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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 ≥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.

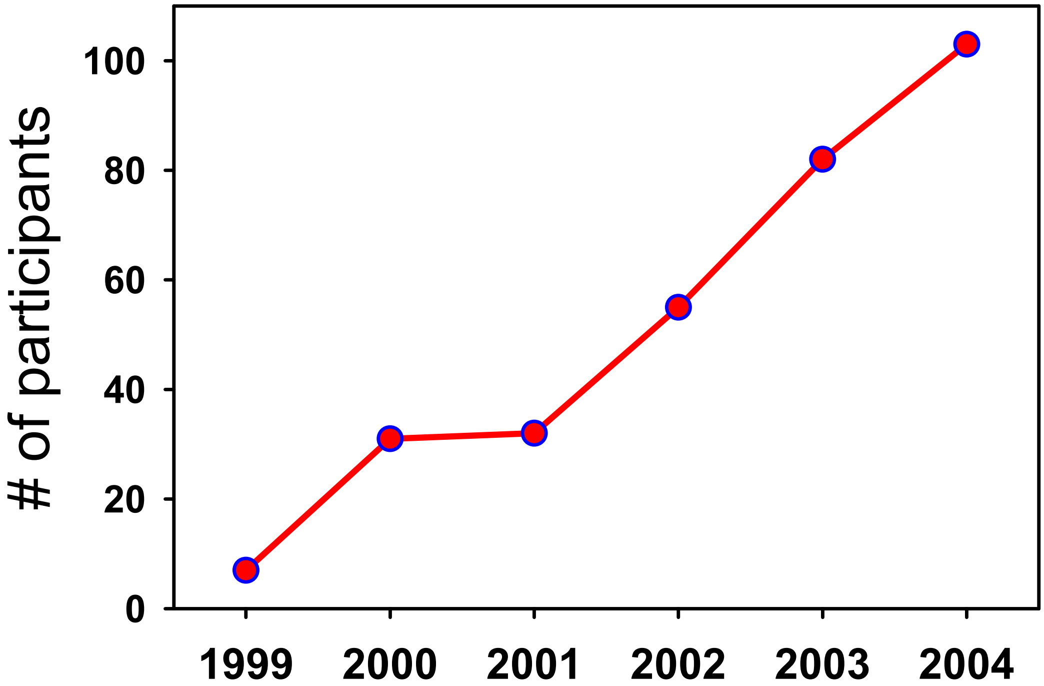
Figure 5. Mean (± SE) and coefficient of variation in number of birds detected per point during the initial passive period (either 3 or 5 minutes in duration) and the subsequent call-broadcast period after the call-broadcast period was truncated to the same duration of the passive period (i.e., birds 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 $\geq$1 bird was detected on $\geq$1 replicate survey. Coefficient of variation within points (B) only includes points at which $\geq$1 bird was detected on $\geq$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).

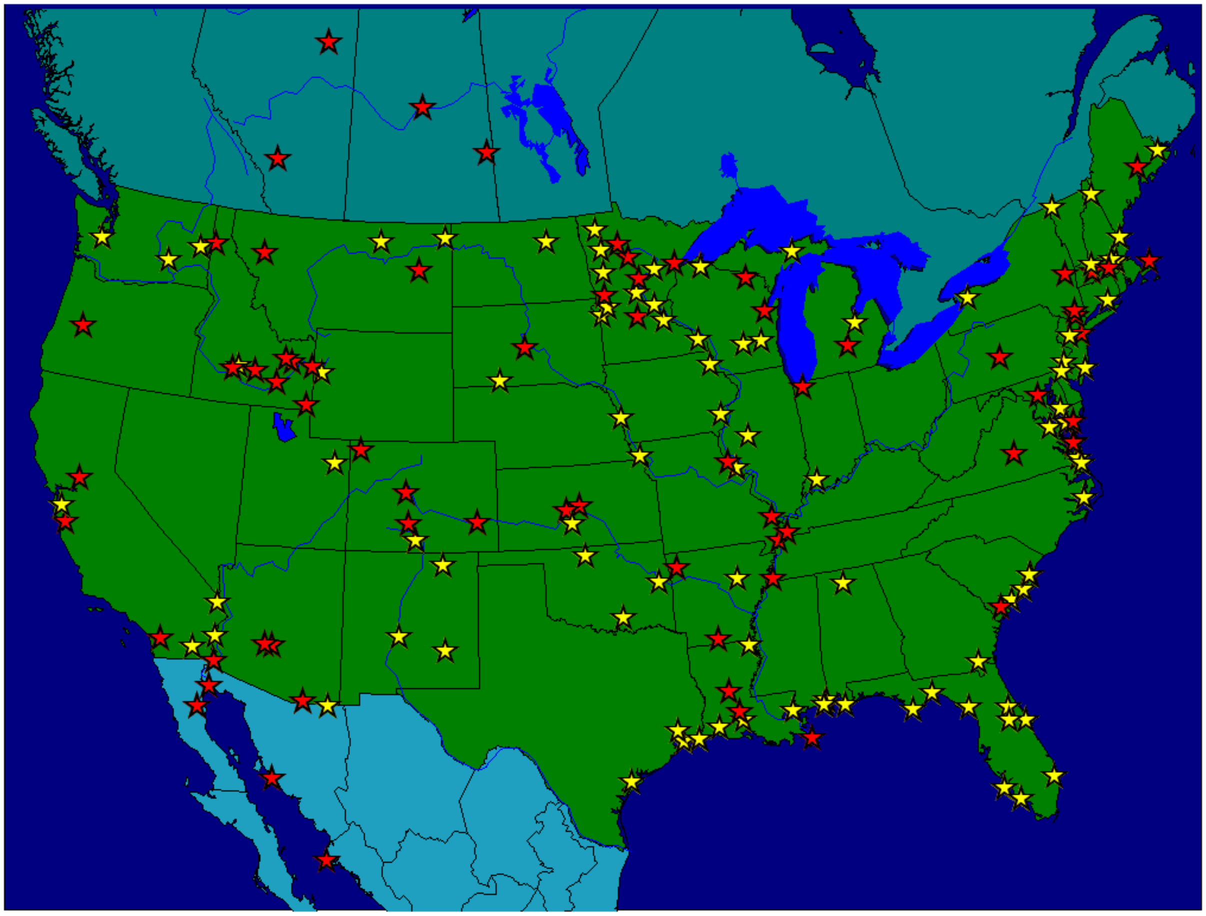
Figure 7. Effects of broadcasting multiple species' calls on number of secretive marsh birds detected. A) Mean (± SE) number of birds detected for each of 8 species of secretive marsh birds on 9-minute surveys that included six 30-second segments of clapper rail calls (circles with black error bars) 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

