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Standardized North American Marsh Bird Monitoring Protocol

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Abstract.—Little is known about the population status of many marsh-dependent birds in North America but recent efforts have focused on collecting more reliable information and estimates of population trends. As part of that effort, a standardized survey protocol was developed in 1999 that provided guidance for conducting marsh bird surveys throughout North America such that data would be consistent among locations. The original survey protocol has been revised to provide greater clarification on many issues as the number of individuals using the protocol has grown. The Standardized North American Marsh Bird Monitoring Protocol instructs surveyors to conduct an initial 5-minute passive point-count survey followed by a series of 1-minute segments during which marsh bird calls are broadcast into the marsh following a standardized approach. Surveyors are instructed to record each individual bird from the suite of 26 focal species that are present in their local area on separate lines of a datasheet and estimate the distance to each bird. Also, surveyors are required to record whether each individual bird was detected within each 1-minute subsegment of the survey. These data allow analysts to use several different approaches for estimating detection probability. The Standardized North American Marsh Bird Monitoring Protocol provides detailed instructions that explain the field methods used to monitor marsh birds in North America. *Received 26 January 2011, accepted 2 April 2011.*

Key words.—bitterns, call-broadcast surveys, detection probability, marsh birds, rails, tape playback.

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The amount of emergent wetland habitat in North America has declined sharply during the past century (Tiner 1984; Dahl 2006; Stedman and Dahl 2008). Populations of many marsh birds that are dependent on emergent wetlands appear to be declining (Tate 1986; Eddleman *et al.* 1988; Conway *et al.* 1994; Conway and Sulzman 2007). Despite evidence of population declines and the need to set responsible harvest limits, a monitoring program specifically designed to determine status and estimate population trends of marsh birds is lacking. The North American Breeding Bird Survey includes survey data on some secretive marsh birds, but does not adequately sample emergent wetlands (Bystrak 1981; Robbins *et al.* 1986; Gibbs and Melvin 1993; Lawler and O'Connor 2004). Marsh birds include all species that primarily inhabit marshes (i.e. marsh-dependent species), and many of these species are considered "inconspicuous" or "secretive." Primary species of concern in North America include King Rail (*Rallus elegans*), Clapper Rail (*Rallus longirostris*), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), Black Rail (*Laterallus jamaicensis*), Yellow Rail (*Coturnicops noveboracensis*), American Bittern (*Botaurus lentiginosus*), Least Bittern (*Ixobrychus exilis*), Pied-billed Grebe (*Podilymbus podiceps*), Limpkin (*Aramus guarauna*), American Coot (*Fulica americana*), Purple Gallinule (*Porphyrula martinica*) and Common Moorhen (*Gallinula chloropus*). The U.S. Fish and Wildlife Service (USFWS) has identified Black Rails, Yellow Rails, Limpkins and American Bitterns as *Birds of Conservation Concern* because they are relatively rare and basic information on status and trends is lacking in most areas (U.S. Fish and Wildlife Service 2008). Moreover, Yellow Rails, Black Rails, Clapper Rails and King Rails are four of the 139 "Focal" species that USFWS has given management priority because they pose special management challenges (U.S. Fish and Wildlife Service 2005). Black Rails, Yellow Rails and Saltmarsh Sharp-tailed Sparrows (*Ammodramus caudacutus*) are three of the 20 species on the National Audubon Society's national 'Watchlist' because they are the 'most imperiled' species (National Audubon Society 2007). Many U.S. states consider these species threatened or of special concern for similar reasons. King Rails are federally endangered in Canada, Least Bitterns are federally threatened in Canada (COSEWIC 2002) and Black Rails are federally endangered in Mexico (Diario Oficial de la Federacion 2002).

Populations of marsh birds may be affected by accumulation of environmental contaminants in wetland substrates because they consume a wide variety of aquatic invertebrates (Odom 1975; Klaas *et al.* 1980; Eddleman *et al.* 1988; Gibbs *et al.* 1992; Conway 1995). Marsh birds are also vulnerable to invasion of wetlands by many invasive plant species (e.g. *Lythrum salicaria*, hybrid *Typha*, *Phalaris arundinacea*, *Phragmites*, etc.) (Gibbs *et al.* 1992; Meanley 1992). Hence, marsh birds may represent "indicator species" for assessing wetland ecosystem quality, and their presence can be used as one measure of the success of wetland restoration efforts (Lewis and Casagrande 1997). Marsh birds also have high recreational value; many of these species are highly sought-after by recreational birders. Finally, several rails are hunted in many U.S. states and Canadian provinces yet we lack the necessary information on population trends and status upon which to set or adjust sustainable harvest levels. For these reasons, numerous federal agencies have been cooperating to monitor marsh bird populations in North America with the hope of gaining better knowledge on status and distribution of these birds and improving estimates of population trends. Continued monitoring will also allow resource managers to evaluate whether management actions or any other activities adversely impact wetland ecosystems. Any action that alters water levels, alters salinity, reduces mudflat/open-water areas, alters invertebrate communities or reduces the amount of emergent plant cover within marsh habitats could potentially affect habitat quality for marsh birds (Conway 1995). To help achieve these goals and to help ensure that marsh bird survey data collected throughout North America would be collected in a consistent manner, I developed a standardized marsh bird survey protocol. The Standardized North American Marsh Bird Monitoring Protocol (or previous versions of it) has been used to collect marsh bird survey data at locations throughout North America beginning in 1999. The protocol is outlined below and is also available on the internet (see website at http://www.cals.arizona.edu/research/azfwru/NationalMarshBird/).

Objectives

The Standardized North American Marsh Bird Monitoring Protocol is intended to provide guidance to individuals planning to survey marsh birds to address different objectives. The most commonly-stated objectives include: 1) document presence or distribution of marsh birds within a defined area, 2) estimate or compare density of secretive marsh birds among management units, wetlands or regions, 3) estimate population trend for marsh birds at local or regional scale, 4) evaluate effects of management actions (often actions that target other species) on secretive marsh birds, and 5) document habitat types or wetland conditions that influence abundance or occupancy of marsh birds. The Standardized North American Marsh Bird Monitoring Protocol allows data sharing and comparisons among sites. U.S. Fish and Wildlife Service has a vested interest in marsh bird populations and their habitats because marsh birds are a trust species, under the protection of the USFWS. The National Wildlife Refuge System of the USFWS has participated in conducting standardized marsh bird surveys based on this protocol since its inception because the refuge system has a disproportionate amount of wetland within their boundaries, and the management actions employed by refuges have the potential to dramatically affect marsh bird populations. However, the protocol has also been used (and continues to be used) by biologists in a wide variety of governmental and nongovernmental agencies and academic institutions.

Density, Abundance and Detection Probability. Abundance is the total number of birds within a defined area of interest. Density is abundance divided by area; for example, the number of birds per hectare of wetland (or birds/ha of emergent vegetation within a wetland). Surveys rarely count all individuals present in the sampling area because detection probability is typically less than 100%. Estimates of abundance or density rely upon estimates of detection probability and either 1) a consistent positive correlation between number of individuals detected during a survey and number of individuals actually present in the area sampled (i.e. low spatial and temporal variation in detection probability), or 2) incorporating environmental covariates into the estimation process that effectively adjust for most of the variation in detection probability. Few reliable estimates of detection probability during marsh bird surveys are currently available (but see Conway *et al.* 1993; Legare *et al.* 1999; Conway and Gibbs 2001; Bogner and Baldassarre 2002; Nadeau *et al.* 2008). However, these survey protocols incorporate methods for estimating several components of detection probability (see Conway *et al.* 2010 for an example of how estimates of detection probability derived from these methods can be useful). Some authors have expressed skepticism about the value of incorporating methods intended to estimate detection probability into surveys (Johnson 2008), but others have advocated for such methods (Burham 1981; Thompson *et al.* 1998; Thompson 2002; Rosenstock *et al.* 2002). Focal marsh bird species were those identified by a group of marsh bird biologists as species for which we lack quality information on status or population trends (Ribic *et al.* 1999).

Population Trend. Population trend is often not well-defined, but a common definition is the percent annual change in population size for a particular species at some defined spatial scale over some defined time period. Estimates of population trend allow managers to determine whether local or regional marsh bird populations are declining and the rapidity at which they are declining. Managers can establish *a priori* population trend thresholds or trigger points below which immediate management action should be taken. Such actions can prevent local extinctions by identifying population problems before they become severe. The North American Breeding Bird Survey provides estimates of population trends for some species of marsh birds, but has insufficient data to estimate trends of the more secretive or rare species.

