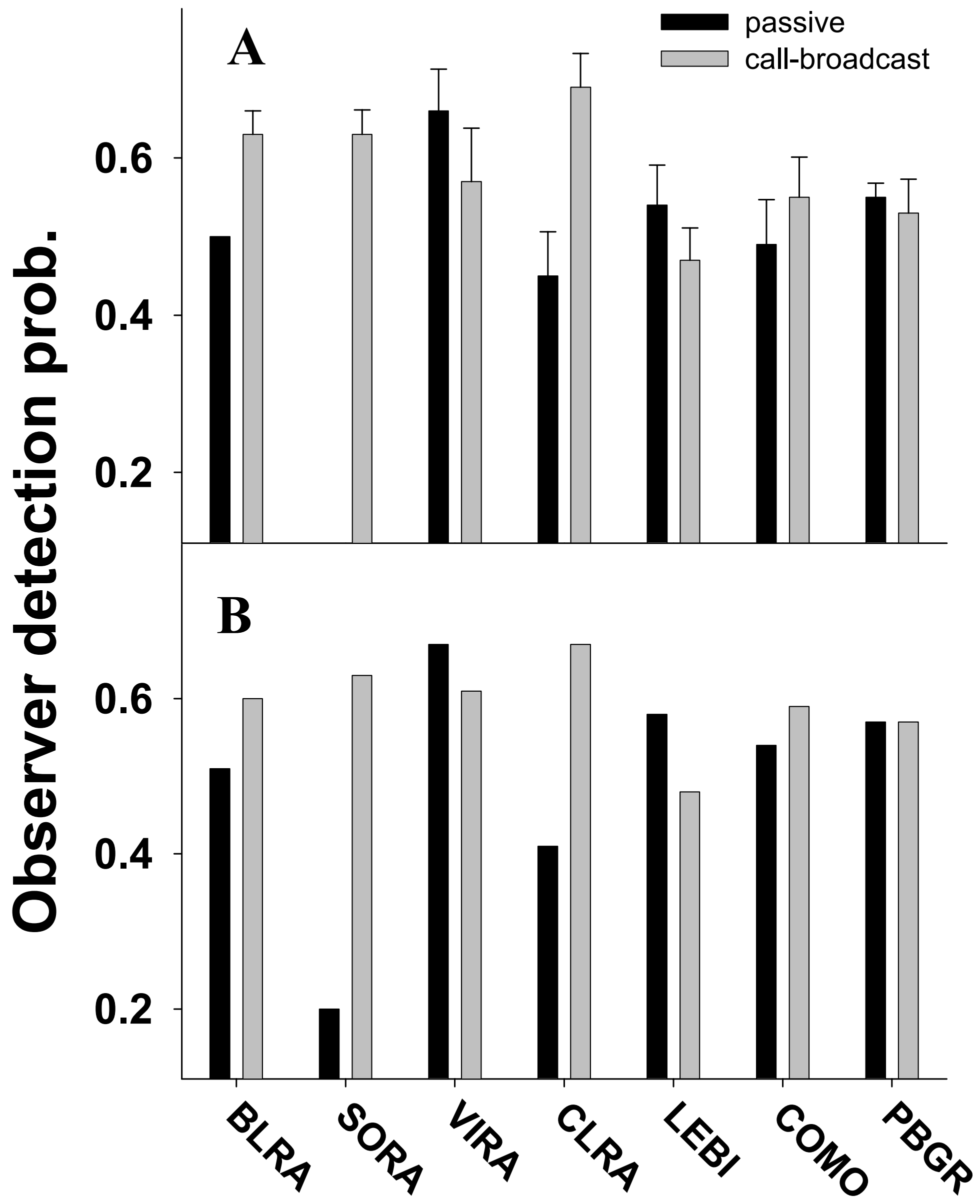


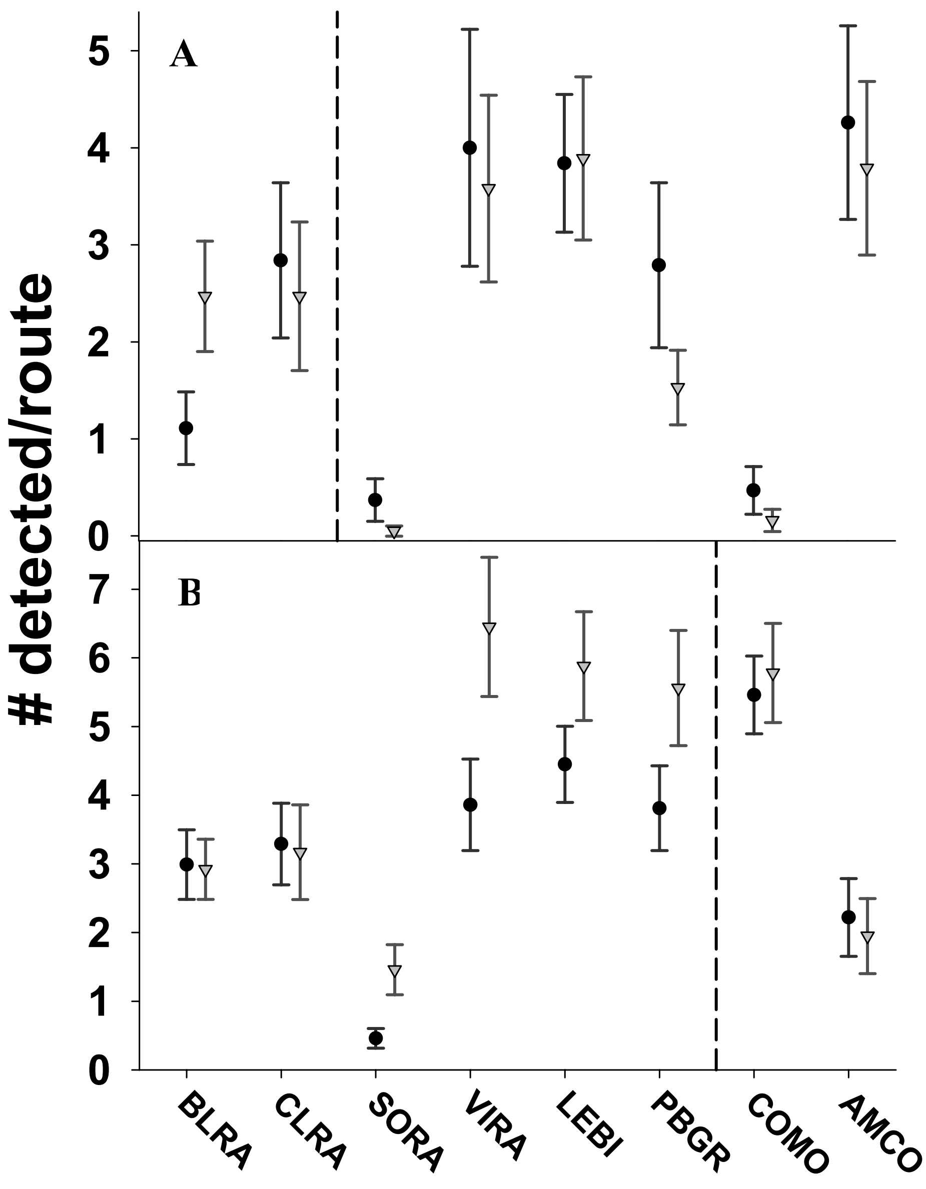
A
B
detected/route
6
5
4
3
2
1
14
12
10
8
6
4
2
BLRA
CLRA
SORA
VIRA
LEBI
PBGR
COMO
AMCO


A
B
passive
call-broadcast
Mean # detected
Coefficient of Variation within points
5
4
2
1
200
150
100
50
BLRA
LEBI
YERA
SORA
VIRA
KIRA
CLRA
AMBI
COMO
PUGA
AMCO
PBGR



A
B
500
300
200
100
0
% increase in mean # detected
30
20
10
0
-10
% decrease in coefficient of variation
BLRA
LEBI
YERA
SORA
VIRA
KIRA
CLRA
AMBI
COMO
PUGA
AMCO
PBGR


A
B
passive
call-broadcast
Observer detection prob.
0.6
0.4
0.2
0.6
0.4
0.2
BLRA
SORA
VIRA
CLRA
LEBI
COMO
PBGR


A
B
detected/route
0
1
2
3
4
5
6
7
BLRA
CLRA
SORA
VIRA
LEBI
PBGR
COMO
AMCO

Appendix 1. Products generated from this project thus far.

