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A UNIFIED STRATEGY FOR MONITORING CHANGES IN ABUNDANCE OF BIRDS ASSOCIATED WITH NORTH AMERICAN TIDAL MARSHES

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Abstract. An effective approach to species conservation involves efforts to prevent species from becoming threatened with extinction before they become listed as endangered. Standardized monitoring efforts provide the data necessary to estimate population trajectories of many species so that management agencies can identify declining species before they reach the point of endangerment. Species that occur in tidal saltmarshes in North America are under sampled by existing broad-scale monitoring programs. We summarize existing local and regional survey efforts for saltmarsh birds and propose a standardized continental protocol for assessing the status and population trends of birds that breed in saltmarshes in North America. The objective of this proposed survey effort is to create a series of interconnected monitoring efforts that will provide information on the status and the changes in status of terrestrial birds living in saltmarsh systems of North America. We describe detailed field protocols for standardized surveys of saltmarsh birds across North America. We recommend morning point-count surveys with an initial 5-min passive period followed by a period of call broadcast. Surveyors record all individual birds detected (regardless of distance) for all species that are associated with saltmarshes and estimate the distance to each individual bird detected. We provide recommendations for standardizing distance between adjacent survey points, how repeat detections across points are recorded, daily and seasonal timing of surveys, timing of surveys relative to tidal cycles, number of replicate surveys per year, and focal species for this standardized survey effort. Recommended survey protocols include methods that allow estimation of various components of detection probability so that stronger inferences can be made based on trends in count data. We explain why the various survey recommendations are made so that potential participants understand the rationale for various aspects of the survey protocols. We also provide sample data forms and an example of how to fill out a data form. These protocols build upon the *Standardized North American Marsh-Bird Monitoring Protocols* by encouraging those interested in saltmarsh passerines (and other saltmarsh birds) to conduct surveys using a standardized protocol similar to that being used for secretive marsh birds. Standardization of this sort will allow data from surveys focusing on saltmarsh passerines to be easily pooled with data from surveys focusing on secretive marsh birds. Implementing these standardized surveys in saltmarshes across North America will help document regional and continental patterns in distribution and abundance of all birds associated with tidal marshes.

Key Words: monitoring, saltmarsh birds, saltmarsh endemics, tidal marsh.

UNA ESTRATEGIA UNIFICADA PARA MONITOREAR CAMBIOS EN LA ABUNDANCIA DE AVES ASOCIADAS CON LAS MARISMAS DE MAREA DE NORTE AMÉRICA

Resumen. Un enfoque efectivo para la conservación de especies incluye esfuerzos para prevenir que las especies se conviertan en peligro de extinción antes de que se enlisten como amenazadas. Esfuerzos de monitoreo estandarizados proveen de datos necesarios para estimar trayectorias de las poblaciones de muchas especies, es por ello que las agencias de manejo pueden identificar especies en declive antes de que alcancen el punto de amenazadas. Las especies que se presentan en marismas saladas en Norte América se encuentran sub muestreadas por programas existentes de monitoreo de amplia escala. Resumimos esfuerzos de muestreos locales y regionales existentes para aves de marismas saladas y proponemos un protocolo continental estandarizado para la valoración del estatus y tendencias de población de aves que se reproducen en marismas saladas en Norte América. El objetivo de este muestreo propuesto es crear una serie de esfuerzos interconectados de monitoreo, que proveerán información sobre el estatus y los cambios en el estatus de aves terrestres que viven en sistemas de marisma salada en Norte América. Describimos protocolos de campo detallados para muestreos de aves de marisma salada a través de Norte América. Recomendamos muestreos de conteo-punto matutinos con un periodo pasivo inicial de 5-minutos, seguido de un periodo de llamado por emisión. Los investigadores grabaron cada ave detectada (a pesar de la distancia) para todas las especies que se encontraban asociadas con marismas saladas y estimaron la distancia para cada individuo de ave detectada. Proveemos recomendaciones para distancia estandarizada entre puntos de muestreo adyacentes, cómo las repeticiones a través de los puntos son grabadas, el ritmo diario y de estación de los muestreos, la sincronía de muestreos relacionados a ciclos de marea, numero de muestreos replicados por año, y especies focales para este esfuerzo de muestro estandarizado. Los protocolos de muestreo recomendado incluyen métodos que permitan la estimación de varios componentes de probabilidad de detección, para que inferencias más fuertes puedan realizarse basándose en tendencias de datos contados. Explicamos por qué las recomendaciones de muestreo se hacen, para que los potenciales participantes entiendan el motivo de varios aspectos de los protocolos de muestreo. También proveemos formatos para datos de muestreo y un ejemplo de como llenar un formato para datos. Estos protocolos construidos basados en los *Protocolos de Monitoreo de Aves de Marisma Estandarizados de Norte América* fomentarán el interés en aquellos interesados en colorines de marisma salada (y otras aves de marisma salada) para conducir muestreos utilizando un protocolo estandarizado similar a aquel utilizado para aves de marisma sigilosas. Una estandarización de este tipo permitiría que los datos de los estudios enfocados en colorines de marisma salada fueran fácilmente de reunir con datos de estudios enfocados en aves sigilosas de marisma salada. Implementar estos estudios estandarizados en marismas saladas a través de Norteamérica ayudaría a documentar patrones regionales y continentales en la distribución y abundancia de todas las aves asociadas con marismas de marea.

Conserving endemic species diversity and preventing extinction and local extirpation are goals of many land-management agencies and non-profit organizations in North America. In the US, the Endangered Species Act (ESA) of 1973 protects species that are at the greatest risk of extinction. However, we cannot afford to wait until species are listed under the ESA to initiate recovery efforts. The average wait time between listing and approval of a recovery plan is currently unacceptably long (Tear et al. 1995) and additional species are listed as endangered faster than they can be recovered. Moreover, recovery efforts for listed species typically involve high costs and low probability of success (Tear et al. 1995). Population monitoring is critical to effective species conservation because monitoring allows us to identify problems before populations are threatened with extinction (Goldsmith 1991, Hagan et al. 1992). Indeed, early detection of declining populations allows more effective and less-costly recovery efforts (Green and Hirons 1991). Hence, a more effective and efficient approach to species conservation is to prevent species from becoming endangered in the first place (Miller 1996). This approach requires identifying declining species before they become endangered.

