A Unified Strategy for Monitoring Changes in Abundance of Terrestrial Birds Associated with North American Tidal Marshes

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Introduction

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 United States, 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. The BBS has had 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 undersampled by existing monitoring programs and needs focused monitoring efforts is tidal salt marshes in North America.

Tidal marsh ecosystems in North America are unique in that they support numerous species and subspecies of endemic birds (this volume). However, while the number of hectares of salt marsh in the U.S. has declined by 30-40% (Horwitz 1978), we lack national information on their status 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; this volume).

Many acres 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 salt marshes 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 salt marshes and the species they support because rising sea levels and increased mosquito control efforts pose immediate threats to many salt marsh 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 salt marshes are restricted to vocal surveys. However, other monitoring activities can provide additional information not possible with vocal surveys alone. For example, collecting capture-recapture or mark-resight data is useful to estimate local population size (and annual survival). Monitoring demographic parameters associated with reproduction (e.g., nesting success, annual fecundity) can provide insight into potential 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. 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 salt marsh 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 salt marsh 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 document is to outline standardized methods for assessing the status of birds that breed in salt marshes. 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 salt marsh 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 years of count data from the BBS for assessing population trends for several hundred species of landbirds. This document aims to encourage a monitoring effort that will help correct that discrepancy by establishing a set of complementary surveys within tidal marsh systems throughout North America.

The information contained here builds upon the *Standardized North American Marsh Bird Monitoring Protocols* (Conway 2004) by encouraging those interested in salt-marsh passerines (and other salt-marsh birds) to conduct surveys using a standardized protocol similar to that being used for secretive marsh birds (i.e., rails, bitterns, etc.). The Standardized North American Marsh Bird Monitoring Protocols (Conway 2004) focus on "secretive" marsh birds (i.e., rails, moorhens, gallinules, bitterns, etc.) and over 100 organizations and biologists throughout North America are already conducting surveys following this protocol (Conway and Timmermans 2004). However, most of these surveys are conducted in freshwater marshes, and most participants only record secretive marsh birds (rails, moorhens, gallinules, bitterns, etc.) during their surveys. This document outlines standardized survey methods that focus on salt-marsh passerines such that these data can be collected in concert (simultaneously) with surveys focusing on secretive marsh birds. The document also provides a standardized survey protocol for those only interested in surveying saltmarsh passerines. Standardization of this sort will allow data from surveys focusing on salt-marsh passerines to be easily pooled with data from surveys focusing on secretive marsh birds. Implementing these standardized surveys in salt marshes 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 salt marshes. Examples include the various subspecies of Large-billed Saltmarsh 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 U.S. (Greenberg and Droege 1990), the 3 subspecies of Song Sparrows (*Melospiza melodia*) that occur in tidal saltmarshes in San Francisco Bay, California (Marshall 1948a, 1948b; Arcese et al. 2002), and the Eastern (*Laterallus jamaicensis jamaicensis*) and California (*L. j. coturniculus*) Black Rail (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 salt marsh birds. For example, Saltmarsh Sharp-tailed Sparrows (*Ammodramus caudacutus*) and Black Rails rarely vocalize. For black rails, we recommend use of call-broadcast surveys to increase vocalization probability. The methods for such broadcasts are discussed in Conway (2004). 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

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.

The list below of potential regions for monitoring birds associated with salt marshes includes all the major tidal systems on the continent. They are not listed in an order that infers 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, South/Central SF 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
Atlantic Coast of Georgia
Coastal South Carolina
Coastal North Carolina and Virginia up 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
The outer cape, Cape Cod Bay, and north to the Gulf of Maine
Coastal Nova Scotia
Bay of Fundy
Gulf of Saint Lawrence excluding Newfoundland
Newfoundland

Definition of Analysis Units Within the Survey Area

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, 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 salt marshes, sometimes bounded by state and provincial boundaries. An initial list of possible analysis units is provided here. The list includes natural groupings of saltmarshes based on location and natural history. Subsampling within any of these units can provide detailed information at smaller scales (such as individual states, counties, refuges) within each saltmarsh system. Our purpose here is to recommend a sampling methodology and sampling framework so that data can be shared and compared among saltmarsh systems in different parts of the continent. If biologists use different approaches to survey marshbirds 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 landbirds in North America. For marsh birds, some efforts have incorporated playbacks, 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 marshbirds across a large geographic area and allow survey data to be pooled with data collected for secretive marsh birds (Conway 2004).