Standardized Survey Protocols

Conway, C. J. 2005. Standardized North American Marsh Bird Monitoring Protocols. Wildlife Research Report #2005-04, U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, Tucson, Arizona.

Manuscripts and Reports

Conway, C. J. 2002. Development and Field-testing of Survey Methods for a Continental Marsh Bird Monitoring Program in North America. Webless Migratory Game Bird Research Program Annual Report. U.S. Fish and Wildlife Service, Denver, CO.

Erwin, R. M., C. J. Conway, and S. W. Hadden. 2002. Species occurrence of marsh birds at Cape Cod National Seashore, Massachusetts. *Northeastern Naturalist* 9:1-12.

Conway, C. J., C. Sulzman, and B. A. Raulston. 2004. Factors affecting detection probability of California Black Rails. *Journal of Wildlife Management* 68:360-370.

Conway, C. J., and C. Nadeau. 2004. Development of a National Marsh Bird Monitoring Program, Quarterly Update, September 2004. USGS Arizona Cooperative Fish and Wildlife Research Unit Report, Tucson, AZ.

Conway, C. J., and S. T. A. Timmermans. 2004. Progress toward developing field protocols for a North American marsh bird monitoring program. In Press *in* C.J. Ralph and T.D. Rich, editors. Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference 2002. U.S. Forest Service General Technical Report PSW-GTR-191.

Wheeler, J., and C. J. Conway. 2005. Pushing Secretive Birds Out In the Open: Marsh Bird Monitoring and Assessment. Pages 3-5 *in* The All-Bird Bulletin: Bird Conservation News and Information. North American Bird Conservation Initiative, June 2005 Issue.

Conway, C. J., and J. P. Gibbs. 2005. Effectiveness of call-broadcast surveys for monitoring marsh birds. *The Auk* 122:26-35.

Conway, C. J., and C. Nadeau. 2005. Development of a National Marsh Bird Monitoring Program, Quarterly Update, May 2005. USGS Arizona Cooperative Fish and Wildlife Research Unit Report, Tucson, AZ.

Conway, C. J., and C. Nadeau. 2005. Development and field-testing of survey methods for a continental marsh bird monitoring program in North America. Pages 34-36 in D.D. Dolton, ed., Webless Migratory Game Bird Research Program, 2004 Annual Report. U.S. Fish and Wildlife Service, Denver, CO.

Conway, C. J., and S. Droege. *In Press*. A Unified Strategy for Monitoring Changes in Abundance of Terrestrial Birds Associated with North American Tidal Marshes. Pages xx-xx *in* R. Greenberg, S. Droege, J. Maldonado, and M. V. McDonald, editors. Vertebrates of Tidal Marshes: Ecology, Evolution, and Conservation. Studies in Avian Biology, Lawrence, Kansas.

Workshops

Developed and presented four separate 3-day training workshop attended by a total of ~100 biologists from 30 different agencies/organizations from across the country. Handled all aspects of training and logistics associated with the workshops:

- 29 February to 1 March 2004, Yuma, Arizona.
- 2-5 March 2004, Yuma, Arizona.
- 21-23 March 2005, Yuma, Arizona.
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Website

www.ag.arizona.edu/srnr/research/coop/azfwru/NMBMP/

Appendix 2. Proposed standardized North American marsh bird monitoring protocols.

ARIZONA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT January 2006

STANDARDIZED NORTH AMERICAN MARSH BIRD MONITORING PROTOCOLS

by Courtney J. Conway

Wildlife Research Report #2005-04

USGS
science for a changing world

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES

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Introduction

The amount of emergent wetland habitat in North America has declined sharply during the past century (Tiner 1984). Populations of many marsh birds that are dependent on emergent wetlands appear to be declining (Tate 1986, Eddleman et al. 1988, Conway et al. 1994), but we currently lack adequate monitoring programs to determine status and estimate population trends. Marsh birds include all species that primarily inhabit marshes (i.e., marsh-dependent species). Primary species of concern in North America include King Rails (*Rallus elegans*), Clapper Rails (*Rallus longirostris*), Virginia Rails (*Rallus limicola*), Soras (*Porzana carolina*), Black Rails (*Laterallus jamaicensis*), Yellow Rails (*Coturnicops noveboracensis*), American Bitterns (*Botaurus lentiginosus*), Least Bitterns (*Ixobrychus exilis*), Pied-billed Grebes (*Podilymbus podiceps*), Limpkins (*Aramus guarauna*), American Coots (*Fulica americana*), Purple Gallinules (*Porphyrula martinica*), and Common Moorhens (*Gallinula chloropus*). The U.S. Fish and Wildlife Service has identified Black Rails, Yellow Rails, Limpkins, and American Bitterns as *Birds of Conservation Concern* because they are relatively rare and we lack basic information on status and trends in most areas (U. S. Fish and Wildlife Service 2002). Many U.S. states consider these species threatened or of special concern for similar reasons. King Rails are federally endangered in Canada and Black Rails are federally endangered in Mexico. Because rails and bitterns consume a wide variety of aquatic invertebrates, populations may be affected by accumulation of environmental contaminants in wetland substrates (Odom 1975, Klaas et al. 1980, Eddleman et al. 1988, Gibbs et al. 1992, Conway 1995). Marsh birds are also vulnerable to invasion of wetlands by purple loosestrife (*Lythrum salicaria*) (Gibbs et al. 1992, Meanley 1992). Hence, marsh birds may represent “indicator species” for assessing wetland ecosystem quality, and their presence can be used as one measure of the success of wetland restoration efforts. Marsh birds also have high recreational value; many species are highly sought-after by recreational birders. Finally, several rails are game species in many states yet we lack responsible population surveys on which to base harvest limits.

For these reasons, numerous federal agencies are cooperating to monitor marsh bird populations in North America to estimate population trends. Continued monitoring will also allow resource managers to evaluate whether management actions or activities adversely impact wetland ecosystems. Any management action that alters water levels, reduces mudflat/open-water areas, alters invertebrate communities, or reduces the amount of emergent plant cover within marsh habitats could potentially affect habitat quality for marsh birds (Conway 1995). The survey protocol outlined below is a standardized survey methodology intended for use on National Wildlife Refuges and other protected areas across North America. Results will be pooled to estimate population trends in these protected areas. These protocols will be modified as problems are identified by participants during the first 1-2 years of the survey effort. Participants are strongly encouraged to follow protocols exactly and to report any problems with implementing the protocols immediately so that we can modify and revise the methodology.

During surveys for primary marsh birds, observers may (at their option) record species of secondary concern that are also under-sampled by other monitoring programs, e.g., grebes, herons, egrets, waterfowl, Forster's and Black Terns (*Sterna forsteri* and *Chlidonias niger*), Wilson's Snipe (*Gallinago delicata*), Sandhill Cranes (*Grus canadensis*), Northern Harriers (*Circus cyaneus*), Belted Kingfishers (*Ceryle alcyon*), Alder and Willow Flycatchers (*Empidonax alnorum* and *E. traillii*), Sedge and Marsh Wrens (*Cistothorus platensis* and *C. palustris*), Red-winged and Yellow-headed Blackbirds (*Agelaius phoeniceus* and *Xanthocephalus xanthocephalus*), Sharp-tailed and LeConte's Sparrows (*Ammodramus caudacutus* and *A. leconteii*), Common Yellowthroats (*Geothlypis trichas*), etc. However, surveyors should limit the number of secondary species to only those species of management concern. Many of the species listed above are adequately sampled by the North American Breeding Bird Survey. Listening or looking for too many secondary species may reduce one's ability to detect primary species.

PARAMETERS TO BE ESTIMATED

Density/abundance indices

Abundance is the total number of birds within a defined area of interest. Density is abundance divided by area, or the number of birds/ha of emergent habitat within a wetland during one season. Surveys rarely count all individuals present in the sampling area because detection probability is typically less than 100%. However, number of birds responding during standardized surveys will provide an index to abundance that will allow comparisons among wetland basins and habitat types. Abundance indices will also allow examination of the effects of management actions (e.g., wetland restoration) on marsh birds by comparing changes in abundance indices between managed and un-managed sites both before and after activities have occurred. Indices also allow comparison among other areas in the region to determine the relative importance/quality of local habitats to regional marsh bird populations. The value of an abundance index relies on a **consistent** positive correlation between number of individuals detected during a survey and number of individuals actually present in the area sampled (i.e., low spatial and temporal variation in detection probability). Few reliable estimates of detection probability during marsh bird surveys are currently available (but see Conway et al. 1993, Legare et al. 1999, Bogner and Baldassarre 2002). However, because we are incorporating methods for estimating components of detection probability into these survey protocols, validation of indices based on call-broadcast surveys for primary marsh bird species will be possible. Because we will estimate distance to each bird detected, we will also evaluate the usefulness of distance sampling to provide estimates of density. We will calculate abundance indices for the primary marsh bird species during the breeding season.