Standardized monitoring efforts provide the data necessary for more scientifically credible listing and de-listing decisions (Gerber et al. 1999). Accurate estimates of population trajectory can save management agencies money and reduce contentious interactions with industry and the general public (Gerber et al. 1999). Large-scale monitoring efforts such as the North American Breeding Bird Survey (BBS) have been useful at identifying declining species before they reach the point of endangerment. The BBS has been useful in helping target management efforts towards several species of terrestrial birds that were declining throughout their range. But the BBS does have limitations—limited success estimating population trends for species or subspecies with restrictive distributions and/or those that have very narrow habitat requirements. Hence, we need to develop standardized monitoring efforts that focus on species or vegetative communities that are not sampled effectively by existing broad-scale monitoring efforts. A good example of an ecosystem that is under sampled by existing broad-scale monitoring programs and needs focused monitoring efforts is tidal saltmarshes in North America.

Tidal-marsh ecosystems in North America are unique in that they support numerous species and subspecies of endemic birds (Greenberg and Maldonado, *this volume*). However, while the number of hectares of saltmarshes in the US has declined by 30–40% (Horwitz 1978), we lack information on the status of saltmarsh birds because the BBS does not adequately sample birds in marshes (Bystrak 1981, Robbins et al. 1986, Gibbs and Melvin 1993, Sauer et al. 2000). The presence of taxa endemic to tidal marshes presents scientists and land managers with the responsibility of ensuring their persistence. Ensuring population viability of these unique species needs immediate attention due to anthropogenic treats to these environments. Indeed, a large number of bird species associated with tidal marshes are considered species of conservation concern, rare, threatened, endangered, or have already gone extinct (Pashley et al. 2000).

Many hectares of tidal marsh in North America have been altered or eliminated as a result of land reclamation, ditching, pesticide application, and other public-works activities. Relatively few studies have focused on saltmarshes despite the fact that these systems are often on publicly owned or protected land. The result is that one of the earth's most unique ecosystems has been allowed to deteriorate and the species associated with these systems have been comparatively unstudied. We need to increase our understanding of saltmarshes and the species they support because rising sea levels and increased mosquito control efforts pose immediate threats to many saltmarsh systems in North America.

Numerous local or regional avian monitoring efforts already exist in North American saltmarshes (Table 1). Most of the coordinated regional monitoring efforts in saltmarshes are restricted to vocal surveys (Erwin et al. 2002). However, other monitoring activities can provide additional information not possible with vocal surveys alone. For example, collecting capture-recapture or mark-resighting data is useful to estimate local population size (and annual survival). Monitoring demographic parameters associated with reproduction (e.g., nesting success and annual fecundity) can provide insight into proximate causes of population change and is useful for long-term studies tracking change over time at specific locations.

Point-count surveys where observers count the number of birds seen or heard during a fixed-time interval are commonly used to estimate population trends across a broad geographic area. Moreover, point-count surveys can be designed so that observers differentiate nest-departure calls (Greenberg 2003) from other vocalizations. Recording the number of nest-departure calls allows surveyors to provide an index of reproductive activity that could be compared across locations or over time. Ideally, a comprehensive monitoring program targeting saltmarsh birds would include point-count surveys to estimate population trends at broad geographic scales as well as nest monitoring and capture-recapture methods for estimating demographic parameters at specific locations. Studies comparing demographic parameters among sites undergoing different management treatments would be particularly helpful for incorporating the needs of saltmarsh birds into future management plans. Conducting long-term demographic studies in marshes that also are sampled as part of a broad-scale vocal survey effort has many benefits (i.e., provides a correlation between survey data and demographic parameters).

The purpose of this chapter is to outline standardized methods for assessing the status of birds that breed in saltmarshes. The objective of this proposed survey effort was to create a series of monitoring efforts that will provide information on the status and the changes in status of terrestrial birds living in saltmarsh systems of North America. We have information on current status of bird populations within only a few of the tidal systems in North America, and we lack appropriate data to estimate population trends (Shriver et al. 2004) or to compare avian abundance among tidal wetlands with any sort of confidence. In contrast, we have over 30 yr of count data from the BBS for assessing population trends for several hundred species of land birds. This document aims to encourage a monitoring effort that will help correct that discrepancy by establishing standardized surveys within tidal-marsh systems throughout North America.

The information contained here builds upon the protocols in Conway (2005) by encouraging those interested in saltmarsh passerines (and other saltmarsh birds) to conduct surveys using a standardized protocol similar to that being used for secretive marsh birds (i.e., rails, moorhens, gallinules, and bitterns). The standardized protocols in Conway (2005) focus on secretive marsh birds and over 100 organizations and biologists throughout North America are already conducting surveys following this protocol (Conway and Timmermans 2005, Conway and Nadeau 2006). However, most participants only record secretive marsh birds during their surveys. This document outlines standardized survey methods that focus on saltmarsh passerines such that these data can be collected simultaneously with surveys focusing on secretive marsh birds. The document also describes a standardized survey protocol for those only interested in surveying saltmarsh passerines. Standardization of this sort will allow data from surveys focusing on saltmarsh passerines to be easily pooled with data from surveys focusing on secretive marsh birds. Implementing these standardized surveys in saltmarshes across North America will help document regional and continental patterns in distribution and abundance of all birds associated with tidal marshes.

In addition to this protocol's broad-scale use to estimate population trends, we recommend that it also be used to inventory poorly known species or subspecies that breed in saltmarshes. Examples include the various subspecies of Savannah Sparrows (*Passerculus sandwichensis*) in coastal California and northwestern Mexico (Wheelwright and Rising 1993), the Coastal Plain Swamp Sparrow (*Melospiza geogiana nigrescens*) in the northeastern US (Greenberg and Droege 1990), the three subspecies of Song Sparrows (*Melospiza melodia*) that occur in tidal saltmarshes in San Francisco Bay, California (Marshall 1948a, b; Arcese et al. 2002), and the Eastern Black Rail (*Laterallus jamaicensis jamaicensis*), and California Black Rail (*L. j. coturniculus*; Eddleman et al. 1994, Conway et al. 2004). Many of the species targeted here have very patchy breeding distributions. The patchy distribution of these species needs to be taken into account when developing a sampling frame to implement these survey protocols.

