U.S. Fish and Wildlife Service
U.S. Department of the Interior

National Wildlife Refuge System

National Protocol Framework for the Inventory and Monitoring of Secretive Marsh Birds

ON THE COVER
Surveyors at Imperial National Wildlife Refuge in Arizona conducting a marsh bird survey. Birds (clockwise from top left): American Bittern, Black Rail, Least Bittern, King Rail, American Coot, Limpkin, Virginia Rail, Sora, Pied-billed Grebe, Common Gallinule. Photographer: C.J.Conway.

NWRS Survey Protocol Signature Page

Protocol Title: National Protocol Framework for the Inventory and Monitoring of Secretive Marsh Birds
Version[1] : Draft 1.0

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Approvals

Action	**Signature/Name**	**Date**
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National I&M[5] Approval:	Jana Newman, National I&M Manager	

Version[1]	**Date**	**Author**	**Change Made**	**Reason for Change**

[1] Version is a decimal number with the number left of decimal place indicating the number of times this protocol has been approved (e.g., first approved version is 1.0.; prior to first approval all versions are 0.*x*; after first approval, all minor changes are indicated as version 1. *x* until the second approval and signature, which establishes version 2.0, and so on).

[4] Signature by Regional I&M Coordinator signifies approval of a protocol framework to be used at multiple stations within a Region.

[5] Signature by National I&M Coordinator signifies approval of a protocol used at multiple stations from two or more Regions.

Survey Protocol Summary

This survey protocol provides standardized methods for monitoring secretive marsh birds during the breeding season and was designed for use by the U.S. Fish and Wildlife Service on national wildlife refuges across North America. The standardized survey methods for marsh birds originated from suggestions during a workshop at Patuxent Wildlife Research Center (Ribic et al. 1999) and the methods were discussed and recommended for widespread use at a subsequent workshop at Patuxent (U.S. Fish and Wildlife Service 2006). The survey methods incorporate a 5-minute passive listening period followed by a series of 1-minute segments of call broadcast to increase detection probability of focal marsh bird species and include several approaches that allow analysts to estimate components of detection probability. We include suggestions and guidance on probabilistic sampling designs and data analysis techniques to meet a variety of local and regional scale management objectives. Survey timing and associated costs will vary among refuges based on logistics and the number and location of survey points.

Suggested citation:

Conway, CJ. 2015. National protocol framework for the inventory and monitoring of secretive marsh birds. Inventory and Monitoring, National Wildlife Refuge System, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

This protocol is available from ServCat https://ecos.fws.gov/ServCat/Reference/Profile/52385

Acknowledgments

This document draws heavily from the North American Marsh Bird Monitoring Protocol (Conway 2011), which was developed based on suggestions during a marsh bird workshop at Patuxent Wildlife Research Center (Ribic *et al.* 1999). The protocol was then discussed, reviewed and recommended for use at a subsequent marsh bird workshop at Patuxent (U.S. Fish and Wildlife Service 2006). The protocol incorporates suggestions from Conway and Gibbs (2001) as well as recent methodological advances in estimating components of detection probability (Nichols et al. 2000; Farnsworth *et al*. 2002; MacKenzie *et al*. 2002). Many people have contributed to the development of the protocol by field testing survey methods and providing suggestions for improvement. Dr. Soch Lor from U.S. Fish and Wildlife Service led a team of biologists that thoroughly reviewed the protocol and provided many recommendations for improvement and standardization. Mark Wimer from U.S.G.S Patuxent Wildlife Research Center developed the initial web-based data entry portal and helped standardize the data entry process for users. Leo Salas and Michael Fitzgibbon of Point Blue Conservation Science have been integral in transferring the marsh bird data to the Avian Knowledge Network and developing a user interface for data entry, data sharing, and data analysis.

Portions of this protocol were adapted from the Landbird Monitoring Protocols (Knutson *et al*. 2008). The following people served on the National Wildlife Refuge System User Acceptance Team (UAT), a committee that worked on modifications of the North American Standardized Marsh Bird Monitoring Protocol, helped to develop the marsh bird database, and reviewed this protocol, to ensure that the monitoring protocol meets the needs and objectives of land managers.

Bruce Peterjohn (USGS Patuxent WRC)
Mark Wimer (USGS Patuxent WRC)
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Element 1: Introduction

Background

The amount of emergent wetland habitat in North America has declined dramatically in the past century (Tiner 1984; Dahl 2006; Stedman and Dahl 2008). Some evidence suggests that populations of many marsh birds that depend on emergent wetlands are declining as a result (Tate 1986; Eddleman *et al.* 1988; Conway *et al.* 1994; Conway and Sulzman 2007). However, limited information is available regarding abundance, distribution, population trends, habitat relationships, and effects of common wetland management actions for most marsh bird species. The North American Breeding Bird Survey provides survey data on some secretive marsh birds. However, many of the survey routes follow roads and thus do not adequately sample emergent wetlands (Bystrak 1981; Robbins *et al.*1986; Gibbs and Melvin 1993; Lawler and O'Connor 2004). Moreover, many marsh bird species are secretive or inconspicuous, seldom observed, and vocalize infrequently, making them difficult to detect during typical avian point-count surveys even when conducted in optimal habitat. Hence, targeted efforts that focus specifically on marsh birds are needed to advance our understanding of abundance, population trends, and effects of management actions on marsh birds.

Marsh birds include species that primarily inhabit marshes (i.e. marsh-dependent species). Focal species for this monitoring framework include those identified by a group of marsh bird biologists as species for which we lack quality information on status or population trends (Ribic *et al.* 1999). The primary species of concern in North America include king rail (*Rallus elegans*), clapper rail (*Rallus longirostris*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), black rail (*Laterallus jamaicensis*), yellow rail (*Coturnicops noveboracensis*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), pied-billed grebe (*Podilymbus podiceps*), limpkin (*Aramus guarauna*), American coot (*Fulica americana*), purple gallinule (*Porphyrula martinica*) and common gallinule (*Gallinula chloropus*). The U.S. Fish and Wildlife Service (USFWS) has identified black rails, yellow rails, limpkins, and American bitterns as *Birds of Conservation Concern* because they are relatively rare and we lack basic information on status and trends in most areas (U.S. Fish and Wildlife Service 2008). Moreover, yellow rails, black rails, clapper rails, and king rails are four of the 139 "Focal" species that USFWS has given priority for active management because they pose special management challenges (U.S. Fish and Wildlife Service 2005). Black rails and yellow rails are two of the 20 species on the National Audubon Society's national 'Watchlist' because they are the 'most imperiled' species (National Audubon Society 2007). Many U.S. states consider these species threatened or of special concern for similar reasons. A targeted monitoring framework is needed due to the relative rarity of these species and the inability of existing large-scale monitoring programs to provide rigorous information on their status and trends.

Marsh ecosystems are extremely vulnerable to large-scale habitat stressors, including loss from conversion to agriculture, invasive vegetation, urban growth, changes in wetland hydrology, lack of disturbance, and/or factors resulting from climate change including sea level rise. Marsh bird species can often serve as indicators for assessing the health of remaining wetland ecosystems, and their presence can be used as one measure of the success of wetland restoration efforts

(Lewis and Casagrande 1997). For example, marsh birds may be affected by accumulation of environmental contaminants in wetland substrates because they consume a wide variety of aquatic invertebrates (Odom 1975; Klaas *et al.* 1980; Eddleman *et al.* 1988; Gibbs *et al.* 1992; Conway 1995). Marsh birds are also vulnerable to changes in wetland plant composition and invasion of wetlands by invasive plant species (Gibbs *et al.*1992; Meanley1992; Nadeau *et al*. 2011). Marsh birds also have high recreational value; many of these species are highly sought-after by recreational birders because they are rare and secretive. Finally, several rails are hunted in many U.S. states and Canadian provinces, yet we lack the necessary information on population trends and status upon which to base sustainable harvest limits.

Evidence of population declines, the paucity of information on many marsh-dependent species, and the need to set responsible harvest limits prompted the need for a monitoring protocol specifically designed to determine status and estimate population trends of secretive marsh birds. Recognizing this need, the U.S. Geological Survey and the U.S. Fish and Wildlife Service held workshops in 1998 and 2006 that emphasized the need for range-wide estimates of abundance, distribution, and population trends, and began advocated a standardized continental monitoring program (Ribic *et al*. 1999; USFWS 2006). Numerous federal agencies have been cooperating to monitor marsh bird populations in North America with the hope of gaining better knowledge on status and distribution of these birds and improving estimates of population trends. Continual field testing and analysis of survey data have provided guidance for subsequent revisions of a unified North American marsh bird monitoring protocol (Conway and Timmermans 2005; Conway and Nadeau 2006; 2010; Conway *et al.* 2008, Conway 2011). Continued monitoring will also allow resource managers to evaluate whether management actions or any other activities adversely impact wetland ecosystems. Any action that alters water levels, alters salinity, reduces mudflat/open-water areas, alters invertebrate communities or alters the amount of emergent plant cover within marsh habitats could potentially affect habitat quality for marsh birds (Conway *et al.* 1993; Conway 1995; Conway *et al*. 2010; Nadeau *et al.* 2011).

The U.S. Fish and Wildlife Service has a vested interest in marsh bird populations and their habitats because marsh birds are trust species, under the protection of the USFWS. The National Wildlife Refuge System of the USFWS has been a key partner in developing and promoting a standardized marsh bird survey protocol because the refuge system has a disproportionate amount of wetland within their boundaries, and the management actions employed by refuges could potentially affect marsh bird populations.

Objectives

The Standardized North American Marsh Bird Monitoring Protocol is intended to provide guidance to individuals planning to survey secretive marsh birds to address a variety of different objectives. The marsh bird monitoring protocol makes use of a standardized set of sampling methods that will allow multiple uses of the resulting data on both local and regional scales. For example, data collected to examine marsh bird response to habitat management can also be used to model occupancy or abundance across a given region, which would be useful information to help guide harvest management.

The most common objectives for those interesting in conducting marsh bird surveys include: 1) document presence or distribution of marsh birds within a defined area; 2) estimate or compare density of secretive marsh birds among management units, wetlands, or regions; 3) estimate population trend for marsh birds at local or regional scales; 4) evaluate effects of management actions (often actions that target other species) on secretive marsh birds; and 5) document habitat types or wetland conditions that influence abundance or occupancy of marsh birds.

Detection Probability

Those who conduct marsh bird surveys are typically interested in estimates of abundance, density, or population trend. Abundance is the total number of birds within a defined area of interest. Density is abundance divided by area (e.g., the number of marsh birds per hectare of wetland). Population trend is the percent annual change in abundance within a defined area of interest over a defined time period. Estimates of population trend allow managers to determine whether local or regional marsh bird populations are declining and how quickly they are declining. Managers can establish *a priori* population trend thresholds or trigger points below which immediate management action should be taken. Such actions can prevent local extinctions by identifying population problems before they become severe. Surveys rarely count all individuals present in the sampling area because detection probability during surveys is typically less than 100%. Hence, most of the parameters that users hope to obtain from marsh bird surveys rely upon estimates of detection probability and either 1) a consistent and positive correlation between the number of individuals detected during a survey and the number of individuals actually present in the area sampled (i.e., low spatial and temporal variation in detection probability), or 2) incorporating environmental covariates into the estimation process that effectively adjust for most of the variation in detection probability. Few reliable estimates of detection probability during marsh bird surveys are currently available (but see Conway *et al.* 1993; Legare *et al.* 1999; Conway and Gibbs 2001, 2011; Bogner and Baldassarre 2002; Nadeau *et al.* 2008). These survey protocols incorporate several alternative methods for estimating components of detection probability (see Conway *et al.* 2010 for an example of how estimates of detection probability derived from these methods can be useful). Some authors have expressed skepticism about the value of incorporating methods intended to estimate detection probability into surveys (Johnson 2008), but others have advocated for such methods (Burham 1981; Thompson *et al*. 1998; Thompson 2002; Rosenstock *et al*. 2002).

Element 2: Sampling Design

Sample design

The sampling design will determine how the data are interpreted and will influence the conclusions and inferences that can be made from the survey data. This protocol relies on random, stratified random, and multi-stage cluster sampling. We include suggestions on several types of sampling designs to address a range of monitoring objectives and logistical constraints. SOP #1, Sampling Design, describes sampling designs appropriate for local and regional scale management objectives.

Sampling units, sample frame, and target universe

This protocol is designed to monitor the entire community of breeding secretive marsh bird species within a defined area. The spatial and temporal distribution of all possible sampling units (i.e., survey points) with a non-zero probability of being selected defines the sampling frame. The target universe (the marsh bird population to which inference can be made) will depend on clearly defined objectives and an appropriate probabilistic sampling design. SOP #1 includes additional details on probabilistic sampling and how to define the target population.

Sample selection and size

Sample size will depend on the management objectives and type of analysis. For analysis of population trend, sample size will depend on the size of the trend, the time frame, as well as patterns of occupancy and abundance of the focal species (Steidl *et al*. 2013). General guidance on the tradeoffs between number of sampling units and number of replicates per sampling unit is provided in SOP #1.

Survey timing and schedule

Optimal survey timing varies temporally, and among species and regions. Surveyors should conduct surveys when detection probability is highest and temporal variation in detection probability is low. This information will likely come from expert knowledge of breeding phenology of the focal species in the target area. Specific guidance on time of day, optimal seasonal timing, and number of replicate surveys are included in SOP #1, Sampling Design.