Population trend

Population trend is the percent annual change in population size for a particular species at some defined spatial scale. Estimates of population trend allow managers to determine whether local or regional marsh bird populations are declining. Managers can establish *a priori* population trend thresholds or trigger points below which immediate management action should be taken. Such actions can prevent local extinctions by identifying population problems before they become severe. We will estimate population trends of marsh birds by using weighted linear regression to estimate annual changes in the number of individuals detected per survey point for each target species. Few estimates of marsh bird population trends currently exist, and reliable estimates of population trends will probably require >5 years of survey data. We will estimate population trends for the primary marsh bird species during the breeding season. We will soon be able to conduct a meaningful power analysis to determine the percent annual change detectable with a specific number of survey points.

Trends in habitat availability

We will also estimate trends in emergent habitat availability at each site. Trends in habitat availability are the percent annual change in the amount of each major wetland habitat type. Information on emergent habitat availability will allow us to: 1) extrapolate density indices to estimate total numbers of marsh birds within a local area, 2) correlate changes in marsh bird numbers with changes in habitat availability to identify potential causes of observed population changes (Gibbs and Melvin 1993), 3) identify emergent habitats that need protection, and 4) design management actions in ways that either improve or minimize adverse effects to preferred habitat of marsh birds.

FIELD PROCEDURES, METHODS, PROTOCOLS

Wetland basins included in surveys

Surveys will be conducted in all emergent marshes (freshwater, brackish, and salt marshes) within the "survey area" that are >0.5 ha in total area. Small, isolated wetland patches (<0.5 ha) can be included, but their inclusion is not mandatory (but once included, they can not be eliminated). The "survey area" can be an entire National Wildlife Refuge (for very small refuges) or a portion of a larger Refuge. If the "survey area" will be a portion of a larger refuge, the participant should divide the refuge or area into *x* potential "survey areas" and randomly select the one (or more) to be used for the survey. Observers should not choose the "survey area" non-randomly based on where they know marsh birds exist (or exist in high density). Such an approach is a biased sampling design that will always lead to perceived population declines (i.e., if you place samples in areas where density is highest then only declines are expected to occur). Hence, we will use an "area-based" sampling frame rather than a "marsh-based" sampling frame. Emergent habitat is not perennial and changes spatially over time - we want a sampling design that allows for that. By sampling "all emergent marshes within one or more defined survey areas" observers will have to add survey points as emergent habitat increases or shifts within their defined management area. If a refuge has various marsh types or fire histories that they want to incorporate into the survey and these marsh types are separated spatially, then the refuge can chose several discrete "survey areas" within which they commit to surveying all of the wetland habitat each year. Once the survey area(s) is selected, a map of the area should be obtained (aerial photo, hand-drawn map, etc.) that identifies roads and extent of emergent marsh patches. Again, **all** marsh patches within the "survey area" must be surveyed each year. As location of marsh patches in the "survey area" change annually, additional survey points must be added to ensure that all marsh patches are surveyed (but no survey points are ever 'dropped' from the survey). Surveys should include as many survey points as needed to cover the area of interest (survey area). The number of survey points to include within a local refuge or management area (or the size of the survey area selected) depends on personnel time available and other logistical constraints. For our pooled analyses, any number of points from a local refuge will be useful. However, to obtain sufficient data to estimate population trends at the local scale, participants should consider approximately 50 survey points or more at a refuge if possible. More points will provide more power to detect local trends. The number of points to include on a particular survey route can vary among routes. The number of points on a particular survey route should correspond to the number that one surveyor can get done in a morning (or evening) survey window. If points are far apart or you are dealing with isolated wetlands, you may only be able to survey a small number of points in a morning (e.g., 6 or 8 or whatever). This would constitute a "route". If travel between adjacent points is relatively easy and the wetland is large, you may be able to complete 15 or more points in one morning/evening (and hence have 15 points on that survey route). One caveat is that the morning/evening survey window should correspond to when marsh birds are most vocal in your area. Although the protocol says that morning surveys should be completed by 10am, marsh birds in some regions may not be very responsive after 8 or 9am. Including fewer points per survey route and surveying an additional morning (rather than fewer routes with lots of points) will typically result in more detections. Remember, marsh birds are typically most vocal in the 2 hours surrounding sunrise and sunset. Once you choose the direction with which you conduct a particular survey route, be consistent (e.g., always conduct route *X* north to south). Being consistent in this respect will assure that each survey point is completed at the same time of day during each replicate survey. This consistency will help to reduce the bias created by diurnal decreases in vocalization probability of marsh birds as the morning progresses (Conway et al. 2004).

Location of survey points

Fixed, permanent survey points will be chosen and marked with inconspicuous markers in the field. If possible, locations of all survey points should also be plotted on maps of each wetland and UTM locations of each point recorded using a GPS receiver. Maps should include the direction in which the speakers should be pointed during the survey at each point. This is not always obvious to someone who has not surveyed the route before, and may create unwanted variation in numbers detected if speaker direction is not consistent. Point spacing in previous studies has varied from 40m to 800m. The more survey points included in an area, the more precise the resulting estimates of local population change. For the standardized continental monitoring program, distance between adjacent survey points is 400 m to avoid the risk of double-counting individual birds and increase the total area covered by monitoring efforts in a local area. If individual refuges want closer point spacing for some local reason (i.e., 50 points with 400m spacing is not possible at a small refuge) then use 200m spacing between points. We can ignore every other point at that particular site for the shared (pooled) data set if we choose to do so, but the individual refuge will still have an adequate local sample size to detect change over time (we can also use data from these individual refuges to evaluate the magnitude of the problem associated with double-counting if points are 200m apart). Once the survey area is selected, and a map of the survey area is available, the participant should choose the initial survey point randomly based on all possible locations for a survey point (all possible marsh-upland interfaces and all possible marsh-open water interfaces). Subsequent survey points should be at regular intervals of 400m. Survey points in ponds should be located either on the upland-emergent interface or on the open water-emergent interface, whichever will allow easier access and travel between survey points. Some marshes may be more effectively surveyed by boat (with survey points on the open water-emergent interface) and others more effectively surveyed on foot (with survey points on the upland-emergent interface). Many local marsh bird survey efforts place survey points at the interface between emergent marsh and upland. This approach minimizes travel time between adjacent points, reduces trampling vegetation within the marsh, and may increase the distance at which observers can hear vocalizing birds due to increased elevation relative to the marsh vegetation. Each survey point receives a unique identification number. The number of survey points in each survey area will be correlated with amount of emergent marsh patches within that survey area. In marshlands that have access throughout, points should be in a 400m grid system (hence, 1 point per 16 ha of marsh). Most marshes will not have access to internal areas of the marsh and points in these marshes should be placed along the upland or open water edges. In many locations, emergent habitat occurs in small patchy marshes less than 16 ha in size. Include at least one survey point in all marshes >0.5 ha within the management area. Additional survey points can be added in small marsh patches as long as they are 400m away from all other survey points. If new marsh patches appear in future years in areas within the predefined management area that did not have emergent marsh previously and did not have survey points, additional survey points must be added (provided that they are ≥400m from existing survey points). Original survey points are never dropped from the survey and are always surveyed in subsequent years. If no appropriate marsh exists at an original survey point, then the observers still make an entry for that point but write in the "Comments" column "no survey conducted because no longer appropriate habitat".