The methods outlined here may still not be sufficient for some species of saltmarsh birds. For example, Saltmarsh Sharp-tailed Sparrows (*Ammodramus caudacutus*) and Black Rails rarely

TABLE 1. DESCRIPTION OF EXISTING AVIAN SURVEY EFFORTS WITHIN TIDAL SALTMARSHES IN NORTH AMERICA.

Name of survey effort	Target species	Surveyors record other species	Lead agency	Year effort began	Frequency	Location	N points or transects	Technique	Contact
Light-footed Clapper Rail Survey	Light-footed Clapper Rail	No	USFWS	1979	Annual	Southwestern CA, northern Mexico	n/a	Territory mapping	RZembal@ ocwd.com.
California Clapper Rail Survey	California Clapper Rail	Other rails	USFWS	1972	Annual or biannual	San Francisco Bay, CA	50–75	Winter high tide airboat survey; breeding call-broadcast survey	Joy_Albertson@ r1.fws.gov.
San Francisco Estuary Wetlands Regional Monitoring Program	All birds	Yes	PRBO Conservation Science	1996	Annual	San Francisco Bay, CA	>1,000	Point counts; territory mapping; demographic monitoring	mherzog@ prbo.org.
Belding's Savannah Sparrow Survey	Belding's Savannah Sparrow	No	USFWS	1986	Every 5 yr	Southern CA	n/a	Territory mapping	RZembal@ ocwd.com.
North American marsh bird Survey[a]	Rails, bitterns, grebes	Some do	USGS	1999	Annual	all North America	~4,200[b]	Point counts with call broadcast	cconway@ usgs.gov.
Coastal Plain Swamp Sparrow Survey	Coastal Plain Swamp Sparrow	No	Smithsonian	2000	Annual	Chesapeake and, Delaware Bays, MD, DE, NJ	141	Roadside point counts	GreenbergR@ si.edu.
Waterbird Monitoring Program at Cape Cod National Seashore	Secretive marsh birds	No	NPS	1999	Every 3–5 yr	Cape Cod National Seashore, MA	42	Point counts with call broadcast	Robert_Cook@ nps.gov.
New England Survey of Saltmarsh Birds	All saltmarsh birds	Yes	Massachusetts Audubon, Maine Dept. Inland Fisheries and Wildlife	1997	One time survey	ME, NH, MA, RI, CT	911	Point counts	gshriver@udel.edu

TABLE 1. CONTINUED.

Name of survey effort	Target species	Surveyors record other species	Lead agency	Year effort began	Frequency	Location	N points or transects	Technique	Contact
Gulf of Mexico Winter Survey of Saltmarsh Birds	Saltmarsh passerines	Yes	Mississippi Department of Marine Resources	2003	Annual	MS	17	Line transects during winter	msw103@ ra.msstate.edu.
Galilee Bird Sanctuary	All birds	Yes	University of Rhode Island	1993	Annual or biannual	Southern RI	31	Point counts	ppaton@URI.edu.
Region 5 National Wildlife Refuge Surveys of Saltmarsh Birds	All birds (emphasis waterbirds)	Some do	USGS, USFWS	2000	Annual	DE to ME	30–40	Spring, fall winter point counts, walking transects	rme5g@c.ms.mail. virginia.edu
North American Breeding Bird Survey	All birds	Yes	USGS	1966	Annual	All North America	~300	Roadside point counts	kpardieck@ usgs.gov.

[a] Incorporates the survey strategy described in this document.
[b] Includes all points including those in freshwater marshes.

vocalize. For Black Rails, we recommend use of call-broadcast surveys to increase vocalization probability. The methods for such broadcasts are discussed in Conway (2005). For Saltmarsh Sharp-tailed Sparrows, a second phase of more intense monitoring methods may need to be added in locations where these hard-to-detect species breed. For example, line-transect surveys that radiate out from each survey point could be used at a subset of marshes whereby observers record the number of birds detected while walking the line transects.

SURVEY AREA AND DEFINITION OF ANALYSIS UNITS

This document is meant to provide guidance to those wishing to conduct surveys for diurnal passerine birds within any tidal marsh in North America from Mexico north through Canada. These protocols are intended to be useful for monitoring birds in marshes dominated by shrubs, emergent wetland plants, and grasses, but not mangrove wetlands. As with all survey efforts, one must define the size of the smallest unit of land that will be analyzed for population changes. The size of that land unit, along with the statistical issues of precision, accuracy, and the analytical model used to calculate change will dictate how many samples the monitoring program will need to meet program objectives. We envision that the smallest analysis unit for this monitoring effort is formed from ecological units of saltmarshes, sometimes bounded by state and provincial boundaries. The list includes natural groupings of saltmarshes based on location and natural history. The following list of potential regions for monitoring birds associated with saltmarshes includes all the major tidal systems on the continent (this list does not imply priority or rank): southeastern Alaska and British Columbia; Strait of Georgia-Puget Sound; coastal Washington to Northern California; San Francisco Bay (with Suisun, San Pablo Bay, and south and central San Francisco Bay subregions); southern California; Baja, and Gulf of California (including Sonora and Sinaloa coastal plains plus Nayarit Marismas Nacionales); Pacific Coast from Jalisco to Chiapas; Gulf of Mexico coast from Rio Bravo (Grande) to Rio Tonala; Tabasco and Campeche Wetlands; Yucatan Peninsula coastal wetlands (including Cozumel); coastal Texas and Louisiana; Mississippi Delta; coastal Mississippi and Alabama; Gulf Coast of Florida; Atlantic Coast of Florida; coastal Georgia; coastal South Carolina; coastal North Carolina and Virginia north to the Chesapeake Bay; western shore of the Chesapeake Bay; eastern shore of the Chesapeake Bay; coastal Virginia, Maryland, and Delaware north of the Chesapeake Bay; Delaware portion of the Delaware Bay; New Jersey portion of the Delaware Bay; coastal New Jersey and Long Island; Long Island Sound; Rhode Island east to Cape Cod's south shore including Martha's Vineyard and Nantucket; outer Cape Cod, Cape Cod Bay, and north to the Gulf of Maine; coastal Nova Scotia; Bay of Fundy; Gulf of Saint Lawrence excluding Newfoundland; and Newfoundland.