Element 3: Field Methods and Sample Processing

Pre-survey logistics and preparation

The Survey Coordinator is the lead biologist in charge of implementing the survey protocol at a land unit or across a group of land units. The Survey Coordinator will select a sampling design (see SOP #1) based on explicit management objectives before the field season begins. Consult with the Regional Biologist, a statistician, or other sampling design experts, if necessary, to ensure that the design meets the defined management and monitoring objectives.

The Survey Coordinator and all field crew members should read and review this entire protocol, including all of the SOPs before the field season begins. The Survey Coordinator will insure that all surveyors are properly trained and meet the qualifications listed (see Element 6, Personnel Training). The Survey Coordinator should organize all of the field equipment listed below, make sure it is ready and functional at the outset of the field season, upload GPS coordinates of survey points into the GPS receiver, and make copies of the field data forms. Surveyors should attempt to navigate to each sampling unit and mark each with flagging tape prior to conducting surveys. This will ensure that surveyors do not waste time looking for the survey points in the field during the narrow survey window. Surveyors will need the following field equipment and supplies to conduct marsh bird surveys:

- Surveyor flagging (to mark survey points)
- GPS receiver
- Clipboard, datasheets, pencils
- CD or mp3 broadcast file (obtained from the program coordinator - see contact info in Appendix F)
- CD or mp3 player
- Amplified speakers
- Batteries for CD or mp3 player and amplified speakers

- Sound level meter with +5 dB precision (e.g., Radio Shack model #33-2050, $35; or EXTECH sound level meter, $99 from Forestry Suppliers, Inc.)
- Rangefinder
- Thermometer
- Water gauge(s)
- Salinity meter (e.g., Oregon Scientific Handheld Salinity Meter [ST228], $25)
- Watch or other time recording device

Batteries should be changed or re-charged frequently (before sound quality declines). Participants should routinely ask themselves if the quality of the broadcast sound is high. Observers should carry replacement batteries and a spare CD or mp3 player on all surveys in case the primary unit fails to operate.

The Survey Coordinator should establish a survey schedule. Guidance for timing of surveys is provided in SOP #1 but should coincide with the peak of breeding activity for the focal species in your region. Survey schedules should allow for flexibility due to weather or other logistical problems.

Establishment of sampling units

Fixed, permanent survey points will be chosen and marked with inconspicuous markers in the field. See SOP #1, Sampling Design, for details on how to select locations for permanent survey points. Each survey point receives a unique identification number. Use a GPS receiver to record the UTM coordinates, UTM zone, and map datum for each survey point. If possible, locations of all survey points should also be plotted on maps of each wetland. Maps should include the direction in which the speakers should point during the survey at each survey point. Inconsistent speaker direction may increase variation in the number of birds detected, and this may not be obvious to a new observer.

Survey points should be located on either the upland-emergent vegetation interface or the open water-emergent vegetation interface. Conducting surveys at points within the interior of marshes is not practical in most inland wetlands due to the tremendous disturbance to emergent plants and the changes in calling behavior of marsh birds caused by walking into the interior of a marsh. However, conducting surveys from upland edges, roadside edges, and open water edges may create some bias in estimation of population trends. Hence, surveyors should record whether each point is:
1) along a ditch, dike, or berm with emergent vegetation on both sides,
2) along a ditch, dike, or berm with emergent vegetation on one side,
3) along a public road with emergent vegetation on both sides,
4) along a public road with emergent vegetation on one side,
5) along an upland/emergent edge (record type of upland: grassland, scrub-shrub, or forest),
6) along an open water/emergent edge,
7) within a narrow water channel or tidal creek with emergent vegetation on both sides,
8) within a contiguous patch of emergent vegetation (also record distance from edge), or
9) other (and provide description of point placement).

Data collection procedures

The standardized North American marsh bird monitoring protocol (Conway 2011) originated from suggestions during a marsh bird workshop at Patuxent Wildlife Research Center (Ribic *et al.* 1999). The protocol was reviewed and endorsed at a subsequent marsh bird workshop at Patuxent (U.S. Fish and Wildlife Service 2006) and incorporates suggestions from Conway and Gibbs (2001, 2011) and recent methodological advances in estimating detection probability (Nichols *et al.* 2000; Farnsworth *et al.* 2002; MacKenzie *et al*. 2002). The survey methods incorporate a 5-minute passive listening period followed by a series of 1-minute segments during which pre-recorded marsh birds calls are broadcast to elicit response from resident marsh birds. Surveyors record each individual marsh bird detected during surveys on a separate line on the datasheet and estimate the distance to each bird. This approach allows analysts to use several methods to estimate components of detection probability. SOP #2 includes detailed instructions on survey methods and how to record data during surveys. Surveyors may obtain datasheets from the program website (http://www.cals.arizona.edu/research/azfwru/NationalMarshBird/). An example of a completed datasheet is provided in Appendix E.

Processing of collected materials

Proofread all datasheets to ensure that they are filled out completely and that the data are legible upon completion of each survey. Mark any corrections in pen (different color than that used to record original data) and document the reason for the correction if necessary. Make a paper or electronic (digital) copy of each datasheet upon return from the field each day. Store originals in a fire and flood proof cabinet, and ensure that copies are stored in a separate building.

End-of-season procedures

At the outset of a new study or project, establish a new project in the Avian Knowledge Network (AKN) database (see SOP #3 for information on data entry and data management). All data should be entered and proofed for accuracy by the end of each field season. Initial and date each datasheet after entering it into the database and again after proofing the electronic record. Once the data are verified and correct in the electronic database, summaries of the data may be downloaded for use in annual reports. A summary of the field season with the survey dates, order or sequence of points, maps of the sampling locations, list of species detected, hazards encountered, or other noteworthy events should be prepared and stored with the season's field datasheets. Ensure that all metadata describing the data collection procedures and storage locations are entered into the AKN database. Additional details on database management and suggestions for data analysis are included in SOP #3 and SOP #4.

Element 4: Data Management and Analysis

Data entry, verification, and editing

The Standardized North American Marsh Bird Monitoring Protocol allows data sharing and comparisons among sites though a shared database managed by the Avian Knowledge Network. SOP #3 provides detailed information on how to enter, proof, and manage marsh bird survey data.

Metadata

The sampling design and the methods followed will determine how the data can be used. Properly documenting the details of your objectives and sampling design is important so that those using the data will understand how and why the data was collected. Various fields exist in the AKN database to provide details on the survey methods, sampling design, and objectives. The study protocol defined in the database also contains a field to include a URL for links to more extensive documentation.

Data security and archiving

Copies of datasheets should be made upon returning from the field and stored in a separate location. The AKN database administrators are responsible for ensuring security and backup of the electronic data stored in the database. SOP #3 and Element 3 provide additional details on end of season procedures and data security and archiving.

Analysis methods

SOP #3 provides general guidance on data analysis to meet a variety of objectives associated with marsh bird monitoring. The main objectives discussed in the SOP are to: 1) provide basic data summaries for use in annual reports, 2) estimate detection probability, 3) estimate abundance, density, or occupancy of marsh bird species, 4) determine species habitat relationships, and 5) analyze long-term trend for individual species over time.

The AKN database has simple reporting functions such as relative species abundance based on defined groupings of land units or management areas. More advanced analyses may require a statistician depending on the complexity of the analyses and expertise of staff. Budget estimates should include funding to analyze data.

Software

A variety of software applications are available for data analysis and display. Simple data summaries and graphs can be prepared using the data visualization and analysis tools available through the AKN online interface (see SOP #3), MS Excel, or specialized graphing software such as Sigma Plot. More complex statistical analyses will require specialized statistical software such as SAS, SPSS, MARK, Distance, or R.

Element 5: Reporting

Implications and application

Regular and timely dissemination of survey results is essential for making informed management decisions. Summarizing bird survey data will help determine if management objectives are being met and will help to identify species in need of conservation. Annual and Synthesis (3-5 years) reports should be prepared for the purpose of summarizing and interpreting point-count survey data and should be submitted to the Project Leader at the land unit. The U.S. Fish and Wildlife Service encourages publication of significant findings in scientific journals or Service publications (U.S. Fish and Wildlife Service 2007).

Annual Reports

Annual reports are required for all surveys each year. Data analysis and report writing should be completed prior to the start of the subsequent survey season. The annual report serves several purposes, including: 1) documenting monitoring activities and archiving data at the end of the field season each year, 2) describing current conditions that may explain abrupt changes in occupancy or abundance, 3) providing information about bird populations and their habitat associated with management actions, and 4) documenting any changes in the monitoring protocols. The report should summarize the field season and describe patterns of bird species composition and relative abundance. The Survey Coordinator should meet with the Project Leader to determine how the survey results should be used to improve management practices.

Analysis and synthesis reports – trends and habitat relationships

Analysis and synthesis reports should be prepared every 3-5 years. The analysis and synthesis report is intended to: 1) evaluate patterns and trends in bird species occupancy or abundance over time, 2) determine if correlations exist between bird abundance and habitat features, disturbance events, or specific hydrologic or other management regimes, 3) determine the amount of change that can be detected, or the sample size needed to estimate population trend within the area of interest, or 4) recommend changes to management strategies based on patterns observed in survey data.

The Project Leader should budget for preparation of reports in the Annual Habitat Work Plan at least every 5 years. The report should document stated objectives, statistical methods, results, and include a discussion of population trend and/or habitat analysis. Peer review is encouraged. The Survey Coordinator should discuss with the Project Leader how the result should be used to inform management.

Sections to include

Objectives and Methods

All reports should include an introduction which explicitly states the specific objectives and the reasons for conducting the survey. This should be followed by methods that describe the exact procedures followed. For field methods included in the survey protocols, it is sufficient to write a brief statement and cite the protocol document. If methods differed from those outlined in the protocol, document the reasons the methods differed, specific procedures followed, and describe analytical methods and assumptions of those methods.

Summary of Results

Include any relevant data summaries and graphs that will help convey patterns detected in the survey data. SOP #4, data analysis, contains additional information and suggestions on how to summarize survey data and produce graphs. Summaries should reflect the objectives identified in the monitoring protocol.

Important Findings

Include a discussion of the implications of the survey results, and how they relate to the survey objectives and relevant management decisions. For example, you may compare the survey results to pre-defined values that may trigger specific management actions or to results from survey efforts in other areas or regions. Discuss the reliability of the survey results, conclusions, and recommendations for changes in management strategies. If the survey results have implications for management decisions, include additional information that will help others understand how the results might be used to inform management. This may include citations of additional studies that support the findings or analysis of additional data with a larger sample size or a larger spatial scale.

Reporting schedule

An annual report should be produced at the end of each field season and should include any interpretations relevant to current management concerns. Annual reports should be completed prior to the start of the subsequent survey season. More complex analyses can be completed less frequently (every 3-5 years).

Report distribution

Results should be discussed with the Project Leader and a copy of the report archived at the refuge station, made available on the station's website, and copies distributed to all interested partners.

Element 6: Personnel Requirements and Training

Roles and responsibilities

The Survey Coordinator is responsible for implementing the monitoring program and ensuring data quality. The survey Coordinator 1) defines management and sampling objectives and selects the appropriate sampling design to meet the stated objectives, 2) hires and trains surveyors prior to the field season, 3) implements survey protocols, 4) oversees data entry, data proofing, and quality control, and 5) analyzes data and prepares annual reports.

The Survey Coordinator will ensure that all surveyors are familiar with all SOPs and know how to operate all field equipment, including GPS, rangefinder, and emergency communication equipment. Observers are encouraged to practice navigating to survey points and to become familiar with the survey areas before starting official surveys. Review safety procedures, first aid, and emergency plans prior to conducting field work.

Qualifications

A well-trained and competent surveyor is essential to the collection of credible, high-quality data. Observer bias is a major source of error in trend analyses of bird populations (Sauer et al. 1994; Kendall et al. 1996). Training has been shown to improve the ability of observers to detect birds (McLaren and Cadman 1999) and to estimate distance to marsh birds during surveys (Nadeau and Conway 2012). Adequate training prior to surveys is particularly important with marsh bird surveys because of the different repertoire of courtship and territory calls that each marsh bird species exhibit, and the similarity of calls among species (Conway 2011). Good hearing ability is essential because most inconspicuous marsh birds are detected only by sound, and many calls are often very faint. Observers must be capable of identifying all focal species by both sight and sound. Additionally, observers must be proficient at estimating the horizontal distance of detected birds from the observer. Observers must also be physically fit enough to navigate to the survey points and able to arrive at their survey point(s) on or before the start of the surveys.

Training

An important part of credible data is having experienced and well-trained observers. A minimum of 7 days of bird identification and survey training in the field is required before surveyors can conduct surveys independently. Many people require more than 7 days of full-time training (as many as 14 days) before they are able to detect most marsh birds that vocalize during a marsh bird survey. All observers should have the ability to identify all common calls of focal and non-focal marsh bird species in their local area. Regularly listening to the recorded calls used for surveys can help you learn calls, but observers should also practice call identification at marshes where the focal species are frequently heard calling. Conduct field training during the time of day when vocalization probability is highest, typically during the 2 hours surrounding sunrise and the 2 hours surrounding sunset. Marsh bird training workshops are often available free of charge during March; contact the Program Coordinator for information on upcoming training workshops.