Timing of surveys

Survey routes can be either morning or evening survey routes. Observers can conduct either morning or evening surveys on a route as long as each survey route is surveyed during the same period (morning or evening) consistently every year (once a route is designated an evening route, it will always be an evening route in perpetuity). Morning surveys begin 30 minutes before sunrise (first light) and should be completed prior to the time when marsh birds cease calling (but never later than 10:00 am). The time in the morning when marsh birds cease calling varies with weather, time of year, and among regions. Evening surveys begin 4 hours before sunset and must be completed by dark (in some regions, marsh birds may not begin calling until 3 or 2.5 hours before sunset). Vocalization probability is typically highest in the 2 hours surrounding sunrise and the 2 hours surrounding sunset - choose optimal survey windows for your region and stick to them each year. Including both morning and evening surveys into a standardized monitoring protocol will provide added flexibility and more potential survey hours for field personnel. Conduct at least 3 surveys annually during the presumed peak breeding season for all primary marsh birds in your area. Each of the 3 replicate surveys will be conducted during a 10-day window, and each of the 10-day windows will be separated by 7 days. Seasonal timing of these 3 replicate survey windows will vary regionally depending on migration and breeding chronology of the primary marsh birds breeding in your area. The first survey should be conducted when migratory passage is over, but prior to breeding. For example, in south-central Washington the first survey should be between 1-10 May, the second survey 17-27 May, and the third survey 3-13 June. Marsh birds are typically most vocal during courtship and egg-laying periods. Try to maintain 2 weeks between each replicate survey. Surveys in tidal marshes should always be conducted at a similar tidal stage for each replicate survey both within and across years. The tidal stage within which to conduct local marsh bird surveys should be based on when highest numbers of marsh birds are likely to be detected in your area; optimal tidal stage for surveys may vary among regions. Many salt marsh passerines are forced to renest during the peak spring high tide, and detection probability is highest during the week after a high spring tide. Clapper rail surveys have been conducted during high tide since 1972 at San Francisco Bay NWR, but high tide was a period of reduced vocalization probability for clapper rails in southern California (Zembal and Massey 1987) and for black rails in northern California (Spear et al. 1999). As a general guideline, surveys in tidal marshes should **not** be conducted on mornings or evenings when high or low tide falls within the morning (or evening) survey window. Our intent is to estimate trends over time in the number of breeding adults, so we want to complete all three annual surveys prior to the initiation of juvenile vocalizations. Three or more surveys are needed to confirm seasonal presence/absence of some marsh bird species in a wetland with 90% certainty (Gibbs and Melvin 1993). Three replicate surveys per year is warranted, **especially** in areas where personnel organizing survey times may not initially know local timing of the breeding cycle of their target species. And, timing of breeding cycle differs among co-existing species of interest (e.g., American bitterns often breed much earlier than least bitterns and rails in some regions, and clapper rails and king rails breed earlier than Virginia rails and soras in some regions). Finally, including $\geq$3 replicates per season will provide us with data on temporal variation in numbers counted (a key parameter needed to conduct reliable power analyses once enough preliminary data are available) and also allow us to estimate the proportion of sites occupied by each species (MacKenzie et al. 2002). However, if for some reason you can not conduct $\geq$3 surveys on your area, we can still use your data to estimate detection probability and to compare passive with call-broadcast survey methods. The 3 survey windows increase our probability of conducting at least one survey during the peak seasonal response period of all primary marsh bird species in a local management area. Contact the program coordinator (see contact information below) or your USFWS regional non-game bird coordinator to help choose the most appropriate survey windows for your area if you are unsure. One observer should expect to survey approximately 10-20 survey points each morning, depending on travel times between survey points and length of your broadcast sequence.

Survey methods

These standardized survey methods for marsh birds are based on suggestions from a 1998 multi-agency workshop at Patuxent designed to aid agencies developing marsh bird monitoring programs (Ribic et al. 1999). The survey methods and protocols described here expand upon suggestions made at the Patuxent marsh bird monitoring workshop (Ribic et al. 1999) and incorporate suggestions from Conway and Gibbs (2001) and recent methodological advances in estimating detection probability and observer bias. Because many marsh birds are secretive, seldom observed, and vocalize infrequently, we will use broadcast calls to elicit vocalizations during vocal surveys (Gibbs and Melvin 1993, Conway et al 2004). But because we want to estimate detectability, estimate density using distance estimators, evaluate the usefulness of call-broadcast for future survey efforts, and survey secondary species, we will also record birds during a passive period prior to broadcasting calls.

At each survey point, observers will record all primary species (rails, bitterns, and pied-billed grebe) detected during both a 5-minute passive period prior to broadcasting recorded calls, and during a period in which pre-recorded vocalizations are broadcast into the marsh. The broadcast sequence includes calls of the primary marsh bird species that are expected breeders in that area and is broadcast using a portable cassette tape player, CD player, or MP3 player. A few potential broadcast systems include:

Cassette Tape Players: Optimus SCP-88 Stereo Cassette Player (Radio Shack #14-1231); or SONY Sports Series CFD-980; or Johnny Stewart Game Caller.
CD or MP3 players: Philips Jogproof CD player AX511217 ($49 at www.surprise.com); Lenoxx, model #CD-50 (Walmart $20); Aiwa XP-SP90 or XP-MP3 Portable CD Player; or Panasonic SL-SX286J or SL-SX280G Personal CD Player (e.g., Radio Shack #14-1231 or #42-6014); or Panasonic SLSX420 ($49.99 Circuit City). Or any cheap portable CD player.
Amplified Speakers: Optimus AMX-4 amplified speakers (Radio Shack #40-1407); or Sony portable speakers (Circuit City for $19.99).

CD or MP3 broadcast equipment will probably produce better quality and more consistent sound than cassette tapes. The recorded calls should be obtained from the Marsh Bird Survey Coordinator (contact info below); request a CD of the species of interest, and we will ensure that it coincides with the protocol. The tape/CD should include exactly 30 seconds of calls of each of the primary marsh bird species interspersed with 30 seconds of silence between each species. The 30 seconds of calls should consist of a series of typical calls interspersed with approximately 5 seconds of silence. For example, an entire survey sequence might look like this:

5 minutes of silence
30 seconds of calls of first primary species configured like this:
    3 Least Bittern *coo-coo-coo* calls
        6 seconds of silence
    3 Least Bittern *coo-coo-coo* calls
        6 seconds of silence
    4 series of Least Bittern *kak* calls
30 seconds of silence
30 seconds of calls of second primary species configured like this:
    2 Sora *whinny* calls
        5 seconds of silence
    3 Sora *per-weep* calls
        5 seconds of silence
    4 Sora *kee* calls
30 seconds of silence
30 seconds of calls of third primary species
    etc.
include a verbal "stop" at end of survey interval so that observers know when to stop the tape or CD

The chronological order of calls on the tape/CD will vary with each survey area, but will always be consistent within a particular survey area across replicate surveys and across years. Species to include in the call-broadcast is up to the individual organizing the local survey effort, but we suggest you include all species believed to be local breeders (species for which you expect to get responses). Order of calls should start with the least intrusive species first, and follow this chronological order: Black Rail, Least Bittern, Yellow Rail, Sora, Virginia Rail, King Rail, Clapper Rail, American Bittern, Common Moorhen, Purple Gallinule, American Coot, Pied-billed Grebe, Limpkin. The calls used for broadcast should include at least the primary advertising call of each species (e.g., '*whinny*' for Sora, '*grunt*' for Virginia Rail, '*clatter*' for Clapper Rail and King Rail, '*kickee-doo*' for Black Rail, *'click-click-click-click-click*' for Yellow Rail, '*coo-coo-coo*' for Least Bittern, '*pump-er-lunk*' for American Bittern). Other calls associated with reproduction should be included if the calls are common in your area for that species. Including all the common calls associated with reproduction of each species on the broadcast sequence will increase detection probability during different times of the breeding season and can help observers learn the less common calls of each target species. A list of common calls for each target species is attached. Calls given while flying or after being flushed (not associated with reproduction) are probably not useful to include in the broadcast sequence. Each individual bird detected (for primary species) during the survey period will be entered on a separate line on the field data form (see example data sheet attached). Observers should record when each individual is detected: during any of the initial 1-min passive segments, and/or during any of the 1-min call-broadcast periods. Observers do not record the number of times a bird responded during each segment. Simply record if the individual was detected during each of the 1-minute segments of the survey. Recording all the segments during which an individual bird is detected is extremely important so that we can determine whether call-broadcast is effective at eliciting additional responses for each of the primary species. These data will help us determine whether or not to use call-broadcast of all primary species during surveys in future years. Moreover, recording whether each individual responds during each 1-min sub-segment allows us to estimate detection probability using capture-recapture models (Farnsworth et al. 2002). Estimates of detection probability are essential for regional/national monitoring efforts so that we can determine how well the count data recorded index true population size/trends. Hence, observers must make a decision as to whether each vocalization heard at a survey point is a new individual for that point or is an individual that vocalized previously from that survey point. Observers should also estimate the distance from each individual bird to the survey point. Estimate distance to each bird when the bird is first detected (birds will approach the call-broadcast [Legare et al. 1999, Erwin et al. 2002] so observers need to record the distance to the bird when the bird was first detected). Recording distance to each individual will allow us to use distance sampling to estimate density for each species in each habitat type. Density indices by habitat type are useful because they allow managers to extrapolate survey data to estimate a minimum number of each marsh bird species on their entire management area. Estimating the distance to some individual birds will involve a lot of uncertainty (ie, estimating distance to birds 5m from the surveyor is much easier than estimating distance to birds that are >100m away). Cooperators are encouraged to add an additional column to their datasheet for "accuracy of distance estimate" where they assign accuracy to one of 3 accuracy categories:

1 = distance estimate is relatively accurate [i.e., $\pm$20m]

2 = accuracy of distance estimate is iffy [i.e., ±60m]

3 = accuracy of distance estimate is believed to be poor [i.e., ±100m])

This can be done after the survey is over at each point because the number of birds detected at a point affects the accuracy of distance estimates to each individual bird.