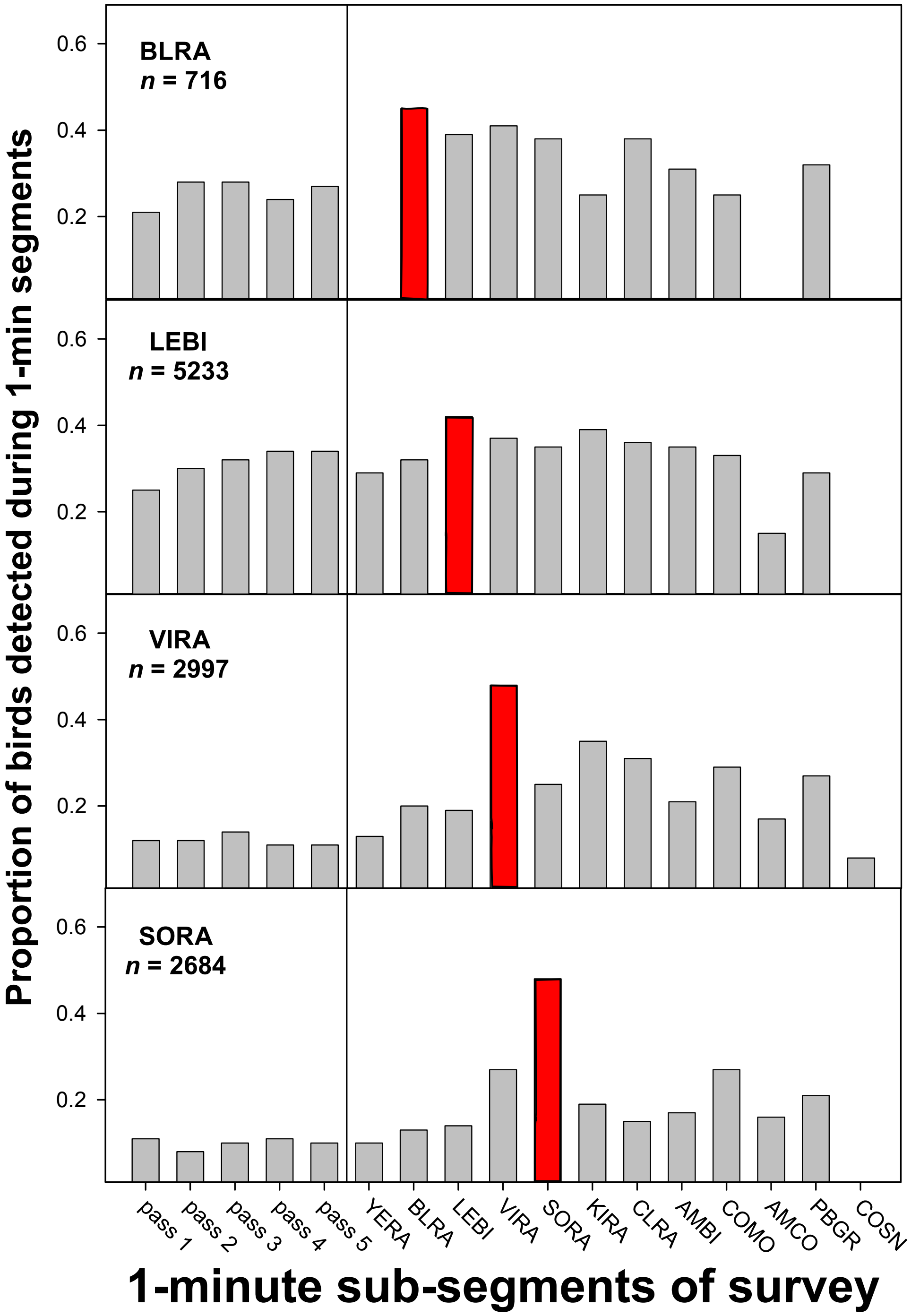
secretive marsh birds on 9-minute surveys that included three 30-second segments each of black rail and clapper rail calls (circles with black error bars) and those that included one 30-second segment of each of 6 species' calls (black rail, least bittern, sora, Virginia rail, clapper rail, pied-billed 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).