Participants at the October 2003 workshop agreed that the methods outlined here should constitute the minimum information collected by everyone working on marshbirds 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. Each participant may choose to record additional information at their site and a list of some optional components are included below.

Point Count Core Components:

- An initial 5-minute passive point-count survey at each survey point followed by a period of call-broadcast.
- Record all individuals detected (irregardless of distance) for all species that are associated with salt marshes (Appendix 1).
- Each individual bird detected is recorded on a separate data line and surveyors record whether each bird was heard and/or seen (and whether each was flying over).
- Surveyors estimate the distance to each bird detected.
- 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.
- Only birds heard or seen in the tidal marshes (or flying over the marsh) are counted even though upland areas may be within the counting radii.
- Daily survey window for counts extends from dawn to 3.5 hours after dawn. Surveys conducted within the first 2 hours after dawn are optimal because detection probability of many species tends to decline after that, but detection remains relatively high for most species for 3.5 hours after dawn.
- Distance between adjacent points can vary among survey areas, but we recommend that all participants use 400m. If a participant wants adjacent points to be closer than 400m due to local reasons, we recommend they use increments of 400m (i.e., 200m).

Distance between adjacent points must be ≥200m if a participant wants to calculate density estimates based on number of birds within a 100m radius of each point.

- Surveys should not begin until 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 weeks. Potential participants are encouraged to contact one of the authors for information on optimal survey timing in their region.
- If possible, surveys should occur during the first week following a high spring tide because many salt marsh passerines are forced to renest and detection probability is high following these high tides.
- Immediately following the 5-minute passive survey, observers broadcast calls of secretive marsh birds to elicit vocalizations of rails, bitterns, and other secretive marsh birds (see Conway and Gibbs 2001, Conway and Timmermans 2004, Conway 2004 for explanation of format for call-broadcast).
- For secretive marsh birds, observers record whether or not each individual bird was detected during each 1-minute interval during both the passive and call-broadcast periods (see Conway 2004 for list of 'secretive marsh birds'). For salt marsh passerines and other marsh birds, participants should only record detection data within the 1-minute 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 from the other species.

The data produced from these surveys will provide analysts with several different 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 3).

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, there are other benefits 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 (A. Royle, pers. comm.).

Participants should conduct 3 surveys annually during the presumed peak breeding season for marsh birds in their area. Each of the 3 replicate surveys should be conducted during a 10-day window, and each of the 10-day windows should be separated by 7 days. Seasonal timing of these 3 replicate survey windows will vary regionally depending on migration and breeding chronology of the primary marsh birds breeding in an area.

Participants should focus on bird species that are associated with salt marsh 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 Dependent Variables:

- An index of abundance based on the total number of birds detected (regardless of distance) along a survey route or within a marshland.
- An estimate of breeding density based on the assumption that all birds are detected within a certain radius (i.e., 50m or 100m) of each point.
- An estimate of breeding density based on distance sampling to correct for the fact that detection probability typically declines with distance from the surveyor.
- An estimate of breeding density that incorporates both distance sampling and capture-recapture models (based on data from the 5 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 3 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 don't 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 similar ancillary information (e.g., tide stage, moon phase, water depth, salinity, vegetation measurements, and current or ongoing management actions) at each survey point. This 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:

- Date
- Name of marsh or study site
- Survey number (whether current survey is the first, second, third at that point this year)
- Unique station number identifying the location of the point count
- Start time
- Wind speed (Beaufort Code)
- Ambient temperature
- Percent cloud cover
- Precipitation
- Days since full moon
- Tide stage
- Salinity content of water
- An estimate of distance to each bird detected
- Type of call given
- Characterization of plant species composition and land use types within a 50m radius of each survey point. These should be recorded annually if possible, but at least once every 5 years. See Conway (2004) for more details on recording plant composition in land use data at each survey point
- Water depth
- Full name of surveyor
- Latitude and longitude to 4 decimal places using a GPS receiver

Rationale for Ancillary Information

S*alinity content 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 levels affect a site's use by species of marsh birds.Such information is relatively easy to collect and can be used as a covariate to control for variation in models estimating population change. Participants can get an Oregon Scientific Handheld Salinity Meter [ST228] for $25.