Survey Routes

The number of survey points to include within a state, local refuge or management area (or the size of the survey area selected) is often dictated by personnel time available and other logistical constraints. A survey route is a permanent grouping of points that are surveyed together by the same surveyor on the same date during a morning (or evening) survey. Each survey point should belong to one (and only one) permanent survey route. The number of points per survey route can vary among routes based on the number of points that one surveyor can survey in a morning (or evening) survey window (see section below titled *Time of day for surveys* for a definition of 'survey window'). A surveyor may only be able to survey a small number of points (e.g. six or eight) in a morning or evening if points are far apart. These 6-8 points would constitute a "survey route". If travel between adjacent points is relatively easy, a surveyor may be able to complete 15 or more points in one morning or evening survey session and hence have 15 points on that survey route. All the survey points that make up one survey route do not necessarily have to be associated with the same patch of marsh. Including fewer points per survey route and surveying an additional morning or evening (rather than fewer routes with lots of points) will typically result in more detections (but will require additional survey days) because marsh birds are typically most vocal in the two hours surrounding sunrise and the two hours surrounding sunset (Conway *et al.* 2004).

Once you choose the direction with which you conduct a particular survey route, be consistent (e.g. always survey the points along route #1 in descending order: point 12 is surveyed first and point 1 is surveyed last). Being consistent in this respect will assure that each survey point is completed at approximately the same time of day during each replicate survey. Consistency in the chronological order in which points on a route are surveyed will help to reduce the sampling variation created by diurnal decreases in vocalization probability of marsh birds as the morning (or evening) progresses (Conway *et al.* 2004). Even though metrics to estimate variation in detection probability are incorporated into the survey protocol, any effort to minimize sampling variation is still advantageous.

Location of Survey Points

Fixed, permanent survey points are chosen and marked with inconspicuous markers in the field. Each survey point receives a unique identification number. Record the latitude and longitude of each survey point using a GPS receiver. If possible, locations of all survey points should also be plotted on maps of each wetland. Maps should include the direction in which the speakers are pointed during the survey at each point. Which direction to orient the speakers is not always obvious to someone who has not surveyed the route before, and may create unwanted variation in numbers detected if speaker direction is not consistent. Survey points are located on either the upland-emergent vegetation interface or the open water-emergent vegetation interface. Conducting surveys at points where observers stand within contiguous patches of emergent marsh vegetation may not be practical in many inland wetlands because of the disturbance to emergent plants (and to calling rates of marsh birds) caused by walking through the dense vegetation. However, conducting surveys from upland edges, roadside edges, and open water edges may create some bias in estimation of population trends. In order to determine the extent to which the placement of points biases results, surveyors should record the local context for each survey point:

1) along a ditch, dike or berm with emergent vegetation on both sides,
2) along a ditch, dike or berm with emergent vegetation on only one side,
3) along a public road with emergent vegetation on both sides,
4) along a public road with emergent vegetation on only one side,
5) along a grassland/emergent edge,
6) along a scrub-shrub/emergent edge,
7) along a forest/emergent edge,
8) along an open water/emergent edge,
9) within a narrow water channel or tidal creek with emergent vegetation on both sides,
10) within a contiguous patch of emergent vegetation (also record distance from edge), or
11) other (and provide description of point placement).

A point is considered "along a public road" if the surveyor is within 25m of the roadside during the survey. Surveyors should also record the type of road (gravel, dirt, paved, etc.). Select the choice that best describes the placement of the point. These data are meant to provide analysts with a method by which they can evaluate whether population trend or density estimates vary depending on where survey points are located. If estimates vary in this regard, analysts have the option of stratifying their estimates to take variation in the placement of points into account.

Point Spacing

Point spacing in previous studies has varied from 40m to 800m (Conway and Gibbs 2001). For setting up new routes associated with the Standardized North American Marsh Bird Monitoring Protocol, we recommend 400m between adjacent survey points to increase the total area covered by monitoring efforts. If points are too close together (i.e. <400m apart), then the call-broadcast at one point may affect the distribution of birds at adjacent points (because birds within earshot often approach call-broadcast; Conway and Gibbs 2011) and hence cause biases in many analyses. Surveyors who want closer point spacing for some local reason should space points by an interval that is easily divisible by 400m (i.e. 200m, 100m). Analysts would then at least have the option of using data only from a subset of points (those that are 400m apart) at that particular site for the shared (pooled) data set if they choose to do so. However, birds are much more likely to have heard the calls broadcast at prior points (and hence alter their vocal behavior) when points are spaced closer than 400m apart. In areas where survey routes have already been established and surveyed in past years, retain the original point spacing; do not delete, ignore or move existing survey points even if spacing between adjacent points is very different than 400m. In marshlands that have access throughout the marsh, points should be in a 400m grid system (hence, one point per 16 ha of marsh). If not all possible points in the grid system can be surveyed, a random or systematic selection of points that can be surveyed should be selected from the potential survey points. Placement of survey points within the wetland is a sampling design issue and observers or survey coordinators should consult a statistician. In many locations, emergent marsh occurs in small patches less than 16 ha in size. In cases like these, include at least one survey point at all marshes >0.5 ha within the management area. Additional survey points should be added at small marsh patches as long as they are 400m away from all other survey points.

What if Area around an Existing Point is no longer Suitable Marsh Bird Habitat?

Original survey points are never dropped from the survey and are always visited in subsequent years. If no suitable habitat is present at an existing survey point during a particular year (e.g. due to drought or change in water flow), then the surveyors should still make an entry for that point on the datasheet and in the database but write in the *Comments* column "no survey conducted because suitable emergent vegetation is not present". Although some of the focal species will very occasionally use wetlands with open water that lack emergent vegetation, these species are all much more abundant in wetlands with emergent vegetation during the breeding season and so surveyors need not conduct surveys at points that no longer have any emergent vegetation. If surveyors do not conduct a survey at one or more existing points, they must record in the database the reason why a survey was not conducted at those points:

1) lack of suitable habitat (due to temporary change such as flooding, drought, mowing, etc.),
2) lack of suitable habitat (due to permanent change),
3) survey not attempted due to logistical reasons.

Time of Day for Surveys

Surveys can either be conducted in the morning or evening. However, once one of these two time periods is chosen, that time period for those points along the survey route cannot be changed. The choice of morning or evening survey period (and the length of each period) should correspond with when marsh birds are most vocal in your area. Vocalization probability is typically highest in the two hours surrounding sunrise and the two hours surrounding sunset (Conway *et al.* 2004). Choose the optimal daily survey time(s) for your region and use them each year. Including both morning and evening surveys into a standardized monitoring protocol provides added flexibility and more potential survey hours for field personnel.

Morning surveys begin 30 minutes before sunrise and should be completed prior to the time when marsh birds cease calling (this varies regionally, but is often two hours after sunrise in southern latitudes and three hours after sunrise in northern latitudes (Conway *et al.* 2004; Gibbs and Melvin 1993). The time in the morning when marsh birds cease calling also varies with temperature and time of year (Conway and Gibbs 2001, 2011).

Evening surveys should begin two hours before sunset and must be completed by 30 minutes after sunset. When conducting evening surveys, surveyors should start their survey route such that they finish the last point at the time when darkness precludes them from seeing their datasheet. The half hour between sunset and complete darkness is often the time when detection probability is highest (C. Conway, unpubl. data).

Number of Surveys per Year and Seasonal Timing of Surveys

Optimal seasonal timing for surveys will vary regionally depending on breeding chronology of the focal marsh birds (Appendix 1) in your area. Conduct at least three surveys annually during the presumed peak of the marsh bird breeding season. The peak breeding season in each location will vary among the coexisting marsh birds in that area. For example, American Bitterns often breed earlier than both Least Bitterns and rails in some regions, and Clapper Rails and King Rails breed earlier than Virginia Rails and Soras in some regions (also see Rehm and Baldassarre 2007). To account for variation in breeding phenology (and hence variation in optimal survey timing) among coexisting species, at least one survey should be conducted within each of the three 15-day survey windows. The three survey windows vary regionally and are based on the average minimum temperatures in May in each location (Appendix 2). The three survey windows increase probability of conducting at least one survey during the seasonal peak in vocalization probability for all focal marsh bird species in the area. In many areas, migrants are still moving through when the breeding season is well underway for local breeders. Hence, some surveys will occur prior to when migration is completed for many marsh birds.

A common goal of marsh bird surveys is to estimate trends over time in the number of breeding adults of each species, so it is optimal to complete all three annual surveys prior to the initiation of juvenile vocalizations. At least three surveys are needed to confirm seasonal presence or absence of some marsh bird species in a wetland with 90% certainty (Gibbs and Melvin 1993). Three replicate surveys per year are also warranted because personnel organizing surveys often do not know the local timing of the breeding cycle of the various marsh bird species at the outset of their survey effort (Rehm and Baldassarre 2007). Finally, including three or more surveys per year will allow for estimation of the proportion of survey routes occupied by each species (MacKenzie *et al.* 2002). However, if for some reason it is not possible to conduct a minimum of three surveys on the area, data collected can still be used for some purposes.