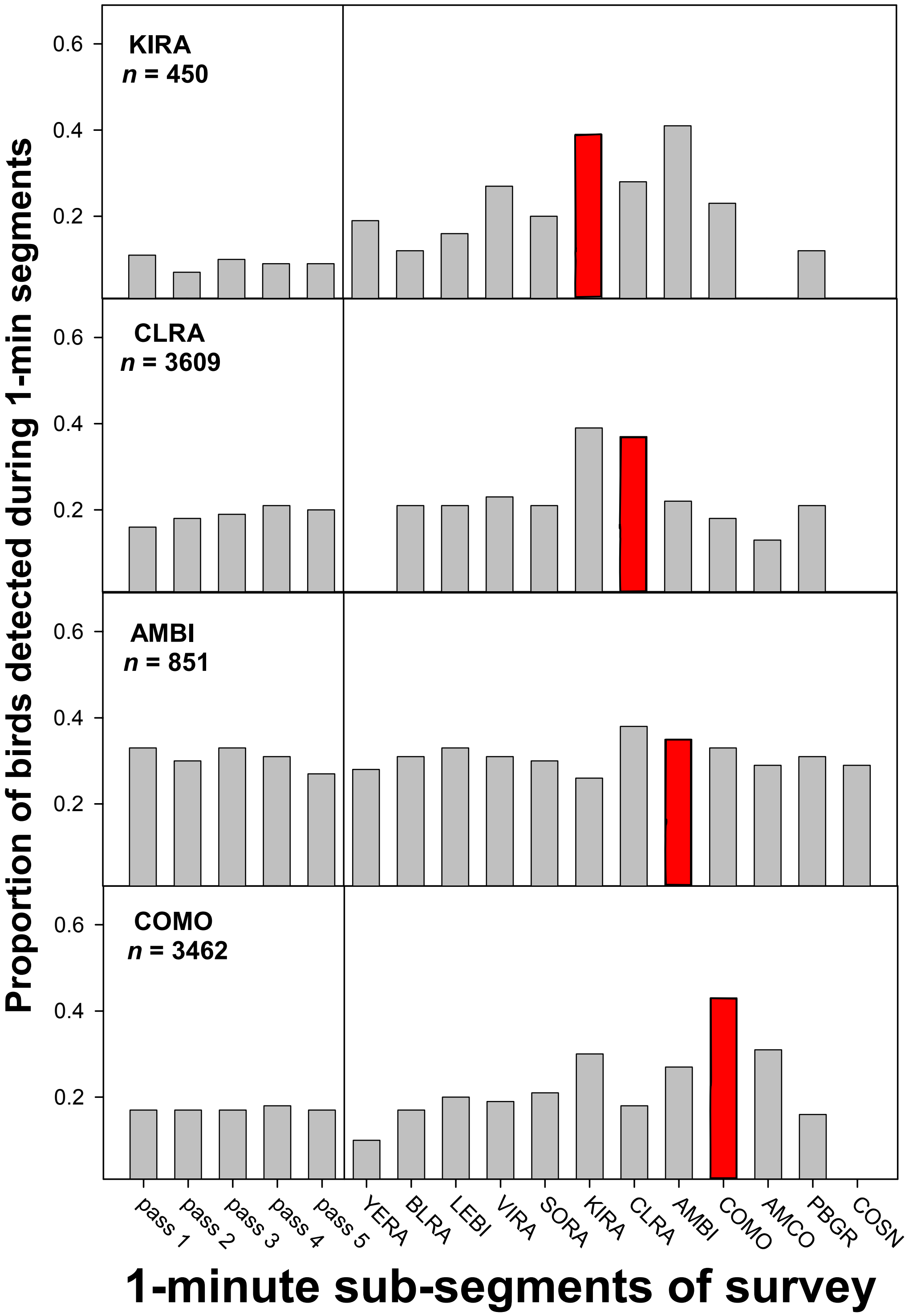
Figure 8. A) Mean (± SE) of observer detection probability for each of 7 species of secretive marsh birds averaged across 11 observers during both the passive segment of the survey and the call-broadcast segment of the survey. We only included data from observer pairs from which x_{11}, x_{12}, x_{21}, 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.

