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

National Wildlife Refuge System

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

Version 1.1

ON THE COVER

Observers 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: CJ Conway.

NWRS Survey Protocol Signature Page

Protocol Title: National Wildlife Refuge System Protocol Framework for the Inventory and Monitoring of Secretive Marsh Birds **Version**[1] 1.1				
Station Name:	**Authors and Affiliations** Courtney Conway, USGS, Idaho Cooperative Fish & Wildlife Research Unit Mark Seamans, USFWS, Division of Migratory Bird Management, Lakewood, CO			
Approvals				
Action	**Signature/Name**			**Date**
Prepared By:	Courtney Conway, USGS, Mark Seamans, USFWS, Lisa Carter, USFWS, Lee O'Brien, USFWS			6/28/2016
Submitted By:	Lee O'Brien, USFWS I&M			6/28/2016
Regional I&M[4] **Approval:**				
National I&M[5] **Approval:**	Jana Newman, National I&M Manager			6/28/2016

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 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 broadcasts to increase detection probability of focal marsh bird species. Several approaches that allow analysts to account for imperfect detection are provided. 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 depending on logistics and the number and location of survey points.

Suggested citation:
Conway CJ and Seamans ME. 2016. National Wildlife Refuge System Protocol Framework for the Inventory and Monitoring of Secretive Marsh Birds, Version 1.1. Inventory and Monitoring, National Wildlife Refuge System, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

This protocol is available from the USFWS Service Catalog (ServCat):
https://ecos.fws.gov/ServCat/Reference/Profile/52385

Acknowledgments

This document draws mainly from the North American Marsh Bird Monitoring Protocol (Conway 2011), which was 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, Royle and Nichols 2003, Kéry *et al*. 2005). Many people have contributed to the development of the protocol by field testing survey methods and providing suggestions for improvement. Dr. Soch Lor from the USFWS led a team of biologists that thoroughly reviewed the protocol and provided many recommendations for improvement and standardization. Mark Wimer from the USGS 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.

Lee O’Brien (USFWS, I&M Branch)
Jaclyn Johnson (Contractor, USFWS I&M Branch)
Bruce Peterjohn (USGS Patuxent Wildlife Research Center)
Mark Wimer (USGS Patuxent Wildlife Research Center)
Lisa Carter (Contractor, USFWS I&M Branch)
Soch Lor (USFWS, Region 7)
Terry Doyle (USFWS, Region 4)
Jennifer Casey (USFWS, Region 5)
Paul Hess (USFWS, Region 5)
Jeanne Holler (USFWS, Region 3)
Alice Hanley (USFWS, Region 3)
Diane Granfors (Region 3, Habitat and Population Evaluation Team)
Kathleen Blair (USFWS, Region 2)
Melinda Knutson (USFWS, Region 3)
Kathleen Carlyle (USFWS, Region 3)
Kelly Chadbourne (USFWS, Region 5)
Erin King (USFWS, Region 5)
Keith Hamilton (Contractor, USFWS I&M Branch)

Contents

List of Tables

List of Figures

Narrative

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 some survey data for secretive marsh birds but 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 surveys are conducted in optimal habitat. Hence, targeted efforts that focus specifically on marsh birds are needed to advance our understanding of the population biology and effects of management actions on marsh birds.

Marsh birds include species that are marsh-dependent. 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), and include: king rail (*Rallus elegans*), clapper rail (*Rallus crepitans*), Ridgway's Rail (*Rallus obsoletus*), 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 (*Porphyrio martinicus*), and common gallinule (*Gallinula galeata*). The U.S. Fish and Wildlife Service (USFWS) has identified the black rail, yellow rail, limpkin, and American bittern as *Birds of Conservation Concern* because they are relatively rare and we lack basic information on status and trends in most areas (USFWS 2008). Moreover, yellow, black, clapper, and king rails are four of the 139 "Focal" species that USFWS has given priority for active management because they pose special management challenges (USFWS 2005). Black, king, and yellow rails were also listed on the National Audubon Society's Watch List in 2014 (National Audubon Society 2007; U.S. NABCI Committee 2014). Many U.S. states consider these species threatened or of special concern for similar reasons.

Marsh ecosystems are extremely vulnerable to large-scale habitat stressors, including loss from conversion to agriculture, invasive vegetation, urban growth, changes in wetland hydrology and river diversions, lack of habitat 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, gallinules, coots, and 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 USGS and USFWS held workshops in 1998 and 2006 that emphasized the need for range-wide estimates of abundance, distribution, and population trends, and advocated for 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 their status and distribution. 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; Nadeau *et al.* 2008; Conway 2011). Continued monitoring will also allow resource managers to evaluate whether management actions or 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 USFWS has the legal responsibility under the Migratory Bird Treaty Act to manage and protect all migratory birds. 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 wetlands within their boundaries, and the management actions used by refuges could affect marsh bird populations. This document was developed to help guide the National Wildlife Refuge System and its Inventory and Monitoring Program in the collection of marsh bird data. However, most of the contents should be useful to a broader audience interested in collecting marsh bird data.

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

Detection Probability – People who conduct marsh bird surveys are typically interested in estimates of abundance, density, or population trend. However, surveys rarely count all individuals present in the sampling area because detection probability during surveys is typically less than 100%. Thus, most of the parameters that users hope to obtain from marsh bird surveys rely upon estimates of detection probability by either 1) assuming a constant 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 (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 (Burnham 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. Standard Operating Procedure (SOP) #1, Sampling Design, describes sampling designs appropriate for local and regional scale management objectives.

Sampling units and sample frame

This protocol is designed to monitor the entire community of breeding marsh bird species within a defined area. The sampling frame is defined as the spatial and temporal distribution of all possible sampling units (i.e., survey points) with a non-zero probability of being selected. The response variable is the abundance (or density, or presence/absence in the case of occupancy) of marsh birds at a survey point. SOP #1 includes additional details on probabilistic sampling and how to define the target population.

Sample selection and sample size

Samples will be randomly selected from all possible samples. A two-tiered design will have two levels of sampling. For example, hexagons that cover the entire study area could delineate sampling units at the largest spatial scale (first tier). After randomly selecting a subset of hexagons, survey points (second tier) can be randomly located in marsh habitat within these selected hexagons.

Sample size will depend on the management objectives, desired precision of results, and type of analysis. For analysis of population trend, sample size will depend on the time frame and the desired precision around the trend estimate, as well as natural variability from 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. Observers 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 national or regional Inventory and Monitoring (I&M) staff, 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 ensure that all observers are properly trained and qualified (see Element 5, 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 coordinates of survey points into a GPS device, and make copies of the field data forms. Prior to conducting surveys observers should attempt to navigate to each survey point and mark each with flagging tape. This will ensure that observers do not waste time looking for the survey points in the field during the narrow survey window. Observers will need the following field equipment and supplies to conduct marsh bird surveys:

- Flagging (to mark survey points)
- GPS
- Clipboard, datasheets, pencils
- Printed site map with survey locations
- CD or mp3 broadcast file (obtained from the program coordinator 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
- Headlamp or flashlight

- Rubber boots, hip waders or chest waders
- Thermometer
- Watch or other time recording device
- Cell phone in case of emergency

If habitat is to be measured observers may need a water gauge and salinity meter (e.g., Oregon Scientific Handheld Salinity Meter [ST228], $25). In addition, the sound level meter should be used to check volume of broadcast equipment prior to going into the field. 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, if possible, a spare CD or mp3 player on all surveys in case the primary unit fails to operate.

The Survey Coordinator will 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 considerations.

Establishment of survey points

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 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 speaker direction from previous surveys 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. Observers should stick to established trails or paths when possible and avoid stepping on clumps of live or dead vegetation, especially during the breeding season, to prevent trampling of nests, nestlings, and/or adult birds. However, conducting surveys from upland edges, roadside edges, and open water edges may create some bias in estimation of population trends. Hence, observers 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 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 responses from resident marsh birds (Conway 2011). Observers 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 for estimation of detection probability using several methods. SOP #2 includes detailed instructions on survey methods and how to record data during surveys. Observers may obtain datasheets from the USFWS Service Catalog (ServCat), reference code 52385 (https://ecos.fws.gov/ServCat/Reference/Profile/52385). An example of a completed datasheet is provided in Appendix E.

Processing of collected materials

At the outset of a new study or project, establish a new project in the Avian Knowledge Network (AKN) database (see Element 3 and SOP #3 for information on data entry and data management). 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

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. Field equipment should be cleaned and batteries removed for storage. 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

Use of the standardized protocols proposed herein 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 were collected. Some fields exist in the AKN database to provide details on survey methods, sampling and observers. There will also be a field in the database for a link to the USFWS Service Catalog (ServCat), where site-specific protocols will be stored and where detailed descriptions of each study should also be stored.