Contact the program coordinator (see contact information below) if the three annual survey windows do not adequately capture the peak breeding seasons of the marsh bird species in your area.

Surveys in Tidal Marshes

When possible, 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 surveys conducted since 1972 have been timed to coincide with a high tide 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). In Mississippi, detection probability and tidal height were positively correlated for Clapper Rails and Seaside Sparrows (*Ammodramus maritimus*), but negatively correlated for Marsh Wrens (*Cistothorus palustris*) (Rush *et al.* 2009).

If no local data are available on optimal tidal stage for conducting marsh bird surveys, surveyors should try to conduct surveys on days when high or low tide does **not** fall within the morning (or evening) survey window (i.e. conduct surveys when tides are coming in or out). Record the following: 1) time of the closest high tide (either the high tide before or after the survey - whichever is closer in time) for each survey point, and 2) tidal amplitude (difference in water level in meters between the highest and lowest tide on that day) on the day of the survey. These tidal features have been shown to influence numbers of birds detected during marsh bird surveys (Nadeau *et al.* 2010).

Survey Methods

These standardized survey methods for marsh birds originated from suggestions during two multi-agency workshops at Patuxent Wildlife Research Center designed to aid agencies developing marsh bird monitoring programs (Ribic *et al.* 1999; U.S. Fish and Wildlife Service 2006), and incorporate suggestions from Conway and Gibbs (2001, 2011) and recent methodological advances in estimating detection probability and observer bias (Nichols *et al.* 2000; Farnsworth *et al.* 2002; MacKenzie *et al.* 2002). Because many marsh birds are secretive, seldom observed and vocalize infrequently, the Standardized North American Marsh Bird Monitoring Protocol instructs surveyors to broadcast calls to elicit vocalizations during surveys (Gibbs and Melvin 1993; Conway *et al.* 2004; Conway and Gibbs 2005; Conway and Nadeau 2010). However, because we want to estimate detection probability, estimate density using distance estimators, analyze data without the biases associated with call-broadcast (Conway and Gibbs 2001, 2011) and survey (for some participants) non-focal species, surveyors will also record birds during a 5-minute passive period prior to broadcasting marsh bird calls. Hence, surveyors will record all focal species (Appendix 1) detected during both a 5-minute passive period prior to broadcasting recorded calls and during a period in which pre-recorded vocalizations of focal marsh birds are broadcast into the marsh.

The recorded calls should be obtained from the Marsh Bird Survey Coordinator (contact info below); request digital recordings of the focal species that breed in your area, and we will ensure that the broadcast sequence coincides with this protocol. The broadcast sequence should include exactly 30 seconds of calls of each of the focal marsh bird species that are expected breeders in your area interspersed with 30 seconds of silence prior to the next focal species' calls. The 30 seconds of calls consist of a series of the most common calls for that species interspersed with approximately 5 seconds of silence. For example, an entire survey sequence might look like this:

5 minutes of silence (include a verbal statement at the end of each minute to alert surveyors)

30 seconds of calls of first focal species configured thus:

- Three Least Bittern *coo-coo-coo* calls
  - Six seconds of silence
- Three Least Bittern *coo-coo-coo* calls
  - Six seconds of silence
- Four series of Least Bittern *kak* calls

30 seconds of silence

30 seconds of calls of second focal species configured like this:

- Two Sora *whinny* calls
  - Five seconds of silence
- Three Sora *per-weep* calls
  - Five seconds of silence
- Four Sora *keep* calls

30 seconds of silence

30 seconds of calls of third focal species, etc.

Include a verbal "stop" at end of the final 30 seconds of silence so that surveyors know when to stop the broadcast (and stop the survey at that point).

Broadcast Equipment and Placement

The broadcast player should be placed upright on the ground (or on the bow of the boat), and sound pressure should be 80-90 dB at 1 m in front of the speaker. Use a sound-level meter to adjust volume of the broadcast player at the beginning of each day. If sound quality distorts when volume on your broadcast equipment reaches 80-90 dB, you should obtain higher-quality broadcast equipment. If the ground is wet, place the speaker on an object as close to the ground as possible. Surveyors should stand 2 m to one side of the speaker while listening for vocal responses (standing too close to the speaker can reduce the surveyors' ability to hear calling birds). Surveyors should point the speaker toward the center of the marsh and should not rotate the speaker during the call-broadcast survey. Speakers should be pointed in the same direction for all replicate surveys. At points where the direction in which to point the speakers is not obvious (i.e. on a road or in a canal bisecting two marshes), surveyors should record the direction of the speakers at each point on a map and on their datasheets and refer to this information on all replicate surveys. Visit the program website to see a list of suitable equipment for broadcasting calls: http://www.cals.arizona.edu/research/azfwru/National MarshBird/).

Species to Include in the Survey Effort

Surveyors must make three decisions regarding the species to include in their survey effort: 1) which species will be recorded on their datasheet, 2) of those species recorded, which species will be recorded during the one-minute segments (i.e. each individual bird of these species will be recorded on a separate row on the datasheet), and 3) of those species recorded, which species' calls will be included in the call-broadcast sequence (Appendix 3). Staff from the U.S. Fish and Wildlife Service's National Wildlife Refuge System have provided guidance on making these decisions for the >500 refuges in the U.S. The program website provides this guidance along with a map overlaying the breeding range of each focal species by USFWS Region (http://www.cals.arizona.edu/research/azfwru/NationalMarshBird/, then click on *Focal Species* and then *breeding distribution*). Surveyors should examine this map to help determine which focal species likely breed in their area and use this information to determine the species to include in the broadcast sequence. For general inventory to document status and distribution, one would include all possible focal species in their area.

Species to Include in the Call-broadcast Sequence

In general, surveyors should include in their survey all of the following species that are thought to breed in the marshes in their area: King Rail, Clapper Rail, Virginia Rail, Sora, Black Rail, Yellow Rail, American Bittern, Least Bittern, Pied-billed Grebe, Limpkin, American Coot, Purple Gallinule and Common Moorhen. The number of species included on the call-broadcast portion of the survey increases the duration of the survey by 1 min per species at each point. So, with eight species, you will spend 13 minutes (including the initial 5 min passive listening period) at each point. If a surveyor is within the breeding range of the American Coot, Common Moorhen or Pied-billed Grebe, broadcasting calls of any of these species is considered optional but strongly recommended (Appendix 3). However, all surveyors should still record all detections of these species (see Appendix 3), even if they do not include one (or all three) of these "focal" species in their broadcast sequence. Participants conducting surveys on National Wildlife Refuges should see the guidance on the program website on which focal species to include in their broadcast sequence for their refuge. Use that list only as guidance and contact the Program Coordinator (see end of document) if you can recommend corrections to the list of suggested species for a particular refuge. The guidance on the website is based on maps of the breeding ranges of the focal species, but these maps are not always accurate in identifying the species that breed locally at a particular refuge. If someone has good local knowledge of the species of secretive marsh birds that breed on a particular refuge, they should contact the Program Coordinator to have the species list updated or verified (even if no changes are necessary). As that occurs, we will update the website to indicate which refuges have had their list of species verified. Keeping the list of recommended species on the website up-to-date is important, so please verify the list of focal species for your sampling location by asking people who are familiar with the marsh birds in your area and send any suggested modifications to the Program Coordinator.

The broadcast sequence includes calls of the focal marsh bird species that are expected breeders in that area. The calls are broadcast on a portable CD or MP3 player with amplified speakers attached. The marsh birds included in the call-broadcast sequence will vary among survey areas, but will always be consistent within a particular survey route across years. Recommended species to include in the call-broadcast sequence for a particular survey route (i.e. at a particular refuge or management area) are listed in Appendix 3. The goal is to include all of the focal species believed to be potential local breeders (species for which you might reasonably expect to get responses during the breeding season). Order of calls start with the least intrusive species first and follow this order: Black Rail, Least Bittern, Yellow Rail, Sora, Virginia Rail, King Rail, Clapper Rail, American Bittern, Common Moorhen, Purple Gallinule, American Coot, Pied-billed Grebe, Limpkin. The order of species on the broadcast sequence was based on recommendations by Ribic *et al.* (1999). The calls used for broadcast include the primary advertising call of each species (e.g. '*whinny*' for Sora, '*grunt*' for Virginia Rail, '*clatter*' for Clapper Rail, '*click-click-click-click-click*' for Yellow Rail, '*coo-coo-coo*' for Least Bittern, '*pump-er-lunk*' for American Bittern). Other calls associated with reproduction are also included for many of the species. Including all the common calls associated with reproduction of each species on the broadcast sequence will likely increase detection probability during different times of the breeding season and can help surveyors learn the less common calls of each of the focal species. A list of common calls for each focal species is provided in Appendix 4.