Sub-sampling within any of these units can provide detailed information at smaller scales such as individual states, counties, and refuges within each saltmarsh system. Our purpose here is to recommend a sampling methodology so that data can be shared and compared among saltmarsh systems in different parts of the continent. If biologists use different approaches to survey marsh birds within each saltmarsh system, then estimates of parameters such as relative abundance are not comparable among areas. Moreover, standardization of survey methods improves efficiency of data sharing and data management. For rare species that are of regional or national conservation concern, we may ultimately need to combine all available survey data (regardless of the survey methods used) to generate a trend estimate. We need careful planning and standardization to insure that all available survey data can be pooled to yield regional or range-wide estimates of population trends. Conforming to a standard sampling protocol may require compromises, but participants benefit by allowing them to put their results into a regional perspective and having the data they collect add to our understanding of marsh-bird dynamics at regional and continental scales.

MONITORING APPROACH

Point-count surveys have been the most common method used to monitor land birds in North America. For marsh birds, some efforts have incorporated call-broadcast, distance estimates, and fixed-radius circular plots into the basic technique of counting birds from a single point (Conway and Gibbs 2005). Line-transect surveys and plot-based searches, i.e., spot mapping, are alternative methods of monitoring marsh birds, but point-count surveys provide the most efficient way of monitoring population trends of marsh birds across a large geographic area and allow survey data to be pooled with data collected for secretive marsh birds (Conway 2005).

Participants at the October 2003 workshop on tidal-marsh vertebrates agreed that the methods outlined here should constitute the minimum information collected by everyone working on marsh birds in tidal systems. Individual collaborators may decide or agree to collect additional information pertinent to each area or each set of study objectives, but participants felt that these core variables were sufficient to meet the goal of creating statistically-informative indices relevant to determining the status of tidal-marsh birds:

1. Conduct initial 5-min passive point-count surveys at each survey point followed by a period of call-broadcast.
2. Record all individuals detected (irregardless of distance) for all species that are associated with saltmarshes (Appendix 1).
3. Record each individual bird detected on a separate data line and record whether each bird was heard and/or seen (and whether each was flying over).
4. Estimate the distance to each bird detected.
5. Include a column for repeats, so that observers can denote an individual bird detected at a point that is thought to be one that was already counted at a previous point.
6. Count only birds heard or seen in the tidal marshes (or flying over the marsh) even though upland areas may be within the counting radii.
7. Count only from dawn to 3 hr after dawn. Surveys conducted within the first 2 hr after dawn are optimal because detection probability of many species tends to decline after that, but detection remains relatively high for many species for 3 hr after dawn.
8. Use 400 m between adjacent points. If a participant wants adjacent points to be closer than 400 m due to local reasons, we recommend they use increments of 400 m (i.e., 200 m). Distance between adjacent points must be ≥200 m if a participant wants to calculate density estimates based on number of birds detected within a 100-m radius of each point.
9. Begin surveys after the bulk of spring migration for resident marsh birds has occurred (typically sometime between early March and mid-June depending on latitude) and should be completed prior to the date when detection probability of target species declines (typically sometime between May and early July depending on latitude and species of interest). In general, surveys should be conducted when calling frequency is highest for focal species. For many tidal-marsh systems this is a survey window of approximately 5 wk. Potential participants are encouraged to contact one of the authors for information on optimal survey timing in their region.
10. Surveys should occur during the first week following a high spring tide because many saltmarsh passerines are forced to renest and detection probability is high following these high tides.
11. Immediately following the 5-minute passive survey, broadcast calls of secretive marsh birds to elicit vocalizations of rails, bitterns, and other secretive marsh birds. See Conway (2005) for explanation of format for call-broadcast.
12. For secretive marsh birds, record whether or not each individual bird was detected during each 1-min interval during both the passive and call-broadcast periods. See Conway (2005) for list of secretive marsh birds. For saltmarsh passerines and other marsh birds, participants should only record detection data within the 1-min intervals if doing so is logistically feasible in their study area. Recording non-marsh species should be avoided as it takes time away from estimating distance for the focal species.

The data produced from these surveys will provide analysts with several options for calculating abundance indices, trend estimates, and detection probability based on the raw counts. An example of a completed data sheet for these survey efforts is attached (Appendix 2).

Because the variability in counts of birds is usually greater among points than within points, surveying more points is sometimes a better strategy for estimating population change than conducting repeated surveys at a smaller number of points (Link et al. 1994). However, other benefits are associated with conducting replicate surveys at each point. Conducting replicate surveys per year at each point expands the possible number of analyses that can be performed on the count data. Replicate surveys reduce the variance of the counts, permitting a more precise measurement of any changes to the index. Replicate surveys are especially useful during the first few years of a monitoring effort so analysts can learn more about the factors affecting these counts and to provide a basis for estimating the sample size needed to detect changes in abundance for target species. Once several years of data are collected in various tidal marshes across North America, analysts can determine the value of replicate surveys for monitoring and make appropriate adjustments to the standardized protocol. Having repeated counts also allows analysts to estimate the number of points that should have detected the species out of the collection of points that never once recorded the species (MacKenzie et al. 2002). Moreover, recent analyses indicate that repeated counts at points can be used to create another estimate of the average abundance of birds across a set of points (Kéry et al. 2005).

Participants should conduct three surveys annually during the presumed peak breeding season for marsh birds in their area. Each of the three replicate surveys should be conducted during a 10-d window, and each of the 10-d windows should be separated by 5 d. Seasonal timing of these three replicate survey windows will vary regionally depending on migration and breeding chronology of the primary marsh birds breeding in an area.

Participants should focus on bird species that breed in association with saltmarsh vegetation (Appendix 1). Individuals of these species flying over the marsh and individuals along the marsh-upland edge will also be counted. We also encourage participants to use methods similar to those outlined here to conduct winter surveys for saltmarsh passerines. Our knowledge of distribution, habitat use, and population trends during winter is poor for most saltmarsh passerines. Some examples of possible response variables that the resultant survey data would produce include:

1. An index of abundance based on the total number of birds detected (regardless of distance) along a survey route or within a marshland.
2. An index of breeding density based on the numbers of birds detected within a certain radius (i.e., 50 or 100 m) of each point.
3. An estimate of breeding density based on distance sampling to correct for the fact that detection probability typically declines with distance from the surveyor.
4. An estimate of breeding density that incorporates both distance sampling and capture-recapture models (based on data from the five 1-min intervals) to account for detection probability being less than 100%.