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 salt marsh birds, so including this parameter 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 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). Relatively few studies have examined the influence of tide stage on detection probability of salt marsh 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 for each replicate survey both within and across years. The tidal stage within which to conduct local marsh bird surveys should be based on when highest numbers of marsh birds are likely to be detected in your area; optimal tidal stage for surveys may vary among regions. Many salt marsh passerines are forced to renest during the peak spring high tide, and detection probability is highest during the week after a high spring tide. Clapper Rail (*Rallus longirostris*) surveys have been conducted during high tide since 1972 at San Francisco Bay NWR, but high tide was a period of reduced vocalization probability for Clapper Rails in southern California (Zembal and Massey 1987) and for Black Rails in northern California (Spear et al. 1999). As a general guideline, surveys in tidal marshes should **not** be conducted on mornings or evenings when high or low tide falls within the morning (or evening) survey window. We need additional research designed to quantify the effects of tide stage on detection probability for all species of salt marsh 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. Below is a list of other information/data that can be collected at each point, and is strongly encouraged if time and interest permit.

Distance to Each Bird

Surveyors should estimate the distance to every bird detected at each point with no maximum limit or upper threshold. Obviously these distance estimates will not always be accurate, but with a large pooled sample size we can use the pooled data set to produce a distance-detection function for each species which will allow us to estimate detection probability using distance sampling methodology. We realize that distance estimation is difficult and accuracy of any one distance estimate is suspect at best. That's OK. Surveyors should just try to ensure that their estimates are not ALWAYS underestimating or ALWAYS overestimating. 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 100-120m 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. One possible bias of the distance "category" approach that is frequently brought up as a drawback is that some observers will "want" birds to be within 100m (or 50m) and hence will sort of unknowingly convince themselves that birds are within 100m whenever one is close. Our approach with developing this standardized protocol is to make it as flexible as possible. Ultimately, some folks will use the count data while ignoring the distance data and others can use the distance data for what it's worth. This approach of allowing flexibility minimizes criticism with how and what data is collected and lets us move forward toward implementation. We realize that distance estimation to each bird is not accurate – surveyors should just do the best they can.

Optional Components:

- Multiple observers at all (or a subset of) points. This approach is often used for training new surveyors and the resultant data provides estimates of observer bias (Nichols et al. 2000).
- Information on the history of management actions (spraying, burning, drawdowns, or other management activities that might affect bird abundance) that occurred in the 100m radius surrounding each point.
- Place a permanent device for recording water depth within the marsh at all (or a subset of) survey points.

Justification for Optional Components:

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 2 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 there would be no additional time 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.

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 information on the history of management actions (spraying, burning, drawdowns, or other management activities that might affect bird abundance) that occurred in the 100m radius surrounding each point will allow analysts to determine whether certain management actions adversely affect marsh bird populations.

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 at survey points will allow analysts to use this important parameter as a covariate in models used to estimate population change.

Sampling Frame

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 frames: 1) random or systematic selection of points, 2) roadside access points, 3) water access points, 4) points within interior marsh, and 5) special places.

Locating points via some form of random or systematic approach is ideal. Spatial variation in marshbird 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 salt marsh 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, impoundment roads, etc. 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 marshland to go unsampled and prevents analysts from making inferences to the entire marshland. One compromise would be to include some roadside access points and some interior marsh points. Survey points along roadsides should be established at 400m intervals along all roads 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 marshbirds), surveyors should record the point on the data form and note that the survey was not conducted because of insufficient habitat.

Water sampling points are located in an analogous manner to roadside access points. In this situation points are placed along rivers or guts that pass through marshes. They are similarly numbered and plotted on maps and the same rules followed for choosing the location of the points and the number of points sampled. 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 400m (0.25 mi) of a road or an accessible waterway (a somewhat arbitrary distance beyond which many birds cannot be heard from a point) is considered unsampled 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/or 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 5 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 5 sampling approaches that point contributes. This information 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 5 different sampling strategies using GIS overlays is recommended. The portions of marshlands that would go unsampled 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 levels of statistical precision needed to detect those changes, define the minimum amount of change in population size that is thought to be important to detect, 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 salt marsh 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 ≥1 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/should be used. Survey data produced from using this protocol could be used in combination with BBS or other survey data to estimate regional or range-wide trends.