The broadcast player should be placed upright on the ground (or on the bow of the boat), and sound pressure should be 80-90 dB at 1 m in front of the speaker. Use a sound-level meter (available at Radio Shack) to adjust volume of the broadcast player at the beginning of each day. If sound quality distorts when volume on your broadcast equipment reaches 80-90 dB, you should obtain higher quality broadcast equipment. If the ground is wet, place the speaker on an object as close to the ground as possible. Observers should stand 2 m to one side of the speaker while listening for vocal responses (standing too close to the speaker can reduce the observer's ability to detect calling birds). Observers should point the speaker toward the center of the marsh and should **not** rotate the speaker during the call-broadcast survey. Speakers should be pointed in the same direction for all replicate surveys. At points where it is not obvious which direction to point the speakers (i.e., on a road or in a canal between two marshes) surveyors should record this information on a map and on their data sheets and refer to this information on all replicate surveys. If observers detect a new bird immediately after the survey period at a particular point (or while walking between points) they should record these birds in a separate column (e.g., write "before" or "after" in the *Comments* column). Observers have the option of recording secondary species (see attached list of example species). At each point, record the total number of each secondary species detected. Hence, individual birds of secondary species do not receive their own line on the data sheet and observers do not record detections in each of the 1-min sub-segments for secondary species (see example data sheet attached). The secondary species included by a surveyor will depend on the marsh birds of interest at that refuge, management area, or physiographic region. For example, participants may want to include secondary species which are thought to be declining or which are not sampled well by other survey efforts. However, surveyors should limit the number of secondary species to only those species of management concern. Many of the other marsh bird species are adequately sampled by the North American Breeding Bird Survey. Listening or looking for too many secondary species may reduce one's ability to detect primary species.

Surveys should only be conducted when wind speed is <20 km/hr, and not during periods of sustained rain or heavy fog. Even winds <20 km/hr (12 mph) affect the detection probability of marsh birds. Participants should postpone surveys if they believe winds are affecting calling probability of marsh birds. Recommendations for conducting surveys in very windy locations include:

1) determine what time(s) of day have the least wind in your area. The daily survey windows in the protocol are recommendations -survey times should be modified under conditions where wind regularly affects vocalization frequency. The important thing is that surveys are conducted during the same daily time window each year at a particular location, and the survey windows at a particular location should be the time of day/night that has the highest detection probability for your target species in your area. In some locations, surveys conducted after sunset (or before sunrise) may have higher detection probability compared to the morning and evening survey windows recommended in the protocol

because strong winds are less frequent during the middle of the night; and

2) try to be flexible with your schedule if you can. For example, plan to conduct a survey on a particular day but postpone to the following day if its too windy, and keep postponing until you get a low-wind day to complete the survey.

If wind speed increases to above 12km/hr during the survey (or sustained rain begins while the survey is already underway), participants should stop the survey and repeat the entire survey route another day (i.e., don't just go back and repeat the remaining points on the route). When surveyors are using a motorized boat or airboat to travel between survey points, the noise generated by the boat may cause birds to stop calling. In these situations, surveyors may choose to include a "settling" period of a fixed amount of time (e.g., 1 minute) prior to starting the 5-minute passive count at each point. We recommend that **no** settling period be included. If a participant includes an initial settling period prior to each survey, the participant should keep that settling period constant among all points and all replicate surveys. Furthermore, the participant should include a comment on every data form stating that such a settling period during which detections were not recorded was included. If included, make the settling period a part of the written survey protocol so that individuals wishing to repeat the effort in future years will know that a settling period was included.

Some areas or some survey points within a survey area will have so many marsh birds calling that observers will find it impossible to record each sub-segment during which each individual bird is detected. For example, an observer may see/hear >20 coots at one survey point. In these situations, simply write down an estimate of the total number of individuals detected for that particular species during the entire survey period on one line of the data sheet (e.g., write "23 AMCO" on one line of the data sheet - see example on sample data sheet attached).

Always conduct each survey route in the same direction with each survey point surveyed in the same chronology. This will reduce temporal variation in numbers counted over replicate surveys and provide greater power to detect trends.

Which species do I include in the call-broadcast sequence?

Most participants should include all of the "primary species" in the list attached that are thought to breed in the marshes to be surveyed. The # of species included on the call-broadcast portion of the survey increases the duration of the survey by 1 min per species at each point. So, with 8 species, you will spend 13 minutes (including the initial 5 min passive listening period) at each point. For participants who want to reduce the length of time at each point, here are several things to consider: only include species on the call-broadcast that you know/assume are breeders; reduce the # of species on the broadcast segment in year 2 to include only those that responded during surveys in year 1 (simply request a new CD); do not include very common species that are fairly well monitored by other survey efforts (e.g., AMCO) in the call-broadcast segment. All observers should still record all detections of all primary marsh bird species, even if you decide not to include all primary species present in your area in the broadcast sequence.

Filling out the data sheet

The data sheet included below must be tailored by each participant to reflect the number and identity of species the participant includes on the broadcast sequence for their area. The number of species columns on the data sheet will differ regionally; include only those species for which call-broadcast is used in your survey (see the 3 sample data sheets attached). For example, if you intend to only broadcast calls of 3 species, then you will have an 8-minute survey sequence at each point (5 minutes of passive listening and 1 minute of call-broadcast for each of 3 species) and will need a data sheet with 8 response columns. If you intend to broadcast calls of 5 species, you will have a 10-minute survey sequence at each point (5 minutes of passive listening and 1 minute of call-broadcast for each of 5 species) and will need a data sheet with 10 response columns. See the example data sheets attached. Prior to the beginning of the survey, write down the day, month, and year at the top of the data sheet. Also write the full name of all observers present during the survey. If more than one observer, write down who recorded the data and **all** individuals that helped identify calling birds. Using multiple observers to detect birds at a point may confound observer bias issues when estimating trend, so its important to record any and all observers who contributed to marsh bird detections (see paragraph regarding double-observer surveys at end of this protocol). Write down the name of the marsh, the name of the refuge and/or management area, and other location information (distance and direction to nearest town, county, state). Write down whether this is the first, second, or third survey of the year at these points in the "Survey #" space at the top of the data sheet. Record ambient temperature, wind speed, wind direction, % cloud cover, precipitation, and other notes of weather conditions, and whether (and when) conditions change during the course of the morning.