Data security and archiving
Electronic copies of datasheets should be made upon returning from the field. The AKN database administrators are responsible for ensuring security and backup of the electronic data stored in the database. SOP #3 and Element 2 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 probabilities, 3) estimate abundance, density, or occupancy of marsh bird species, 4) determine species habitat relationships, and 5) analyze long-term trends 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 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 USFWS encourages publication of significant findings in scientific journals or USFWS publications (USFWS 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 completed on a time interval consistent with original survey objectives. For general and ongoing surveys (e.g., surveys with status and trend objectives) we recommend preparing analysis and synthesis reports at least every 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. 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 in reports

Objectives and Methods – All reports should include an introduction that explicitly states the 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, the 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 with regards to 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. Additional information may include citations of additional studies that support the findings or provide analyses of additional data with larger sample sizes or at larger spatial scales.

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 and archiving

Results should be discussed with the Project Leader and a copy of the final report archived at the refuge station, uploaded to ServCat 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 observers 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 ensures that observers 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. Observers should review safety procedures, first aid, and emergency plans prior to conducting field work.

Qualifications

A well-trained and competent observer 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 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 gathering 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 observers 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 someone learn calls, but observers should also practice call identification at marshes where the focal species frequently vocalize. 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. Whether a motorized boat or non-motorized, a float plan and other safety recommendations should be followed (i.e. life jackets, portable radio, etc).

Distance Estimation – Observers should also be trained to accurately estimate distance to calling marsh birds. Methods for training observers to accurately estimate distance include: 1) place a CD or MP3 player in the marsh at an known distance and with varying speaker directions (e.g., directly toward and away from observers) and have observers estimate distance to the recorded call, 2) choose a landmark 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 observers can tag along on surveys conducted by more experienced observers in their region prior to starting their own surveys. They should conduct 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. Observers 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 observers or potential observers 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 2, 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 6.1. Estimated annual costs to conduct this survey on a station.

Personnel/Equipment	Estimated Annual Cost
Survey Coordinator (refuge staff)	$0
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 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

Alldredge MW, Pacifici K, Simons TR, Collazo JA, Shriner SA. 2007. Time-of-detection method for estimating abundance from point count surveys. Auk 124:652-664.

Allen T, Finkbeiner SL, Johnson DH. 2004. Comparison of detection rates of breeding marsh birds in passive and playback surveys at Lacreek National Wildlife Refuge, South Dakota. Waterbirds 27:277-281.

Bogner HE, Baldassarre GA. 2002. The effectiveness of call-response surveys for detecting least bitterns. Journal of Wildlife Management 66:976-984.

Bookhout, TA. 1995. Yellow Rail (Coturnicops noveboracensis). No. 139 in The Birds of North America (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania; American Ornithologists' Union, Washington, D.C

Buckland ST, Anderson DR, Burnham KP, Laake JL, Borchers DL, Thomas L. 2001. Introduction to distance sampling: estimating abundance of biological populations. New York, NY: Oxford Press.

Burnham, KP. 1981. Summarizing remarks: Environmental influences. Studies in Avian Biology 6:324-325.

Bystrak D. 1981. The North American breeding bird survey. Studies in Avian Biology 6: 34-41.

Comer P, Faber-Langendoen D, Evans R, Gawler S, Josse C, Kittel G, Menard S, Pyne M, Reid M, Schulz K, Snow K, and Teague J. 2003. Ecological systems of the United States: a working classification of U.S. terrestrial systems. NatureServe, Arlington, Virginia. http://www.natureserve.org/library/usEcologicalsystems.pdf

Conway CJ. 1995. Virginia Rail (*Rallus limicola*). *In* The birds of North America. No. 173. (A. Poole, P. Stettenheim and F. Gill, Eds.). Philadelphia, Pennsylvania: The Academy of Natural Sciences.

Conway CJ. 2011. Standardized North American marsh bird monitoring protocol. Waterbirds 34:319-346.

Conway CJ, Droege S. 2006. A Unified Strategy for Monitoring Changes in Abundance of Birds Associated with North American Tidal Marshes. Studies in Avian Biology 32:382-397.

Conway CJ, Eddleman WR, Anderson SH. 1994. Nesting success and survival of Virginia rails and soras. Wilson Bulletin 106:466-473.

Conway CJ, Eddleman WR, Anderson SH, Hanebury LR. 1993. Seasonal changes in Yuma Clapper Rail vocalization rate and habitat use. Journal of Wildlife Management 57:282-290.

Conway CJ, Gibbs JP. 2001. Factors influencing detection probabilities and the benefits of call-broadcast surveys for monitoring marsh birds. Laurel, Maryland: Final Report, USGS Patuxent Wildlife Research Center.

Conway CJ, Gibbs JP. 2005. Effectiveness of call-broadcast surveys for monitoring marsh birds. Auk 122:26-35.

Conway CJ, Gibbs JP. 2011. Summary of the intrinsic and extrinsic factors affecting detection probability of marsh birds. Wetlands 31:403-411.

Conway CJ, Nadeau CP. 2006 Development and field-testing of survey methods for a continental marsh bird monitoring program in North America. Wildlife Research Report #2005-11. USGS Arizona Cooperative Fish and Wildlife Research Unit, Tucson, AZ.

Conway CJ, Nadeau CP. 2010. The effects of conspecific and heterospecific call-broadcast on detection probability of marsh birds in North America. Wetlands 30:358-368.

Conway CJ, Nadeau CP, Piest L. 2010. Fire helps restore natural disturbance regime to benefit rare and endangered marsh birds endemic to Colorado River. Ecological Applications 20:2024-2035.

Conway CJ, Sulzman C. 2007. Status and habitat use of the California black rail in the southwestern U.S.A. Wetlands 27:987-998.

Conway CJ, Sulzman C, Raulston BA. 2004. Factors affecting detection probability of California Black Rails. Journal of Wildlife Management 68:360-370.

Conway M, Nadeau CP, Conway CJ. 2010. Optimal seasonal timing of marsh bird surveys and the effect of water quality on marsh bird relative abundance in south Florida. Wildlife Report # 2010-03, USGS Arizona Cooperative Fish and Wildlife Research Unit, Tucson, Arizona.

Conway CJ, Timmermans STA. 2005. Progress toward developing field protocols for a North American marshbird monitoring program. USDA Forest Service General Technical Report. PSW-GTR-191.

Dahl TE. 2006. Status and trends of wetlands in the conterminous United States 1998 to 2004. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service.

Dail D, Madsen L. 2011. Models for estimating abundance from repeated counts of an open metapopulation. Biometrics 67:577-587.

Eddleman WR, Flores RE, Legare ML. 1994. Black rail (*Laterallus jamaicensis*). No. 123 in The Birds of North America (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania; American Ornithologists' Union, Washington, D.C.

Eddleman WR, Knopf FL, Meanley B, Reid FA, Zembal R. 1988. Conservation of North American rallids. Wilson Bulletin 100:458-475.

Erwin RM, Conway CJ, Hadden SW. 2002. Species occurrence of marsh birds at Cape Code National Seashore, Massachusetts. Northeastern Naturalist 9:1-12.

Farnsworth GL, Pollock KH, Nichols JD, Simons TR, Hines JE, Sauer JR. 2002. A removal model for estimating detection probabilities from point-count surveys. Auk 119:414-425.

Field SA, Tyre AJ, Possingham HP. 2005. Optimizing allocation of monitoring effort under economic and observational constraints. Journal of Wildlife Management, 69:473–482.
Flores RE, Eddleman WR. 1995. California black rail use of habitat in southwestern Arizona. Journal of Wildlife Management 59:357-363.

Gibbs JP, Melvin SM. 1993. Call-response surveys for monitoring breeding waterbirds. Journal of Wildlife Management 57:27-34.

Gibbs JP, Melvin S, Reid FA. 1992. American Bittern (*Botaurus lentiginosus*). *In* The Birds of North America. No. 18. (A. Poole, P. Stettenheim and F. Gill, Eds.). Philadelphia, Pennsylvania: The Academy of Natural Sciences.

Harms TM, Dinsmore SJ. 2014. Influence of season and time of day on marsh bird detections. Wilson Journal of Ornithology 123:30-38.

Homer C, Dewitz J, Fry J, Coan M, Hossain N, Larson C, Herold N, McKerrow A, Van Driel JN, Wickham JD. 2007. Completion of the 2001 National Landcover Database for the conterminous United States. Photogrammetric Engineering and Remote Sensing 73:337-341.

Johnson DH. 2000. Statistical considerations in monitoring birds over large areas. Strategies of bird conservation: the Partners in Flight planning process (R. Bonney, D. N. Pashley, R.J. Cooper, and L. J. Niles, Eds.). U.S.D.A. Forest Service Proceedings RMRS-P-16.

Johnson DH. 2008. In defense of indices: the case of bird surveys. Journal of Wildlife Management 72:857-868

Johnson DH, Gibbs JP, Herzog M, Lor S, Niemuth ND, Ribic CA, Seamans M, Shaffer TL, Shriver WG, Stehman SV, Thompson WL. 2009. A sampling design framework for monitoring secretive marshbirds. Waterbirds 32:203-215.

Kendall WL, Peterjohn BG, Sauer JR. 1996. First-time observer effects in the North American Breeding Bird Survey. Auk 113:823-829.