Conducting Surveys for Salt Marsh Passerines Only

A standardized marsh bird monitoring protocol that targets rails, bitterns, and other secretive marsh birds (Conway 2004) is already developed and being used by hundreds of biologists in a variety of federal, state, and nongovernmental organizations across North America. This marsh bird monitoring effort includes the use of call broadcast to increase detection probability for certain species. Individuals currently participating in this program have the option of recording all marsh birds, including those not on their broadcast sequence (i.e., salt marsh passerines). Hence, individuals wanting information on salt marsh passerines are encouraged to include a call-broadcast portion following the initial 5-minute 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 encouraged to follow the survey methods outlined here for the first 5-minute passive point-count survey. Doing so will allow their data to still be comparable to the initial 5-minutes of data from other marsh bird survey efforts. There are substantial benefits in having all individuals conducting surveys within both fresh and saltwater marshes in North America to use similar methods to the extent 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 local 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. 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. Although error associated with these distance estimates will probably be high, the estimates will still be valuable for some analyses as long as there is not systematic bias in distance estimates. Surveyors don't have to pinpoint exactly where each bird is located, they just have to estimate the distance with as much accuracy as they can. For example, if a surveyor may believe that 50, 100, 200 or 300m is the best he/she can do (which is essentially the same thing as putting all birds into broad categories). However, if they can be more precise with their estimate, then we encourage them do so. Methods for training observers to estimate distance include: 1) place a tape recorder in the marsh at an known distance and have observers estimate distance, 2) choose a piece of vegetation in the marsh where the bird is thought to be calling from and use a range-finder to determine distance, 3) have an observer estimate the distance to a bird that is calling with regularity and is near a road or marsh edge, then have a second observer walk along the road/edge until they are adjacent to that calling bird, and then measure this distance (by pacing or use of a GPS). Surveyors should use some combination of these 3 methods prior to the survey season to practice estimating distances to calling birds. *Two-observer surveys* (see below) are very useful in this regard. After a survey is complete, the 2 observers can discuss not only what they heard, but how far each person estimated the distance to each bird. Periodic double-observer surveys not only produce estimates of observer bias (see above) 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 (audiogram) 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/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. CDs with calls of secretive marsh birds in your area should be obtained from the author of this document and new CDs should be requested if quality declines. CD players and amplified speakers should be good quality and batteries should be changed or re-charged frequently (before sound quality declines). Participants should routinely ask themselves if the quality of the broadcast sound is high. Observers should always carry replacement batteries on all surveys. A sound level meter with $\pm$5 dB precision (e.g., Radio Shack model #33-2050 for $34.99; or EXTECH sound level meter, $99 from Forestry Suppliers, Inc.) should be used to standardize broadcast volume (alternatively, Radio Shack should be willing to help you set your broadcast level appropriately using the sound meter in the store). If participants need help with purchasing broadcast equipment, contact the author. A small boat/canoe may be useful for surveying larger wetland habitats adjacent to open water, reducing travel time between survey points. When using a boat, use the same boat and motor on each survey each year to control for possible effects of engine noise on detection probability. If a different boat or different motor is used (or the same boat/motor just sounds better or worse than usual) make a note of the change in the *Comments* column. A spare CD player should be kept close-by in case the primary unit fails to operate. A prototype field data form for use on vocal surveys is attached to this document (Appendix 2). The number of columns on the data sheet will vary among survey areas depending on the number of bird species included in the call-broadcast segment of your survey so participants will have to tailor the data sheet below to suite their own broadcast sequence.

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Table 1. Description of existing avian survey efforts within tidal salt marshes in North America.

Name of survey effort	Target species	Surveyors record other spp?	Lead agency	Year effort began	Frequency	Location	# 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	Richard Zembal
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
San Francisco Estuary Wetlands Regional Monitoring Program	All birds	yes	PRBO Conservation Science	1996	annual	San Francisco Bay, CA	>1000	Point counts; territory mapping; demographic monitoring	Mark Herzog
Belding's Savannah Sparrow survey	Belding's Savannah Sparrow	no	USFWS	1986	Every 5 years	Coastal southern CA	n/a	Territory mapping	Richard Zembal
North American marsh bird survey[1]	Rails, bitterns, grebes	some do	USGS	1999	annual	Throughout North America	~3200[2]	Point counts with call broadcast	Courtney Conway
Coastal Plain Swamp Sparrow survey	Coastal Plain Swamp Sparrow	no?	Smithsonian	2000	annual	Chesapeake Bay, MD Delaware Bay, DE, NJ	141	Roadside point counts	Russ Greenberg
Waterbird Monitoring Program at Cape Cod National Seashore	Secretive marsh birds	no	NPS	1999	Every 3-5 years	Cape Cod National Seashore, MA	42	Point counts with call broadcast	Steve Hadden
New England survey of salt marsh birds	All salt marsh birds	yes	Mass. Audubon, Maine Dept. Inland Fisheries & Wildlife	1997	One time survey	Coastal ME, NH, MA, RI, CT	911	Point counts	Greg Shriver
Gulf of Mexico winter survey of salt marsh birds	Salt marsh passerines	yes	Mississippi Dept. of Marine Resources	2003	annual	Coastal MS	17	Line transects during winter	Mark Woodrey, Robert Cooper

Table 1. Continued.