The Survey Coordinator or technicians conducting surveys may be required to take the Department of the Interior Motor Boat Operation Certification Course if motorboats are required to access survey points.

Distance Estimation

All observers should also be trained to accurately estimate distance to calling marsh birds, and to identify the common species of wetland plants within the survey area. Methods for training observers to accurately estimate distance include: 1) place a CD or MP3 player in the marsh at an known distance and have observers estimate distance to the recorded call, 2) choose a piece of vegetation in the marsh where the bird is thought to be calling from and use a rangefinder to determine distance, 3) have an observer estimate the distance to a bird that is calling with regularity and is at a very acute angle to a road or marsh edge, then have a second observer walk along the road/edge until they are adjacent from that calling bird, and then measure this distance (by pacing or use of a GPS). Observers may also practice estimating distance to stationary objects (e.g. a tree or flag pole) and use a GPS or tape measure to verify the correct distance to the object.

Multiple-observer surveys

Multiple-observer methods (described in SOP #2) can be very useful during training. After completing a survey, the observers can discuss what they heard and their distance estimates to each bird. Periodic multiple-observer surveys not only produce estimates of detection probability (see SOP #4) but also allow participants to determine whether one person is constantly underestimating or overestimating distance to calling birds. First-time surveyors can tag along on surveys conducted by more experienced surveyors in their region prior to starting their own surveys. They should do at least one “trial run” before their first data collection window begins to become familiar with the data sheet and practice recording the data properly.

Hearing tests

Hearing acuity is important because ~90% of secretive marsh birds detected during a marsh bird survey are heard and not seen, and many of the calls are very faint. Surveyors are strongly encouraged to have a hearing test (audiogram) at a qualified hearing or medical clinic before, during, or immediately after the survey season each year. We encourage surveyors or potential surveyors to discuss the results of their hearing with their doctor and with their supervisor (or the Program Coordinator) to determine whether the quality of the data they collect may be compromised. These data could be included as a covariate and would help control for observer bias in trend analyses.

Element 7: Operational Requirements

Budget

Element 3, pre-survey logistics and preparations, provides a list of required equipment. A 4-wheel drive truck or boat (kayak, canoe, or motorboat) may be needed to access some sampling units. Computers will be needed for data entry, data analysis, and report writing. Field and travel costs (per diem, fuel or mileage, and lodging) will vary according to the number and spatial extent of sampling units and logistical constraints.

Table 1. Estimated Costs of Survey

Personnel/Equipment	Estimated Cost
Survey Coordinator (refuge staff)	$0
Field observers and data entry techs (Biological Technicians or volunteers)	$0 – $5,000
Statistician (contract)	$ 2,000
Equipment (MP3 player, amplified speakers, GPS units, waders, batteries, clipboards, datasheets, rangefinder, sound meter)	$1,000
TOTAL	$3,000 – 8,000

Schedule and staff time

The survey schedule will vary among regions according to local breeding phenology of focal species. Guidance on appropriate survey windows is included in SOP #1 and Appendix B. Schedules should be flexible to allow for unforeseen changes in the survey schedule due to weather or other logistical constraints. The staff time required will depend on the amount of wetland vegetation, the number of sampling units, time required to travel between points, and other survey logistics. Survey Coordinators should also plan time in the schedule for data entry, analysis, and report writing.

Coordination

Coordination may be required among biological survey staff and staff or contractors that are responsible for implementing management actions such as prescribed fire, irrigation, mowing, herbicide treatments, or other habitat manipulations. Coordination may also be required for shared use of equipment, vehicles, boats, or computer equipment. Coordination may also be warranted among land units on a regional or national scale, and with other agencies or NGOs conducting marsh bird surveys in your area.

Element 8: References

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Standard Operating Procedure 1: Sampling Design

This SOP provides options for sampling designs to be used with point-count surveys for secretive marsh birds during the breeding season. The sampling design is a critical component of all monitoring efforts and determines the inferences that can be made from the survey data. Managers must first identify their management objectives for marsh birds and what information is needed to inform the key management decisions. The sampling design may be tailored to address specific refuge information needs. The guidance provided is designed to help refuges select an appropriate sampling design to address their management objectives.

This SOP includes sampling designs derived from Knutson *et al*. (2008) and Johnson *et al*. (2009). Multiple options for sampling designs are included to accommodate different management objectives. The Survey Coordinator at a refuge should work with his/her supervisor and the Regional Refuge Biologist prior to beginning the survey to define the management and sampling objectives and choose the appropriate sampling design. Documenting the details of your sampling design in the AKN database is important so that users of the survey data have a clear understanding of how the data were collected. Instructions on how to document details of the sampling design are included in SOP #3.

Target Population and Sampling Frame

This protocol is appropriate for conducting point-count surveys of breeding marsh birds that are difficult to detect with typical passive surveys; it is not designed to monitoring other bird guilds, such as landbirds or other waterbirds. The list of focal species is included in SOP#2 (Conducting Surveys). The target population that will be monitored by the protocol is the community of marsh birds in the sample area during the breeding season. Hence, the sample area will dictate the target population. For example, if refuge staff want to survey only impounded wetlands on the refuge, then the target population is marsh birds on impounded wetlands. If managers survey the entire refuge at randomly selected points, then the target population is marsh birds throughout the refuge. The sampling frame is that population of sampling units (typically locations) that most closely approximates the target population and that has some possibility of being sampled (e.g., the entire refuge, management unit Z, all wetland habitats on the refuge, etc.). Each monitoring plan should clearly define the target population in the objectives and define the sampling frame in the sampling design so that the area or population for which the summary information applies is made clear.

A fundamental rule of a sampling design is that inference can only be made to locations that had an opportunity to be sampled. For example, if large areas of the refuge are inaccessible, and hence not in the sampling frame (no possibility of being sampled), then you can’t extrapolate or attribute your survey results to those areas. You should be able to describe your sampling frame and create a map that identifies areas that are not accessible (or not sampled for any other reason) and, hence, not included in the sampling frame. Statistical consultation is strongly recommended when planning a new monitoring effort.

The protocol relies on random or stratified random sampling for most land units. For very large land units, or areas with extensive wetland cover, Generalized Random Tessellation Stratified

Design (GRTS) ensures that samples are spatially balanced across the target area and simplifies replacement of inaccessible or otherwise unusable sample points (Stevens and Olsen 2004; Lister and Scott 2008). GRTS is appropriate for multi-stage cluster sampling designs across regions or other large areas.

Objectives

The sampling designs detailed in this SOP can be used to address several management objectives, all of which estimate bird abundance or occupancy. The specific management objectives should be explicitly stated before beginning a monitoring program (Johnson 2000).

Inventory

Managers may wish to conduct an inventory to estimate relative abundance (birds/point surveyed), density (birds/hectare), or occupancy (proportion of sites occupied) to determine status of marsh bird species on the refuge. This objective is applicable to obtaining baseline data for the site, and for obtaining pilot data to estimate sample sizes needed for evaluating management objectives (see details below regarding sample size). For this objective, sampling the largest number of points possible will yield the highest probability of detecting a large proportion of the species present.

Estimating trend (change over time)

A commonly stated objective is to estimate the change in abundance, density, or occupancy of marsh bird species over time on a land unit or at a regional or continental scale. For this objective, monitoring would continue for >5 years. The management objectives should explicitly state the magnitude (%) of change you wish to detect and the time frame over which you wish to detect it, and the sampling objectives should state the level of uncertainty you are willing to accept (e.g., I am willing to accept a 10% chance of inferring an increase or decrease when one does not exist).

Management actions

Some land managers may want to evaluate the effect of management actions on changes in abundance, density, or occupancy of a species. Management objectives should state the desired difference between management actions in abundance or occupancy that you wish to detect and sampling objectives should identify the level of confidence that the objectives have been achieved (e.g., the abundance or occupancy threshold is within 10% of the true values).

Habitat associations

Land managers may wish to identify habitat features that influence changes in abundance, density, or occupancy of marsh bird species. Managers should define a set of competing models containing variables that may explain expected changes (e.g., plant succession, species composition, vegetation structure, management actions, climate variables, salinity, or hydrologic conditions). Managers would then collect data on those environmental variables that are included in the models as well as the bird survey data.

Survey timing and schedule

One visit per year to a sampling point is the minimum required for estimating change in abundance or density. One visit per year will allow managers to maximize the number of points visited given a finite amount of personnel time available and may be appropriate if sufficient resources for multiple visits are not available. However, three or more surveys are needed to confirm seasonal presence/absence of some marsh bird species in a wetland with 90% certainty (Gibbs and Melvin 1993). Including ≥3 visits per year will allow estimation of the proportion of sites occupied by each species (MacKenzie *et al*. 2002). However, if for some reason you are unable to conduct ≥3 surveys on your area, the data can still be used for many purposes (i.e., to estimate detection probability, to compare passive with call-broadcast survey methods, to estimate trend, to assess the effects of changes in management).

Three visits to each point per year is also warranted because detection probability varies seasonally, and managers often do not know the local timing of the breeding cycle for their target species at the outset of their survey effort (Rehm and Baldassarre 2007; Conway *et al.* 2010). Optimal seasonal timing for surveys will vary regionally depending on breeding phenology of the focal marsh bird species. Surveyors should conduct at least 3 surveys annually during the presumed peak of the marsh bird breeding season. The peak breeding season in each location will vary among bird species within each region. For example, American bitterns often breed earlier than both least bitterns and rails in some regions, and clapper rails and king rails breed earlier than Virginia rails and soras in some regions (also see Rehm and Baldassarre 2007). Conducting one survey within each of the recommended survey windows will help account for this variation among coexisting species. Recommendations on timing for each of the 3 survey windows are based on average minimum temperatures in May for each region (Appendix B). The 3 survey windows increase the probability of conducting at least one survey during the peak seasonal response period of all focal marsh bird species in the area. In many areas, migrants are still moving through when the breeding season is well underway for local breeders. Hence, some surveys will occur prior to when migration is completed for many marsh birds. A common goal of marsh bird surveys is to estimate trends over time in the number of breeding adults of each target species, so we want to make all 3 visits prior to the initiation of juvenile vocalizations. Contact the program coordinator (see contact info in Appendix F) if you feel that the 3 annual survey windows do not adequately capture the peak breeding seasons of the target species in your area.

Time of Day

Survey routes can be either morning or evening survey routes; vocalization probability of marsh birds is typically highest in the 2 hours surrounding sunrise and the 2 hours surrounding sunset.. Surveyors can conduct either morning or evening surveys on a survey route as long as each survey route is surveyed during the same period (morning or evening) consistently every year (once a route is designated an evening route, it will always be an evening route). Morning surveys begin 30 minutes before sunrise (dawn) and should be completed prior to the time when marsh birds cease calling (this time varies regionally, but is often 2 hours after sunrise in southern latitudes and 3 hours after sunrise in northern latitudes). The time in the morning when marsh birds cease calling also varies with temperature and time of year. Evening surveys should begin 2 hours before sunset and must be completed by dark (30 minutes after sunset). When conducting evening surveys, surveyors should start their survey route such that they finish the last point when it is getting too dark to see their datasheet. The half hour between sunset and complete darkness is often when detection probability of marsh birds is highest. The morning or evening survey window should correspond to when marsh birds are most vocal in your area. Determine the optimal daily survey window for your region and stick to them each year.

Including both morning and evening surveys into a standardized monitoring protocol will provide added flexibility and more potential survey hours for field personnel.

Surveys in Tidal Marshes

Tidal fluctuations can affect detection probability of marsh birds by altering behavior and vocalization rates, but these effects may vary among species and regions. The decrease in vegetative cover during high tides may increase visual detections for some passerine species, but may also decrease vocalizations due to increased predation risk (Rush *et al.* 2009). Many salt marsh passerines are forced to re-nest following flooding during peak high tides, hence, detection probability is highest during the week following high spring tide (Rush *et al*. 2009). Clapper rail surveys have been timed to coincide with a high tide since 1972 at San Francisco Bay NWR, but high tide was a period of reduced vocalization probability for clapper rails in southern California (Zembal and Massey 1987) and for black rails in northern California (Spear *et al*. 1999). However, clapper rail and least bittern detections were positively correlated with tide height on the Gulf of Mexico (Rush *et al*. 2009; Nadeau *et al.* 2010), and clapper rail detections were highest during mid-tide in Maryland (Lehmicke *et al.* 2013).

When possible, surveys in tidal marshes should always be conducted at a similar tidal stage for each visit to a route both within and across years. The tidal stage within which to conduct local marsh bird surveys should be based on when the highest numbers of marsh birds are likely to be detected in your area; optimal tidal stage for surveys may vary among regions. If no local data is available on optimal tidal stage for conducting marsh bird surveys, participants should try to conduct surveys on days when high or low tide does **not** fall within the morning (or evening) survey window (i.e., conduct surveys when tides are coming in or out). Surveyors within tidal marshes should record the following: 1) time of the closest high tide (either the high tide before or after the survey - whichever is closer) for each survey point, and 2) tidal amplitude (difference in water level in meters between the highest and lowest tide on that day) on the day of the survey. These tidal features have been shown to influence numbers of birds detected during marsh bird surveys (Nadeau *et al*. 2010).