Additional indices and methods for accounting for variation in detection probability are possible if all (or a subset) of points are surveyed three (or more) times per year. Replicate surveys at a point can provide estimates of site occupancy and estimates of the probability of missing a species at a point where it is indeed present (MacKenzie et al. 2002). Replicate surveys at a point also provide a method of calculating the percent area occupied by each species. For these reasons, we recommend that participants conduct three replicate surveys per year at each point (but those who are only able to conduct one or two replicate surveys per year are still encouraged to participate and follow these survey methods).

Several factors are known to affect detection probability of birds in tidal marshes. Some of these factors can be measured and accounted for during the data-analysis stage either by eliminating survey data that do not meet minimal conditions or adding the factor as a covariate in the analyses. Below is a list of necessary information that needs to be collected at each point.

Ancillary Information at Each Point

In addition to using standardizing methods for conducting bird surveys in marshlands, we recommend that surveyors collect ancillary information (e.g., salinity of water, moon phase, tide stage, water depth, vegetation measurements, and current or ongoing management actions) at each survey point. These ancillary data may help document patterns of association between bird populations and geographic locations, habitats, and management actions. Such patterns may help generate hypotheses regarding possible causes of population change. Required ancillary information: (1). date, (2). name of marsh or study site, (3). full name of surveyor, (4). survey number (whether current survey is the first, second, or third at that point this year), (5). unique station number identifying the location of the point count, (6). latitude and longitude to four decimal places using a GPS receiver, (7). start time, (8). wind speed (Beaufort Code), (9). ambient temperature, (10). percent cloud cover, (11). amount of precipitation during past 24 hrs, (12). days since last full moon, (13). time of last high tide, (14). salinity of water, (15). an estimate of distance to each bird detected, (16). type(s) of call given, (17). water depth of the marsh at the time of the survey, and (18). characterization of plant-species composition and land-use types within a 50-m radius of each survey point. Information on plant species and land-use should be recorded annually if possible, but at least once every 5 yr. See Conway (2005) for more details on recording plant composition and land-use data at each survey point.

Rationale for Ancillary Information

Weather variables

Wind speed, ambient temperature, percent cloud cover, and amount of precipitation during the past 24 hr are factors that can influence vocalization probability of marsh birds (Conway and Gibbs 2001, 2005) and the ability of observers to hear marsh-bird calls. Hence, recording these parameters can help explain some variation across years in number of marsh birds counted.

Moon phase

Amount of moon light can potentially affect detection probability of some marsh birds. For example, the number of Black Rails detected on surveys in California was positively correlated with amount of moon light the preceding night (Spear et al. 1999). Relatively few studies have examined the influence of moon phase on detection probability of saltmarsh birds, so recording the number of days since last full moon in a broad-scale monitoring effort will provide guidance for revised protocols and future survey efforts.

Tide stage

Stage of the tidal cycle can potentially affect detection probability and habitat occupancy of some marsh birds. For example, the number of Black Rails detected on surveys in California was negatively correlated with tide height (Spear et al. 1999). Tide stage can also affect access to some saltmarshes. Relatively few studies have examined the influence of tide stage on detection probability of saltmarsh birds, so including this parameter in a broad-scale monitoring effort will provide guidance for revised protocols and future survey efforts. Until more information is available on the effects of tide stage, surveys in tidal marshes should always be conducted at a similar tidal stage at each point for each replicate survey both within and across years. The tidal stage within which to conduct local marsh-bird surveys should be based on when highest numbers of marsh birds are likely to be detected in your area; optimal tidal stage for surveys may vary among regions. Many saltmarsh passerines are forced to renest during the peak spring high tide, and detection probability for these species is highest during the week after a high spring tide (Shriver 2002). Clapper Rail (*Rallus longirostris*) surveys have been conducted during high tide since 1972 at San Francisco Bay National Wildlife Refuge, but high tide was a period of reduced vocalization probability for Clapper Rails in southern California (Zembal and Massey 1987) and for Black Rails in northern California (Spear et al. 1999). Current guidelines for conducting Clapper Rail surveys in San Francisco Bay suggest that surveys should not be conducted during high tides or during full moon periods and should be conducted when tidal sloughs are no more than bank full (M. Herzog, Point Reyes Bird Observatory, unpubl. data). As a general guideline, surveys in tidal marshes should not be conducted on mornings or evenings when high or low tide falls within the morning (or evening) survey time period. We need additional research designed to quantify the effects of tide stage on detection probability for all species of saltmarsh birds. Conway and Gibbs (2001) provide a review of previous studies that have examined the effects of environmental factors on detection probability of secretive marsh birds.

Salinity of water

Salinity varies spatially both within and among marshes and can also vary over time. Participants are encouraged to record the salinity content of the water directly in front of each point on each survey. Salinity level may affect a site's use by certain species. Such information is relatively easy to collect and can be used as a covariate to control for variation in models estimating population change. Handheld salinity meters are available for <$30.

Distance to each bird

Surveyors should estimate the distance to every bird detected at each point with no maximum limit or upper threshold. Recording the distance to a calling bird that is not visible will often require the surveyor to provide a rough estimate of distance based on the volume of the call. Obviously these distance estimates will not always be accurate, but with a large pooled sample size the pooled data set can be used to produce a distance-detection function for each species which will allow the estimation of detection probability using distance-sampling methodology. We realize that distance estimation is difficult and accuracy of any one distance estimate is suspect. That is acceptable. Surveyors should just try to ensure that they are not always underestimating or always overestimating distance to birds. Participants should note in the comments column of the data sheet their perceived accuracy of their distance estimates. Having observers put each bird into distance categories (rather than estimate distance) may make them feel a little better, but the potential for bias is still the same (analyses will require that we make the distance variable continuous and use the mid-point of each category). Estimating whether a bird is 80–100 or 100–120 m away is just as problematic as estimating actual distance to each bird. We can always convert distance estimates to distance categories after the fact if observers estimate distance. Ultimately, some analysts may use the count data while ignoring the distance data and others can use the distance data for what it is worth. See Conway and Nadeau (2006) for more information on rationale for estimating distance to each bird.