Estimating Distance to Each Focal Bird

Surveyors should estimate the distance from the survey point to each individual bird. Recording distance to each individual bird will allow analysts to use distance sampling techniques to estimate density for each species in each habitat type and for each surveyor. Surveyors need to estimate the distance to each bird when the bird was first detected during the survey. Several authors have suggested that secretive marsh birds often move toward the broadcast source prior to vocalizing (Legare *et al.* 1999; Erwin *et al.* 2002), and systematic movement toward the surveyor violates an important assumption of distance sampling. More research is needed to address the magnitude of this potential problem for each focal species, but analysts will likely use distance estimates only from birds detected during the initial passive portion of the survey (i.e. those that were detected prior to being exposed to call-broadcast). Estimating density from only a subset of birds detected (those initially detected during the 5-min passive period in this case) does not introduce bias in distance sampling as long as the other assumptions of distance sampling are met (Buckland *et al.* 2001). Density indices by habitat type are useful because they allow managers to extrapolate survey data to estimate a minimum number of each marsh bird species on their entire management area. The distance at which most individuals are detected varies among the focal species (Conway and Nadeau 2006). Surveyors are encouraged to use a range finder to help them determine the distance to specific landmarks surrounding each survey point, which will help estimate the distance to calling marsh birds. Other methods for improving one's ability to estimate distance include: 1) tying surveyors' flagging at 50m and 100m away from each survey point in each cardinal direction, and 2) carrying aerial photos of the marsh with 50m-, 100m- and 200m-radius circles drawn around each survey point. Estimating the distance to some individual birds will involve a lot of uncertainty (i.e. estimating distance to birds 5m from the surveyor is much easier than estimating distance to birds that are >100m away). Indeed, distance sampling often led to overestimates of density of songbirds in eastern deciduous forest (Alldredge *et al.* 2007b, 2008). However, some surveyors (those that had received prior training in distance estimation to calling marsh birds) were able to estimate distance to calling secretive marsh birds that they could not see with minimal bias (average difference between estimated and actual distance varied among the focal species from 0 to 24 m in Arizona and California based on 29-115 trials per species; Nadeau and Conway, unpublished data). More studies are needed to estimate the bias and accuracy of surveyors' distance estimates to calling marsh birds and the factors that affect bias and accuracy. Surveyors should enter on the datasheet and in the database which of the following distance estimation aids they used: Unaided, Distance Markers, Range Finder, Range Finder and Maps, Maps or Aerial Photos or Distance Not Recorded.

The Data Sheet

An electronic copy of a datasheet should be obtained from the Survey Coordinator or the program website (http://www.cals.arizona.edu/research/azfwru/NationalMarshBird/) to ensure that all pertinent data are recorded properly. These datasheets can then be tailored by each surveyor to meet local needs as long as none of the standards in this protocol are compromised. The number of species columns on the datasheet will differ across survey areas. For example, if calls of only three species will be broadcast, then the survey duration will be eight minutes at each point (five minutes of passive listening and one minute of call-broadcast for each of three species) and will need a datasheet with eight response columns. If calls of five species will be broadcast, then the survey duration will be ten minutes at each point (five minutes of passive listening and one minute of call-broadcast for each of five species) and will need a datasheet with ten response columns. A hypothetical example of a completed datasheet is provided in Appendix 5. Prior to the beginning of the survey, write down the day, month and year at the top of the data sheet. Write out the month or use a three-letter abbreviation to avoid confusion between day and month (i.e. so that 6 May is not confused with 5 June). Also write the full name of all persons present during the survey. If more than one person was present, write down who recorded the data and **all** persons that helped identify calling birds. Because detection probability can differ substantially among surveyors (Kendall *et al.* 1996; Link and Sauer 1998; Conway *et al.* 2004; Sauer *et al.* 2004), analysts may wish to control for observer bias when estimating trend (similar to the approach used by analysts of BBS data; Sauer *et al.* 2008), so participants should record any and all surveyors who contributed to marsh bird detections (see the *multiple-observer surveys* section). Write down the name of the survey route and the name of the survey area or management unit.

Recording Detections of Focal, Broadcast Species

When you arrive at the first survey point, write down the unique identification number of the survey point and the time. Start the survey. When an individual of a focal species is detected, write the species name in the "Species" column. You can use the four-letter acronym for the species or write the full species name. A list of standard four-letter species acronyms is provided in Appendix 1. Put a "**1**" in each detection column in which that individual is detected aurally and put an "**s**" in each column in which the individual is detected visually (including flying overhead). For example, if an individual Virginia Rail vocalizes during the first one minute of passive listening, put a "**1**" in the first column. Regardless of whether that individual calls once or many times during the first minute, only put one "**1**" in the first column. If that same individual bird is still calling during the second minute of passive listening, then also put a "**1**" in the second column. If the same individual calls during the 30 seconds when Sora calls are being broadcast or the 30 seconds of silence immediately following the Sora sequence, put a "**1**" in the column for "SORA". If that same individual bird calls again during the Virginia Rail sequence, also put a "**1**" in the "VIRA" column, and so on. Hence, if an individual bird is calling constantly throughout the survey period, you will have a "**1**" in every column for that individual. If the individual is heard and seen, put both a "**1**" and an "**s**" in the appropriate column(s). If you hear a call of the same species but from a different individual (or from an individual of another species), start a new row on the data sheet and follow the same protocol just described. Recording whether each individual bird is or is not detected during each 1-min segment allows analysts to use removal models or time-of-detection methods (Farnsworth *et al.* 2002; Alldredge *et al.* 2007a) to estimate detection probability (see Conway *et al.* 2010 for an example). Surveyors may have difficulty determining whether a call is coming from a new individual or an individual detected earlier at that survey point. Surveyors must often decide whether a call is that of a new individual or one already detected without seeing the bird by using their best judgment (this is a challenge on all bird surveys regardless of the protocol used). In general, be conservative and assume that a call is from the same bird if the call came from the same general location (i.e. a similar direction and not too far from the location of the original call). The number of rows filled out on the datasheet will differ among survey points and will correspond to the total number of individual focal marsh birds detected at each point. If no marsh birds are detected at a survey point, record the point number and starting time, and write "no birds" in the *Species* column. A sample datasheet is included as an example of what survey data might look like (Appendix 5). If the surveyor hears a marsh bird but is unsure of its identity, the surveyor should write "unknown" in the *Species* column and record all data for this individual as described above. Make a verbal description of the unknown call in the *Comments* column (e.g. 'soft "kak-kak-grr" - sounds like BLRA but harsher'). Descriptions of unknown calls are for your own use (not entered into database) and will aid your future identification of unknown calls if that call is heard repeatedly. If time permits, the surveyor can return to the point with another expert birder who may be able to help identify that "unknown" bird or with sound recording equipment so that they can send the recording of the call to the Program Coordinator for identification. Some species of marsh birds give paired duets and surveyors can often distinguish pairs of birds during surveys. Always record each member of a pair on its own individual row of the datasheet. Record "pair" in the *Comments* columns for each of the two birds that are thought to be members of a mated pair.

Recording Detections of Focal, Non-broadcast Species

Whenever possible, these species (see Appendix 3) are recorded the same way as 'focal, broadcast species' above, but their calls are not broadcast during the call-broadcast portion of the survey. If surveyors are overwhelmed by the number of focal birds detected, then they record these species differently than the focal, broadcast species (see the *What to do if the surveyor becomes overwhelmed with too many detections* section).

Recording Detections of Non-focal Species (OPTIONAL)

We recommend that surveyors do not record non-focal species during surveys (also see Johnson *et al.* 2009). However, some surveyors will want to record all species detected (including passerines, waterfowl, raptors, etc.) or perhaps a subset of all species detected (i.e. include marsh-dwelling passerines, wading birds but not other species) during their marsh bird surveys. Surveyors need to be certain that they focus their attention on the focal marsh birds (especially in areas where densities of secretive marsh birds are relatively high). If a surveyor feels strongly that they must record species in addition to the focal species listed in Appendix 3, the shared database can accommodate these data but data on non-focal species should be recorded differently. At each point, record the total number of each non-focal species detected within each of three distance categories (≤50m, 51-100m, and >100m). Individual birds of non-focal species do not receive their own line on the data sheet and surveyors do not need to record detections of non-focal birds using the 1-min segments (Conway and Droege 2006).