Spatial considerations

To develop the sampling universe, spatial databases may be used with GIS to identify wetlands and select sampling units. The National Wetland Inventory maps (NWI; Wilen and Bates 1995), National Land Cover Database maps (NLCD; Homer *et al.* 2007), or the National Hydrography Dataset provide wetland classification data that can be used to determine the sampling universe. Sampling units (i.e. survey points) should be spaced 400m apart to limit the frequency with which individual birds are double counted (Conway 2011).

Sample size for temporal trend

Sample size for detecting temporal trend will depend on the management objectives, desired minimum trend, and the time frame over which surveys are conducted. Managers should determine how much change is meaningful from a management perspective. Establishing explicit monitoring objectives that address the magnitude of change and confidence limits desired will help subsequent efforts to judge the success of the monitoring relative to the objectives. Over short time frames, trends of <5% per year are not likely to be detected, even for common species (Thogmartin *et al.* 2007, Steidl *et al*. 2013).

The statistical power required to detect a temporal trend (the probability of detecting change in abundance in a population when one actually exists) will vary with both the characteristics of populations (i.e., occupancy and abundance) and the sampling effort (number of points and number of years sampled). Detection probability has a relatively minor influence relative to other population characteristics. Managers can increase power to detect trend by increasing the number of survey routes, the number of survey points per route, and the number of visits to each survey route within each year (Steidl *et al*. 2013). The number of sampling units (routes or points) necessary to detect a trend will depend on the magnitude of the trend, duration of the study, and characteristics of the species that influence detection probability. For example, rare species may require 100 survey routes to achieve 80% power to detect a 3% annual decline in abundance after 20 years (assuming 0.5 detection probability, 10 points per survey route, and 3 visits to points each year), while a more common species such as clapper rail may require only 40 routes under the same assumptions (Steidl *et al.* 2013). A study in Maine suggested 2-3 visits per year at a minimum of 40 routes may be needed to detect a 25% decline (Gibbs and Melvin 1993). Hence, ensuring the sampling effort meets the stated objectives will require prior knowledge of the proportion of sites likely to be occupied by the focal species in the area of interest. When occupancy is low, surveying more sites less frequently is generally more efficient than surveying fewer sites more frequently; for common species, the opposite allocation is generally more efficient (Field *et al.* 2005; MacKenzie and Royle 2005). Surveying sites too infrequently, however, incurs a greater loss of statistical power than does surveying too few sites; therefore, having a sufficient number of visits per site is an important design criterion for monitoring efforts (Field *et al.* 2005). For marsh bird monitoring, an effective strategy with few drawbacks is to maximize the number of sampling units (points) on each survey route. However, the number of survey points per route is constrained by the narrow time periods during the morning and evening when marsh bird surveys are most effective (Conway 2011). Consultation with a statistician is recommended given the complexities of the issue.

Sample Designs

Sample Design #1: Random Sampling

This design will address all of the objectives listed above and is appropriate for small to large land units where most of the wetland area is accessible. To select survey points, place a grid with 400m-x-400m cells over the land unit or management area of interest. Select all 400m-x-400m grid cells where ≥50% of the cell is composed of emergent marsh vegetation. This subset of cells with ≥50% emergent marsh vegetation represents the sampling frame. The percentage of emergent marsh vegetation necessary for inclusion in the sampling frame can be adjusted downward if the refuge has only a small amount of emergent marsh vegetation, if the patches of marsh are typically small, or for other logistical reasons. However, the threshold used should be explicitly stated in the sampling design. Randomly select ≥50 of these grid cells to sample (depending on the size of the area in the sampling frame) plus 20 replacement grid cells. Locate the center of each grid cell as the survey point and upload the ≥50 survey points into a GPS unit. Overlay roads, trails, waterways, or other elements to determine access points. Surveyors should attempt to navigate to each point, and if a point is inaccessible, it can be replaced with another cell (the first on the list of replacement grid cells).

Sample Design #2: Random Sampling, Stratified by access

This design can address all of the objectives listed above and is suitable when large areas of the target sampling frame are difficult to access, or linear features such as roads, levees, or trails characterize all of the accessible areas. Stratification is based on the difficulty of access. Alternatively, Design #1 may be used if access is not limited by roads or trails or inaccessible areas are removed from the sampling frame.

To select survey points, place a 400m-x-400m grid over the refuge or management area. Identify all of the 400m-x-400m grid cells that contain ≥50% emergent marsh vegetation. Overlay roads, trails, edges between emergent wetland vegetation and open water along waterways, or other access routes. Classify each grid cell as accessible (Class 1) if it intersects ≥1 of these linear access routes or difficult to access (Class 2) if it does not. Highlight all linear access routes that overlay all Class 1 sampling points. Employ a sampling program that identifies all potential survey points along these linear access routes, with the maximum number of points whereby each point is separated by ≥400m. This is the sampling frame for Class 1 points. Randomly select ≥50 of the potential Class 1 survey points to sample. Identify the center of all Class 2 grid cells. This is the sampling frame for Class 2 points. Randomly select ≥20 of the potential Class 2 points to sample. Consult with a statistician to further refine the number of Class 1 and Class 2 cells to sample based on numbers of each within the sampling frame taking into account logistical constraints and precision.

Sample Design #3: Random Sampling, Stratified by Habitat Type

This design can address all objectives listed above. Stratification is based on one or more features that are relevant to your management objective (e.g., habitat type, NWI classification, hydrologic regime, management strategy, etc.). Stratification is useful when a simple random sample might miss or under-sample one or more types of wetlands that are of interest. This is possible, for example, when a wetland type is rare or small in area relative to other types but is thought to be important to one or more of your target species or is the target of specific management actions that you wish to evaluate.

Place a 400m-x-400m grid over the refuge or management area, and select all 400-x-400 grid cells with ≥50% emergent marsh vegetation. This is the sampling frame. Classify each of the cells into categories based on the stratification feature you wish to employ. Randomly select ≥50 cells within each strata, plus additional replacement points in case some of the initial points cannot be accessed.

The centers of the selected cells are the sampling points and their locations should be uploaded to the GPS unit. Overlay roads, trails, marsh ecotones within waterways, or other access points. Navigate to each cell and replace with the first replacement cell if it is not accessible.

Sample Design #4: Two stage cluster sampling

This sampling design addresses objectives related to monitoring changes in abundance over time. This sampling design is derived from Johnson *et al*. (2009) and is appropriate for use on large land units (i.e., those at a state, regional, or national). This design is also appropriate for use where large areas of wetlands may be inaccessible.

The sampling universe is the habitat (i.e., emergent marsh vegetation) potentially used by focal marsh bird species during the breeding season. Sampling sites are selected using a 2-stage cluster sample, where primary sampling units (PSUs) are chosen systematically, and secondary sampling units (SSUs) within each PSU are selected using a randomized, spatially balanced procedure.

Primary sampling units can be land units or land areas such as EPA hexagons (White 2007), and would be chosen systematically. For example, PSUs could be identified by overlaying a hexagon grid over the sampling area, and selecting those grid cells with ≥10% of emergent marsh vegetation. Secondary sampling units would be wetlands or portions of wetlands within each PSU. Secondary sampling units would be selected randomly through Generalized Random Tesselation Sampling (GRTS; Stephens and Olsen 2004) or the Lister and Scott (2009) method. Since the nature of wetlands vary both among and within regions, Johnson *et al.* (2009) suggest stratifying the sampling universe into small (<3ha) discrete wetlands, and larger (>3ha) wetlands. This demarcation is based on the 200m radius within which many marsh bird calls can be heard (Allen *et al.* 2004; Conway and Nadeau 2006). Each wetland or portions of wetlands would also be categorized as accessible or inaccessible.

If the PSU contains only small, discrete wetlands, a maximum of ten should be sampled. GRTS can be used to select ten discrete wetlands if >10 are present within a PSU. If the PSU contains only large (or portions of large) wetlands, GRTS or Lister-Scott methods applied to a continuous spatial domain may be used to select sampling units in accessible wetlands. The number of sampling units selected within the PSU will depend on the area of wetlands available for sampling. Sample size guidelines from a pilot study in Wisconsin based on 40km^2 hexagonal cells and 400m minimum spacing between sampling units recommended by Conway (2011) is provided in Table SOP 1.1. Using oversampling during the selection procedure will allow for the availability of replacement points if an initial sampling unit is deemed inaccessible during groundtruthing.

Table 2. Proposed secondary sampling unit sample-size guidelines, based on the number of accessible discrete sampling sites (*k*) and the area of accessible extensive wetland within a primary sampling unit (Johnson *et al.* 2009).

Available		**In Sample**	
Discrete (*k*)	**Extensive**	**Discrete**	**Extensive**
1-10	<1	All available	0
>10	<1	10	0
0	1-20	0	2
0	20-80	0	4
0	80-160	0	6
0	160-240	0	8
0	>240	0	10
k (*k*>0)	1-20	Min (8, k)	2
k (*k*>0)	20-80	Min (6, k)	4
k (*k*>0)	80-160	Min (4, k)	6
k (*k*>0)	160-240	Min (2, k)	8
k (*k*>0)	>240	Min (2, k)	10-min (2, k)

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Standard Operating Procedure 2: Conducting Surveys

The standardized survey methods for marsh birds (Conway 2011) originated from suggestions during 2 multi-agency workshops at Patuxent Wildlife Research Center designed to aid agencies developing marsh bird monitoring programs (Ribic *et al.* 1999; U.S. Fish and Wildlife Service 2006), and they incorporate suggestions from Conway and Gibbs (2001) and methods for estimating detection probability and observer bias (Nichols *et al.* 2000; Farnsworth *et al.* 2002; MacKenzie *et al.* 2002). Because many marsh birds are secretive, seldom observed, and vocalize infrequently, the protocol methods employ broadcast calls to elicit vocalizations during surveys (Gibbs and Melvin 1993; Conway *et al.* 2004; Conway and Gibbs 2005; Conway and Nadeau 2010). But because analysts may also want to estimate detection probability, estimate density using distance estimators, analyze data without the biases associated with call-broadcast (Conway and Gibbs 2001), and survey non-focal species, surveyors also record birds during a 5-minute passive period prior to broadcasting marsh bird calls. Hence, surveyors will record all individuals of focal species (Appendix A) detected during both a 5-minute passive period prior to broadcasting recorded calls, and during a period in which pre-recorded vocalizations of focal marsh birds are broadcast into the marsh.

Broadcast equipment and placement

The recorded calls should be obtained from the Marsh Bird Survey Program Coordinator (see contact info in Appendix F); request digital recordings of the focal species that breed in your area. The broadcast sequence should include exactly 30 seconds of calls of each of the focal marsh bird species that are expected breeders in your area interspersed with 30 seconds of silence between each species' calls. The 30 seconds of calls consist of a series of the most common calls for that species interspersed with approximately 5 seconds of silence. A verbal "stop" at the end of the sequence indicates the end of the survey at that point.

The broadcast player should be placed upright on the ground (or on the bow of the boat), and sound pressure should be 80-90 dB at 1 m in front of the speaker. Use a sound-level meter to adjust volume of the broadcast player at the beginning of each day. If sound quality distorts when volume on your broadcast equipment reaches 80-90 dB, you should obtain higher quality broadcast equipment. If the ground is wet, place the speaker on an object as close to the ground as possible. Observers should stand 2 m to one side of the speaker while listening for vocal responses (standing too close to the speaker can reduce the observer's ability to hear calling birds). Observers should point the speaker toward the center of the marsh and should not rotate the speaker during the call-broadcast survey. Surveyors should point the speakers in the same direction for all replicate surveys. At points where it is not obvious which direction to point the speakers (i.e., on a road or in a canal bisecting two marshes) surveyors should record the direction of the speakers at each point on a map and on their data sheets and refer to this information on all subsequent surveys at that point.

Species to include in the survey effort

Participants must make 3 decisions regarding the species to include in their survey effort: 1) which species will be recorded on their datasheet, 2) of those species recorded, which species will be recorded during the one-minute segments (i.e., each individual bird of these species will be recorded on a separate row on the datasheet), and 3) of those species recorded, which species calls' will be included in the call-broadcast sequence.

Species to include in the broadcast sequence

In general, the broadcast sequence should include calls of all of the following focal marsh bird species that are thought to breed in the area (species for which you might reasonably expect to get responses during the breeding season): black rail, yellow rail, Virginia rail, sora, king rail, clapper rail, least bittern, American bittern, limpkin, American coot, purple gallinule, common gallinule, and pied-billed grebe,. The marsh birds included in the call-broadcast sequence will vary among survey areas (and hence, among participants), but should be consistent within a particular survey area across repeat visits and across years. The number of species included on the call-broadcast portion of the survey increases the duration of the survey by 1 min per species at each point. So, with 8 species, you will spend 13 minutes (including the initial 5 min passive listening period) conducting a survey at each point. Within the breeding range of the American coot, common gallinule, or pied-billed grebe, broadcasting calls of any of these species is optional but strongly recommended (Appendix C). However, all surveyors should still record the number of individuals detected at each point for these 3 species (see Appendix C), even if they do not include one (or all 3!) of these "focal" species in their call-broadcast sequence. Moreover, participants are given the option of recording data for these 3 species in the one-minute segments or simply recording the total number of individuals detected (by species) at each point (Appendix C). See the program website for guidance on which species to include in your call-broadcast sequence at each refuge in the U.S. The program website also includes a map overlaying the breeding range of each focal species. This map will help determine which focal species likely breed in your area and, hence, guide decisions on which species to include in the call-broadcast sequence (http://ag.arizona.edu/srnr/research/coop/azfwru/NationalMarshBird)

The chronological order of broadcasted calls should start with the least intrusive species first, and follow this chronological order: black rail, least bittern, yellow rail, sora, Virginia rail, king rail, clapper rail, American bittern, common gallinule, purple gallinule, American coot, pied-billed grebe, limpkin. The order of species on the broadcast sequence was based on recommendations by Ribic *et al.* (1999). The calls included in the call-broadcast sequence include the primary advertising call(s) of each species (e.g., '*whinny*' for sora, '*grunt*' for Virginia rail, '*clatter*' for clapper rail, *'click-click-click-click-click*' for yellow rail, '*coo-coo-coo*' for least bittern, '*pump-er-lunk*' for American bittern, etc.). Other calls associated with reproduction are also included for many of the species. Including all the common calls associated with reproduction of each species on the broadcast sequence is thought to increase detection probability during different times of the breeding season and can help observers learn the less common calls of each target species. A list of common calls for each target species is attached (Appendix D).