Call type

Including the types of calls given by each bird detected allows analysts to account for variation among observers in their ability to identify different calls and account for the fact that the probability of detection differs among different call types. Controlling for call type may improve our ability to estimate population trends across time by accounting for variation in observers' ability to identify species' calls. Each focal species of secretive marsh bird has two–five common calls. Some of these calls are loud, raucous, easy to learn, and unique (easy to hear at a great distance and difficult to confuse with other calls). Others are soft or easy to confuse with other species' calls. Hence, the observer detection probability for a particular species likely differs depending on the type of call given. Recording the call(s) given by each bird allows observers to estimate population trends of a particular species in several ways: (1) using all detections regardless of call given, (2) restricting the analysis to include only birds that gave the most common call for that species, or (3) restricting the analysis to include only birds that gave the most distinguishable call for that species. Data on calls given by each species can also help account for the potential bias associated with long-term surveys if the timing of the breeding season changes over time. Many marsh birds have particular calls (e.g., the Virginia Rail's [*Rallus limicola*] *ticket* and the Clapper Rail's *kek*) that are only given during the pairing and early mating season. The proportion of these calls relative to calls given by mated pairs (e.g., the Virginia Rail's *grunt* and the Clapper Rail's *clatter*) can provide a basis for testing whether the timing of the breeding season has changed over time and whether or not surveys were conducted during the same stage of the breeding cycle in different locations. These data can also be used to refine the seasonal survey windows in the continental protocol so that surveys are conducted during the same stage of the breeding cycle in each region of North America (to the extent possible).

Water depth

Water depth affects the suitability of a marshland for many species of marsh birds and water depth can change over time in response to both natural and anthropogenic processes. Recording water depth during each survey can help explain some of the variation in the number of birds counted each year. Water depth is known to affect abundance of marsh birds and water depth in marshlands often varies greatly across years and even across replicate surveys within a year. Recording water depth will allow analysts to use this important parameter as a covariate in models used to estimate population change. To do so, place a permanent device for recording water depth within each marsh at which surveys are conducted and record water depth before or after each survey (i.e., before the first survey point or after the final survey point on each morning that surveys are conducted).

Plant species composition and land use

Participants should include information on the management actions (spraying, burning, draw downs, or other management activities that might affect bird abundance) that have recently occurred in the 100-m radius surrounding each point. Participants should also document plant composition surrounding each survey point. Plant composition within a tidal marsh naturally changes over time. The rate of such changes may increase due to predicted increases in sea levels. Changes in plant composition within tidal marshes may also be exacerbated by man-made hydrological changes resulting from such actions as manipulation of sediment deposition, changes in nutrient inputs, changes in farming practices in the surrounding landscape, and manipulation of the way water enters and exits a marsh. Characterizing the changes in plant composition surrounding each survey point will allow analysts to determine whether changes in bird abundance are correlated with changes in plant composition. Similarly, recording the date of management actions (spraying, burning, draw downs, or other management activities that might affect bird abundance) that have recently occurred in the 100-m radius surrounding each point will allow analysts to determine whether certain management actions adversely affect marsh-bird populations.

A recommended, but optional, component in each survey area involves the use of multiple observers at a subset of surveys (Conway and Nadeau 2006). The double-observer technique (Nichols et al. 2000) is a very useful way of detecting differences in observer detection probability (i.e., observer bias) among surveyors. However, it does have the drawback of requiring that two observers be present at a point. Moreover, the method only corrects for biases associated with differences caused by observer bias. Because many people travel in marshes in pairs there will be times when no additional person-hours would be required to conduct double-observer surveys. Double-observer surveys are also a very useful method of determining whether newly trained surveyors are ready to conduct surveys independently. Comparing survey results after a survey is complete provides a useful means of giving surveyors feedback on particular species or groups of species for which they need more practice. Double-observer surveys do not need to be conducted at every point and participants may want to conduct these surveys at a subset of points each year to have estimates of observer bias and to identify individuals who have poor hearing or low detection abilities.

SAMPLING METHODOLOGY

Conducting surveys in tidal marshes can present some logistical difficulties. Many tidal marshes are in remote locations, terrain can be treacherous, access is often limited, and changing tides can pose challenges for coordinating safe entry and departure routes. Consequently, conducting surveys at a system of point-count stations placed randomly or systematically throughout a large tidal marsh would be logistically difficult in many systems. Hence, workshop participants explored alternative approaches for locating survey stations within a tidal marsh. Participants discussed five alternative sampling methodologies: (1) random or systematic selection of points, (2) roadside access points, (3) water access points, (4) points within interior marsh, and (5) points placed at special locations.

Locating points via some form of random or systematic approach is ideal. Spatial variation in marsh-bird abundance is typically high within a marshland; birds are often clumped within particular areas. Points can be stratified to account for difficulty of access, patterns of marsh vegetation, hydrology, or perceived importance of particular areas within the marshes in a region (e.g., marshlands on national wildlife refuges). Using a systematic grid placed over a map of the marshland to locate sampling points is a good way to ensure that a marshland is adequately sampled. Tide stage affects behavior of saltmarsh birds and needs to be considered when choosing locations of survey points.

Roadside access points can be used effectively in situations where roads come in close contact with marshlands. Examples include bridge crossings, roads through marshlands, boat-access points, and impoundment roads. Conducting point-count surveys at roadside access points has numerous logistical benefits. These areas are usually easily accessible, safe, dry, and appealing to potential surveyors. However, using roadside-access points to survey tidal-marsh birds causes large sections of interior marshland to go un-sampled and prevents analysts from making inferences to the entire marshland. One compromise would be to include some roadside- and water-access points and some interior-marsh points. Survey points along roadsides and waterways should be established at 400-m intervals along all roads and waterways within the marshland. If all of the points cannot be surveyed, the participant should subdivide the marshland into sectors such that each sector has an equal number of potential survey points. The participant should then randomly select which of the sectors will be sampled and all suitable points in that sector should be sampled. Because the location of suitable marsh vegetation can change over time, participants may need to add additional survey points (but never eliminate points) in future years to ensure that all suitable areas within the sector are sampled. If the marsh vegetation surrounding a pre-existing survey point is no longer present (and hence the area is no longer suitable for any marsh birds), surveyors should record the point on the data form and note that the survey was not conducted because of insufficient habitat. One difficulty with water-access points is that marshes can sometimes overtake small channels or open water areas, making it difficult for surveyors to access these points in future years.