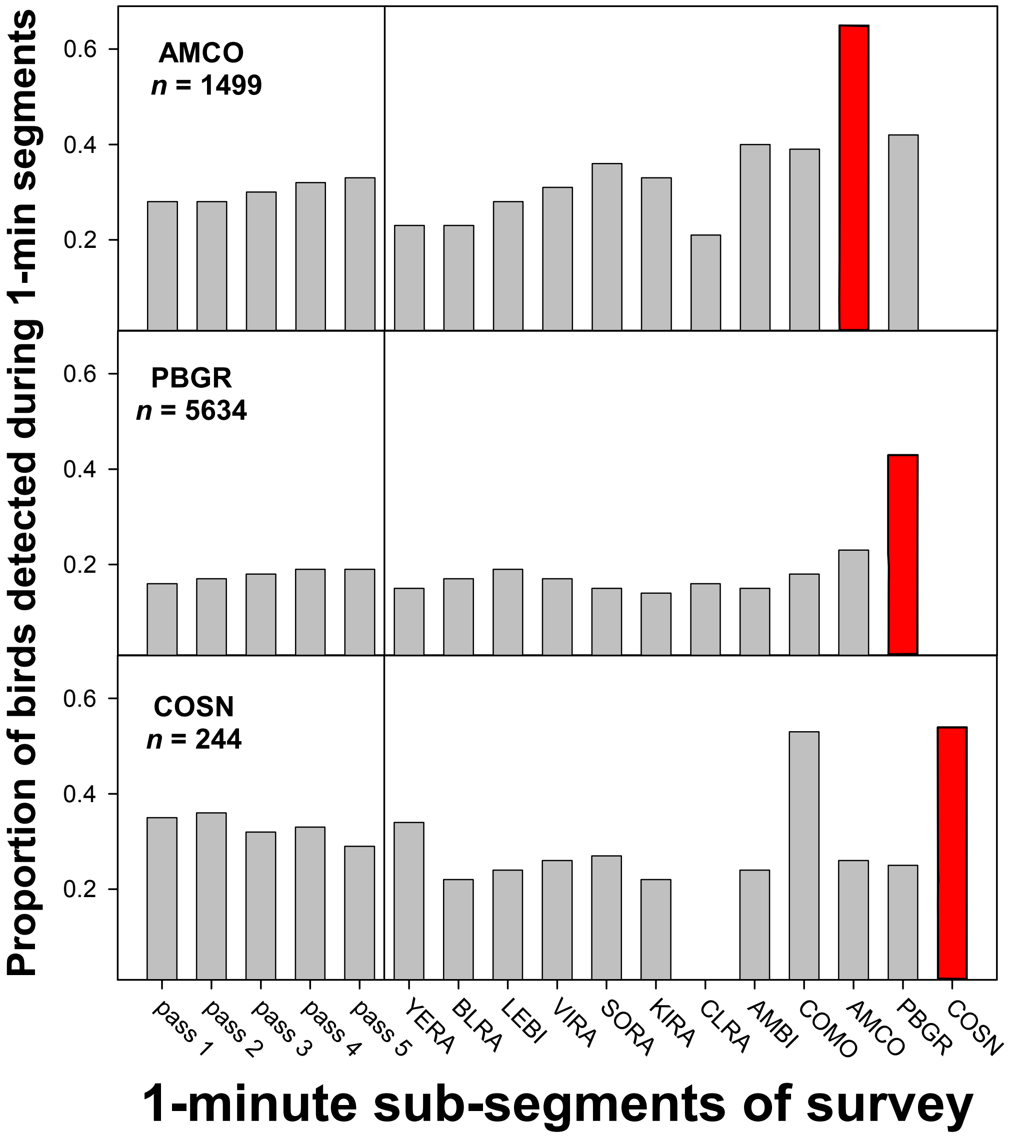


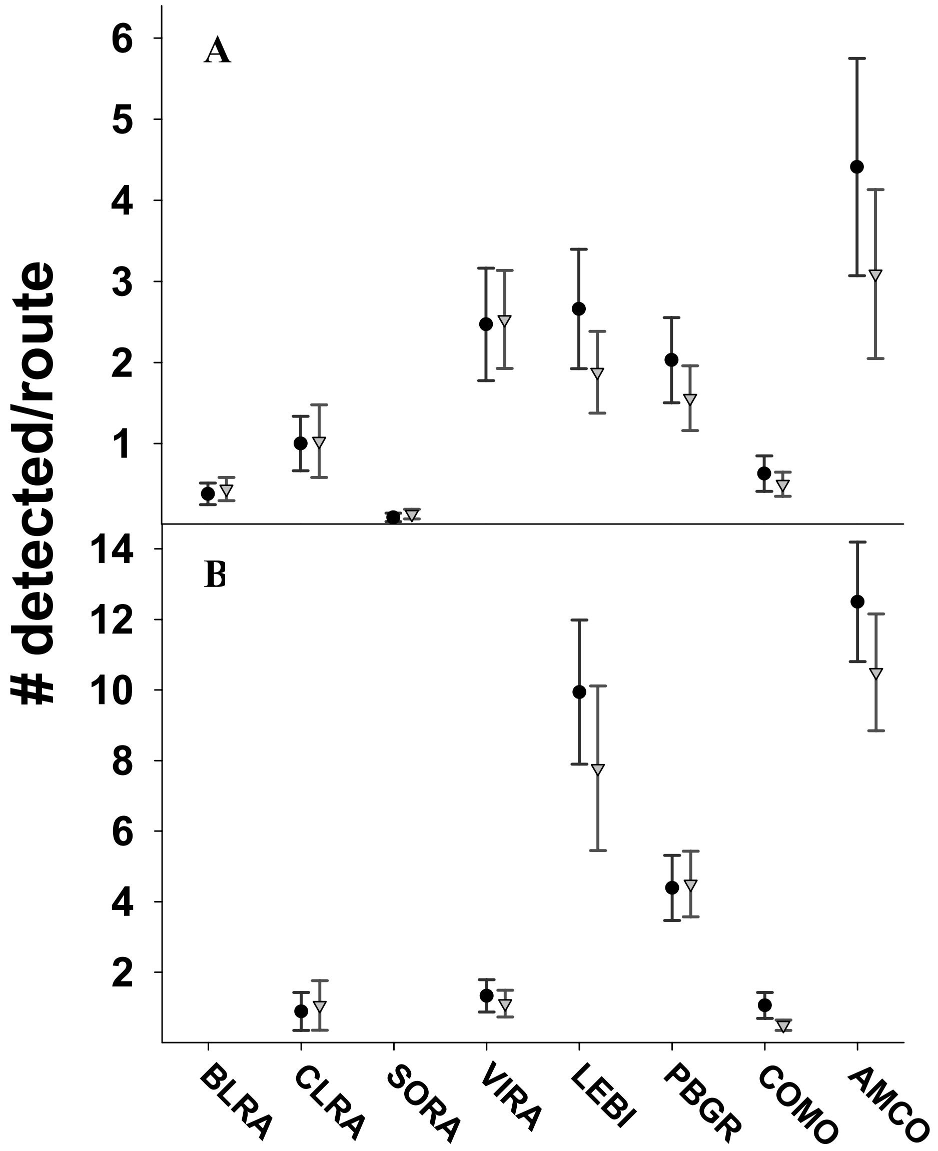
# of participants
0
20
40
60
80
100
1999
2000
2001
2002
2003
2004