Kéry M, JA Royle, Schmid H. 2005. Modeling avian abundance from replicated counts using binomial mixture models. Ecological Applications 15:1450-1461.

Klaas EE, Ohlendorf HM, Cromartie E. 1980. Organochlorine residues and shell thicknesses in eggs of the Clapper Rail, Common Gallinule, Purple Gallinule, and Limpkin (Class Aves), eastern and southern United States, 1972-74. Pesticides Monitoring Journal 14:90-94.

Knutson M, Danz GNP, Sutherland TW, Gray BR. 2008. Landbird Monitoring Protocol for the U.S. Fish and Wildlife Service, Midwest and Northeast Regions, Version 1. La Crosse, WI: Biological Monitoring Team Technical Report BMT-2008-01. U.S. Fish and Wildlife Service

Lawler JJ, O'Connor RJ. 2004. How well do consistently monitored breeding bird survey routes represent the environments of the conterminous United States? Condor 106:801-814.

Legare ML, Eddleman WR, Buckley PA, Kelly C. 1999. The effectiveness of tape playback in estimating black rail density. Journal of Wildlife Management 63:116-125.

Lehmicke AJJ, Bowman JL, Banning AE, Vasilas BL. 2013. Effect of tide level and time of day on detection rate and abundance of clapper rails (*Rallus longirostris*) in a Mid-Atlantic tidal marsh system. Waterbirds 36:364-368.

Lewis C, Casagrande DG. 1997. Using avian communities to evaluate salt marsh restoration. Pages 204-236 *in* Restoration of an Urban Salt Marsh (D. G. Casagrande, Ed.). New Haven, Connecticut: Yale School of Forestry and Environmental Studies Bulletin Series 100.

Link WA, Sauer JR. 1998. Estimating population change from count data: application to the North American Breeding Bird Survey. Ecological Applications 8:258-268.

Lister AJ, Scott CT. 2008. Use of space-filling curves to select sample locations in natural resource monitoring studies. Environmental Monitoring & Assessment DOI 10.1007/s10661-008-0184-y.

MacKenzie DI, Nichols JD, Lachman GB, Droege S, Royle JA, Langtimm CA. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255.

MacKenzie DI, Royle JA. 2005. Methodological insights: designing occupancy studies: general advice and allocating survey effort. Journal of Applied Ecology 42:1105-1114.

Maley JM, Brumfield RT. 2013. Mitochondrial and next-generation sequence data used to infer phylogenetic relationships and species limits in the Clapper/King rail complex. Condor 115:316-329.

Martin K, Nicola K, Bazin R. 2014. Optimizing Repeat-Visit, Call-Broadcast Nocturnal Surveys for Yellow Rails (*Coturnicops noveboracensis*). Waterbirds 68–78.

McLaren AA, Cadman MD. 1999. Can novice volunteers provide credible data for bird surveys requiring song identification? Journal of Field Ornithology 70:481-490.

Meanley B. 1992. King Rail (*Rallus elegans*). *In* The Birds of North America. No. 3. (A. Poole, P. Stettenheim and F. Gill, Eds.). Philadelphia, Pennsylvania: The Academy of Natural Sciences.

Nadeau CP, Conway CJ. 2012. Field Evaluation of distance-estimation error during wetland-dependent bird surveys. Wildlife Research 39:311-320.

Nadeau CP, Conway CJ, Conway M, Ogonowski M. 2011. Habitat requirements of California black rails, Yuma clapper rails, and western least Bitterns: an adaptive management approach, Final Report to Wildlife Conservation Fund, Arizona Game and Fish Department. Wildlife Research Report #2011-06, USGS Arizona Cooperative Fish and Wildlife Research Unit, Tucson, AZ.

Nadeau CP, Conway CJ, Conway M, Reinman J. 2010. Variation in clapper rail and least bittern detection probability among tidal Stages on the northern coast of the Gulf of Mexico. Wildlife Research Report #2010-01, U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, Tucson, Arizona.

Nadeau CP, Conway CJ, Smith BS, Lewis TE. 2008. Maximizing detection probability of wetland-dependent birds during point-count surveys in northwestern Florida. Wilson Journal of Ornithology 120:513-518.

National Audubon Society. 2007. The 2007 Audubon Watchlist. New York: National Audubon Society.

Nichols JD, Hines JE, Sauer JR, Fallon FW, Fallon JE, Heglund PJ. 2000. A double-observer approach for estimating detection probability and abundance from point counts. Auk 117:393-408.

Odom RR. 1975. Mercury contamination in Georgia rails. Proceedings of the Annual Conference of the Southeastern Association of Game & Fish Commissions 28:649-658.

Pacifici K, Simons TR, Pollock KH. 2008. Effects of vegetation and background noise on the detection process in auditory avian point-count surveys. Auk 125:600-607.

Popper, KJ, Stern MA. 2000. Nesting ecology of yellow rails in southcentral Oregon. Journal of Field Ornithology. 71:460-466.

Rehm EM, Baldassarre GA. 2007. Temporal variation in detection of marsh birds during broadcast of conspecific calls. Journal of Field Ornithology 78:56-63.

Ribic CA, Lewis S, Melvin S, Bart J, Peterjohn B. 1999. Proceedings of the marsh bird monitoring workshop. Fort Snelling, Minnesota: USFWS Region 3 Administrative Report.

Robbins CS, Bystrak D, Geissler PH. 1986. The breeding bird survey: Its first fifteen years, 1965-1979. Washington, D.C.: U.S. Dept. of the Interior, Fish and Wildlife Service Resource Publication 157.

Rosenstock SS, Anderson DR, Giesen KM, Leukering T, Carter MF. 2002. Landbird counting techniques: Current practices and an alternative. Auk 119:46-53.

Royle JA. 2004. *N*-Mixture models for estimating population size from spatially replicated counts. Biometrics 60:108–105.

Royle JA, Nichols JD. 2003. Estimating abundance from repeated presence-absence data or point counts. Ecology 84:777-790.

Rush SA, Soehren EC, Stodola W, Woodrey MS, Cooper RJ. 2009. Influence of tidal height on detection of breeding marsh birds along the northern Gulf of Mexico. Wilson Journal of Ornithology 121:399-405.

Sauer JR, Link WA, Royle JA. 2004. Estimating population trends with a linear model: Technical comments. Condor 106:435-440.

Sauer JR, Peterjohn BG, Link WA. 1994. Observer differences in the North American Breeding Bird Survey. Auk 111:50-62.

Sidie-Slettedahl AM, Jensen KC, Johnson RR, Arnold TW, Austin JE, Stafford JD. 2015. Evaluation of autonomous recording units for detecting 3 species of secretive marsh birds. Wildlife Society Bulletin. 39:626–634.

Spear LB, Terrill SB, Lenihan C, Delevoryas P. 1999. Effects of temporal and environmental factors on the probability of detecting California black rails. Journal of Field Ornithology 70:465-480.

Stedman S, Dahl TE. 2008. Status and trends of wetlands in the coastal watersheds of the Eastern United States 1998 to 2004. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service.

Steidl RJ, Conway CJ, Litt AR. 2013. Power to detect trends in abundance of secretive marsh birds: effects of species traits and sampling effort. Journal of Wildlife Management 77:445-453.

Stevens DL, Olsen AR. 2004. Spatially balanced sampling of natural resources in the presence of frame imperfections. Journal of the American Statistical Association 99:262-278.

Tate J. 1986. The blue-list for 1986. American Birds 40:227-236.

Thogmartin WE, Gray BR, Gallagher M, Young N, Rohweder JJ, Knutson MG. 2007. Power to detect trend in short-term time series of bird abundance. Condor 109:943–948.

Timmermans STA, Badzinski SS, Ingram JW. 2008. Associations between breeding marsh bird abundances and Great Lakes hydrology. Journal of Great Lakes Research 34:351-364.

Thomas L. 1996. Monitoring long-term population change: why are there so many analysis methods? Ecology 77:49-58.

Thompson WL. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. Auk 119:18-25

Thompson WL, White GC, Gowan C. 1998. Monitoring Vertebrate Populations. San Diego, California: Academic Press.

Tiner RW. 1984. Wetlands of the United States: current status and recent trends. Washington, D.C.: U.S. Fish and Wildlife Service, National Wetland Inventory

U.S. Fish and Wildlife Service. 2005. The U.S. Fish and Wildlife Service’s Focal Species Strategy for Migratory Birds. Arlington, Virginia: Division of Migratory Bird Management.

U.S. Fish and Wildlife Service. 2006. Proceedings of the 2006 Marsh Bird Monitoring Technical Workshop, March 6-8, 2006. Laurel, Maryland: Patuxent Wildlife Research Center.

U.S. Fish & Wildlife Service. 2007. Management of Fish and Wildlife Service scientific publications: recommended outlets, procedures and policies. Arlington, VA: U.S. Fish & Wildlife Service Science Committee.

U.S. Fish and Wildlife Service. 2008. Birds of Conservation Concern 2008. Arlington, Virginia: U. S. Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management.

U.S. NABCI Committee. 2014. The state of the birds 2014; United States of America. Available at: http://www.stateofthebirds.org/

White D. 2007. Spatial grid networks. U.S. Environmental Protection Agency, Western Ecology Division, Corvallis, Oregon.