The non-focal species included by a surveyor will depend on the marsh birds of interest at that refuge, management area or physiographic region. For example, surveyors may want to include non-focal species which are thought to be declining or which are not sampled well by other survey efforts. However, analysts will need to know which additional species were being recorded so that these data are meaningful (i.e. if no YHBLs are recorded at a point, analysts need to know whether a surveyor detected zero YHBLs or merely did not record YHBLs on their survey). Therefore, each surveyor must enter in the database their list of "non-focal" species that they were recording during their survey. Please take into consideration that the number of "non-focal" species included in your survey effort may reduce your ability to record all the relevant data for the 26 focal species (Appendix 1) that are the focus of the Standardized North American Marsh Bird Monitoring Protocol. Moreover, many of the non-focal species may be adequately sampled already by the North American Breeding Bird Survey. Indeed, Johnson *et al.* (2009) cautioned against surveyors recording non-focal species for fear that the surveyor would miss focal species while paying attention to non-focal species.

Record Types of Calls Given

Knowing seasonal patterns of different call types in a local area provides useful information. For example, the frequency of different calls given (e.g. single *clatter*, paired *clatter*, *kek* or *kek-burr* for a Clapper Rail) varies throughout the season (Conway *et al.* 2004; Conway, unpubl. data). Frequency of different calls given may also vary across regions. Different call types have different functions (see Appendix 4) and can indicate pairing status and stages of the nesting cycle in a local area (allowing refinement of local survey windows). Moreover, detection probability and observer bias differ with different call types (e.g. Least Bittern '*kak*' and the first part of a Virginia Rail '*tick-it*' can be confused with Clapper Rail '*kek*' calls) and accuracy of distance estimation may vary with call type (Conway and Nadeau 2006; Conway, unpubl. data). Hence, estimates of population trends based on data from only those call types that have low observer bias might increase power to detect true population trends due to reductions in temporal variation in counts. Further research is needed to determine the extent that accuracy of trend estimates can be improved (if at all) by including only those birds that gave certain types of calls, but there are additional benefits of having observers record call types on surveys (Conway and Gibbs 2001, 2011). For these reasons, surveyors should record all types of calls given for each focal marsh bird detected in the *Calls* column on the datasheet (see sample datasheet; Appendix 5). Refer to the program website to listen to examples of each common call type: http://www.cals.arizona.edu/research/azfwru/NationalMarshBird/.

Birds Detected at a Prior Survey Point or between Points

If surveyors detect a new bird immediately after the survey period at a particular point (or while walking between points) they can record these birds on a separate row and record "yes" in the *Outside Survey* column. Recording birds detected outside of the actual survey period may be useful information for some of the focal species that are particularly rare at a local site (species for which detections during the actual surveys are rare). If a surveyor detects a focal bird during a survey and the surveyor believes that the call was given by the same individual bird which was detected and recorded at a previous survey point, the surveyor should record all the relevant data for that bird and then enter a "Yes" in the *Detected at a Previous Point* column on the datasheet. When in doubt, be conservative as to whether an individual bird detected at the current point was the same individual recorded at a previous point (i.e. record "Yes" when in doubt).

Recording birds that were detected outside of the standardized survey times (i.e. outside of the 10-min survey at a point) can be useful because these birds are secretive and rarely vocalize. For inventory purposes, surveyors may not want to ignore these detections, especially if, for example, they represent the only Black Rail detected all day or all year. However, a problem arises if one of these birds detected outside of the standardized survey period is then detected at a subsequent point **during** the standardized survey period. For example, if: 1) the surveyor detects a Black Rail after the 10-min survey period at point #3 and records that bird on its own row on the datasheet (and writes "No" in the *Detected at a Previous Point* column and "yes" in the *Outside Survey* column), and 2) the surveyor then detects the same Black Rail during the 10-min survey period at point #4. Recording "Yes" in the *Detected at a Previous Point* column for the entry at point #4 creates a problem because: For many analyses (including estimates of population trend) analysts may want to ignore all entries that have a "Yes" in the *Detected at a Previous Point* column and all entries that have a "Yes" in the *Outside Survey* column so that all individual birds are counted only once. In the scenario above, the Black Rail would have been ignored altogether from trend analyses. Hence, for the situation described above, the surveyor should write "No" in the *Detected at a Previous Point* column for the entry at point #4, and then go back and change the "No" to "Yes" in the *Detected at a Previous Point* column for the initial entry for this bird at point #3 (when the bird was detected after the 10-min survey period).

Recording Whether Focal Birds are Within the "Target Area"

A common goal of marsh bird surveys is to document the effects of management actions on marsh birds, but adjacent areas may have received different management actions. Two adjacent areas with different management histories presents a problem if some birds detected at a survey point are within one area but others are within another area (with a different management history). For clarity, some participants who use this protocol will have certain survey points that were located specifically to count birds within a certain "target area". For example, four points along a survey route were located with the intent to count marsh birds within "impoundment A" and five points along that same survey route were located with the intent to count marsh birds within "impoundment B". However, surveyors at these nine points detect birds both within these impoundments and also in adjacent areas outside these impoundments. Participants often would like to count all birds detected at each point, but also delineate which ones were within these impoundments. Hence, surveyors should record, to the best of their ability, whether each bird detected was or was not in their "target area". In the example above, the "target area" is impoundment A for points 1-4 and the "target area" is impoundment B for points 5-9. If some (or all) of your points are associated with a "target area", the name of that target area should be identified in the database for each point. Some participants may not have any "target area" associated with any of their survey points, and can therefore leave the "Target Area" column blank on the datasheet (and in the database). For example, you may not have any explicit "target areas" associated with any of your survey points if you are conducting surveys primarily to estimate population trend, determine status and distribution, or to identify habitat relationships. If the marshes you survey undergo different management actions, then identifying a distinct "target area" associated with each survey point may be useful, whereby surveyors can record whether each bird they detect at each point was or was not within that "target area". The "target area" may be different at each survey point along a survey route. If a participant has different management units or specific marshes that some of their survey points are intended to monitor (or if the participant sees value in differentiating among units or marshes), they should add a column to their datasheet titled "*In target area*" and record a "Y" or an "N" for each focal bird detected (see Appendix 5).

If the Surveyor Becomes Overwhelmed with too Many Detections

Because many of the focal species occur at relatively low densities through much of their range, many surveyors will detect few or no individual birds at any given survey point. However, some survey points within a survey area will have so many marsh birds calling that surveyors will have difficulty recording data during each 1-min segment in which each individual focal bird is detected. For example, a surveyor may see or hear >20 American Coots at one survey point. When many birds are calling simultaneously, surveyors can have difficulty 1) deciding whether they are hearing new individuals or previously-detected ones, 2) writing new individuals on a new line of the datasheet, and 3) finding the correct line on which they had noted previously-detected birds. In these situations, here are a few comments, observations and suggested remedies. First, individual surveyors do improve, with practice, at recording the required information and making the necessary decisions even with relatively high numbers of calling birds at a point. However, everyone has a threshold at which the numbers of calling marsh birds get too high at a particular point. Exceeding one's 'tolerance threshold' occurs more frequently when a surveyor has many species in their call-broadcast sequence (and hence many detection columns on their datasheet). Below is a list of solutions for when a surveyor becomes overwhelmed, in decreasing order of preference (try those nearer to the top of the list before resorting to those nearer to the bottom). A surveyor often does not know until after the survey has started at a particular point that (s)he is becoming overwhelmed and is not effectively assigning the correct calls to the correct columns (individuals).

1) Include a circle on each row of the datasheet and make a 'tick' on each circle identifying the general direction of that individual (the ticks on a circle, along with the distance estimate, will help you differentiate one individual from other individuals of that species as more are detected at that point - see the column titled "Direction" in Appendix 5).

2) If the problem is common on a particular survey route, reduce the number of species in your call-broadcast sequence. For example, eliminate American Coots, Common Moorhens and Pied-billed Grebes from your call-broadcast sequence so that you have fewer species on your call-broadcast sequence. In other words, still record data for all individuals of all focal marsh bird species in the same way, but just reduce the number of columns on the datasheet (and length of the call-broadcast sequence).

3) For those focal species that are of lower management or conservation interest in your survey area (e.g. American Coots, Common Moorhens, Pied-billed Grebes), simply write down an estimate of the total number of individuals detected within each of three distance categories (≤50m, 51-100m, >100m) for that particular species at that point (e.g. write "AMCO: 0; 12; 23" on one line of the data sheet - see example on sample data sheet attached; Appendix 5). Use the 1-min segments only for the focal species of higher management concern (e.g. Black Rails, Yellow Rails, King Rails, Clapper Rails, bitterns). Surveyors must record on the datasheet (and in the database) the points at which they were overwhelmed and could not record data for individual birds on separate rows of the datasheet (for focal species).

4) At points at which the surveyor becomes overwhelmed, the surveyor should ensure that all individuals detected are recorded on the datasheet even if that means failing to record distance estimates to each focal bird and failing to include each bird on a separate line (i.e. at

a minimum, surveyors always need to provide an estimate of the total number of individuals detected at each point for each of the focal species).