Estimating distance to each focal bird

Surveyors should estimate the distance from the survey point to each individual bird. Recording distance estimates to each individual bird will allow analysts more options when analyzing the data, including: 1) use of distance sampling techniques to estimate density for each species in each habitat type and for each surveyor, and 2) use different spatial scales by excluding birds detected at different distances from the survey point. Density indices by habitat type will allow managers to extrapolate survey data to estimate a minimum number of each marsh bird species on their entire management area.

Surveyors should estimate distance to each bird when the bird is first detected since birds may approach the call broadcast during the survey (Legare *et al.* 1999; Erwin *et al.* 2002), which violates an important assumption of distance sampling. More research is needed to address the magnitude of this potential problem for each focal species, but analysts will likely only use distance estimates from birds detected during the initial passive period of the survey (those detected prior to the call broadcast). Estimating density from a subset of birds detected during the 5-min passive period would not introduce bias as long as the other assumptions of distance sampling are met (Buckland *et al.* 2001). The distance at which most individuals are detected varies among the focal species (Conway and Nadeau 2006). Like all measurements, estimating distance to individual birds during surveys includes measurement error. However, training surveyors to estimate to distance to calling marsh birds can decrease bias (Nadeau and Conway 2012). Surveyors are encouraged to use a range finder to help them determine the distance to specific landmarks surrounding each survey point, which will help estimate the distance to calling marsh birds. Other methods for improving one's ability to estimate distance include: 1) tying surveyors flagging at regular intervals away from each survey point in each cardinal direction, or 2) carrying aerial photos of the marsh with 50m-, 100m-, and 200m-radius circles drawn around each survey point. Estimating the distance to some individual birds will involve a lot of uncertainty (i.e., estimating distance to birds 5m from the surveyor is much easier than estimating distance to birds that are >100m away). Surveyors should enter on the datasheet and in the database which of the following distance estimation aides they used: 1) unaided, 2) distance markers, 3) range finder, 4) range finder and maps, or 5) maps or distance bands drawn on aerial photo.

Filling out the data sheet

An electronic copy of a data sheet should be obtained from the Program Coordinator or the program website (http://www.cals.arizona.edu/research/azfwru/NationalMarshBird/) to ensure that all pertinent data is recorded properly (an example of a completed datasheet is included in Appendix E). These data sheets can then be tailored by each participant to meet any local needs as long as none of the standards in the protocol are compromised. The number of species columns on the data sheet will differ among participants. For example, if you intend to only broadcast calls of 3 species, then you will have an 8-minute survey sequence at each point (5 minutes of passive listening and 1 minute of call-broadcast for each of 3 species) and will need a data sheet with 8 response columns (one for each minute of the survey). If you intend to broadcast calls of 5 species, you will have a 10-minute survey sequence at each point (5 minutes of passive listening and 1 minute of call-broadcast for each of 5 species) and will need a data sheet with 10 response columns. Prior to the beginning of the survey, write down the day, month, and year at the top of the data sheet. Write out the month or use a 3-letter acronym to avoid confusion between day and month (i.e., so that 6 May is not confused with 5 June). Record the full name of the observer that recorded the bird detection data during the survey. If more than one observer was present, write down who recorded the data and **all** individuals that helped identify calling birds. Do not record individuals that were present but merely observing. Since detection probability may differ among observers (Kendall *et al*. 1996; Link and Sauer 1998; Conway *et al.* 2004; Sauer *et al.* 2004), analysts may wish to control for observer bias when estimating trend (similar to approaches used for analyzing BBS data; Sauer *et al.* 2004). Using multiple observers to detect birds at a point may confound observer bias issues when estimating trend, so it’s important to record any and all observers who contributed to marsh bird detections (see paragraph regarding multiple-observer surveys at end of this SOP). Record the name of the survey route and the name of the refuge and/or management area. Record any ancillary information that may have influenced vocalizations or detection probability in the *Comments* column. For example, types of boats used during surveys (canoe vs. 25hp outboard motor vs. air boat) can potentially affect vocalization probability of marsh birds. Hence, surveyors should record the type of boat used during surveys. Use the same boat and motor on each survey each year to control for possible effects of engine noise on detection probability. If a different boat or different motor is used (or the same boat/motor just sounds better or worse than usual) make a note of the change in the *Comments* column.

Recording detections of focal species

- When you arrive at the first survey point, write down the unique identification number of the survey point and the time.
- Start the survey.
- When a bird is detected, write the 4-letter code for the species name in the “Species” column. A list of 4-letter AOU species acronyms is attached to this protocol (Appendix A). Put a “**1**” in each detection column in which that individual is detected aurally and put a “**s**” in each column in which the individual is detected visually (including flying overhead). For example, if an individual Virginia rail calls during the first 1 minute of passive listening, put a “**1**” in the first column. Regardless of whether that individual calls once or many times during the first minute, you only put one “**1**” in the first column. If that same individual bird is still calling during the second minute of passive listening, then also put a “**1**” in the second column. Regardless of whether an individual bird calls during the 30 seconds when Sora calls are being broadcast or the 30 seconds of silence immediately following the Sora sequence, put a “**1**” in the column for “SORA”. If that same individual bird calls again during the Virginia rail sequence, you also put a “**1**” in the column “VIRA”, and so on. Hence, if an individual bird is calling constantly throughout the survey period, you will have a “**1**” in every column for that individual.
- If the individual is heard **and** seen, put both a “**1**” and an “**s**” in the appropriate column(s).
- If you hear a call of the same species but from a different individual (or from an individual of another species), start a new row on the data sheet and follow the same protocol just described for this individual bird.
- Recording whether each individual bird responds during each 1-min segment allows analysts to use removal models or time-of detection methods (Farnsworth *et al.* 2002; Alldredge *et al.* 2007) to estimate detection probability (see Conway *et al.* 2010 for an example). Surveyors may have difficulty determining whether a call is coming from a new individual or an individual detected earlier at that survey point. Surveyors must often make this decision without seeing the bird by using their best judgment (this is a challenge on all bird surveys, regardless of the protocol used). In general, be conservative and assume the call is from the same bird if the call came from the same location. The number of rows filled out on the data sheet will differ among survey points and will correspond to the total number of individual focal marsh birds detected at each point.

- If no marsh birds are detected at a survey point, record the point number and starting time, and write “no birds” in the *Species* column. A sample data sheet is included as an example of what survey data might look like (Appendix E).
- If the observer hears a marsh bird but is unsure of its identity, the observer should write “unknown” in the *Species* column and record all data for this individual as described above. Write a description of the unknown call in the *Comments* column (e.g., soft “kak-kak-grr” - sounds like BLRA but harsher’). This will aid future identification of unknown calls if that call is heard repeatedly.
- Some species of marsh birds give paired duets and some participants may want to distinguish pairs of birds during surveys. Always record each member of a pair on their own individual row on the datasheet (i.e., 2 rows for a pair of birds). You may record “pair” in the *Comments* columns for both of the 2 birds that are thought to be members of a mated pair.

Recording detections of focal, non-broadcast species

Record these species (see Appendix C) in the same way as focal broadcast species above, even when their calls are not broadcast during the call-broadcast portion of the survey. If the surveyor is overwhelmed with bird detections, they may record these species differently (see section titled ***what to do when the surveyor is overwhelmed with too many detections*** for specific instructions on how to handle this type of situation).

Recording non-focal species (optional)

We recommend that surveyors do not record non-focal species (also see Johnson *et al.* 2009). However, some participants may want to record all species detected (passerines, waterfowl, raptors, etc.) or perhaps a subset of all species detected (e.g., marsh-dwelling passerines, wading birds but not all species) during their marsh bird surveys. Others will want to focus their attention only on the focal marsh birds (especially in areas where densities of secretive marsh birds are relatively high). The shared database can accommodate this flexibility, but data on non-focal species are recorded differently. At each point, record the total number of each non-focal species detected within each of 3 distance categories (≤50m, 51-100m, and >100m). Individual birds of non-focal species do not receive their own line on the data sheet and observers do not record detections of non-focal birds in each of the 1-min segments (Conway and Droege 2006).

The non-focal species included by a surveyor will depend on the marsh birds of interest at that refuge, management area, or physiographic region. For example, participants may want to include non-focal species which are thought to be declining or which are not sampled well by other survey efforts. However, analysts will need to know which additional species were being recorded in order to make these data meaningful (i.e., if no YHBLs are recorded at a point, we need to know whether a surveyor detected zero YHBLs or merely did not record YHBLs on their survey). Hence, each participant must enter in the database their list of “non-focal” species that they were recording during their survey. By recording this list of “non-focal” species, analysts will know whether no entry for a particular species indicates that none were detected. The number of “non-focal” species included in your survey effort may reduce your ability to record all the relevant data for the 24 focal species that are the focus of this monitoring protocol. Moreover, many of the non-focal species may be adequately sampled already by the North American Breeding Bird Survey. Johnson *et al*. (2009) also cautioned against recording non-focal species for fear that surveyors would miss focal species.

Recording types of calls

Knowing seasonal patterns of different call types in a local area provides useful information. For example, the frequency of different calls given (e.g., single *clatter*, paired *clatter*, *kek*, or *kek-burr* for a clapper rail) varies throughout the season (Conway *et al*. 2004). Frequency of different calls given may also vary across regions. Different call types have different functions (see appendix D) and can indicate pairing status and stages of the nesting cycle in a local area, which will allow for refinement of local survey windows. Moreover, detection probability and observer bias may differ with different call types (e.g., least bittern '*kak*' and Virginia rail '*tick*' can be confused with clapper rail '*kek*' calls) and accuracy of distance estimation may vary with call type (Conway and Nadeau 2006; Nadeau and Conway 2012). Hence, incorporating call types into trend analyses can potentially increase power to detect true population trends. For these reasons, observers should record all types of calls given for each target marsh bird detected in the *Calls* column on the data sheet (see sample data sheet; Appendix E). Refer to the program website to listen to examples of common call types for each focal species: http://www.cals.arizona.edu/research/azcfwru/NationalMarshBird/.

Birds detected at a previous point or between points

If surveyors detect a new individual of a focal species immediately after the survey period at a particular point (or while walking between points) they should record these birds on a separate row and put a "**1**", an "**s**", or both in the O*utside Survey Period* column. Recording birds detected outside of the standardized survey period may provide useful information, especially for some focal species that are particularly rare and not often detected during surveys. For inventory purposes, surveyors may not want to ignore these detections, especially if they represent the only black rail detection for the day or the year. If a participant detects a focal bird during a survey and the participant believes that this is the same individual bird that was detected and recorded at a previous survey point, the participant should record all the relevant data for that bird and then enter a "Yes" in the *Detected at a Previous Point* column on the datasheet. When in doubt, be conservative as to whether an individual bird detected at the current point was the same individual recorded at a previous point (i.e., record "Yes" when in doubt). A problem may arise in an instance where a bird is detected outside of the survey period, and is then detected at the subsequent survey point *during* the standard survey period. For example, if 1) the surveyor detects a black rail after the 10-minute survey period at a point #3 and records that bird on its own row on the datasheet (and writes "No" in the *Detected at a Previous Point* column and records the detection in the *Outside Survey* column), and 2) the surveyor then detects that same bird during the 10-min survey at a subsequent survey point (point #4), and records "yes" in the *Detected at Previous Point* column, this may create a problem during analysis. For many analyses, including estimates of population trend, analysts may ignore detections with a "yes" in the *Detected at a Previous Point* column, and all detections in the *Outside Survey* column so that all individual birds are counted only once. In this situation, the surveyor should write "No" in the *Detected at a Previous Point* column for the entry at point #4 where the individual bird was detected during the survey, and then go back and change the "No" to "Yes" in the *Detected at a Previous Point* column for the initial entry at point #3 for this bird (when it was detected after the survey period).

Recording whether focal birds are in the "target area"

A common objective is to document the effects of management actions on marsh birds, but survey points are often adjacent to areas that have undergone different management actions. This presents a problem if some birds detected at a survey point are within one area but others are within another area (with a different management history). Hence, surveyors should record whether each bird detected was or was not in a specific "target" management area. The name of the target area should be indicated on the datasheet and in the database for each survey point. You may also add a column to the datasheet (or attach a map) to indicate the management units or specific marshes where each bird was detected.