Wilen BO, Bates MK. 1995. The US Fish and Wildlife Service's National Wetlands Inventory project. Vegetatio 118:153-169.

Williams BK, Nichols JD, Conroy MJ. 2001. Analysis and management of animal populations. Academic Press, San Diego, CA.

Zembal R, Massey BW. 1987. Seasonality of vocalizations by Light-footed Clapper Rails. Journal of Field Ornithology 58:41-48.

Standard Operating Procedures

SOP 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 or I&M biologists 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 monitor other bird guilds, such as landbirds or other waterbirds. The list of focal species is included in SOP #2. The *target population* that will be monitored using 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 wants 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 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 survey results cannot be extrapolated to those areas. The Survey Coordinator should describe the 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 estimate variability in abundance or occupancy to address several management objectives. 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.

Change/Trend – A commonly stated management objective is to increase abundance, density, or occupancy of marsh bird species over time on a land unit or at regional or continental scales. For this kind of objective, monitoring would usually continue for >5 years. The management objectives should explicitly state the desired magnitude (%) of change to be detected and the time frame for detecting this change. The sampling objectives should state the acceptable level of uncertainty (e.g., accepting a 10% chance of inferring an increase or decrease when one does not exist).

Effectiveness of Management Actions – Some land managers may want to evaluate the effect of specific management actions on changes in abundance, density, or occupancy of a species. Objectives should state the desired difference between management actions in abundance or occupancy to be detected, 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 included in the models as well as bird survey data.

Survey timing and schedule

One visit per year to a sampling point is the minimum required for estimating abundance or density. One visit per year will allow managers to maximize the number of points visited if sufficient resources for multiple visits are not available. However, three or more surveys are needed to estimate seasonal presence/absence of some marsh bird species in a wetland given that detection probability is imperfect (Gibbs and Melvin 1993). Including ≥3 visits per year will allow for estimation of the proportion of sites occupied by each species (MacKenzie *et al*. 2002). However, if only 1or 2 visits per site can be conducted, 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 cycles for their target species at the outset of their survey effort (Rehm and Baldassarre 2007; Conway *et al.* 2010). Observers 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, and clapper rails and king rails breed earlier than Virginia rails and soras (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 the 3 survey windows are based on average minimum temperatures in May for each region (Appendix B). The three 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. Thus, some surveys will occur before migration is completed for many marsh birds. When a survey objective is to estimate trends in the number of breeding adults of each target species, all 3 visits should occur prior to the initiation of juvenile vocalizations. Contact the program coordinator (see Appendix F) the 3 recommended 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. Observers can conduct either morning or evening surveys on a survey route. However, to reduce variation in detection probability, it is recommended that 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 before 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, observers 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 (but see Harms and Dinsmore 2014). 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 target species 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.

Yellow rail surveys are an important exception to the timing during the day for surveys recommended in the previous paragraph. Yellow rails predominantly call at night (Bookhout 1995, Popper and Stern 2000). Thus, it is recommended that surveys take place 1 hour after sunset to 1 hour before sunrise (Martin *et al*. 2014). In addition, if yellow rails are to be the sole target of a survey, alternative sampling designs and field methods, such as remote listening devices, may be considered (Sidie-Slettedahl *et al*. 2015).

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). Breeding season surveys for Ridgeway's rail (formerly California clapper rail) on Don Edwards San Francisco Bay NWR are conducted when sloughs are less than full bank. High tide was a period of reduced vocalization probability for Ridgway's 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 similar tidal stages for each visit to a route within and across years. The optimal tidal stage for conducting local marsh bird surveys should be based on when the highest numbers of marsh birds are likely to be detected; optimal tidal stage for surveys may vary among regions. If local data is not available to determine when to conduct 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. Surveys within tidal marshes should record: 1) time of the closest high tide (either 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 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 precision of trend estimate, and the time frame over which surveys are conducted. Managers should determine how much change is meaningful from a management perspective. Establishing explicit study 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 (i.e., <10 years), 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). Steidl *et al*. (2013) suggested that detection probability had a relatively minor influence on statistical power to detect a temporal trend relative to other population characteristics such as the number of site occupied. However, Steidl *et al*. (2013) did

not assess the effect on power if detection probability varied temporally, nor did they assess how spatial variation in detection probability (e.g., detection varying among habitat types) might affect power to detect differences among different management types. Variation in detection probability over space and time is well documented for marsh birds (e.g., Conway *et al*. 1993, 2004; Harms and Dinsmore 2014; Lehmicke *et al*. 2013), thus surveys for marsh birds should be designed to account these sources of variation.

Managers can increase power to detect trend by increasing the number of survey points, 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 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). However, the number of survey points 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 400 x400 m cells over the land unit or management area of interest. Select all 400 x 400 m grid cells where $\geq$50% of the cell is composed of emergent marsh vegetation. This subset of cells with $\geq$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 the desired number of grid cells to sample (depending on the size of the area in the sampling frame) plus replacement grid cells. Locate the center of each grid cell as the survey point and upload the $\geq$50 survey points into a GPS unit. Overlay roads, trails, waterways, or other elements to determine access points. Observers 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 400 x 400 m grid over the refuge or management area. Identify all of the 400 x 400 m 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 access routes or as difficult to access (Class 2) if it does not. Highlight all access routes that overlay all Class 1 sampling points. Employ a sampling program that identifies all potential survey points along these access routes, with the maximum number of points whereby each point is separated by ≥400 m. This is the sampling frame for Class 1 points. Randomly select the desired number of 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 the desired number of Class 2 points to sample. Consult with a statistician to determine 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.

Place a 400 x 400 m grid over the refuge or management area, and select all 400 x 400 m 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 the desired number of 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 estimating abundance and monitoring changes in abundance over large areas. It 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 two-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 Tessellation 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 (<3 ha) discrete wetlands, and larger (>3 ha) wetlands. This demarcation is based on the 200 m 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 or a simple random sample 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, Lister-Scott, or simple random sampling 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 40 km^2 hexagonal cells and 400 m 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 ground-truthing.

Table SOP 1.1. Guidelines for number of secondary sampling units, based on the number of accessible discrete sampling points (*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)

Additional pilot studies in the Midwest (Michigan and Ohio) used the same design as Wisconsin except they did not stratify the sample by small and large wetlands. In areas where sampling small wetlands is part of the objectives, it is recommended that the stratification in Table SOP 1.1 be used.

SOP 2: Conducting Surveys

Most marsh birds are secretive, seldom observed, and vocalize infrequently, thus the survey protocol employs broadcast calls to elicit vocalizations during surveys (Gibbs and Melvin 1993; Conway *et al.* 2004; Conway and Gibbs 2005; Conway and Nadeau 2010). 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, observers 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 sequence, 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 starts with a 5-minute passive period during which one-minute increments are indicated (e.g., "minute two" indicates the start of minute two). After the 5-minute passive period, the sequence includes exactly 30 seconds of calls for every focal marsh bird species that are expected breeders in the 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 recording indicates the end of the survey at that point. The total duration of the broadcast sequence will depend on the number of species in the area. For example, if the survey is targeting five secretive marsh bird species, then the broadcast sequence will be 10 minutes long (a 5-minute passive period followed by 1 minute for each species).

The broadcast player should be placed 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 the broadcast equipment reaches 80-90 dB, 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. Observers 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) observers 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 three 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, Ridgway's 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. Within the breeding range of the American coot, common gallinule, or pied-billed grebe, broadcasting calls of these species is optional but strongly recommended (Appendix C). However, observers should still record the number of individuals detected at each point for these 3 species (see Appendix C) even if they do not include them in their call-broadcast sequence. Moreover, participants have the option of recording data for these 3 species by 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 will 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/Ridgway's 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). 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 in Appendix D.

Estimating distance to each focal bird

Observers should estimate the distance from the survey point to the initial detection location of each bird. Recording distance estimates allows analysts more options when analyzing the data, including: 1) use of distance sampling techniques to estimate densities for each species in each habitat type and for each observer, and 2) use of 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 population size for each species on their management area.

Observers should estimate distance to the initial detection location of each bird because 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 use distance estimates only from birds detected during the initial passive period of the survey. Estimating density from 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). Obtaining accurate distance estimates requires training observers in order to decrease potential bias (Nadeau and Conway 2012). Observers are encouraged to use a rangefinder to help them determine the distance to specific landmarks surrounding each survey point, which will help them estimate the distance to calling marsh birds. Other methods for improving distance estimates include: 1) prior to the survey tying 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 uncertainty (i.e., estimating distance to birds 5m from the observer is much easier than estimating distance to birds that are >100m away). Observers should record on the datasheet and enter in the database which of the following distance estimation aides was used: 1) unaided, 2) distance markers, 3) rangefinder, 4) rangefinder and maps, or 5) maps or distance bands drawn on aerial photo. Observers should also be aware that a bird's orientation when calling (facing toward or away) can influence distance estimates. Training and experience will help observers recognize when this is occurring.