Distinguishing King Rails from Clapper Rails

King Rails breed in freshwater marshes and Clapper Rails breed in saltwater marshes (except the Yuma Clapper Rail that breeds in freshwater marshes in Arizona and California; Conway *et al.* 1993). Both species have similar calls. In marshes near coastal areas, surveyors may not be able to determine whether birds heard calling are King Rails or Clapper Rails. In those situations, surveyors should record these individuals as KCRA (King-Clapper Rails).

Recording Ambient Noise Level

Surveyors should record the level of background noise during the survey at each survey point. Background noise can be used as a covariate in future analyses because level of background noise varies spatially and temporally and influences detection probability during bird surveys (Pacifici *et al.* 2008). Categorize the background noise at each point on a scale from 0 to 4 (or 9):

0 = *no background noise during virtually all of the survey,*

1 = *faint background noise during at least half of the survey,*

2 = *moderate background noise (probably cannot hear some birds beyond 100m during >30 seconds of the survey),*

3 = *loud background noise (probably cannot hear some birds beyond 50m during >30 seconds of the survey),*

4 = *intense background noise (probably cannot hear some birds beyond 25m during >30 seconds of the survey).*

9 = *not recorded.*

Weather Restrictions

Weather can affect detection probability of marsh birds (Conway and Gibbs 2001, 2011). Surveys should only be conducted when wind speed is <20 km/hr (5.5 m/sec; 12 mph), and not during periods of sustained rain or heavy fog. Even winds <20 km/hr affect the detection probability of marsh birds (C. Conway, pers. obs.). Surveyors should postpone surveys if they believe winds are affecting calling probability of marsh birds. Recommendations for conducting surveys in very windy locations include:

1) Determining what time(s) of day has the least wind in your area. The daily survey windows in the protocol are recommendations; survey times should be modified under conditions where wind regularly affects vocalization frequency or observer detection rates. It is important that surveys be conducted during the same daily time window each year at a particular location, and that survey windows at a particular location should be at the time of day or night which has the highest detection probability for the focal species present in your area. In some locations, surveys conducted after sunset (or before sunrise) may have higher detection probability compared to the morning and evening survey windows recommended in the protocol because strong winds may be less frequent during the middle of the night. In these situations, surveys should be conducted at night.

2) Trying to be flexible with your schedule, if you can. For example, plan to conduct a survey on a particular day but postpone to the following day if wind affects calling behavior (or observers' ability to hear calls), and keep postponing until you get a day that meets the acceptable weather criteria to complete the survey.

If wind speed increases to above 20 km/hr during the survey (or sustained rain begins while the survey is already underway), surveyors have two options: 1) stopping the survey and repeating the entire survey route another day, or 2) returning within the next five days to resume the survey at the time it was stopped to repeat the remaining points on the route. Repeating the entire route on a day with better weather conditions will likely reduce annual variation in detection probability and increase the accuracy of trend estimates because most of the focal species stop calling entirely with even moderate wind speeds (and hence detection probability drops to almost 0%).

Weather Conditions

Record ambient temperature, wind speed and sky condition at each survey point. Weather variables (wind speed, in particular) influence detection probability of the focal species and can change dramatically during the 2.5 hours typically required to complete a survey route. Use the same wind speed codes and sky condition codes as the North American Breeding Bird Survey. Record a Beaufort Number (0-5) on data sheet, not mi/hr or km/hr, for wind speed (National Weather Service 2011). Record whether you measured the ambient temperature in degrees Celsius (°C) or degrees Fahrenheit (°F). Record the appropriate National Weather Service sky code (0-9) on the data sheet to document the extent of cloud cover and presence of fog or precipitation (North American Breeding Bird Survey 2011).

Water Conditions Associated with each Survey Point (or each Management Unit)

Water level influences abundance and distribution of marsh birds (Conway *et al.* 1993; Eddleman *et al.* 1994). Water levels vary annually and even daily in some marshes and these fluctuations can explain spatial and temporal changes in marsh bird abundance. Some National Wildlife Refuges control water levels in some of their management units and have the ability to directly affect marsh birds via water management. Hence, surveyors should try to place one or more water gauges for measuring water level in permanent locations at points that have the same hydrologic regime (i.e. the same daily and annual fluctuations in water level) as the marshes being surveyed. If all marshes along a survey route are subject to the same hydrologic regime (i.e. all survey points are in the same river system or are in a single management unit with the same hydrologic regime), then only one water gauge is needed for that entire route. If a survey route has points split between ≥2 management units (or ≥2 areas with different hydrologic regimes), then ≥2 water gauges are necessary and surveyors should record on the data sheet the water gauge associated with each survey point. Water level at each water gauge should be recorded immediately before or immediately after a morning or evening survey route is completed. Each water gauge must be “reset” (recalibrated) each year because freezing and thawing can cause gauges to move laterally. Water gauges should be placed in an area where the water is deepest to avoid zero readings when there is still water in other parts of the marsh. These water gauges are not meant to explain differences in birds detected among points along a route, but rather the readings from these water gauges will help explain variation in numbers of marsh birds detected across years and across the three annual surveys of each route. Hence, these water depths can be used as covariates in many analyses of marsh bird survey data (i.e. in estimates of trend). Surveyors should record the type of water gauge used for measuring water depth (i.e. bathymetry, monitoring wells, piezometer, river readings at gauge, staff gauge stuck into the wetland, etc.). Placing water gauges might not be possible on all survey routes, especially those that survey wetlands on private lands, but permission should be sought from land owners or land management agencies to place water gauges on as many survey routes as possible. Water depth can vary widely from year to year in many wetlands, and changes in water depth have tremendous effects on suitability of a marsh for particular species. Hence, any efforts to quantify annual changes in water depth will dramatically improve an analyst’s ability to estimate trends (and help explain the cause of some trends).

Salinity Content of Water

In coastal marshes or any marshes with varying salinity levels, surveyors are encouraged to record the salinity content of the water directly in front of each point on each survey. Salinity levels affect habitat suitability for many species of marsh birds (i.e. King Rails are thought to occur only in marshes with low salinity and Clapper Rails only in marshes with high salinity) and such information is relatively easy to collect and can be used to help shed more light on the effect of salinity on distribution and abundance of marsh birds. Moreover, salinity levels in coastal marshes may change with changes in sea levels as a result of climate change, so documenting changes in salinity levels over time will help document the effects of sea level rise.

Date of Last Natural Disturbance

Record the month and year of the last flood, wild fire, hurricane, monsoon, tornado, straightline winds or other major disturbance that occurred in the "target area" that each survey point is intended to survey. Record the month and year for each of those disturbance events that potentially affected marsh bird abundance or marsh bird habitat structure. Record these dates for each survey point, once per year (or more often if a natural disturbance occurs between two replicate surveys during the same year).

Select the choice that best describes the disturbance that occurred at the point. The following is a list of the choices:

building construction	drained (drained wetland)
road construction	clear-cut
fire	selective harvest
chemical treatment	hurricane
trail construction	destructive use (non-harvest)
ice damage	wind event/blow down
insect damage	other

Date of Last Management Action

Many common wetland management activities (e.g. prescribed fire, drawdown, flooding, disking, mowing, grazing, herbicide application) may affect abundance of marsh birds. For example, periodic burning of emergent marshes benefits Clapper Rails and Black Rails along the Lower Colorado River (Conway *et al.* 2010). Hence, surveyors should record the month and year of the last time each of the above management activities occurred in the 50-m radius area surrounding each survey point. Recording the date of past management activities will allow analysts to evaluate the effects of common management actions on marsh bird abundance at a large (continental) spatial scale with the pooled data.

Inclusion of an Initial Settling Period (NOT RECOMMENDED)

When surveyors are using a motorized boat or airboat to travel between survey points, the noise generated by the boat may cause birds to stop calling. In these situations, surveyors may choose to include a "settling" period of a fixed length of time (e.g. one minute) prior to starting the 5-min passive count at each point. Otherwise, we recommend that **no** settling period be included. If a surveyor includes an initial settling period prior to each survey, the surveyor should keep that settling period constant for all future surveys at those points. If included, make the settling period a part of a written survey protocol for future surveyors and part of the datasheets for that site so that individuals wishing to repeat the effort in future years will know that a settling period was included.