Galilee Bird Sanctuary	All birds	yes	Univ of Rhode Island	1993	Annual or biannual	Southern RI	31	Point counts	Peter Paton, Frank Golet, Bill Eddleman
Region 5 NWR surveys of salt marsh birds	All birds (emphasis waterbirds)	some do	USGS, USFWS	2000	annual	DE to ME	30-40	Spring, fall, winter Point counts, walking transects	Michael Erwin, Jan Taylor
North American Breeding Bird Survey	All birds	yes	USGS	1966	annual	Throughout North America	~300	Roadside point counts	Keith Pardieck

[1]Incorporates the survey strategy described in this document.

[2]Includes all points including those in freshwater marshes.

Appendix 1. Bird species (and their alpha codes for the Bird Banding Lab) associated with salt marshes in North America that are the emphasis of this survey effort. Surveyors should record all individuals detected for each of these species during surveys in salt marsh systems.

GRHE	green heron
GBHE	great blue heron
TRHE	tricolored heron
LBHE	little blue heron
YCNH	yellow-crowned night heron
BCNH	black-crowned night heron
GREG	great egret
SNEG	snowy egret
CAEG	cattle egret
GLIB	glossy ibis
WFIB	white-faced ibis
WHIB	white ibis
NOHA	northern harrier
OSPR	osprey
BLRA	black rail
SORA	sora
VIRA	Virginia rail
YEAR	yellow rail
CLRA	clapper rail
AMBI	American bittern
LEBI	least bittern
WILL	willet
BNST	black-necked stilt
WISN	Wilson's snipe
FOTE	Forster's tern
BEKI	belted kingfisher
SEWR	sedge wren
MAWR	marsh wren
COYE	common yellowthroat
SSTS	saltmarsh sharp-tailed sparrow
NSTS	Nelson's sharp-tailed sparrow
SWSP	swamp sparrow
SAVS	Savannah sparrow
SESP	seaside sparrow
SOSP	song sparrow
RWBL	red-winged blackbird
BTGR	boat-tailed grackle
GTGR	great-tailed grackle

Appendix 2. Sample data form for bird surveys in North American tidal marshes.

Date:
Marsh:
Observer:
Survey#:

Temperature:
Wind speed:
Cloud cover:
Precipitation:
Days since full moon:

put a ‘1’ in appropriate column if bird was heard but not seen, an ‘s’ if bird was seen but not heard, ‘1s’ if bird was seen and heard

sta #	time	Species	Responded During:								calls	repeat?	distance	Comments
			5-min passive period											
			1st	**2nd**	**3rd**	**4th**	**5th**	BLRA	LEBI	CLRA				

Appendix 3. Example of filled-out data form for marsh bird surveys in North American tidal marshes.

Date:
Marsh:
Observer:
Survey#:

Temperature:
Wind speed:
Cloud cover:
Precipitation:
Days since full moon:

put a '1' in appropriate column if bird was heard but not seen, an 's' if bird was seen but not heard, '1s' if bird was seen and heard

sta #	time	Species	Responded During:								calls	repeat?	distance	Comments
			5-min passive period											
			1st	2nd	3rd	4th	5th	BLRA	LEBI	CLRA				
1	0545	RWBL	1	1	1	1	1				song		20	
		SOSP	1		1						song		45	
		CLRA		1			1			1	kek		250	
		SOSP		1	s	1					song		80	
		SWSP			1						NDC		12	
2	0558	CLRA								1	kek	y	300	
3	0612													No birds
4	0628	MAWR	1	1			1s				song		10	
		MAWR	1s	1s	1	1	1				song		40	
		MAWR	1		1						call		65	
		MAWR		1			1				song		120	
		BLRA			1			1	1	1	grr		35	
		COYE			1						song		100	
		COYE			1	1s	1				call		40	
		BLRA						1			kkd		20	
5	0648	RWBL	s	s									50	
		GBHE			s									flyover
		CLRA									clatter	n	150	after the survey