Any location within a marsh that is not within 400 m of a road or an accessible waterway (a somewhat arbitrary distance beyond which many birds cannot be heard from a point) is considered un-sampled marsh interior. These areas need to be defined and then sampling locations can be regularly spaced throughout as a way to supplement or complement roadside and water access points. The spacing and number of points will be determined by the sample size requirements for the region and the ease by which those points can be sampled.

Participants may also want to survey special places, either because they are known to be important areas for target species or because they are of interest for special management or research efforts. Departures from regular spacing or surveying special places outside of a defined sampling frame would either need to have a statistical justification (such as a stratification scheme) or the additional points treated separately during analysis. For example, it is completely appropriate to put in a point at a spot simply because that location is known to have high numbers of birds. Indeed, you might have some high counts or discover rare species there, but that point would have to be treated separately in analyses.

An investigator or group of investigators may employ any combination of the five sampling approaches discussed above, but the results from those surveys must always be tempered by an explicit reminder of the limits to the inferences which can be made using each of these approaches. Moreover, participants need to record explicitly how each survey point was identified and to which of the five sampling approaches that point contributes. This information needs to be in the database and will be very important to analysts who will need to know the scope of inference possible from the data collected at each site.

Reviewing the consequences of using any of these five different sampling strategies using geographic information system (GIS) overlays is recommended. The portions of marshlands that would go un-sampled using any of the above combinations of sampling strategies and the relative costs in terms of number of points and access time will be more apparent. This approach would allow sampling alternatives to be scrutinized prior to the start of sampling.

NUMBERS OF SAMPLING POINTS

Determining optimal or sufficient sample sizes for a region requires someone to estimate the temporal variability of the proposed counts, choose a period of years over which estimates of change are desired, define the minimum amount of change in population size that is thought to be important to detect, define the minimum levels of statistical precision needed to detect those changes, and choose an analytical approach to measuring change that permits sample sizes to be estimated using some form of power analysis. Hence, an estimate of the number of sampling points needed to estimate trends in saltmarsh birds is not currently possible, but will be available once various individuals collect data following this protocol.

The ability to yield range-wide trend estimates largely depends on the sampling frame used to locate survey points, the number of points surveyed that detect more than one individual of a particular species, and variation in detection probability of that species. This manuscript summarizes a standardized survey method, and does not address or make recommendations regarding the number of survey points at which this protocol will or should be used.

CONDUCTING SURVEYS FOR SALTMARSH PASSERINES ONLY

A standardized marsh-bird monitoring protocol that targets rails, bitterns, and other secretive marsh birds (Conway 2005) is already developed and being used by hundreds of biologists in a variety of federal, state, and nongovernmental organizations across North America (Conway and Nadeau 2006). This marsh-bird monitoring effort includes the use of call broadcast to increase detection probability for certain species that are otherwise difficult to detect. Individuals currently participating in this program have the option of recording all marsh birds, including those not on their broadcast sequence (e.g., saltmarsh passerines). Hence, individuals wanting information on saltmarsh passerines are encouraged to include a call-broadcast portion following the initial 5-min passive point count so that their data will be compatible with other marsh-bird surveys in their region. However, some organizations or biologists may not want to include call-broadcast for certain reasons. These individuals are to follow the survey methods outlined here for the first 5-min passive point-count survey. Doing so will allow their data to be comparable to the initial 5-min of data from other marsh-bird survey efforts. Substantial benefits come from having all individuals conducting surveys within both fresh and saltwater marshes in North America using as similar methods as possible. Organizations interested in potentially conducting avian surveys within any marshland system in North America are encouraged to contact the authors of this paper to discuss standardization of survey methods and the extent to which they can or cannot follow the protocols outlined in this document.

PERSONNEL AND TRAINING

All observers should have the ability to identify all common calls of marsh-bird species in their area. Observers should listen to recorded calls of the species common in their area and also practice call identification at marshes (outside the intended survey area if necessary) where the common species in their region are frequently heard calling. All observers should take and pass a self-administered vocalization identification exam each year prior to conducting surveys. All observers should also be trained to estimate distance to calling marsh birds, and to identify the common species of emergent plants on their area. Methods for training observers to estimate distance include: (1) broadcast calls in the marsh at an known distance and have observers estimate distance, (2) choose a piece of vegetation in the marsh where the bird is thought to be calling from and use a range finder to determine distance, and (3) have an observer estimate the distance to a bird that is calling with regularity and is near a road or marsh edge, have a second observer walk along the road or edge until adjacent to that calling bird, and then measure this distance by pacing or use of a GPS receiver. Surveyors should use some combination of these three methods prior to the survey season to practice estimating distances to calling birds. Double-observer surveys are very useful in this regard. After a survey is complete, the two observers can discuss not only what species they heard, but how far each person estimated the distance to each bird. Periodic double-observer surveys not only produce estimates of observer bias but also allow participants to determine whether one person is constantly underestimating or overestimating distance to calling birds. All surveyors should also have a hearing test at a qualified hearing or medical clinic before, during, or immediately after the survey season each year. These data can be included as a covariate and will help control for observer bias in trend analyses. New participants should do at least one trial run before their first data-collection window begins because it takes time to get used to the data sheet and recording the data appropriately.

EQUIPMENT AND MATERIALS

If possible, fixed survey points should be permanently marked with inconspicuous markers and numbered. Portable GPS receivers should be used to mark survey points onto aerial maps. GPS coordinates of each permanent survey point should be recorded and saved for reference in future years. A compact disc (CD) with calls of secretive marsh birds in your area should be obtained from the first author of this document (C. Conway) and new CDs should be requested if quality declines. CD players and amplified speakers should be good quality and batteries should be changed or re-charged frequently (before sound quality declines). Participants should routinely ask themselves if the quality of the broadcast sound is high. Observers should always carry replacement batteries on all surveys. A sound level meter with ±5 dB precision (Radio Shack model #33-2050 for $34.99; or EXTECH sound-level meter, $99 from Forestry Suppliers, Inc.) should be used to standardize broadcast volume. A small boat or canoe may be useful for surveying larger wetland habitats adjacent to open water, reducing travel time between survey points. When using a boat, use the same boat and engine on each survey each year to control for possible effects of engine noise on detection probability. If a different boat or different engine is used, make a note of the change in the comments column on the datasheet (Appendix 2). A spare CD player should be carried in case the primary unit fails to operate. A prototype field data form for use on vocal surveys is attached to this document (Appendix 2). The number of columns on the datasheet will vary among survey areas depending on the number of bird species included in the call-broadcast segment of your survey so participants will have to tailor the datasheet below to suite their own broadcast sequence. Contact the first author for an electronic copy of the data form.