Multiple-observer Surveys (OPTIONAL)

Estimating detection probability associated with a particular survey protocol is helpful when attempting to interpret count data produced from a monitoring program. The extent to which trends in count data represent the underlying trend in true abundance depends on the variation in detection probability and magnitude of observer bias. One way to estimate observer bias associated with our survey effort is via a modification of the double-observer method (Nichols *et al.* 2000). Two or more trained surveyors record data independently at a series of survey points (for examples, see Conway *et al.* 2004; Nadeau *et al.* 2008). Having ≥2 observers record data independently at a point is an improvement over the original method described by Nichols *et al.* (2000) because analysts can estimate detection probability for both observers (and this approach does not assume that the secondary observer is always correct if discrepancies occur). Nichols *et al.* (2000) did not recommend this approach only because they were concerned that two observers standing next to each other could not record terrestrial birds (where many detections are visual and surveyors often use binoculars to detect and identify birds) independently. However, independent observations are possible during marsh bird surveys (C. Conway, pers. obs.) where the large majority of detections are aural (Conway *et al.* 2004; Nadeau *et al.* 2008). Hence, whenever possible, surveys should be conducted by two or more surveyors simultaneously. Each surveyor should fill out a separate datasheet and should record their data separately without discussing data with the other surveyor. Surveyors should not point out a call or a bird to the other surveyors during the survey period. Each surveyor should stand 1-2 meters away from each other and should keep their pen on their data sheet at all times so that one surveyor is not cued by the sudden writing activity of another surveyor. Once the survey for that morning or evening is completed, the surveyors can look over each other's data and discuss discrepancies, but the data should not be altered; obvious mistakes should be noted in the *Comments* column but not changed (the differences between the surveyors in number of birds detected at each point is what allows analysts to estimate surveyor bias so these differences should not be altered). The Program Coordinator can provide a dataform for recording which birds were detected by both surveyors and which were only detected by one of the surveyors. Multiple-observer surveys will obviously not be possible at all times and at all locations, but try to use multiple-observer surveys whenever possible so that analysts can obtain sufficient data to estimate observer bias.

Hearing Tests (OPTIONAL)

Surveyors are strongly encouraged to have a hearing test (audiogram) at a qualified hearing or medical clinic before, during, or immediately after the survey season each year. We encourage surveyors or potential surveyors to discuss the results of their hearing with their doctor <u>and</u> with their supervisor (or the Program Coordinator) to determine whether the quality of the data they collect may be compromised. Remember, ~90% of marsh bird detections are aural, and many calls are very faint or are given by birds a long way off. For example, 43% of Clapper Rails detected during surveys along the Lower Colorado River were detected at distances ≥100m from the surveyor. Hearing ability could be included as a covariate and might help control for observer bias in trend analyses because many of the focal species often give very faint calls that are difficult for people with hearing impairments to detect (C. Conway, pers. observ.).

Personnel and Training

All surveyors should have the ability to identify all common calls of focal and nonfocal marsh bird species in their local area. Regularly listening to the recorded calls used for surveys can help you learn calls, but surveyors should also practice call identification at marshes (outside the intended survey area if necessary) where the focal species are frequently heard calling. Annual training workshops occur, so contact the Program Coordinator for information on upcoming training workshops. All surveyors should also be trained to estimate distance to calling marsh birds, and to identify the common species of wetland plants within the survey area. Methods for training surveyors to accurately estimate distance include: 1) place a broadcast device with speakers in the marsh at a known distance and have surveyors estimate distance, 2) identify a piece of vegetation in the marsh where the bird is thought to be calling from and use a range-finder to determine distance to that plant, 3) have a surveyor estimate the distance to a bird that is calling with regularity and is near a road or marsh edge, then have a second surveyor walk along the road/edge until they are adjacent from that calling bird, and then measure this distance (by pacing or use of a GPS) and determine how accurate the surveyor was at estimating distance. *Multiple-observer surveys* (see above) are very useful here - after the survey is complete have the two surveyors discuss what they heard and their distance estimates to each bird. Periodic multiple-observer surveys not only provide estimates of detection probability (see above) but also provide insights regarding whether a surveyor might be consistently underestimating or overestimating distance to calling birds (this information does not tell you which observer is correct, but indicates that at least one observer is estimating with bias and hence both should receive more training). First-time surveyors can "tag along" on surveys conducted by more experienced surveyors in their region prior to starting their own surveys. They should do at least one "trial run" before their first data collection window begins because errors are less likely if surveyors take time to get used to the data sheet so that they can record the appropriate data correctly. Another training tool is the Western Great Lakes Birder Certification Program (http://www.uwgb.edu/birds/certification/index-1.htm).

Supplies Needed for Surveys

- surveyor flagging (to mark survey points)
- GPS receiver
- clipboard, datasheets, pencils
- CD or MP3 file of focal species' calls (obtained from the Program Coordinator - see contact info below)
- broadcast device
- amplified speakers
- batteries for the broadcast device and the amplified speakers
- sound level meter with ±5 dB precision
- thermometer
- water gauge(s)
- salinity meter (e.g. Portable Salinity Refractometer from Forestry Suppliers, $90)

Batteries should be changed or recharged frequently (before sound quality declines or devices die during a survey). Surveyors should routinely ask themselves if the quality of the broadcast sound is high. Obtain a new broadcast device or a new set of calls if quality seems to decline. Surveyors should always carry replacement batteries on all surveys. A spare broadcast device should be kept closeby in case the primary unit fails to operate.

Data Entry

Surveyors are urged to enter their data to the pooled database online at: http://www.pwrc.usgs.gov/point/mb/. Each new survey site needs to register using this portal currently maintained by the U.S. Geological Survey's Patuxent Wildlife Research Center in order to enter and manage data. The database was specifically built to accommodate procedures of the Standardized North American Marsh Bird Monitoring Protocol and was designed to facilitate data management. Surveyors will be able to proof their data on the website after it has been entered and will be able to obtain an electronic copy of their data (in MS Access) immediately after entry. The database enables efficient entry and storage of marsh bird survey data and ensures that data are entered in a consistent way that minimizes errors.

Organizational Information

Visit the National Marsh Bird Monitoring Website (http://www.cals.arizona.edu/research/azfwru/NationalMarshBird/) for additional information on these protocols, obtaining datasheets, obtaining digital recordings of calls and marsh bird monitoring in general. E-mail the name, address, phone number and e-mail address of all surveyors to the address below. An e-mail distribution list will be used to disseminate information regarding training workshops and other information to each surveyor. Several USFWS National Wildlife Refuges and several participants from other organizations began using these marsh bird survey methods in 1999 (Conway and Nadeau 2006). Over 300 participants have used the Standardized North American Marsh Bird Monitoring Protocol and submitted data to a pooled database which includes data from over 80,000 marsh bird surveys (Conway and Nadeau 2006). For assistance obtaining digital calls of the focal species, additional information or questions regarding standardized marsh bird survey methods please contact:

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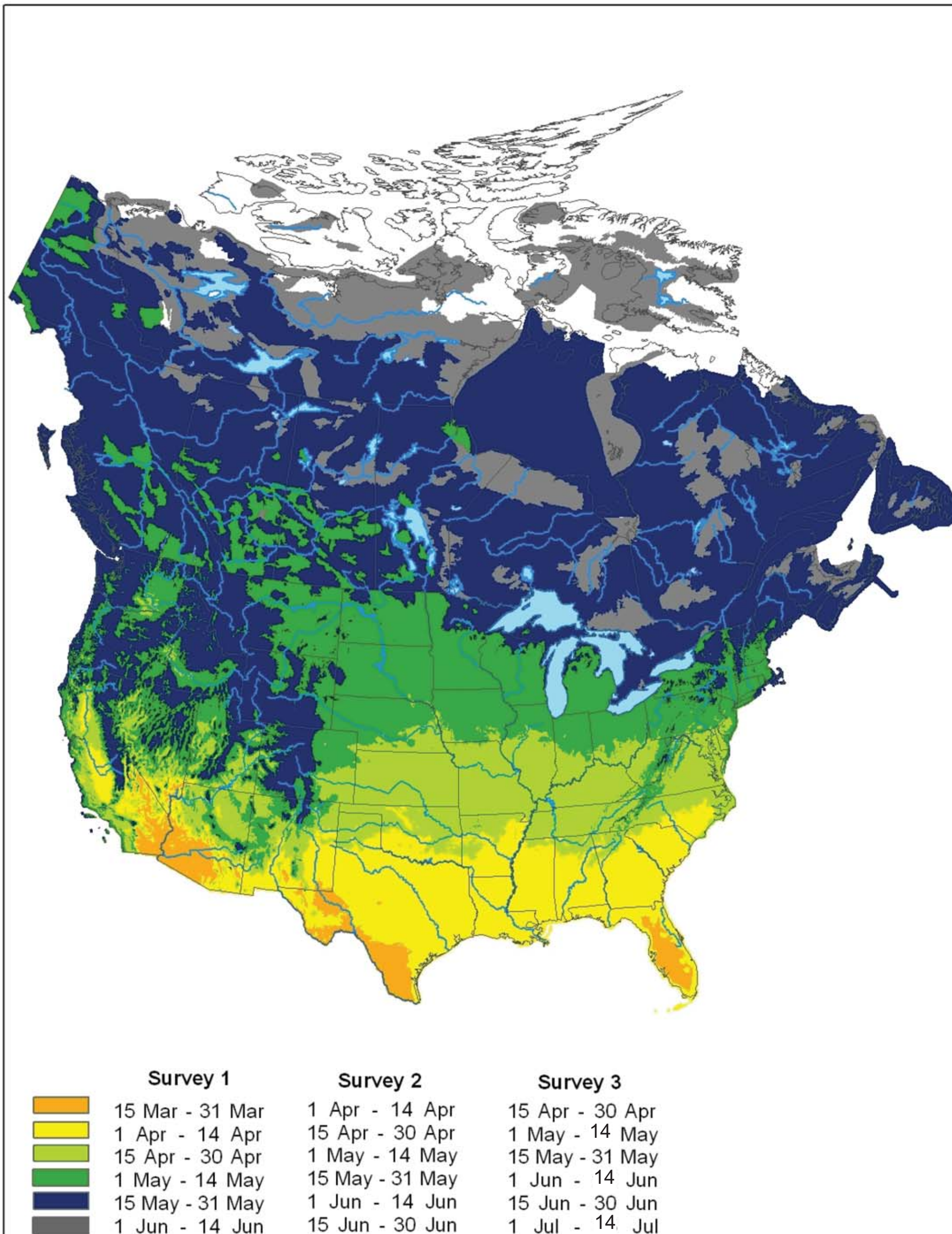
Appendix 1. AOU 4-letter species acronyms for the marsh birds that are the focus of this protocol.