What to do if the surveyor becomes overwhelmed with detections

Many of the focal species occur at relatively low densities through much of their range. Hence, many surveyors will detect few or no individual birds at any given survey point. However, some survey points within a survey area will have so many marsh birds calling that observers will find it impossible to record each 1-min segment during which each individual focal bird is detected. For example, an observer may see/hear >20 American coots at one survey point. When many birds are calling simultaneously, it can be difficult for the observer to:

1) decide whether they are hearing new individuals or previously detected ones,
2) write new individuals on a new line of the datasheet, and
3) find the correct line where they wrote down previously detected birds.

In these situations, we provide a few comments, observations, and suggested remedies. First, individual surveyors do get better at this with practice even with relatively high numbers of calling birds at a point. However, everyone has a threshold when the numbers of calling marsh birds get too high at a particular point. This problem occurs more frequently when a participant has many species in their call-broadcast sequence (and hence many detection columns on their datasheet). If a participant knows at the end of the call-broadcast at a particular point that he/she was overwhelmed and didn't effectively assign the correct calls to the correct columns (individuals), then they should write a note in the *Comments* column saying that the data in the one-minute segments is dubious. The total number of birds detected at that point will still be useful. If this problem is common on your surveys, below is a list of solutions in decreasing order of preference:

1) Include a circle on each row of the datasheet and make a 'tick' on each circle identifying the general direction of that individual (this will help you differentiate one individual from other individuals of that species as more are detected at that point);
2) Reduce the number of species in your call-broadcast sequence (e.g., eliminate American coots, pied-billed grebes, and common gallinules from your call-broadcast sequence). In other words, still record data for all individuals of all focal marsh bird species in the same way, but just reduce the # of columns on the datasheet (and length of the call-broadcast sequence);
3) For those focal species that are of lower management/conservation interest in your survey area (e.g., American coots, common gallinules, pied-billed grebes), simply write down an estimate of the total number of individuals detected within each of three distance categories for that particular species at that point on one line of the data sheet (e.g., write "AMCO: 0; 12; 23" on one line of the data sheet instead of recording each individual on a separate line - see example on sample data sheet attached; Appendix E). Only use the 1-

min segments for the focal species of higher management concern (e.g., black rails, yellow rails, king rails, clapper rails, bitterns);

4) At a minimum, surveyors should ensure that all individuals detected are recorded, even if that means estimating only the total number of individuals detected at each point (i.e., write "23 CLRA" on one line of the data sheet and ignore the distance estimates).

It is important that surveyors record on the datasheet (and in the database) times when they were overwhelmed and could not record data for individual birds on separate rows of the data sheet (for focal species).

Distinguishing between king and clapper rails

King rails breed in freshwater marshes and clapper rails breed in saltwater marshes (except the Yuma clapper rail that breeds in freshwater marshes in Arizona and California; Conway *et al.* 1993). Both species have similar calls. Moreover, a recent genetic study suggested that clapper rails and king rails are paraphyletic with species limits corresponding to geography rather than current species designations (Maley and Brumfield 2013). Hence, surveyors in marshes near coastal areas may not be able to determine whether birds heard calling are king rails or clapper rails. In those situations, surveyors should record these individuals as KCRA (King-Clapper Rails).

Recording ambient noise level

Surveyors should record the level of background noise during the survey at each survey point. This information can be used as a covariate in future analyses because level of background noise varies spatially and temporally and influences detection probability during bird surveys (Pacifici *et al*. 2008). The level of background noise at each survey point should be categorized as follows:

Table 3. Background Noise Rating Scale

Scale	Description
0	No background noise
1	Faint background noise
2	Moderate background noise (probably can't hear some birds beyond 100m)
3	Loud background noise (probably can't hear some birds beyond 50m)
4	Intense background noise (probably can't hear some birds beyond 25m)

Weather restrictions

Weather can affect detection probability of marsh birds (Conway and Gibbs 2001; 2011). Surveyors should only conduct surveys when wind speed is <20 km/hr, and not during periods of sustained rain or heavy fog. Even winds <20 km/hr (12 mph) affect the detection probability of marsh birds. Surveyors should postpone surveys if they believe winds are affecting their hearing ability or vocalization probability of marsh birds. Recommendations for conducting surveys in locations that frequently have high wind speeds include:

1) Determine what time(s) of day have the least wind in your area. The daily survey windows in the protocol are recommendations; survey times should be modified under conditions where wind regularly affects vocalization probability. The important thing is that surveys are conducted during the same daily time window during each visit each year at a particular location, and the

survey windows at a particular location should be the time of day or night that has the highest detection probability for your target species in your area. In some locations, surveys conducted after sunset (or before sunrise) may have higher detection probability compared to the morning and evening survey windows recommended in the protocol because strong winds are less frequent during the middle of the night. In these situations, surveys should be conducted at night.

2) Try to be flexible with your schedule if possible. For example, plan to conduct a survey on a particular day but postpone to the following day if it is too windy, and continue postponing until the weather meets the criteria to complete the survey. If wind speed increases to >20km/hr during the survey, or sustained rain begins while the survey is already underway, surveyors should stop the survey and repeat the entire survey route another day (i.e., don't just go back and repeat the remaining points on the route). Repeating the entire route on a day with better conditions will likely reduce annual variation in detection probability and increase the accuracy of trend estimates because most focal species stop calling entirely with even moderate wind speeds (hence detection probability drops to nearly 0%)

Recording weather conditions

Record ambient temperature, wind speed, wind direction, and sky condition at each survey point. We use the same wind speed codes and sky condition codes as the North American Breeding Bird Survey (see below). Record the ambient temperature in degrees Celsius (^{o}C) and record wind direction in degrees (0-360^{o}).

Table 4. Wind Speed Codes[1]

Beaufort Number	Wind Speed Indicator	Wind Speed (mi/hr)	Wind Speed (km/hr)
0	Smoke rises vertically	<1	<2
1	Wind direction shown by smoke drift	1-3	2-5
2	Wind felt on face; leaves rustle	4-7	6-12
3	Leaves & small twigs in constant motion; light flag extended	8-12	13-19
4	Raises dust and loose paper; small branches are moved	13-18	20-29
5	Small trees with leaves sway; crested wavelets on inland	19-24	30-38

[1] Enter Beaufort Numbers on data sheet. Not mi/hr or km/hr.

Table 5. Sky Condition Codes[1]

Code	Description
0	Clear or a few clouds
1	Partly cloudy (scattered clouds) or variable sky
2	Cloudy (broken) or overcast
4	Fog or smoke
5	Drizzle
7	Snow
8	Showers

[1] Enter these U.S. Weather Bureau code numbers on data sheet.

Recording water levels

Water level may influence abundance and distribution of marsh birds (Conway *et al.* 1993; Eddleman *et al*. 1994; Flores and Eddleman 1995; Timmermans *et al.* 2009; Nadeau *et al.* 2011).

Water levels vary annually and even daily in some marshes and these fluctuations can explain spatial and temporal changes in marsh bird abundance. Some National Wildlife Refuges control water levels in some of their management units and have the ability to directly benefit marsh birds via water management. Hence, surveyors should place one or more water gauges for measuring water level in permanent locations at ≥1 point within each marsh unit within which birds might be detected during the survey . In other words, place a water gauge within each area that may have a distinct hydrologic regime (different daily or annual fluctuations in water level)). If all marshes along a survey route are subject to the same hydrologic regime (i.e., all survey points are in the same river system or are in a single management unit with the same hydrologic regime), then only one water gauge is needed for that entire survey route. If a survey route has points split between ≥2 management units (or ≥2 areas with different hydrologic regimes), then ≥2 water gauges are necessary and participants should record on the data sheet the water gauge associated with each survey point. Water level at each water gauge should be recorded immediately before or immediately after a morning or evening survey route is completed. Surveyors should also record the type of water gauge used for measuring water depth (i.e., bathymetry, piezometer, river readings at ACOE's gauge, staff gauge stuck into the wetland, etc.). Each water gauge must be "re-set" (recalibrated) each year because freezing and thawing can cause gauges to move laterally. Water gauges should be placed in an area where the water is deepest to avoid zero readings when there is still water in other parts of the marsh. Water gauges are not meant to explain differences in birds detected among points, but rather will help explain variation in numbers of birds detected through time (seasonal changes or changes across years). These water depth measurements can be used as covariates in analyses to explain changes in marsh bird abundance. Water depth can vary widely from year to year in many wetlands, and changes in water depth can have tremendous effects on habitat suitability for marsh birds. Hence, any efforts to quantify annual changes in water depth will dramatically improve an analyst's ability to estimate trends (and help explain the cause of some trends).

Recording salinity

In coastal marshes or any marshes with varying salinity levels, surveyors are encouraged to record the salinity content of the water directly in front of each point on each survey. Salinity affects habitat suitability of many species of marsh birds and such information is relatively easy to collect and can be used as a covariate to control for variation in estimates of population change, and may shed more light on the effect of salinity on the distribution and abundance of marsh birds. Moreover, salinity levels in coastal marshes may change with changes in sea level rise as a result of climate change, and may be used to document the effects of sea level rise on marsh bird distributions.

Recording date of fire, disturbance, or management action

Periodic burning of emergent marshes may benefit some marsh birds (Conway *et al.* 2010) and several refuges are involved with local studies examining the effects of fire on marsh birds. Hence, record the date of the last burn or any other major disturbance event or management action that could alter marsh bird abundance or habitat structure. Record the month and year of the last flood, wild or prescribed fire, hurricane, monsoon, tornado, or other major disturbance that occurred in the 100m area surrounding each survey point. Record these dates for each survey point, once per year (or more often if a natural disturbance occurs between 2 visits to a point during the same year). If all you know is that the area surrounding a particular survey point hasn't been disturbed or burned in the past *x* years, then record >*x* years at that point. This information will allow analysts to evaluate the effects of fire and other natural disturbances or management actions on marsh bird abundance at a large (continental) spatial scale with the pooled data. The data produced will supplement more detailed studies evaluating the effects of fire being conducted on specific refuges and will help produce management recommendations regarding the usefulness of fire as a tool for managing marsh bird populations. This information will also help managers assess marsh bird vulnerability to increases in the frequency and severity of storms associated with climate change.

Inclusion of an initial settling period (NOT recommended)

When surveyors are using a motorized boat or airboat to travel between survey points, the noise generated by the boat may cause birds to stop calling. In these situations, surveyors may choose to include a "settling" period of a fixed amount of time (e.g., 1 minute) prior to starting the 5-minute passive count at each point. Otherwise, we recommend that **no** settling period be included. If a participant includes an initial settling period prior to each survey, the participant should keep that settling period constant among all points and all replicate surveys. Furthermore, the participant should include a comment on every data form stating that a settling period during which detections are not recorded must be included. If included, make the settling period a part of the written survey protocol and part of the datasheets for that site so that individuals wishing to repeat the effort in future years will know that a settling period was included.

Multiple observer surveys (optional)

Estimating detection probability associated with a particular survey protocol is essential when attempting to interpret count data produced from a monitoring program. The extent to which trends in count data represent the underlying trend in true abundance depends on variation in detection probability and observer bias. Independent multiple-observer surveys will allow analysts to estimate observer bias (Nichols *et al.* 2000). This approach involves 2 or more trained observers recording data independently at a series of survey points (Conway *et al.* 2004; Nadeau *et al.* 2008). Hence, whenever possible, surveys should be conducted by 2 or more observers simultaneously. Each observer should fill out a separate data sheet and should record their data separately without discussing anything with the other observer. Observers should not point out a call or a bird to the other during the survey period. Each observer should stand 1-2 meters away from each other and should keep their pen on their data sheet at all times so that one observer is not cued by the sudden writing activity of another observer. Once the survey for that morning/evening is completed, the observers can look over each other's data and discuss discrepancies, but the data should not be altered; obvious mistakes should be noted in the *Comments* column but not changed. The difference between the observers in number of birds detected at each point is what allows analysts to estimate observer bias so these differences should not be altered. For those conducting multiple-observer surveys, contact the Program Coordinator to obtain a form so that observers can record which birds both surveyors detected and which were only detected by one of the surveyors. Multiple-observer surveys will obviously not be possible at all times and at all locations, but try to use multiple observer surveys whenever possible so that analysts can obtain sufficient data to estimate observer bias**.**

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Standard Operating Procedure 3: Data Management

This SOP describes the Avian Knowledge Network's data management system and provides instructions for data entry, data validation, and data management. The Survey Coordinator should establish an account and a study protocol in the database before the start of the field season. This needs to be done only once (at the start of a multi-year monitoring effort).

Database description

Beginning in 2014, responsibility for data management changed from USGS Patuxent Wildlife Research Center (PWRC) to the Avian Knowledge Network (AKN) and Point Blue. AKN is a central database repository and was designed to manage point-count survey data using a web interface. The database also stores data from other large-scale avian monitoring efforts and hosts data collections from a variety of sources. The shared database structure allows data sharing and comparisons among sites, and contains tools for describing, entering, evaluating, and downloading data. Data owners are responsible for determining access levels for users and setting restrictions for data sharing.