Filling out the data sheet

An electronic copy of a data sheet should be obtained from the Program Coordinator or the USFWS Service Catalog (ServCat) (https://ecos.fws.gov/ServCat/Reference/Profile/52385) to ensure that all pertinent data are recorded properly (an example of a completed datasheet is included in Appendix E). These data sheets can be tailored to meet local needs as long as the protocol standards are not compromised. The number of columns on the data sheet will differ among participants depending on the number of species on the playback list. For example, if you intend to only broadcast calls of 3 species, then you will have an 8-minute survey 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). Before beginning 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 not participating. 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 and not accounting for multiple observers to detect birds at a point may bias trend estimates, 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 *Notes* column. For example, types of boats used during surveys (canoe vs. 25 hp outboard motor vs. air boat) can potentially affect vocalization probability of marsh birds. Hence, observers 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 *Notes* column.

Recording detections of focal species

- When you arrive at the first survey point, write down the unique identification code of the survey point, the time, and weather information.
- Start the broadcast sequence.
- 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 an "**H**" in each detection column in which that individual is detected aurally and put an "**S**" in each column in which the individual is detected visually (including flying overhead). For example, if an individual Virginia rail is heard calling during the first 1 minute of passive listening, put an "**H**" in the first column (PASS 0-1) under Passive. Regardless of whether that individual calls once or many times during the first minute, you only put one "**H**" in the first column. If that same individual bird is still calling during the second minute of passive listening, then also put an "**H**" 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 an "**H**" in the column for "SORA". If that same individual bird calls again during the Virginia rail sequence, you also put an "**H**" in the column "VIRA", and so on. Hence, if an individual bird is calling constantly throughout the survey period, you will have an "**H**" in every column for that individual.
- If the individual is heard **and** seen, put both an "**H**" 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 above to record 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). Observers may have difficulty determining whether a call is coming from a new individual or an individual detected earlier at that survey point. Observers 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. An example data sheet of what survey data might look like is included in Appendix E.
- If the observer hears a marsh bird but is unsure of its species, the observer should write "UNKN" for unknown in the *Species* column and record all data for this individual as described above. Write a description of the unknown call in the *Notes* 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 *Notes* columns for 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 observer is overwhelmed with bird detections, they may record these species differently (see section titled: ***What to do when the observer 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 observers 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 database can accommodate this flexibility, but data on non-focal species are recorded differently. At each point, record on your data sheet the total number of each non-focal species detected in the *Count (Flocks)* column and enter a distance bin (less than or equal to 50 m = "L50", greater than 50 m = "G50", greater than 100 m = "G100", or no distance recorded = "NR") in the *Distance* column. Do not record detections of non-focal birds in each of the 1-min segments (Conway and Droege 2006). When entering data into the AKN database, you will record non-focal species that are not marsh birds (e.g., bald eagles) separately from non-focal marsh birds. Non-focal marsh birds are entered in the same table as focal marsh birds. For these records, you will not record an observation (H or S) in the time or call-back columns, but follow the instructions described previously in this section. For non-focal species that are not marsh birds (e.g., bald eagles), there is a separate table in the AKN database labeled **Non-focal Species Observations**. Here you will specify the point and species detected, and indicate the total number of individuals detected in the appropriate distance bin (0-50, 50-100, >100, NR).

The non-focal species included by an observer 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 an observer detected zero YHBLs or merely did not record YHBLs on their survey). Hence, each participant must enter on the data sheet the 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 species that are the focus of this monitoring protocol. Moreover, many of the non-focal species may be adequately sampled already by other annual surveys (i.e., the North American Breeding Bird Survey, mid-winter water bird survey, etc).

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 analyses can potentially increase power to detect population trends. For these reasons, observers should record all types of calls given for each target marsh bird detected in the *Call type* 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 observers detect a new individual of a focal species immediately after the survey period at a particular point (or while moving between points) they should record these birds on a separate row and put a "H", an "S", or both in the O*utside 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, observers 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 "Y" in the *Duplicate* 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 "Y" when in doubt). If a bird is detected outside the survey period at a survey point, and then detected during the survey period at a subsequent point, the observer should not record the bird in the *Duplicate* column for the subsequent point. The same bird should be recorded as "H" or "S" in the *Outside Period* column for the initial survey point.

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, observers should record whether the bird was detected outside a specific "target" management area in the *Notes* column. The name of the target area should be indicated on the datasheet and in the database for each survey point. You may also indicate in the *Notes* column (or attach a map), the management unit or specific marsh where each bird was detected.

What to do if the observer becomes overwhelmed with detections

Most of the focal species occur at relatively low densities through much of their range. Hence, many observers 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. Clapper rails in extensive salt marsh and sora in large freshwater marshes are two species where it is possible to detect a dozen or more individuals at a survey point. Another 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.

Here we provide a few comments, observations, and suggested remedies when observers become overwhelmed by detections. First, individual observers 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 comment in the *Notes* column saying that the data in the one-minute segments are uncertain. 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) In advance of the survey 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, record data for all individuals of all focal marsh bird species in the same way, but 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 for that particular species in the *Count (Flocks)* column 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-minunte segments for the focal species of higher management concern (e.g., black rails, yellow rails, king rails, clapper rails, bitterns);
4) At a minimum, observers 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 the estimated number of birds in the *Count (Flocks)* column on the data sheet and enter a distance bin (<50, 50+, or 100+ m) in the *Distance* column).

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

Distinguishing between king and clapper rails

King rails breed in freshwater marshes and clapper rails breed in saltwater marshes except for the Yuma clapper rail and Ridgeway's rail that breed in freshwater marshes in Arizona and California (Conway *et al.* 1993). There is some overlap in habitat use between king and clapper rails in brackish marshes. 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, observers in marshes near coastal areas may not be able to determine whether birds heard calling are king or clapper rails. In those situations, observers should record these individuals as KCRA (King-Clapper Rails).

Recording ambient noise level

Observers should record the level of background noise at each survey point. This information can be used as a covariate in 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 SOP 2.1. Background noise-rating scale

Scale	Description
0	No background noise
1	Faint background noise (probably can hear birds to 200m)
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). Observers should conduct surveys only when wind speed is <20 km/hr (12 mph), and not during periods of sustained rain or heavy fog. Even winds <20 km/hr affect the detection probability of marsh birds. Surveys in light rain or drizzle are typically okay, but observers should postpone surveys if they believe rain or winds are affecting their hearing ability or the vocalization probability of marsh birds. Recommendations for conducting surveys in locations that frequently have high winds 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 the target species in your area.

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 >20 km/hr during the survey, or sustained rain begins while the survey is already underway, observers should stop the survey and repeat the entire survey route another day (i.e., don't return and finish 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, and sky condition at each survey point. 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 Fahrenheit (^{o}F).

Table SOP 2.2. 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 SOP 2.3. 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
3	Sand/dust storm
4	Fog or smoke
5	Drizzle
6	Snow
7	Snow/sleet
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.* 2008; 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, observers are encouraged to place one or more water gauges for measuring water level in permanent locations at $\geq$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.

Observers 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 (optional)
In coastal marshes or any marshes with varying salinity levels, observers are encouraged to record the salinity content of the water directly in front of each survey point. Salinity affects habitat suitability for many marsh birds. This information is relatively easy to collect, and can be used as a covariate in estimates of population change, and may provide insights into the effect of salinity on the distribution and abundance of marsh birds. Moreover, salinity levels in coastal marshes may change with sea level rise 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 (see SOP #5 for where and how to record disturbance). 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 (see **Date entry, verification and editing in SOP #3** for when to enter these data). 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 for 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)
A motorized boat should be used only for accessing survey points when no other method is feasible. When observers 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, observers 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 observers who repeat the effort in future years will know that a settling period was included. The longer the settling period used, the shorter the amount of time available for surveying additional points.

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 observer 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 *Notes* 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 observers detected and which were only detected by one of the observers. 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**.**

SOP 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 will need to register with AKN and be assigned as a Project Leader for a project. As Project Leader, they can then assign protocols, study methods and access to the project, before data entry begins. This process needs to be completed only once to establish the project. For more comprehensive guidance on using the AKN database, please download the user's manual at: https://ecos.fws.gov/ServCat/Reference/Profile/55678.

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 Conservation Science (hereafter Point Blue). AKN is a central database repository 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 access roles

AKN allows different access levels for users. Each "project" is assigned at least one Project Leader who is responsible for assigning a role to each user requesting access to the data for a specific project. A "project" is a suite of survey locations managed by the same person(s) 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" who has access rights for data entry and data verification and can also download data, but only for discrete sections of each record. The Project Leader has more comprehensive access privileges that include capabilities to define, manage, and download data. Project Leaders can download data in a variety of formats by specific project, sampling units or routes, and a specified date range. The "Analyst" access level will provide access to specific data and a set of tools for summarizing and analyzing data. SOP #4 provides additional information on data analysis and reporting.