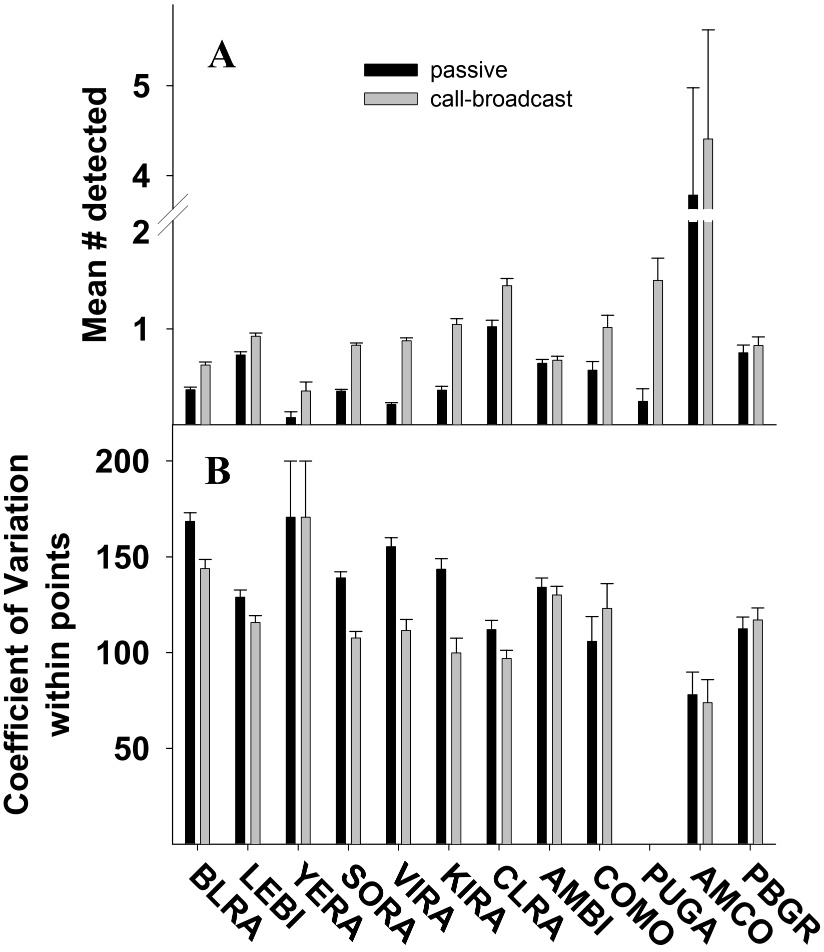

BLRA
n = 716
LEBI
n = 5233
VIRA
n = 2997
SORA
n = 2684
0.6
0.4
0.2
Proportion of birds detected during 1-min segments
pass 1
pass 2
pass 3
pass 4
pass 5
YERA
BLRA
LEBI
VIRA
SORA
KIRA
CLRA
AMBI
COMO
AMCO
PBGR
COSN
1-minute sub-segments of survey

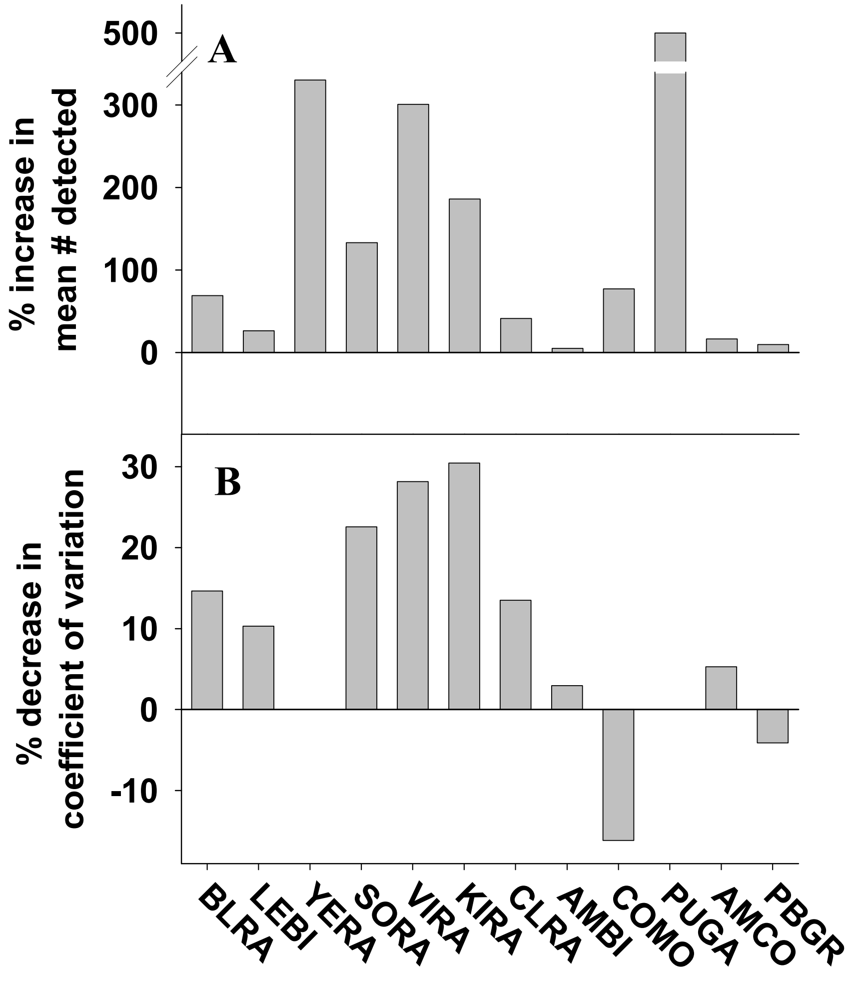

Proportion of birds detected during 1-min segments
KIRA
n = 450
CLRA
n = 3609
AMBI
n = 851
COMO
n = 3462
0.6
0.4
0.2
pass 1
pass 2
pass 3
pass 4
pass 5
YERA
BLRA
LEBI
VIRA
SORA
KIRA
CLRA
AMBI
COMO
AMCO
PBGR
COSN
1-minute sub-segments of survey