Data access roles

AKN allows different access levels for each type of user. Each "project" is assigned at least one Project Leader who is responsible for assigning a role to each user who requests access to the data for a specific project. A "project" is a suite of survey locations that are managed by the same person or group of people where the survey data are collected for the same reason(s) and the survey methods are the same. One type of user is a "Biologist" and a Biologist has access rights that include data entry and data verification, but not the ability to download data. A person with a Biologist access level may enter and edit data until the data sharing levels are set (see below). The Project Leader has more comprehensive access privileges that include capabilities to define, manage, and download data. Project Leaders can download data by selecting specific projects, sampling units or routes, or a specified date range. Project Leaders can download data in a variety of formats, including .csv (MS Excel), as well as .kml or .shp files that contain spatial attributes. The Analyst access level provides access to an optimized database and a set of tools for summarizing and analyzing data. SOP #4 provides additional suggestions on data analysis and reporting.

Getting started

The database is accessed through an online web interface (http://data.prbo.org/science/biologists/). No special software is needed. Most users who previously had access to the PWRC database have been migrated to the new AKN database. You may determine if you already have an account by visiting the login screen and typing in your email address. To obtain a new account, you may register on the AKN website.

New users will be asked what "project" they would like to be a part of when they log into the web interface. Currently, "projects" are only searchable by the project ID number. Project Leaders will need to approve any request for a particular user to be added to a project. Existing users should already be attached to one or more projects, and will be asked to choose a project to work on upon logging in. It is possible for each user to be a member of more than one project.

Creating a new project

If you are starting a new monitoring effort (i.e., a new "project"), you will need to create an account (see above) and a new project. Currently, only the database administrators can create a new project, and will assign a Project Leader to each new project. Leo Salas and Michael Fitzgibbon at Point Blue Conservation Science are the current database administrators (see Appendix F for contact information). Project Leaders will then determine which user accounts will have the different levels of access and can assign additional Project Leaders.

Data entry, verification, and editing

Data entry

The Survey Coordinator should ensure that the surveyor proofreads all datasheets at the end of each day to ensure they are readable and complete. Make any needed corrections on the datasheets in pen (i.e., do not erase entries – cross out errors and write the corrections in pen) and describe the reason for the correction. Scan or make paper copies of all datasheets upon returning from the field. Originals should be archived and stored in a flood and fireproof location.

All data is currently entered through an online web interface (http://data.prbo.org/science/biologists/). Uploading of data from excel formats may be possible in the future, as Point Blue and the AKN develops phase II of their data management effort. All information that is included on a data sheet should be entered in the database. Study protocols, which include attributes such as the broadcast sequence used, are chosen by the Project Leader. Currently, only the database administrators may define new study protocols, but the ability for Project Leaders to define their own study protocol may be available in the future. If you have collected vegetation data, these data will be entered into a separate database designed for this purpose.

Data entry screens follow in logical order consistent with the datasheets. Data entry technicians choose a project, then enter site specific variables for each sampling unit, followed by bird detections and associated variables. Help functions are available for most fields that provide a description or list of possible entries. Required fields will prompt the data entry technician to complete an entry for that field before allowing them to continue to the subsequent page.

Site conditions

Changes in habitat conditions at a particular sampling unit (e.g., extreme drought) may help explain changes in bird occupancy or abundance at a site. The user interface for site conditions is based on the protocol defined by the Project Leader. This section allows users to enter conditions such as weather or tidal height at the time of the bird survey. Users may also enter dates of disturbance events such as prescribed fire or restoration actions that occur separately from bird surveys to describe any changes in habitat conditions (See SOP #2, Recording date of fire or disturbance).

Verification

The data entry technician should initial and date each datasheet to indicate that the data has been entered into the electronic database. The database will show a "raw" status to indicate that the data has been entered, but not yet verified. The data entry technician should notify the Survey Coordinator when the data is entered and ready for verification. The Survey Coordinator (or another data entry technician) should carefully compare the data sheets with the data that is in the electronic database, and discuss any errors with the data entry technician or the survey observer. The database contains an option to mark when the data is proofed/verified. Once the electronic data is verified, the status will change from “raw” to “clean” to indicate that the electronic data record has been verified. Initial and date each datasheet again to indicate that the electronic data has been proofed.

The database provides some tools to assist with data proofing and verification. The proofing page provides the raw data, as well as a summary of point level data, with a list of species detected, including AOU codes and common and scientific names. It also includes a list of species from the E-Bird database detected at that location to provide a comparison with species that were previously observed in the area. These tools may be helpful for highlighting potential errors or exciting/unexpected results.

Editing

If changes are made to “clean” data, the status will revert to” raw”, and those data must be verified again. A record is automatically updated to include the date of the modification and who made the modification. Notes should be added to indicate the reason for the modification. Once the data is verified, and the status changed from “raw” to “clean”, the Project Leader can review the data and set the data sharing level (i.e., the extent to which the data will be available to others). Users with Biologist access may no longer edit data after data sharing levels are set. The Project Leader has access to modify the data at any time.

Data sharing

The Project Leader determines the level of data sharing after the data has been entered and verified. All data entered through the AKN web interface is stored in a central data warehouse, and the data owners (Project Leaders) determine how their data is shared with the public. The levels of access range from a more restricted view, where data may be available in visualization tools, but not available for download, to unrestricted views which give the public direct access to download the raw data. An option is also available which gives explicit permission for access to the data only by individual request. This option may be appropriate for endangered species records or data from private lands. Additional details for each of the levels of security can be found on the AKN website (http://www.avianknowledge.net/index.php?page=data-access).

Metadata

The database contains a variety of fields to store important details about study methods. Storing as much detail as possible about how the data was collected will help those analyzing the data to understand how and why the data was collected and how to use and interpret the data. The protocol defined in the database includes a field for a URL to link to additional metadata that cannot be stored in the database, such as additional details on the study design or links to supporting documentation or publications.

Data security and archiving

AKN, in cooperation with the User Acceptance Team, develops electronic data entry forms and incorporates quality control features into the database design. AKN employs a variety of tools and data filters to ensure data quality. The AKN administrators are responsible for data archiving, data security, and database design and management, and for performing periodic backups of all data residing in the central database. The Survey Coordinator should download a copy of the data at the end of each field season after the data has been entered and verified, and archive a copy of the data on a local computer (i.e., at the refuge). AKN will also provide automated functions to generate reports and data summaries.

Standard Operating Procedure 4: Data Analysis

This SOP provides general guidance for analysis of data collected from point-count surveys for secretive marsh birds conducted using passive and call-broadcast methods as described in SOP #2. These guidelines are intended to meet multiple objectives of land managers, including documenting presence and distribution of marsh bird species, estimating population trends, determining habitat relationships, and assessing the effects of management actions. A wide variety of statistical methods may be used to meet these objectives, and it is beyond the scope of this protocol to provide instructions for every possible analytical method. While some analyses require little statistical training, more complex methods may require consultation with a statistician.

Sources of variation

One of the main objectives of many monitoring efforts is to estimate the magnitude and direction of population changes over time on individual land units or groups of land units across a region. The raw number of observations recorded during surveys provides an index of relative abundance of individuals, but does not account for heterogeneity in detection probability.

In addition to variation in bird abundance across space or time, many factors can influence the number of birds detected during surveys, including: time of day, observer, survey date, reproductive status, weather conditions, habitat features, background noise, and bird density (Sauer et al. 1994; Conway and Gibbs 2011). Although the survey protocols described in SOP #2 attempt to minimize this variation, the influence of potentially important covariates should be incorporated into analyses whenever possible and periodically evaluated. The survey design includes design elements that are intended to provide the analyst with several alternative methods to account for heterogeneity in detection probability, including distance estimation (Buckland et al. 2001), removal models (time to detection; Farnsworth et al. 2002), conducting multiple visits within a season (Royle 2004; MacKenzie and Royle 2005), and multiple-observer surveys (Nichols et al. 2000).

Sampling designs

The methods used to collect data ultimately influence how those data may be interpreted and the inference that can be made from statistical analyses. The ability to make inference about marsh bird populations across an entire land unit or region will depend on all areas having a non-zero chance of being sampled. SOP #1 provides information on probabilistic sampling designs and the target population to which inference can be made. Clearly defined objectives associated with the monitoring effort will determine how the data are collected and how the data will be used to inform management decisions.

Analyses

Inventory: species composition and distribution

A summary of the species detected can be generated at the end of each field season using a variety of tables and graphs. Suggestions include:

- A summary of the number of points surveyed and the suite of species detected at each land unit of interest.

- A table with the total number of detections per survey point per visit for each species at each land unit of interest.
- Graphs with relative abundance (numbers of individuals per survey point) and frequency (proportion of sites where each species was detected) for each year and each land unit.
- Descriptive statistics summarizing the number of individuals detected in different time periods, distance intervals, habitat types, or management units.
- Map of spatial distribution of species detected.

The AKN database has a variety of analysis tools that provide simple tables and graphs of survey data. In the Analyst application, you can select locations (e.g., land units, transects, or points), species or species guilds, date ranges, and habitat types. The output includes a table with a summary of point level estimates of relative abundance, as well as a graph showing simple linear trends in relative abundance over time for each survey route. These graphs can be saved for use in annual reports. The basic tables created do not account for pseudo-replication among survey points (random effects are not included). Alternatively, you may also download the data in a .csv file and create summaries and graphs in other software applications.

Population trend and habitat analysis

More complex analyses such as population trends can be carried out periodically. Consultation with a statistician is recommended in most cases to properly account for variation in observers and other sources of heterogeneity in detection probability.

A variety of simple regression techniques may be used to model population trend using indices of population size versus time (Thomas 1996). These methods allow the incorporation of covariates and the assumed distribution of residuals, but will not account for variation in detection probability. When trends are estimated as ratios of raw counts or as regressions of count indices over time, undetected trends in detection probability can either mask changes in abundance or cause erroneous inference about the magnitude and direction of trends in abundance. Methods such as distance sampling may account for detection probability, but sufficient data for each species and observer may not be available at the scale of a single land unit. A number of assumptions are inherent in distance sampling techniques that may be difficult to meet (Johnson 2008). For example, the assumptions that birds do not move, and that distances are recorded accurately may be violated during call-broadcast surveys (Legare *et al.* 1999; Nadeau and Conway 2012). More research is needed to address the magnitude of these problems for each focal species. One potential solution is to use distance estimates only from birds detected during the initial passive portion of the survey (i.e. those that were detected prior to call-broadcast), which would eliminate the bias caused by birds moving towards (or away from) the call-broadcast device but the other assumptions of distance sampling must still be met (Buckland *et al*. 2001). Any analyses incorporating distance sampling must also address the fact that habitat suitability is typically not homogeneous with respect to point placement.

Various other techniques that have been developed to directly estimate detection probability have been incorporated into the standardized survey methods outlined in SOP #2. Removal models assume vocalization frequency is the major factor influencing detection, and use a maximum likelihood estimator to estimate detection probability of individual birds recorded during each 1-minute time interval during the survey period (Farnsworth 2002). Detection probability may also be estimated using multiple-observer methods, where 2 or more independent observers collect data simultaneously on surveys (Nichols *et al*. 2000). The difference between the observers in number of birds detected at each point allows estimates of detection probability for each observer. Additional techniques exist to estimate abundance or occupancy (proportion of sites occupied) based on data from multiple visits at each sampling unit per year (Mackenzie et al. 2002; MacKenzie and Royle 2005; Dail and Madsen 2011). These methods can incorporate covariates to investigate sources of variation in detection probability and relationships between habitat characteristics and bird abundance or occupancy.

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Appendix A: AOU Codes

Table 6. AOU 4-letter species acronyms for focal marsh bird species.