When you arrive at the first survey point, write down the unique identification number of the survey point and the time. Start the survey. When a bird is detected, write the species name in the "Species" column. You can use the 4-letter acronym for the species or write the full species name. A list of 4-letter AOU species acronyms is attached to this protocol. Put a "**1**" in each column in which that individual is detected based on vocalizations and put a "**s**" in each column in which the individual is detected visually (including flying overhead). For example, if an individual Virginia Rail calls during the first 1 minute of passive listening, put a "1" in the first column. Regardless of whether that individual calls once or many times during the first minute, you only put one "1" in the first column. If that same individual bird is still calling during the second minute of passive listening, then also put a "1" in the second column. If the same individual calls during the 30 second Sora sequence or the 30 seconds of silence immediately following the Sora sequence, put a "1" in the column for "SORA". If that same individual bird calls again during the Virginia Rail sequence, you also put a "1" in the column "VIRA", and so on. Hence, if an individual bird is calling constantly throughout the survey period, you will have a "1" in every column for that individual. If the individual is heard **and** seen, put both a "1" and a "**s**" in the appropriate column. If you hear a call of the same species but from a different individual (or from an individual of another species), you start a new line on the data sheet and follow the same protocol just described for this individual bird. The difficulty is determining whether a call is coming from a new individual or a individual detected earlier at that survey point. Observers must make this decision without seeing the bird by using their best judgement. Follow the same procedure at subsequent survey points. If an individual detected at one survey point is thought to be an individual that was recorded at a previous survey point, write "y" in the "*Detected at a Previous Point*?" column. Be conservative when in doubt as to whether an individual bird detected at the current point was the same individual recorded at a previous point (i.e., record "y" when in doubt). The number of lines filled out on the data sheet will differ among survey points and will correspond to the total number of individual marsh birds detected at each point. If no marsh birds are detected at a survey point, record the point number and starting time, and write "no birds" in the comment column. A sample data sheet is included as an example of what survey data might look like. If the observer hears a marsh bird but is unsure of its identity, the observer should write "unknown" in the Species column and record all data for this individual as described above. Make a verbal description of the unknown call in the *Comments* column (e.g., 'soft kak-kak-grr - sounds like BLRA but harsher'). This will aid future identification of unknown calls if that call is heard repeatedly. When the survey is complete at a point, write down the UTM coordinates (and datum used) from the GPS unit (or return on another day and record). Because location of survey points may affect trends, record whether each point is adjacent to an upland-wetland interface, a water-wetland interface, is in the marsh interior, and/or is along a roadside. Record any ancillary information that may have influenced vocalizations or detection probability in the Comments column (e.g., record whether surveyor is using a different boat or different boat motor that is more or less noisy than that used on previous surveys). There are indications that periodic burning of emergent marshes may benefit some marsh birds. Indeed, several refuges are involved with local studies examining the effects of fire on marsh birds. Hence, it would be useful for all participants to record the "month and year of last burn" for the 100-m radius area surrounding each survey point. If all you know is that the area surrounding a particular survey point hasn't burned in the past *x* years, then record >*x* years at that point. This information will allow us to evaluate the effects of fire on marsh bird abundance at a large (continental) spatial scale with the pooled data. The data produced will supplement the more detailed studies evaluating the effects of fire being conducted on specific refuges and will help make management recommendations regarding the usefulness of fire as a tool for managing marsh bird populations.

Difficulty when many individuals of the primary species are detected at a point

Because many of these species occur at relatively low densities through much of their range, most participants will detect few or no individual birds at any given survey point. However, the large number of individuals detected at some points make recording difficult. For example, if >5 individuals of 1 species are heard during any 1-minute segment during the survey, I have difficulty recording them all in the correct columns/rows and keeping up with which row goes with which individual bird. When many birds are calling simultaneously, it can be difficult for the observer to 1) decide whether they are hearing new individuals or previously-detected ones, 2) write new individuals on a new line of the datasheet, and 3) find the correct line where they wrote down previously-detected birds. In these situations, here are a few comments, observations, and suggested remedies. First, individual surveyors do get better at this with practice even with relatively high numbers of calling birds at a point. However, everyone has a threshold when the numbers of calling marsh birds get too high at a particular point. This problem occurs more frequently when a cooperator has lots of species (and hence columns) on their call-broadcast sequence. If a participant knows at the end of the call-broadcast at a particular point that he/she was overwhelmed and didn't effectively assign the correct calls to the correct columns (individuals), then write a note in the Comments Column saying that the sub-interval information is dubious. If this problem is common on your surveys, below is a list of solutions in decreasing order of preference. If you choose options #3 or #4 you need to make a very clear comment on your data sheet about what you were and were not recording at each point:

1) Include a circle next to each marsh bird detected and make a 'tick' identifying the general direction of that individual (this will help you differentiate one individual from other individuals of that species as more are detected at that point),
2) Reduce the number of species in your call-broadcast sequence. Only use call-broadcast for species of management/conservation interest and/or species known to respond well to call-broadcast (e.g., eliminate bitterns, coots, pied-billed grebes, and moorhens from your call-broadcast sequence so that you have <5 species on your call-broadcast sequence). Still record data for all individuals of all marsh bird species in the same way, but just reduce the # of columns.
3) For those primary species that are of lower management/conservation interest in your survey area (e.g., coots, moorhens, pied-billed grebes), only record the total number of individuals detected at that point and only use the sub-intervals for the primary species of higher management concern (e.g., black rails, yellow rails, king rails, clapper rails, bitterns). Make sure you make a clear note on the top of your datasheets that explains your deviation from the standard protocol.
4) Only record the **first** interval during which each individual is detected (as opposed to each and every interval). Be sure that you make a clear note on the top of your datasheets that you are only recording the **first** interval during which each individual is detected.

Habitat measurements

Natural changes in water level and management activities (e.g., dredging, wetland restoration efforts, prescribed burning, etc.) can lead to dramatic changes in marsh vegetation. Patterns of distribution and local population trends of marsh birds can often be best explained by local changes in wetland vegetation. Consequently, quantifying the proportion of major vegetation types (e.g., % *Typha domingensis*, *Scirpus olneyi*, *Scirpus californicus*, *Phragmites communis*, *Spartina foliosa*, *Salicornia virginica*, *Baccharis glutinosa*, *Populus fremontii*, open water, mudflat) surrounding each survey point each year can help identify the cause of observed changes in marsh bird populations. Vegetation will be quantified at 2 scales: observers should visually estimate the proportion of each major vegetation type within a 50m-radius circle around each survey point, and aerial photographs will be used to periodically determine the amount of each major vegetation type on the management area. In some locations, there is substantial seasonal change in annual growth in emergent plants. Participants should record vegetation data at a time that overlaps the breeding season for all of their target marshbirds. The important thing is to sample at a time when you are most likely to detect important changes in vegetation 5 or 10 years from now (changes that might help explain increases or decreases in number of marshbirds detected). If the vegetation doesn't change during the annual survey period, participants should consider quantifying vegetation within the 50-m radius circles during their final survey each year. However, **vegetation data does not have to be collected while the vocal survey is being conducted** (it might be most effective to make a separate trip to each survey point to collect vegetation data). Whichever time vegetation surveys are conducted, participants should be sure to quantify vegetation at that same time each year. As an example, visual estimates of proportions of each vegetation type at a survey point might look like this: 15% water, 10% California bulrush, 20% three-square bulrush, 5% southern cattail, 20% seep willow, 10% mudflat, 20% upland shrub community. Record vegetation data to the species level because some marsh birds preferentially use only one species of emergent plant. Record vegetation data in the Comments column of the data sheet or on a separate data form. Vegetation at each point is only recorded once each year. Participants should enlist the help of a botanist or other qualified assistance to conduct vegetation surveys (remember, these survey do not have to be conducted during one of your vocal surveys). If the vegetation changes substantially at a particular point during the course of a single survey season, participants should make a note in the Comments column stating how the vegetation has changed over the course of the season. Participants should collect vegetation data at all points each year (even if no emergent vegetation currently exists at some points during some years) to document changes over time in habitat availability. Not conducting the marsh bird survey at a set of points from a previous year due to lack of suitable habitat may occur in some years due to reduction in the water table, but you should still fill out a data sheet for these points and write in the Comments section "these points were not surveyed due to lack of suitable emergent vegetation resulting from local/regional drought". It is important that we do this so that the points get entered into the regional database as "no suitable habitat" (as opposed to failure to survey for logistical reasons). Because most survey points will be at the marsh/upland or marsh/open-water interface, approximately half of the 50-m radius circle within which you record vegetation data might be “upland vegetation". There is no need to characterize upland vegetation by species. Hence, include categories in your vegetation classification called "upland vegetation", “road”, and "open water" if appropriate. There may be some points that are on peninsulas or in narrow open water channels (surveyed by boat) and these points may have emergent marsh within most of the 50-m radius circle. Differentiating plants by species is difficult in some taxa and not all participants will be able to consult with a botanist prior to categorizing the vegetation types at each of their survey points. In these cases, participants can pool species by taxa or functional group (e.g., sedge spp., bulrush spp., mixed shrub). Aerial photographs of the entire survey area that allow delineation of the area of emergent vegetation should be obtained annually if possible.

Personnel and Training

All observers should have the ability to identify all common calls of primary and secondary marsh bird species in their local area. Regularly listening to the recorded calls used for surveys can help learn calls, but observers should also practice call identification at marshes (outside the intended survey area if necessary) where the primary species are frequently heard calling. All observers must pass a self-administered vocalization identification exam each year prior to conducting surveys. This exam should be a sequence requested from the program coordinator. Observers should not have heard the exam CD prior to taking the exam. All observers should also be trained to accurately determine distance to calling marsh birds, and to identify the common species of emergent plants on the management area. Methods for training observers to accurately estimate distance include: 1) place a tape recorder in the marsh at an known distance and have observers estimate distance, 2) choose a piece of vegetation in the marsh where the bird is thought to be calling from and use a range-finder to determine distance, 3) have an observer estimate the distance to a bird that is calling with regularity and is near a road or marsh edge, then have a second observer walk along the road/edge until they are adjacent from that calling bird, and then measure this distance (by pacing or use of a GPS) and see how accurate the observer was at estimating distance. *Two-observer surveys* (see below) are very useful here - after the survey is complete have the 2 observers discuss not only what they heard, but how far each person estimated the distance to each bird. Periodic double-observer surveys not only produce estimates of detection probability (see below) but also allow participants to determine whether one person is constantly underestimating or overestimating distance to calling birds. Observers should also have a hearing test (audiogram) at a qualified hearing or medical clinic before, during, or immediately after the survey season each year. These data will be included as a covariate and will help control for observer bias in trend analyses. New participants should do at least one "trial run" before their first data collection window begins because it takes time to get used to the data sheet and recording the data appropriately.