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This document is based on many discussions with researchers, managers, and biometricians on the need and the optimal methods for improved monitoring of all birds associated with marshlands. In particular, the participants of the marsh-bird monitoring workshop held in 1998 (Ribic et al. 1999), the participants of the tidal-marsh vertebrate workshop held in October 2003, and the encouragement of J. Taylor from Region 5 of the USDI Fish and Wildlife Service, laid the groundwork and created the impetus for holding a workshop on creating a system of tidal-marsh-bird surveys. C. Hunter, J. Bart, R. Greenberg, and C. Marti provided helpful comments that improved the manuscript.

APPENDIX 1. SALTMARSH BIRD SPECIES (AND BIRD BANDING LABORATORY ALPHA CODES) OF PARTICULAR IMPORTANCE FOR SURVEYS. SEE CONWAY (2005) FOR COMPLETE LIST OF MARSH BIRDS (THOSE ASSOCIATED WITH BOTH FRESHWATER AND SALTWATER MARSHES).

AMBI	American Bittern	*Botaurus lentiginosus*
LEBI	Least Bittern	*Ixobrychus exilis*
GRHE	Green Heron	*Butorides virescens*
GBHE	Great Blue Heron	*Ardea herodias*
TRHE	Tricolored Heron	*Egretta tricolor*
LBHE	Little Blue Heron	*Egretta caerulea*
SNEG	Snowy Egret	*Egretta thula*
GREG	Great Egret	*Ardea alba*
CAEG	Cattle Egret	*Bubulcus ibis*
YCNH	Yellow-crowned Night Heron	*Nyctanassa violacea*
BCNH	Black-crowned Night Heron	*Nycticorax nycticorax*
GLIB	Glossy Ibis	*Plegadis falcinellus*
WFIB	White-faced Ibis	*Plegadis chihi*
WHIB	White Ibis	*Eudocimus albus*
NOHA	Northern Harrier	*Circus cyaneus*
OSPR	Osprey	*Pandion haliaetus*
BLRA	Black Rail	*Laterallus jamaicensis*
YERA	Yellow Rail	*Coturnicops noveboracensis*
SORA	Sora	*Porzana carolina*
VIRA	Virginia Rail	*Rallus limicola*
CLRA	Clapper Rail	*Rallus longirostris*
BNST	Black-necked Stilt	*Himantopus mexicanus*
WILL	Willet	*Catoptrophorus semipalmatus*
WISN	Wilson's Snipe	*Gallinago delicata*
FOTE	Forster's Tern	*Sterna forsteri*
BEKI	Belted Kingfisher	*Ceryle alcyon*
SEWR	Sedge Wren	*Cistothorus platensis*
MAWR	Marsh Wren	*Cistothorus palustris*
COYE	Common Yellowthroat	*Geothlypis trichas*
SSTS	Saltmarsh Sharp-tailed Sparrow	*Ammodramus caudacutus*
NSTS	Nelson's Sharp-tailed Sparrow	*Ammodramus nelsoni*
SESP	Seaside Sparrow	*Ammodramus maritimus*
SOSP	Song Sparrow	*Melospiza melodia*
SWSP	Swamp Sparrow	*Melospiza georgiana*
SAVS	Savannah Sparrow	*Passerculus sandwichensis*
RWBL	Red-winged Blackbird	*Agelaius phoeniceus*
BTGR	Boat-tailed Grackle	*Quiscalus major*
GTGR	Great-tailed Grackle	*Quiscalus mexicanus*

APPENDIX 2. Example of completed data form for marsh bird surveys in North American tidal marshes.

Marsh Bird Survey Data Sheet

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

Name of marsh or route : Hidden Shores Marsh

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

Survey replicate # : 2

Water depth (cm): 12

Salinity content (ppt): 20

	Before	After
Temperature *(°F)*:	10	21
Wind speed *(mph)*:	0	1
Cloud cover *(%)*:	15	60
Precipitation:	none	none
Days since full moon:	5	
Time of last high tide:	0513	

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

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

Station#	Start Time (military)	Background noise	Species	Responded During:											# Detected	Call Type(s)	Direction	Distance (m)	Detected at a Previous Point	Comments
				Before	Pass 0-1	Pass 1-2	Pass 2-3	Pass 3-4	Pass 4-5	BLRA 5-6	LEBI 6-7	VIRA 7-8	CLRA 8-9	After						
HSM1	0610	0	BLRA		1	1				1						grr		95	N	
			RWBL		1	1	1	1	1							song		20	N	
			SOSP		1		1									song		45	N	
			BLRA			1				1	1	1	1	1		kkkerr		110	N	
			SOSP			1	s	1								song		80	N	
			VIRA				1s					1				ticket, grunt		30	N	
			SWSP					1								NDC		12	N	

APPENDIX 2. CONTINUED.

HSM2	0621	1	CLRA	1												p-cltr		40	N	
			CLRA	1												p-cltr		45	N	
			VIRA									1				grunt		100	Y	
			CLRA											1		Throaty hoo		10	N	
HSM3																				*Not surveyed; no habitat*
HSM4	0650	1	COMO		1	1	1		1		1		1			wipeout		150	N	
			MAWR		1	1			1s							song		10	N	
			MAWR		1s	1s	1	1	1							song		40	N	
			MAWR		1		1									call		65	N	
			MAWR			1			1							song		120	N	
			SORA									1				perweep		210	N	
			RWBL												16					too many to list by line
HSM5	0705	2																		*No birds detected*

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

If the call type is not one of the above listed types, describe the call in the comments column. See Conway (2005) for complete list of call types.

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