Getting started

The database is accessed through an online web interface (https://data.pointblue.org/science/biologists/). No special software is needed. While most users who previously had access to the PWRC database have had their user names and information migrated to the new AKN database, they don't have access to the database user interface until they register for a researcher account in AKN. To determine if you have an existing account, visit the login screen and type your email address. If your email address is not recognized as belonging to a registered user, you will be provided a link where you may register for an account.

New users are asked to enter the "Project ID" they would like to be a part of when they log into the web interface. The Project ID will be the name of the refuge, in all caps, no spaces, and the land unit type abbreviated (e.g., AGASSIZNWR or BOWDOINWMD), with a few exceptions. If not sure of the Project ID, the user should contact the Project Leader for the project to obtain that information. Project Leaders, that are designated to receive registration requests, will approve requests for users to be associated with a project. Each user may be a member of more than one project. The project(s) to which the user has been assigned will be displayed on the home page upon login.

Creating a New Project – When starting a new monitoring survey, a new project must be created in the AKN system. First, verify that the project (or refuge station) does not already exist in the AKN system. If the project already exists, you only need to assign this protocol to the project (if it is not already) and proceed with entering location, observer, and observation data. Currently, only Point Blue or a database administrator and Regional I&M Data Managers can create a new project and assign Project Leaders to each new project. Contact information for the database administrator can be found in Appendix F. Project Leaders can then determine access levels for each user, and can assign additional Project Leaders on their projects. Protocols and study methods are also assigned to a project by the Project Leader.

Data entry, verification, and editing

Data Entry – Field crews should proofread all datasheets at the end of each day to ensure they are legible and complete. When corrections are necessary on the datasheets, do not erase entries but instead cross out errors, write the corrections in ink, 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 are currently entered through the AKN online web interface (https://data.pointblue.org/science/biologists/). Uploading data from Excel or other formats has been developed and is being tested for possible use in the future. All information recorded on a data sheet should be entered into the database. If vegetation data are collected, these data are entered under Site Conditions (see SOP #5).

Data entry screens are consistent with the order information is recorded on the datasheets: a project is initially chosen, then site specific variables for each sampling unit are entered followed by bird detections and associated variables. Help functions are available for most fields. Data must be entered in all required fields before the user will be able to save the record.

Site Conditions – The user interface for site conditions is based on the protocol assigned by the Project Leader. This section allows users to enter conditions such as weather, tidal height, dates of disturbance events such as prescribed fire or restoration actions that occur separately from bird surveys, and describe any changes in habitat conditions (See SOP #2, for recording date of fire or disturbance, and SOP #5 for recording vegetation information).

Verification – Each datasheet should be initialed and dated to indicate when the data were entered into the electronic database. The database will show a “RAW” status to indicate that the data have been entered but not verified. The Survey Coordinator should be notified when the data are ready for verification. The Survey Coordinator or someone they designate should carefully compare the datasheets with the data in the electronic database. All discrepancies should be rectified through communication with the data entry technician or observer. Once the verification process is complete the database contains an option to mark the data as proofed and “CLEAN”. Initial and date each datasheet again to indicate when the electronic data was proofed.

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

Editing – If changes are made to "CLEAN" data, the status will revert to" RAW" and those data must be verified again. Notes should be added to indicate the reason for the modification. Once the data are verified the Project Leader can review the data and set the data sharing level to allow access by 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 – All data entered through the AKN web interface is stored in a central data warehouse, and the Project Leaders determine how their data is shared with the public. The levels of access range from a restricted view, where data are available via visualization tools but not available for download, to unrestricted views which give direct access to download the shared data. Another option gives explicit permission for data access only by individual request. This option may be appropriate for endangered species records or data from private lands. Additional details concerning data access levels can be found on the AKN website (http://www.avianknowledge.net/index.php?page=data-access).

Metadata

In 1994, Executive Order 12906 called for the establishment of the National Spatial Data Infrastructure (NSDI) defined as the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and non-profit sectors, and the academic community. The FGDC develops geospatial data standards for implementing the NSDI. Many agencies have incorporated the FGDC Content Standard for Digital Geospatial Metadata (CSDGM) and Biological Data Profile as part of their regular data management and markup practices. However, the FGDC has also endorsed the international ISO 19115 Geographic Information Metadata standard and encourages federal agencies to follow or transition to this standard wherever and whenever possible. More information about FGDC and ISO metadata standards can be found online at: www.fgdc.gov/metadata/geospatial-metadata-standards. Using the attached data sheets and entering data for the required fields in the AKN database, will ensure that all required metadata is recorded.

The AKN database will include a field for providing a link to additional information stored in ServCat about each project that is not stored in the database, such as additional details on the study design, links to supporting documentation, and/or publications.

Data security and archiving

The Survey Coordinator will archive raw survey data, field notes, and photographs in compliance with relevant USFWS data standards (www.fws.gov/stand) and pursuant to the USFWS Policy on Service Information and Technology Architecture (270 FW 1; www.fws.gov/policy/270fw1.html) and the USFWS Policy on Electronic Records (282 FW 4; www.fws.gov/policy/282fw4.html).

For safekeeping, the Survey Coordinator will store one hard copy of data and associated materials at the station and one in a secure location off the station. This includes both raw and summarized survey data, as well as associated maps, photographs, and field notes. As data are digitized, do the same with electronic files. Field notes should be retained even after data are digitized.

At the termination of a survey, or every 3 to 5 years, archive the protocol and any amendments, associated metadata, maps, photographs, field notes, data sheets, electronic data files, a record of the locations (or dispositions) of archived specimens, together with interim and final reports, as a package. This package should be duplicated and stored in two places, one at the coordinating station and one in a secure location off the station (e.g. the Regional Office, another station, or other location that is reasonably accessible to station staff). Reports and site-specific protocols should also be stored in the USFWS Service Catalog (ServCat).

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, database design and management, and for performing periodic backups of the central database. The Survey Coordinator should download a copy of the data at the end of each field season after the data have been verified, and archive a copy of the data on a local computer and on ServCat where the site-specific protocols and reports are stored. AKN also provides functions to generate reports and data summaries.

SOP 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 attempts to minimize this variation, covariates that potentially influence detection probability should be incorporated into analyses whenever possible. The survey design includes elements 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 inferences possible from statistical analyses. A random sampling design where all areas have a nonzero chance of being sampled will have the fewest assumptions allow for the most general inferences about marsh bird populations. 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 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 the following tables and graphs.

- A summary of the number of points surveyed and the suite of species detected at each land unit.
- A table with the total number of detections per survey point per visit for each species at each land unit.
- Graphs with the raw numbers of individuals detected per survey point and the 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.
- A map of spatial distribution of species detected.

The AKN database has a variety of analytical tools that provide simple tables and graphs of survey data. In the Analyst application, you can select locations, 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 do not account for pseudo-replication among survey points (random effects are not included). Alternatively, data can be downloaded as a .csv file to allow summaries and graphs to be created 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 observer 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 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, unaccounted for trends in detection probability can either mask changes in abundance or cause erroneous inferences about the magnitude and direction of trends in abundance. Williams *et al*. (2001) provide a general overview of many techniques used to estimate abundance when detection probability is <1. Distance sampling methods (Buckland *et al*. 2001) may account for detection probability; however, sufficient data for each species and observer may not be available at the scale of a single land unit to calculate these probabilities. A number of assumptions inherent in distance sampling techniques 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, which would eliminate the bias caused by birds moving in response to 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 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 *et al*. 2002). Detection probability may also be estimated using 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 the proportion of sites occupied based on data from multiple visits to each sampling unit per year (Mackenzie *et al*. 2002; Royle and Nichols 2003; Royle 2004; 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.

SOP 5: Associating Standardized Vegetation Classes with Survey Locations

Authors: Lee E. O'Brien, Melinda G. Knutson

Introduction

Linking natural resource surveys to a standardized set of vegetation classes increases the long-term value of the survey data and supports data analysis at broad spatial scales (landscapes or ecoregions). The vegetation class associated with each survey location is an important attribute (covariate) that may be needed for future, currently unanticipated, applications of the data set. *At a minimum, most natural resource surveys should document the standardized vegetation class associated with each survey location.* For some surveys, this will suffice for documenting vegetation conditions. For other surveys, additional environmental attributes (plant species cover estimates, stem counts, water temperature, etc.) will be needed and separate SOP's for collecting this information will be needed.

This SOP provides guidance for associating standardized and mapped vegetation classes (hereafter referred to as 'vegetation classes') with natural resource data collected at points or polygons. The SOP can be used in any terrestrial or wetland survey when a minimum documentation of vegetation is needed. (Marine systems are not included at this time.) Survey coordinators can link sample locations with vegetation classes in advance of the field season and print them on the field data sheets and project maps. One advantage of this approach is that field staff with minimal botanical training can verify that the associated vegetation class is found at the survey location or, if the assignment is incorrect, can assign another vegetation class from a short list of those found in the study area.

How Are Vegetation Classes Standardized and Mapped?