Equipment/materials

Where possible, fixed survey points will be permanently marked with inconspicuous markers and numbered. Portable GPS receivers should be used to mark survey points onto aerial maps. GPS coordinates of each permanent survey point should be recorded and saved for reference in future years. CDs with calls of primary species should be obtained from the program coordinator (see contact info below), and new CDs should be requested if quality declines. CD players and amplified speakers should be good quality and batteries should be changed or re-charged frequently (before sound quality declines). Participants should routinely ask themselves if the quality of the broadcast sound is high. Observers should always carry replacement batteries on all surveys. A sound level meter with $\pm$5 dB precision (e.g., Radio Shack model #33-2050 for $34.99; or EXTECH sound level meter, $99 from Forestry Suppliers, Inc.) should be used to standardize broadcast volume (alternatively, Radio Shack should be willing to help you set your broadcast level appropriately using the sound meter in the store). If participants need help with purchasing broadcast equipment, contact the coordinator below. A small boat/canoe may be useful for surveying larger wetland habitats adjacent to open water, reducing travel time between survey points. When using a boat, use the same boat and motor on each survey each year to control for possible effects of engine noise on detection probability. If a different boat or different motor is used (or the same boat/motor just sounds better or worse than usual) make a note of the change in the *Comments* column. A spare CD player should be kept close-by in case the primary unit fails to operate. Three prototype field data forms for use on vocal surveys are attached to this protocol. The number of columns on the data sheet will vary among survey areas depending on the number of bird species included in the call-broadcast segment of your survey so participants will have to tailor one of the data sheets below to suite their own broadcast sequence.

DATA COLLECTION, ANALYSIS, SUMMARY AND ROUTINE REPORTING

A. Field data. Field data will be manually entered in the field on a data form (see example attached) and transferred weekly to an electronic form. At each survey point, observers should record: full name of observer, name of data recorder (if different from observer), name of wetland, date, survey point #, start time, species of each individual detected, the intervals during which each bird was detected, and distance to each individual bird from the survey point. Each individual bird detected should be recorded on a new line on the data form. An overview map of the survey area with all roads and all survey points numbered on the map should be developed for field personnel conducting surveys and made available for future years. All data forms should be reviewed by a supervisor within 24 hours of each survey so that mistakes can be identified and corrected promptly. Copies of original data forms should be stored in two separate locations.

B. Data entry/Database management. Data will be entered into a common spreadsheet program (EXCEL, Lotus, QuattroPro, dBase, etc) as soon after collection as possible, preferably within 1 week of data collection. Timely data entry limits mistakes, reduces probability of loss of data, and helps identify potential sampling biases and logistical problems that might be corrected in future surveys. Completed surveys will be printed out after entry into the spreadsheet and compared to original data forms to assure data quality. Electronic spreadsheets containing field data will be backed up weekly. If data entry time is not available at the local site, send copies of the data sheets to the address below and we will enter the data for you. Submit your data promptly at the end of the field season to the address below so that regional summaries and analyses can be conducted and sent back to program participants. Also, submit a copy of the tape or CD used during the survey effort on your area.

C. Data reporting. Send or email the name, address, phone#, and email address of all participants to the address below. This list will be used to disseminate information to each participant at the end of each field season and to send results of annual data analyses. An annual report should be completed each year for each site. After each season, survey data should be summarized and summaries should include the mean number of individuals detected per survey point during both passive and broadcast periods for each marsh bird species. Summaries should identify locations on the management area with seasonal concentrations of marsh birds. After several years, survey data can be used to estimate population trends of marsh birds on the management area using regression analyses. Survey data will also allow comparison of birds detected during initial passive periods and during call-broadcast to evaluate the usefulness of using call-broadcast surveys to monitor marsh birds. These comparisons will allow improvement of field methods in future years. On a regional basis, estimates of population trend from areas undergoing management activities can be compared to trends from areas that have not been subject to management activities to evaluate the long-term effectiveness of management efforts.

REGIONAL CONTEXT AND INTEGRATION WITH OTHER MONITORING PROTOCOLS

Estimates of population change in marsh bird populations on the survey area will be compared to local population changes in other parts of the region and to other regions. Comparisons among other local areas in the region will allow local managers to determine the importance of local wetlands to regional population health by identifying whether marsh bird populations on their management area are doing better or worse relative to other areas. Several U.S. Fish and Wildlife Service National Wildlife Refuges began using these marsh bird survey methods in 1999. We currently have over 60 refuges and management areas participating. We will continue refinement of survey methods based on feedback, logistical problems identified, and inconsistencies identified by participants. Your participation is needed now to ensure that **your** national monitoring program works. Survey data collected using the protocol described above will help our efforts to develop the most rigorous continental monitoring program possible for marsh birds. Please send any survey data to the address below. For assistance obtaining appropriate CDs, additional information, or questions regarding standardized marsh bird survey methods, please contact:

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ADDITIONAL OPTIONAL COMPONENTS TO SURVEY PROTOCOL

Recording water depth at each point (or each management unit)

Water level definitely influences abundance and distribution of marsh birds. Water levels vary annually and even daily in some marshes and these fluctuations can explain spatial and temporal changes in marsh bird abundance. Some National Wildlife Refuge control water levels in some of their management units and have the ability to directly benefit marsh birds via water management. Participants are encouraged to place gauges for measuring water level in permanent locations at numerous points within their survey area(s). Water level should be recorded before or after each marsh bird survey. If water levels vary annually (or seasonally) within your survey area, we recommend that this component be incorporated into your marsh bird survey effort.

Recording noise level at each point

Recording the level of background noise during the survey at each survey point is useful for trend analysis. This information can be used as a covariate in future trend analyses because level of background noise varies spatially and temporally and influences detection probability. Categorize background noise at each point on a scale from 0 to 4 (0= no background noise, 1=faint background noise, 2=moderate background noise (probably can't hear some birds beyond 100m), 3=loud background noise (probably can't hear some birds beyond 50m), 4=intense background noise (probably can't hear some birds beyond 25m). Each cooperator can decide whether they have the time and/or need to record noise level at each point. If noise levels are periodically high enough to reduce observers' ability to detect calling marsh birds, this optional component is recommended.

Recording types of calls given

Knowing season patterns of different call types in a local area provides useful information. For example, the frequency of different calls given (e.g., single *clatter*, paired *clatter*, *kek*, or *kek-burr* for a clapper rail) varies throughout the season. Frequency of different calls given may also vary across regions. Different call types have different functions and can indicate pairing status and stages of the nesting cycle in a local area (allowing refinement of local survey windows). Moreover, detection probability and observer bias may differ with different call types (e.g., least bittern '*kak*' and Virginia rail '*tick*' can be confused with clapper rail '*kek*' calls) and accuracy of distance estimation may vary with call type. Hence, incorporating call types into trend analyses can potentially increase power to detect true population trends. For these reasons, observers are encouraged to record all types of calls given for each target marsh bird detected. Add an additional column (*"Calls*") to your data sheet and record call type(s) given for each individual bird detected (see sample data sheets).

Multiple-observer surveys

Estimating detection probability associated with a particular survey protocol is essential when attempting to interpret count data produced from a monitoring program. The extent to which trends in count data represent the underlying trend in true abundance depends on detection probability and observer bias associated with the particular survey method. We will estimate observer bias associated with our survey effort using the double-observer method (Nichols et al. 2000). This approach involves 2 or more trained observers recording data independently at a series of survey points (Conway et al. 2004). Hence, whenever possible, surveys should be conducted by 2 or more observers simultaneously. Each observer should fill out a separate data sheet and should record their data separately without discussing anything with the other observer. Observers should not point out a call or a bird to the other during the survey period. Each observer should stand 1-2 meters away from each other and should keep their pen on their data sheet at all times so that one observer is not cued by the sudden writing activity of another observer. Once the survey at a particular point is completed, the observers can look over each others data at that point and discuss discrepancies, but that data should not be altered; obvious mistakes should be noted in the *Comments* column **but not changed.** The differences between the observers in number of birds detected at each point is what allows us to estimate observer bias so these differences should not be altered. Double-observer surveys will obviously not be possible at all times and at all locations, but try to use multiple observers whenever possible so that we can obtain sufficient data to estimate observer bias.