AMCO
n = 1499
PBGR
n = 5634
COSN
n = 244
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

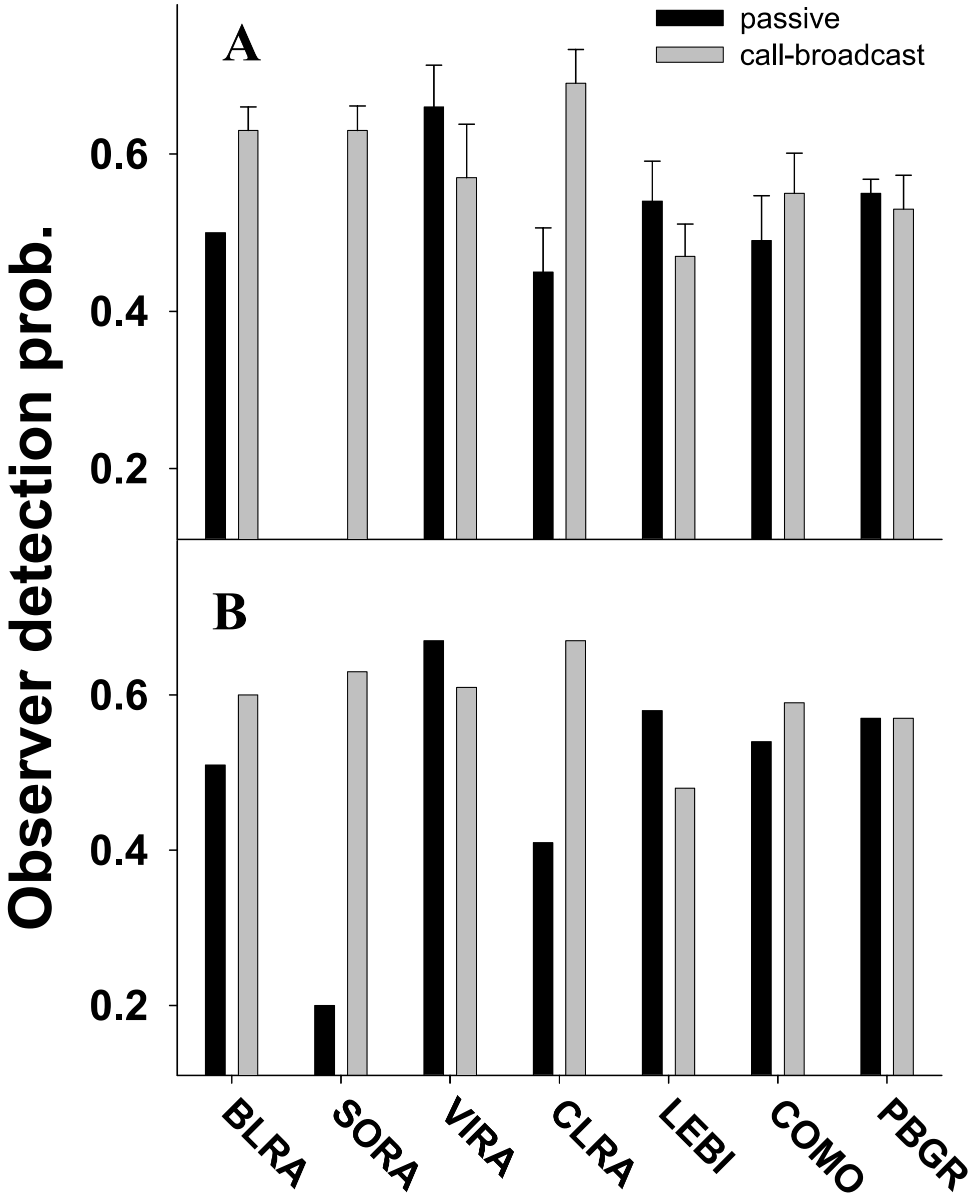


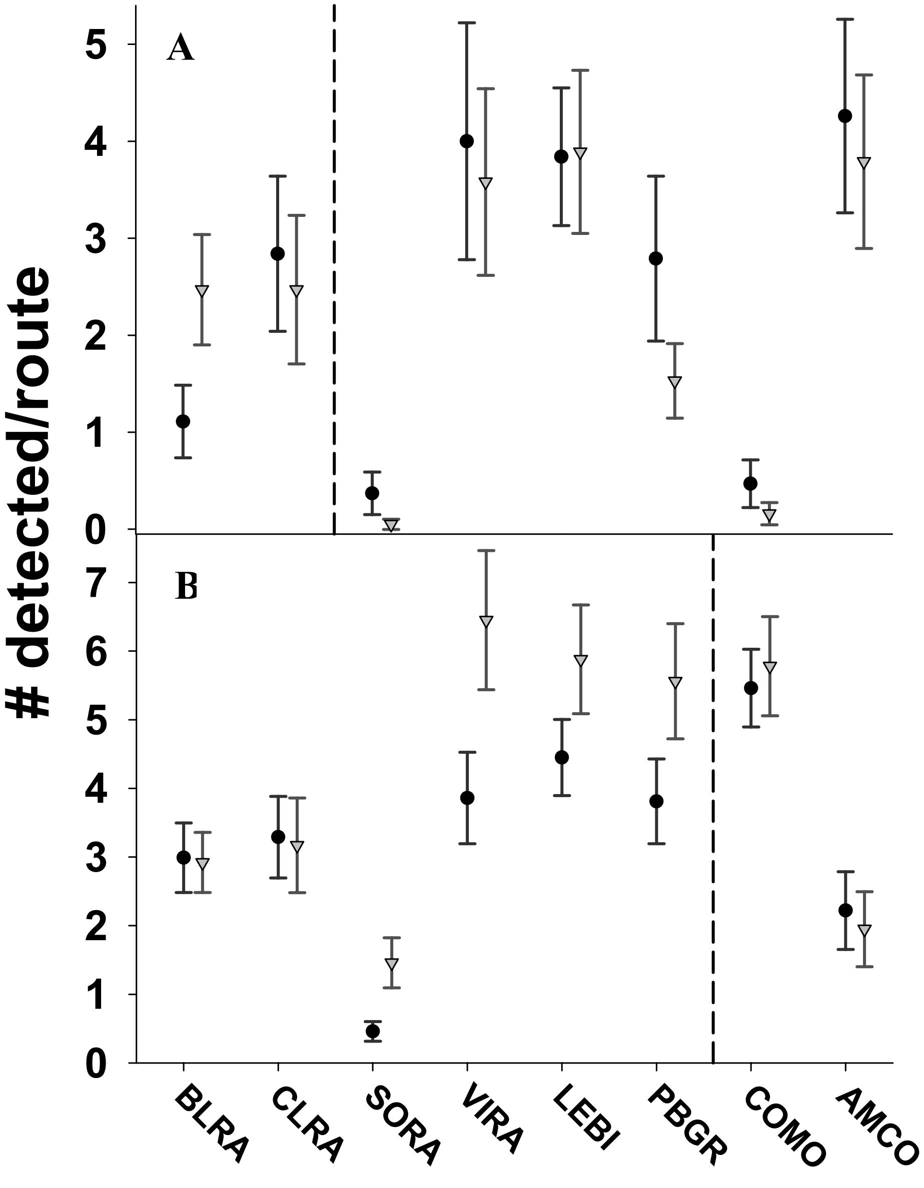
detected/route
A
6
5
4
3
2
1
B
14
12
10
8
6
4
2
BLRA
CLRA
SORA
VIRA
LEBI
PBGR
COMO
AMCO


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



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


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


A
B
detected/route
0
1
2
3
4
5
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.
- planned for 21-23 March 2006, Yuma, Arizona.

Presentations

Conway, C. J. 2005. A standardized North American marsh bird monitoring program. National Estuarine Research Reserve Research Coordinator Annual Meeting, Grand Bay, Mississippi, 17 February 2005. INVITED.

Conway, C. J. 2004. Natural History and Ecology of Rails. Yuma Birding and Nature Festival, Yuma, AZ. 17 April 2004. INVITED.

Conway, C. J. 2003. Development of regional and national monitoring programs for estimating population trends of sensitive taxa. USFWS, Region 2 Project Leaders Meeting, San Antonio, TX. 14 January 2003. INVITED

Conway, C. J. 2003. Benefits of multi-species monitoring of marsh birds. Yuma Clapper Rail-Marsh Bird Monitoring Protocol Meeting, USFWS Ecological Services Office, Phoenix, AZ. 21 February 2003. INVITED

Conway, C. J., J. Bart, and S. Timmermans. 2002. Towards a North American marsh bird monitoring program. Third International Partners-in-Flight Conference, Monterey, CA. INVITED.

Conway, C. J. 2002. Status of Black Rails in western North America. USFWS Lower Colorado River EcoTeam meeting. Parker, AZ. 25 March 2002. INVITED.

Conway, C. J. 2002. A program for estimating population trends of marsh birds on National Wildlife Refuges across North America. Southwest Region Refuge Biological Workshop. Albuquerque, NM. 31 July 2002. INVITED.

Conway, C. J. 2002. National marsh bird monitoring program. Southeast Regional Biologists' meeting. Okefenokee, GA. 7 November 2002. INVITED

Conway, C. J. 2001. “Continental Marshbird Monitoring Program”, North American Bird Conservation Initiative; Marshbird Conservation Workshop, Denver, CO. 22 Aug 2001. INVITED.

Website

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

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