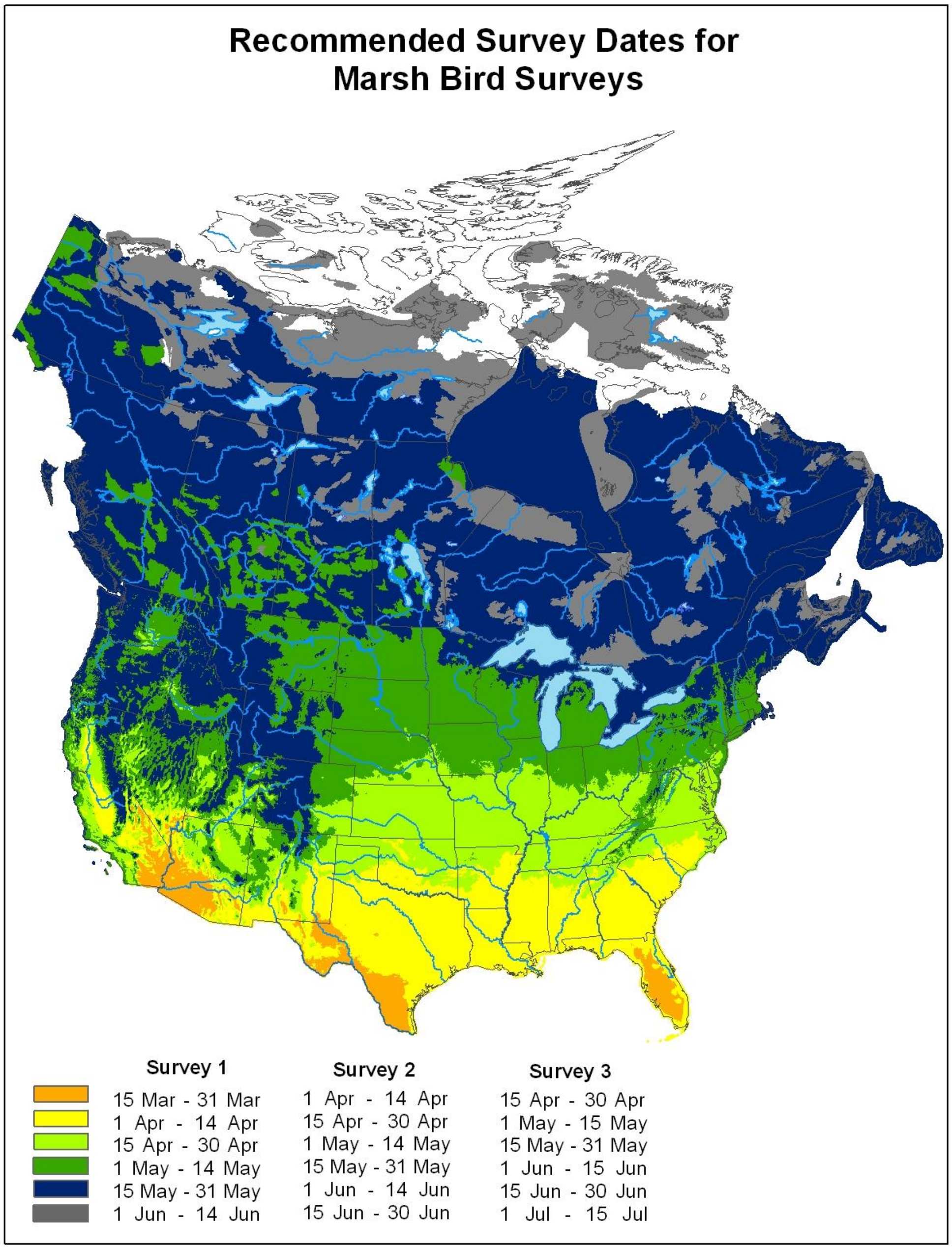
Acronym	Marsh Bird Species
BLRA	Black Rail
YERA	Yellow Rail
SORA	Sora
VIRA	Virginia Rail
KIRA	King Rail
CLRA	Clapper Rail
KCRA	King/Clapper Rail
YBCR	Yellow-breasted Crake
LEBI	Least Bittern
AMBI	American Bittern
LIMP	Limpkin
PUGA	Purple Gallinule
COGA	Common Gallinule
AMCO	Americsan Coot
CARC	Caribbean Coot
PBGR	Pied-billed Grebe
LEGR	Least Grebe
EAGR	Eared Grebe
RNGR	Red-necked Grebe
HOGR	Horned Grebe
CLGR	Clark’s Grebe
WISN	Wilson’s Snipe
BLTE	Black Tern
SALS	Saltmarsh Sparrow
NESP	Nelson’s Sparrow
SESP	Seaside Sparrow
WILL	Willet (Eastern)

Examples of non-focal species; each cooperator should decide which non-focal species to include in their surveys in advance and list these species on their datasheet and in the database so that analysts (and surveyors in future years) will know the list of species recorded in prior years. Choosing too many non-focal species may cause surveyors to become overwhelmed with data collection at the expense of data on the focal species. Once non-focal species are included, every surveyor at that station should record them in the same manner each year so that the data for that species from that station are valid.

Acronym	Marsh Bird Species
GRHE	Green Heron
GBHE	Great Blue Heron
GLIB	Glossy Ibis
FOTE	Foster’s Tern
SEWR	Sedge Wren
MAWR	Marsh Wren
LCSP	Le Conte’s Sparrow
SWSP	Swamp Sparrow
YHBL	Yellow-headed Blackbird

Appendix B: Survey Timing

Figure 1. Dates of 3 annual survey windows for different areas in North America. The isoclines are based on average maximum temperatures in May, from PRISM at Oregon State University (for the U.S.) and Environment Canada (for Canada).



Appendix C: Focal Species and Field Data

The following is a table of focal marsh bird species and their field data requirements for conducting marsh bird monitoring. These are species for which the marsh bird survey protocol is designed to monitor well. Surveyors should always record at least the total number of individuals detected at each point for all of these species.

Table 7. Focal marsh bird species and their field data requirements for conducting marsh bird monitoring.

Species	Broadcast Required?[1]	Record 1 Individual/Line
Broadcast		
BLRA	YES	YES
YERA	YES	YES
SORA	YES	YES
VIRA	YES	YES
KIRA	YES	YES
CLRA	YES	YES
LEBI	YES	YES
AMBI	YES	YES
LIMP	YES	YES
PUGA	YES	YES
COGA	Recommended	YES, except[2]
AMCO	Recommended	YES, except[2]
CARC	Recommended	YES, except[2]
PBGR	Recommended	YES, except[2]
Non-broadcast		
WILL	NO	YES, except[2]
RNGR	NO	YES, except[2]
EAGR	NO	YES, except[2]
HOGR	NO	YES, except[2]
CLGR	NO	YES, except[2]
LEGR	NO	YES, except[2]
WISN	NO	YES, except[2]
SALS	NO	YES, except[2]
NELS	NO	YES, except[2]
SESP	NO	YES, except[2]
BLTE	NO	YES, except[2]

[1] BROADCAST REQUIRED: Species for which surveyors must broadcast call if they are within the breeding range of that species. Recommended = use of broadcast is optional (BUT strongly encouraged) for these speceis even if surveys are within breeding range of that speceis.

[2] Record each individual on one row of the data form except at points where the surveyor is overwhelmed because too many focal birds are being detected at that point (see SOP #2).

Appendix D: Call Types

Table 8. List of the most common calls for the focal species of marsh birds.

Species	Standardized Call Name	Sibley Name	BNA Name(s)[1]	Possible function	BNA website?[1]
AMBI	Pump-er-lunk	Bloonk-adoonk	Pump-er-lunk and dunk-a-doo	Mate attraction, territorial signal	
AMBI	Chu-peep	Chu-peep	Chu-peep	During copulation ceremony	
AMBI	Kok	Kok-kok-kok	Kok-kok-kok or haink	When flushed	
AMCO	Burr-up		Puhk-cowah; cooah	Perturbation (puhk-cowah male; cooah female)	Y
AMCO	Hic-up	priKi	Pow-ur	Perturbation (pow-ur male)	Y
AMCO	Honk				
BLRA	Kik-kic-kerr	Keekeedrr, deedeeedunk	Kickee-doo or kic-kic-kerr, or ki-ki-do	Mate attraction, territorial signal	Y
BLRA	Grr	Krr-krr-krr, growling	Growl, grr-grr-grr, brrr or churr-churr-churr	Alarm call, territorial defense	Y
BLRA	Churt		Churt; curt; yip, bip, or kik; yelp; kek, ki	Alarm call	
BLRA	Tch	Ink-ink-ink	Kik-kik-kik or kuk-kuk-kuk; ink-ink-ink	When on the nest?	
CLRA	Clatter	Clapper	Clapper or clatter; chock-chock; cac-cac-cac or jupe-jupe-jupe	Mate communication	Y
CLRA	Kek	Ket	Kek-kek-kek, kik-kik,kik, bup-bup-bup	Mate attraction (male)	Y
CLRA	Kek-burr	Ket-ket-karr	Kek-burr	Mate attraction (female)	Y
CLRA	Kek-hurrah	Grunting	Kek-hurrah		Y
CLRA	Hoo		Hoo; oom-oom-oom		
CLRA	Squawk		Screech or shriek; chase squeal or kak	Alarm call, territorial disputes	
CLRA	Purr		Purr; agitated purrrr; churr		
COGA	Wipe-out	Pep-pep-pehr-peehr	Cackle – ka-ka-ka-ka-ka-kee-kree-kree-kree		Y
COGA	Keep	Kulp, keek	Squawk, yelp, cluck		Y
COGA	Giddy-up				Y
KIRA	Clatter	Clapper	Cheup-cheup-cheup; jupe-jupe-jupe, gelp-gelp-gelp, chac-chac-chac	Mate communication	Y
KIRA	Kek	Ket	Kik-kik-kik	Mate attraction (male)	Y
KIRA	Kek-burr	Ket-ket-karr		Mate attraction (female)	Y
KIRA	Squawk				
LEBI	Coo	Poopoopoo	Coo or cooing; tut-tut-tut	Mate attraction	Y
LEBI	Kak	Rick-rick-rick	Gack-gack	Mate communication, alarm call	Y

Species	Standardized Call Name	Sibley Name	BNA Name(s)[1]	Possible function	BNA website?[1]
LEBI	Ert	Kuk	Tut-tut-tut; quoh, hah or cackle	Alarm call	Y
LEBI	Ank-ank		Ank-ank	When flushed	
LIMP	Kreow	kwEEEeeeer, KIAAAar	Kreow	Mate attraction	Y
LIMP	Gon		Gon		
PBGR	Owhoop	Ge ge gadum gadum gwaaaaow	Series of wut, whut, or kuk notes followed by 4-20 kaow or cow notes	Courtship, communication between pair, territorial	Y
PBGR	Hyena	Chatter	Ek-ek-ek, hn,hn,hn	Greeting call	Y
PUGA	Cackle	Pep-pep-pePAA-pePAA, to-to-terp	Cackle		Y
PUGA	Squawk		Gheeek!		Y
SORA	Whinny	Whinny	Descending whinny	Territorial defense, mate communication	Y
SORA	Per-weep	kooEE	Per-weep, kerwee, ter-ee	Mate attraction?	Y
SORA	Keep	Keek	Kee or weep	Alarm call	Y
VIRA	Tick-it	Gik gik gik gik gidik gidik gidik gidik	Tick-it	Mate attraction (male)	Y
VIRA	Kicker	Chi chi chi chi treerr	Kicker	Solicitation (female)	Y
VIRA	Grunt	Grunt	Grunt	Mate communication	Y
VIRA	Squawk	Skew; kweek	Kiu	Alarm call, territorial dispute	Y
VIRA	Kikik	Kikik ik-ik, pit-ti-ti-tip			Y
YERA	click-click	Clicking, tic-tic tictictic	Click-click, click-click-click	Mate attraction	Y
YERA	Cackle	Cackle	Cackle		
YERA	Wheeze	Wheezing, clucking	Wheezes	Hostility	

[1] Names(s) of calls listed in The Birds of North America (http://bna.bnirds.cornell.edu/bna/)

Appendix E: Sample Datasheet

National Marsh Bird Monitoring Program Survey Data Sheet

Date *(eg 10-May-04)*: 20 April 2006
Name of marsh or route : Hidden Shores Marsh
Observer(s) *(list all)**: Chris Nadeau, Bob Blabla

Multiple Observer Survey: Y / [✓ N]
Boat type: John boat (20 hp)
High tide time:
Water depth:

List all non-focal species surveyed:
SESP, AMCO

location: Mallard Marsh 1
depth (in) 0

location: Duck Pond 1
depth (in) 5

location:
depth (in)

**list all observers in order of their contribution to the data collected*
put an "S" in the appropriate column if the bird was seen, a "1" if the bird was heard, and "1S" if both heard and seen

Station#	Start Time (military)	Temp (F)	Sky	Wind (Beaufort)	Salinity (ppt)	Background noise	Species	Responded During											Call Type(s)	Direction	In target area	Distance (meters)	Distance Aide	Detected at a Previous Point	Comments
								Pass 0-1	Pass 1-2	Pass 2-3	Pass 3-4	Pass 4-5	BLRA	LEBI	YERA	SORA	VIRA	Outside survey period							
HSM1	1710	66	0	1		0	BLRA	1	1				1					1	grr	○	Y	95	1	N	
							BLRA		1				1	1	1	1	1		kic-kic-kerr	○	N	110	1	N	
							VIRA			1S					1				Tick-it, grunt	○	N	30	1	N	
HSM2	1721	67	0	3		2	no birds																		
HSM3	1750	68	1	2		1	CLRA	1	1									1S	clatter	○	Y	40	0	N	pair
							CLRA											S	clatter	○	N	45	0	N	pair
							VIRA		1	1	1				1		1		grunt	○	Y	100	0	Y	
							CLRA										1		throaty hoo	○	Y	10	0	N	
							AMCO (10)													○					
							SESP (1)													○					
HSM4																				○					Not surveyed unsuitable habitat
HSM5	1810	72	1	2		1	COGA	1	1	1		1		1		1			wipeout	○	Y	150	3	N	
							SORA				1	1			1	1			per-weep	○	Y	210	3	N	
							SESP (2;3;12)													○					

Background noise: 0=*no noise;* 1=*faint noise;* 2=*moderate noise (probably can't hear some birds beyond 100m);* 3=loud noise (probably can't hear some birds beyond 50m); 4=*intense noise (probably can't hear some birds beyond 25m)*
Beaufort scale: 0=*smoke rises vertically;* 1=*wind direction shown by smoke drift;* 2=*wind felt on face; leaves rustle; 3=leaves & small twigs in constant motion a* and light flag extended; 4=*raises dust and loose paper -- small branches are moved;* 5=*small trees with leaves sway --crested wavelets on inland waters*
Sky: 0=*clear or a few clouds;* 1=*partly cloudy or variable sky;* 2=*cloudy or overcast;* 4=*fog or smoke;* 5=*drizzle;* 6=*snow;* 8=*showers*
Distance Aide: 0 *none* 1 *range finder* 2 *distance bands on aerial photo* 3 *surveyor flags tied to vegetation*

Appendix F: Contact Information

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U.S. Fish and Wildlife Service
U.S. Department of the Interior

National Wildlife Refuge System