Ecological systems are recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. These ecological systems are represented by standardized and mapped vegetation classes that are readily identifiable by conservation and resource managers in the field (Comer *et al*. 2003). Several federal and NGO agencies employ these standards and have developed useful tools; we employ the USGS National Gap Analysis Program (GAP) Land Cover Map. The GAP map uses vegetation classes from NatureServe's Ecological System Classification (Comer *et al*. 2003) and the National Vegetation Classification (NVC) System; these are the same vegetation classes used by the LANDFIRE program to model fire behavior and predict disturbance potential. The GAP map covers the entire U.S. including Alaska, Hawaii and Puerto Rico.

The standardized vegetation classifications (defined as Class, Formation, Macrogroup, and Ecological System) for a state, county, or Landscape Conservation Cooperative (LCC) can be perused with the GAP Land Cover Data Viewer. If you click on a location on the map, a description of the class and a range map pop up. This tool can be used to generate a master list of the land cover classes in the vicinity of the study area. Full descriptions of the classes are available from NatureServe Explorer for states, provinces, Forest Service Ecoregions, and MRLC 2000 Map Zones. For example, a search for 'oak', with Wisconsin selected as a state, turns up a list of classifications, one of which is 'North-Central Interior Dry Oak Forest and Woodland'. A detailed description is provided.

Linking Vegetation Classes to Sample Locations

The survey coordinator will oversee the assignment of vegetation classes to sample locations. GIS technical skills are required to conduct the overlay analysis. With the sample location coordinates (and datum) in hand, the GIS technician will overlay the survey location coordinates on the GAP land cover map (available for download by regions, LCCs, states or for the whole country: here) and create a site-specific map showing the vegetation classes that the sample locations fall within and the list of sites with their expected vegetation class. Additionally, a master list of all the vegetation classes found in the study area is needed for reference in the event that the assigned vegetation class is in error. Descriptions of the vegetation classes can be downloaded from NatureServe for states, ecoregions, or map zones: here.

The survey coordinator will prepare data sheets for each survey location and print the associated vegetation class on the data sheet. The fields shown in Table 1 should be added to the data sheets and databases that are used for the survey. The database should provide a pick-list of all potential vegetation classes likely to be documented during the survey.

Table SOP 5.1. Fields to be added to wildlife survey data sheets or databases.

- Sample Site ID # ________________________
  (Geographic coordinates should have been recorded with survey data)
- Survey Date ____________________
- Vegetation Class NVC Subclass: [Full name from the GAP database – to be filled in by the survey coordinator]
- Vegetation Class Ecological System: [Full name from the GAP database – to be filled in by the survey coordinator]
- Is site within the designated Ecological System? Y or N
- If not, what Ecological System is it in? (refer to local list)
- ____
- Is the site within 100m of an edge or ecotone? Y or N
- If yes, what is the secondary Ecological System? (refer to local list)
  ____
- Disturbances (from list, multiple disturbances can be recorded):
  ____
- Notes about the site:
  ____

  ____

Recording Disturbances

Disturbances, both natural and human-induced, can affect the condition of the vegetation and be observed at the survey location. In addition to verifying the associated vegetation class, the field observer should document disturbances (Table 2). This includes any recent management or natural disturbances that have changed the structure or composition of the vegetation. The disturbance should be detectable by the field observer at the time of the survey; most observable disturbances will have occurred within the last two years. Some disturbances, such as tree blow-downs, may be visible much longer than two years and should be documented. If a recent disturbance occurred (e.g. mowed), but there is no observable change to the expected structure or composition of the vegetation (vegetation has regrown), then do not record as a disturbance.

Categories of disturbance can be presented as a pull-down menu in the database and multiple sources of disturbance (≤ 5) can be selected (Table 2). 'No disturbance' is the default value.

Table SOP 5.2. Disturbances that may affect the structure and composition of the vegetation.

Disturbances	
Animal damage	Invaded by exotic species
Chained	Mowed
Construction: building	Plowed/Disked
Construction: road	Prescribed burn
Construction: trail	Treated with fertilizer
Destructive use (non-harvest)	Treated with herbicide
Drought damage	Treated with insecticide
Flooded	Wetland: drained
Forest: clear-cut	Wetland: fall drawdown
Forest: selective harvest	Wetland: spring drawdown
Grazed	Wildfire
Hurricane damage	Wind event/blow down
Ice damage	Other (write in)
Insect damage	No disturbance

Workflow and Detailed Instructions for Documenting Vegetation Classes and Disturbances

- Download a GAP map for your region.
- Overlay your survey locations on the vegetation classification map and derive the NVC Subclass and the Ecological System associated with each location.
- Print the Subclass and Ecological System name on each datash*eet al*ong with the Site ID (Location name/number). Print a list of all Ecological Systems likely to be encountered at survey locations on the back of the data sheet as a reference.
- Enter the NVC Subclass and Ecological System name into the database when the locations are set up. Ensure that pick-lists for the vegetation classes and disturbances are correctly set up in the database for data entry.
- Print the pick-list of potential disturbances (Table 2) on the data sheet.
- Train observers to recognize, on the ground, the Ecological Systems associated with survey locations in the study area and any other potential Ecological Systems they may need to record.
- Field observers will verify, in the field, that the primary Ecological System assignment to each survey location is accurate or note on the data sheet what the correct classification should be (referring to the list on the back of the data sheet).
- Secondary Ecological System designations will be made on location (in the field) by the observer or recorder. *The secondary Ecological System is identified only if a different Ecological System is located within 100 m of the sample site.* Stated another way, locations that have secondary Ecological Systems have an edge or ecotone within 100 m. The error associated with many digital maps requires that this designation be made in the field. The secondary Ecological System name field in the database will be 'NA' as a default and will be updated as needed by the survey coordinator after field verification.

- Field observers will document up to 5 types of disturbances that they observe at the survey location on the data sheet; record 'none' if no disturbances are observed.
- Enter the vegetation classification information into the database, along with other field observations.
- Archive the GIS maps used to select the sample locations and the GAP maps used to assign the classes, along with other survey materials, in ServCat. This will allow for post-hoc analysis of attributes such as point count distances to edges, level of fragmentation, size of patches, etc., that may prove useful in the future.
- If the survey coordinator needs assistance with GIS maps and overlays, contact the AKN Node administrator, or the Refuge System Inventory and Monitoring Program for assistance.

References

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of the United States: a working classification of U.S. terrestrial systems. NatureServe, Arlington, Virginia. http://www.natureserve.org/library/usEcologicalsystems.pdf

Appendices

Appendix A: AOU Codes

Table A.1. AOU 4-letter species acronyms for focal marsh bird species.

Acronym	Species	Acronym	Species
BLRA	black rail	AMCO	American coot
YERA	yellow rail	CARC	Caribbean coot
SORA	sora	PBGR	pied-billed grebe
VIRA	Virginia rail	LEGR	least grebe
KIRA	king rail	EAGR	eared grebe
CLRA	clapper rail	RNGR	red-necked grebe
RIRA	Ridgway's rail	HOGR	horned grebe
KCRA	king/clapper rail	CLGR	Clark's grebe
YBCR	yellow-breasted crake	WISN	Wilson's snipe
LEBI	least bittern	BLTE	black tern
AMBI	American bittern	SALS	saltmarsh sparrow
LIMP	limpkin	NESP	Nelson's sparrow
PUGA	purple gallinule	SESP	seaside sparrow
COGA	common gallinule	WILL	willet (Eastern)