Recording salinity content of water

In coastal marshes or any marshes with varying salinity levels, participants are encouraged to record the salinity content of the water directly in front of each point on each survey. Salinity levels affect use by various species of marsh birds and such information is relatively easy to collect and can be used as covariates to control for variation in models estimating population change. Participants can get an Oregon Scientific Handheld Salinity Meter [ST228] for $25.

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National Marsh Bird Monitoring Program Survey Data Sheet

Date *(eg 10-May-04)* **:**

Name of marsh or route :

Observer(s) *(list all)** **:**

Survey replicate # :

	Before	**After**
Temperature *(°F)* **:**		
Wind speed *(mph)* **:**		
Cloud cover *(%)* **:**		
Precipitation *(see below)* **:**		

**list all observers in order of their contribution to the data collected*

put an "S" in the appropriate column if the bird was seen, a "1" if the bird was heard, and "1S" if both heard and seen

Station#	Start Time (military)	Background noise	Species	**Responded During:**											Call Type(s)	Direction	Distance (meters)	Detected at a Previous Point	Comments
				Before	Pass 0-1	Pass 1-2	Pass 2-3	Pass 3-4	Pass 4-5	BLRA 5-6	LEBI 6-7	VIRA 7-8	CLRA 8-9	After					

Call Types: BLRA: *kicky-doo, grr, churt* CLRA: cltr, kburr, kek, khurrah LEBI: *coo, kak, ert* VIRA: *grunt, ticket, kicker*

If the call type is not one of the above listed types, describe the call in the comments column

Precipitation: light rain, rain, heavy rain, light snow, snow, heavy snow, fog, none

Background noise: 0 *no noise* 1 *faint noise* 2 *moderate noise (probably can't hear some birds beyond 100m)*
3 *loud noise (probably can't hear some birds beyond 50m)* 4 *intense noise (probably can't hear some birds beyond 25m)*

Pg___of____

Date *(eg 10-May-04)*: **Name of marsh or route :** **Observer(s)** *(list all)**:

				Responded During:															
Station#	Start Time (military)	Background noise	Species	Before	Pass 0-1	Pass 1-2	Pass 2-3	Pass 3-4	Pass 4-5	BLRA 5-6	LEBI 6-7	VIRA 7-8	CLRA 8-9	After	Call Type(s)	Direction	Distance (meters)	Detected at a Previous Point	Comments

National Marsh Bird Monitoring Program Survey Data Sheet

Date *(eg 10-May-04)* **:** 20 April 2006

Name of marsh or route : Hidden Shores Marsh

Observer(s) *(list all)** **:** Chris Nadeau, Bob Blabla

Survey replicate # : 2

	Before	After
Temperature *(°F)* **:**	10	21
Wind speed *(mph)* **:**	0	1
Cloud cover *(%)* **:**	15	60
Precipitation *(see below)* **:**	none	none

**list all observers in order of their contribution to the data collected*

put an "S" in the appropriate column if the bird was seen, a "1" if the bird was heard, and "1S" if both heard and seen

Station#	Start Time (military)	Background noise	Species	Responded During: Before	Pass 0-1	Pass 1-2	Pass 2-3	Pass 3-4	Pass 4-5	BLRA 5-6	LEBI 6-7	VIRA 7-8	CLRA 8-9	After	Call Type(s)	Direction	Distance (meters)	Detected at a Previous Point	Comments
HSM1	1710	0	BLRA		1	1				1					grr		95	N	
			BLRA			1				1	1	1	1	1	kicky-doo		110	N	
			VIRA				1S					1			ticket, grunt		30	N	
HSM2	1721	1	CLRA	1											p-cltr		40	N	
			CLRA	1											p-cltr		45	N	
			VIRA									1			grunt		100	Y	
			CLRA											1	throaty hoo		10	N	
HSM3																			Not surveyed unsuitable habitat
HSM4	1750	1	COMO		1	1	1		1		1		1		wipeout		150	N	
			SORA									1			perweep		210	N	

Call Types: BLRA: *kicky-doo, grr, churt* CLRA: cltr, kburr, kek, khurrah LEBI: *coo, kak, ert* VIRA: *grunt, ticket, kicker*

If the call type is not one of the above listed types, describe the call in the comments column

Precipitation: light rain, rain, heavy rain, light snow, snow, heavy snow, fog, none

Background noise: 0 *no noise* 1 *faint noise* 2 *moderate noise (probably can't hear some birds beyond 100m)*
3 *loud noise (probably can't hear some birds beyond 50m)* 4 *intense noise (probably can't hear some birds beyond 25m)*

List of AOU 4-letter species acronyms for primary marsh birds in North America.

Primary species

SORA	sora
VIRA	Virginia rail
CLRA	clapper rail
KIRA	king rail
BLRA	black rail
YERA	yellow rail
AMCO	American coot
COMO	common moorhen
PUGA	purple gallinule
LIMP	limpkin
PBGR	pied-billed grebe
AMBI	American bittern
LEBI	least bittern

Examples of Secondary Species (these are just some examples - there are other wetland birds that a participant may want to include; each cooperator should decide which secondary species to include in their surveys in advance and list these species on their datasheet so that all participants in future years will know the list of species recorded in prior years)

LEGR	least grebe (1 cooperator has included LEGR in their call-broadcast sequence)
EAGR	eared grebe (1 cooperator has included EAGR in their call-broadcast sequence)
GRHE	green heron (1 cooperator has included GRHE in their call-broadcast sequence)
GBHE	great blue heron
GLIB	glossy ibis
WFIB	white-faced ibis
WHIB	white ibis
NOHA	northern harrier
SACR	sandhill crane
WILL	willet
WISN	Wilson’s snipe (1 cooperator has included WISN in their call-broadcast sequence)
FOTE	Forster’s tern
BLTE	black tern
BEKI	belted kingfisher
ALFL	alder flycatcher
WIFL	willow flycatcher
SEWR	sedge wren
MAWR	marsh wren
COYE	common yellowthroat
YEWA	yellow warbler
SSTS	saltmarsh sharp-tailed sparrow
NSTS	Nelson’s sharp-tailed sparrow
LCSP	LeConte’s sparrow
SWSP	swamp sparrow
SAVS	Savannah sparrow
SESP	seaside sparrow (1cooperator has included SESP in their call-broadcast sequence)
RWBL	red-winged blackbird
YHBL	yellow-headed blackbird
BTGR	boat-tailed grackle

List of the most common calls for the primary target species of marsh birds

Black Rail: *kickee-doo* (primary breeding call), *grr-grr-grr, churt, ticuck*
Least Bittern: *coo-coo* (male advertisement), *kak-kak-kak*, *gack-gack* (given from nest), *ank-ank* (given when flushed)
Yellow Rail: *click-click*, *wheese* (female call), *descending cackle* (pair maintenance), *squeak* (given by retreating bird)
Sora: *whinny* (territorial defense and mate contact), *per-weep*, *kee* (may be given to attract mates)
Virginia Rail: *grunt* (pair contact, territorial call), *tick-it* (male advertisement call), *kicker* (female advertisement call)*, kiu* (sharp, piercing call)
King Rail: *chac-chac* (pair communication), *kik-kik-kik* (mating call)
Clapper Rail: *clatter* (pair contact, territorial call), *kek* (male advertisement call), *kek-burr* (female advertisement call), *kek-hurrah ,hoo, squawk* (chase squeal), *purr*
American Bittern: *pump-er-lunk* (territorial/advertisement call), *chu-peep* (given during copulation ceremony), *kok-kok-kok* (given when flushed)
Common Moorhen: *cackle* (primary advertising call), *squawk, yelp, cluck*, *purr*
Purple Gallinule: *cackle* (primary advertising call), *squawk*, *grunt*
American Coot: *pow-ur* (crowing for territorial defense), *puhk-ut* (warning), *puhk-kuh-kuk* (crowing for territorial challenge), *puhlk*, *tack-tack* (cackling), *kerk* (sharp cough)
Pied-billed Grebe: 3-part gurgling song, *quaa-aaa-aaa* (wavering, guttural copulation call), *kwah* (alarm call), *ek-ek-ek* (rapid, staccato greeting call), *tshick-tshick*
Limpkin: *krr-oww*