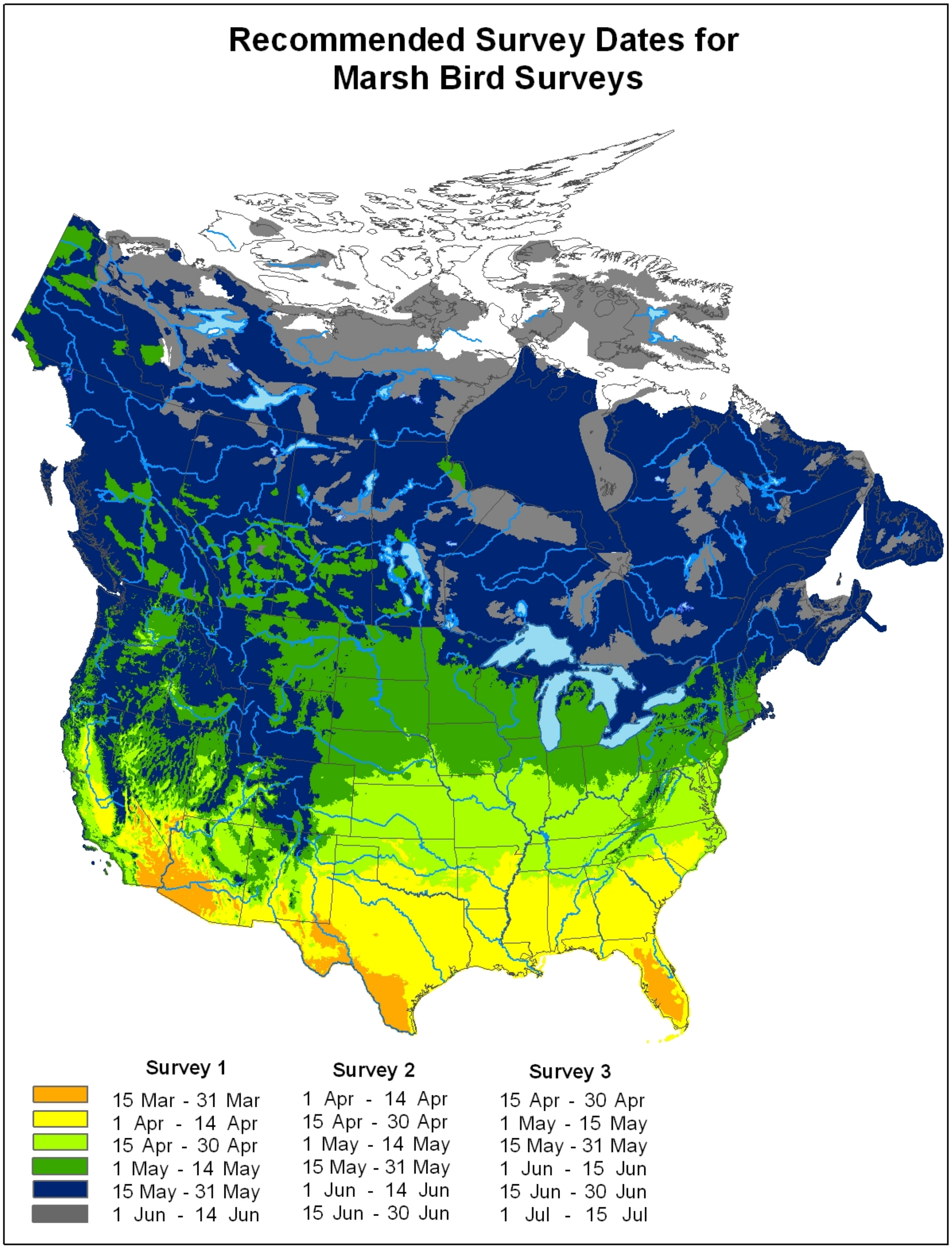
Examples of non-focal marsh-bird species; each cooperator should decide which non-focal species to include in their surveys in advance and list these species on their datasheet and in the database so that analysts and future observers will know the list of species recorded in prior years. Choosing too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

Table A.2. AOU 4-letter species acronyms for non-focal marsh bird species.

Acronym	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 B.1 Recommended 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. Observers should always record at least the total number of individuals detected at each point for all of these species.

Table C.1. Focal marsh bird species and their field data requirements for conducting marsh bird monitoring.

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

[1] BROADCAST REQUIRED: Species for which observers 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 observer is overwhelmed because too many focal birds are being detected at that point (see SOP #2).

Appendix D: Call Types

Table D.1. 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

Table D.1. (continued)

Species	Standardized Call Name	Sibley Name	BNA Name(s)[1]	Possible function	BNA website?[1]
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
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 and Blank Datasheets

NWRS Marsh Bird Survey Data Sheet (Sample)

Page ____ of ____

Date: April 20,2016
Name of marsh or route: Hidden Shores Marsh
High tide time: 23:40
Tide: 4
Multiple Observer Survey: Y / N
Observer(s): * Jane Rail Joe Coot

Temperature (F): 68°
Sky: 1
Wind (Beaufort): 2
Background noise: 1
Salinity (ppt): 1.5
Water depth (in): 6

Non-focal spp surveyed: SESP, AMCO

Distance aide: 1
Boat type: John boat (20 hp)

** List all observers in order of their contribution to the data collected*
Put an "S" in the appropriate column if the bird was seen, an "H" if the bird was heard, or "HS" if both heard and seen. Enter "Y" in Duplicate column if it is believed the same bird was detected and recorded at a previous survey point.

Point #	Start time (military)	Species	Detected During: Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Calls (specify call sequence): BLRA	LEBI	YERA	SORA	VIRA							Outside period	Distance (m)	Duplicate ?	Call type	Direction	Count (flocks)	Notes
HSM1	17:10	BLRA	H	H				H											H	95		grr			
		BLRA		H				H	H	H	H	H								110		kic-kic-kerr			
		VIRA			HS					H										30		tick-it, grunt			
HSM2	17:21	no birds																							
HSM3	17:50	CLRA	H	H															HS	40		clatter			pair
		CLRA																	S	45		clatter			pair
		VIRA		H	H	H				H		H								100	Y	grunt			
		CLRA										H								10		throaty hoo			
		AMCO																		50+				10	
		SESP																		<50				1	
HSM4																									Not surveyed - unsuitable habitat
HSM5	18:10	COGA	H	H	H		H		H		H									150		wipeout			
		SORA				H	H			H	H									210		per-weep			
		SESP																		50+				2	
		SESP																		100+				4	

Tide: 1=high; 2=almost high and rising; 3=almost high and falling; 4=half tide, rising; 5=half tide; falling; 6=almost low, rising; 7=almost low, falling; 8=low; 9=not applicable
Sky: 0=clear or a few clouds; 1=partly cloudy or variable sky; 2=cloudy/overcast; 3=sand/dust storm; 4=fog or smoke; 5=drizzle; 6=snow; 7=snow/sleet; 8=showers; 9=not recorded
Beaufort Scale: 0=calm, smoke rises vertically; 1=wind direction shown by smoke drift; 2=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 sway, crested wavelets on inland waters; 6=larger branches moving; 7=whole trees moving; 8=other-see notes; 9=not recorded
Background noise: 0=no noise (<40 dB); 1=faint noise (40-45 dB); 2=moderate noise (probably can't hear some birds beyond 100m, 45-50 dB); 3=loud noise (probably can't hear some birds beyond 50m, 50-60 dB); 4=intense noise (probably can't hear some birds beyond 25m, >60 dB; 9=not recorded
Distance Aide: 0=none; 1=rangefinder; 2=distance bands on aerial photo; 3=observer flags tied to vegetation; 9=not recorded

NWRS Marsh Bird Survey Data Sheet

Date:

Name of marsh or route:

High tide time:

Tide:

Multiple Observer Survey: Y / N

Observer(s): *

Temperature (F):

Sky:

Wind (Beaufort):

Background noise:

Salinity (ppt):

Water depth (in):

Non-focal spp surveyed:

Distance aide:

Boat type:

** List all observers in order of their contribution to the data collected*
Put an "S" in the appropriate column if the bird was seen, an "H" if the bird was heard, or "HS" if both heard and seen. Enter "Y" in Duplicate column if it is believed the same bird was detected and recorded at a previous survey point.

Point #	Start time (military)	Species	**Detected During:**																Outside period	Distance (m)	Duplicate ?	Call type	Direction	Count (flocks)	Notes
			Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	**Calls** (specify call sequence)																	
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		
																							O		

Tide: *1=high; 2=almost high and rising; 3=almost high and falling; 4=half tide, rising; 5=half tide; falling; 6=almost low, rising; 7=almost low, falling; 8=low; 9=not applicable*
Sky: *0=clear or a few clouds; 1=partly cloudy or variable sky; 2=cloudy/overcast; 3=sand/dust storm; 4=fog or smoke; 5=drizzle; 6=snow; 7=snow/sleet; 8=showers; 9=not recorded*
Beaufort Scale: *0=calm, smoke rises vertically; 1=wind direction shown by smoke drift; 2=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 sway, crested wavelets on inland waters; 6=larger branches moving; 7=whole trees moving; 8=other-see notes; 9=not recorded*
Background noise: *0=no noise (<40 dB); 1=faint noise (40-45 dB); 2=moderate noise (probably can't hear some birds beyond 100m, 45-50 dB); 3=loud noise (probably can't hear some birds beyond 50m, 50-60 dB); 4=intense noise (probably can't hear some birds beyond 25m, >60 dB; 9=not recorded*
Distance Aide: *0=none; 1=rangefinder; 2=distance bands on aerial photo; 3=observer flags tied to vegetation; 9=not recorded*

Appendix F: Contact Information

Marsh Bird Monitoring Program Coordinator

Dr. Courtney J. Conway
USGS, Idaho Cooperative Fish & Wildlife Research Unit
875 Perimeter Dr., MS 1141
University of Idaho
Moscow, ID, 83844, USA
Ph: (208)-885-6336
FAX: 208-885-9080
E-mail: cconway@usgs.gov

Avian Knowledge Network Database Support

Jaclyn A. Johnson
Natural Resource Program Center (NRPC)
1201 Oakridge Drive, Suite 320
Fort Collins, CO 80525
Ph: (970)-267-2183
E-mail: Jaclyn_Johnson@fws.gov

Avian Knowledge Network Database Administrators

Robert Serafini
Informatics Program Manager
Point Blue Conservation Science (*formerly PRBO*)
3820 Cypress Drive, Suite 11
Petaluma, CA 94954
Ph: (707) 781-2555 x368
E-mail: rserafini@pointblue.org

Dr. Leo A. Salas
Quantitative Ecologist – Climate Change & Informatics Group
Point Blue Conservation Science (*formerly PRBO*)
3820 Cypress Drive, Suite 11
Petaluma, CA 94954
Ph: (707) 781-2555 x334
E-mail: lsalas@pointblue.org

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

National Wildlife Refuge System