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

Examples of Non-focal Species **these are just some examples -there are other wetland birds that a surveyor may want to include; each cooperator should decide which non-focal species to include in their surveys in advance and list these species on their datasheet and in the database so that analysts (and surveyors in future years) will know the list of species recorded in prior years. One caution to remember - choosing too many non-focal species may cause surveyors to become overwhelmed with data collection and non-focal species should not be recorded at the expense of data on the focal species. Once a station decides to include certain non-focal species, every surveyor at that station should record them in the same manner each year so that the data for that species from that station are valid.**

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



Appendix 2. Dates of 3 annual survey windows for different areas in North America. The isoclines are based on average maximum temperatures in May, from PRISM at Oregon State University (for the U.S.) and Environment Canada (for Canada).

Appendix 3. List of the focal marsh bird species and their field data requirements for conducting marsh bird monitoring using the North American Marsh Bird Monitoring Protocol for NWRS. These are the species for which the Marsh Bird Monitoring Program is designed to monitor well. Surveyors should always record at least total # detected at each point for all these species.

	Species	Broadcast Required?[1]	Record One Individual/Line?
Broadcast			
	BLRA	YES	YES
	YERA	YES	YES
	SORA	YES	YES
	VIRA	YES	YES
	KIRA	YES	YES
	CLRA	YES	YES
	YBCR	YES	YES
	LEBI	YES	YES
	AMBI	YES	YES
	LIMP	YES	YES
	PUGA	YES	YES
	COMO	Recommended	YES, except[2]
	AMCO	Recommended	YES, except[2]
	CARC	Recommended	YES, except[2]
	PBGR	Recommended	YES, except[2]
Non-broadcast			
	WILL (Eastern)	NO	YES, except[2]
	RNGR	NO	YES, except[2]
	EAGR	NO	YES, except[2]
	HOGR	NO	YES, except[2]
	CLGR	NO	YES, except[2]
	LEGR	NO	YES, except[2]
	WISN	NO	YES, except[2]
	SSTS	NO	YES, except[2]
	NSTS	NO	YES, except[2]
	SESP	NO	YES, except[2]
	BLTE	NO	YES, except[2]

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

[2]*Record each individual on one row of the data form except at points where the surveyor is overwhelmed because too many focal birds are being detected at that point (see page 332 of the protocol).*

Appendix 4. List of the most common calls for the focal species of marsh birds.

Species	Standardized Call Name	Sibley Name(s)	BNA Name(s)[1]	Possible Function	Sample on BNA[1] website
AMBI	pump-er-lunk	bloonk-adoonk	pump-er lunk and dunk-a-doo	mate attraction, territorial signal	
AMBI	chu-peep	chu-peep	chu-peep	during copulation ceremony	
AMBI	kok	kok-kok-kok	kok-kok-kok or haink	when flushed	
AMCO	burr-up		puhk-cowah; cooah	perturbation (puhk-cowah male, cooah female)	y
AMCO	hic-up	priKI	pow-ur	perturbation (pow-ur male)	y
AMCO	honk				
BLRA	kic-kic-kerr	keekeedrr, deedeedunk	kickee-doo or kic-kic-kerr, or ki-ki-do	mate attraction, territorial signal	y
BLRA	grr	krr-krr-krr, growling	Growl, grr-grr-grr, brrrr or churr-churr-churr	alarm call, territorial defense	y
BLRA	churt		churt; curt; yip, bip or kik; yelp; kek, ki	alarm call	
BLRA	tch	ink-ink-ink	kik-kik-kik or kuk-kuk-kuk-kuk; ink-ink-ink	when on the nest?	
CLRA	clatter	clapper	Clapper or Clatter; chock-chock; cac-cac-cac or jupe-jupe-jupe	mate communication	y
CLRA	kek	ket	kek-kek-kek, kik-kik-kik, bup-bup-bup	mate attraction (by male)	y
CLRA	kek-burr	ket-ket-karr	kek-burr	mate attraction (by female)	y
CLRA	kek-hurrah	grunting	kek-hurrah		y
CLRA	hoo		Hoo; oom-oom-oom		
CLRA	squawk		Screech or Shriek; Chase Squeal or kak	alarm call, territorial disputes	
CLRA	purr		purr; agitated purrrr; churr		
COMO	wipe-out	pep-pep-pehr-peehr	cackle - ka-ka-ka-ka-ka-kee-kree-kree-kree		y
COMO	keep	kulp, keek	squawk, yelp, cluck		y
COMO	giddy-up				
KIRA	clatter	clapper	cheup-cheup-cheup, jupe-jupe-jupe, gelp-gelp-gelp-gelp-; chac-chac-chac	mate communication	y
KIRA	kek	ket	kik-kik-kik	mate attraction (by male)	y
KIRA	kek-hurrah	grunting			

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

Appendix 4. (Continued) List of the most common calls for the focal species of marsh birds.

Species	Standardized Call Name	Sibley Name(s)	BNA Name(s)[1]	Possible Function	Sample on BNA[1] website
KIRA	kek-burr	ket-ket-karr		mate attraction (by female)	y
KIRA	squawk				
LEBI	coo	poopoopoo	coo or cooing; tut-tut-tut	mate attraction	y
LEBI	kak	rick-rick-rick	gack-gack	mate communication, alarm call	y
LEBI	ert	kuk	tut-tut-tut; quoh, hah or cackle	alarm call	y
LEBI	ank-ank		ank-ank	when flushed	
LIMP	kreow	kwEEEeeer, KIAAAar	kreow	mate attraction	y
LIMP	gon		gon		
PBGR	owhoop	ge ge gadum gadum gwaaaaow	series of wut, whut or kuk notes followed by 4-20 kaow or cow notes	courtship, communication between pair, territorial	y
PBGR	hyena	chatter	ek-ek-ek, hn-hn-hn	greeting call	y
PUGA	cackle	pep-pep-pePAA-pePAA, to-to-terp	Cackle		y
PUGA	squawk		gheeek!		y
PUGA	cac-cac	grunt	Slow Clucking and Grunt Call; cac-cac-cac		
SORA	whinny	whinny	descending whinny	territorial defense, mate communication	y
SORA	per-weep	kooEE	per-weep; ker-wee; ter-ee	mate attraction?	y
SORA	keep	keek	kee or weep	alarm call	y
VIRA	grunt	grunt	grunt	mate communication	y
VIRA	tick-it	gik gik gik gik gidik gidik gidik gidik	tick-it	mate attraction (by male)	y
VIRA	kicker	chi chi chi chi treerrr	kicker	solicitation (by female)	y
VIRA	squawk	skew; kweek	kiu	alarm call, territorial dispute	y
VIRA	kikik	kikik ik-ik, pit-ti-ti-tip			y
YERA	click-click	clicking, tic-tic tictictic	click-click, click-click-click	mate attraction	y
YERA	cackle	cackle	cackle		
YERA	wheeze	wheezing, clucking	wheezes	hostility	

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

National Marsh Bird Monitoring Program Survey Data Sheet

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

Multiple Observer Survey: Y / N
Boat type: John boat (20 hp)
High tide time:
Water depth:
location: Mallard Marsh depth (in) 10
location: Duck Pond depth (in) 15
location: depth (in)

List all non-focal species surveyed:
SNEG

**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

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

Background noise: 0 = *no noise;* 1 = *faint noise;* 2 = *moderate noise (probably can't hear some birds beyond 100m);* 3 = loud noise (probably can't hear some birds beyond 50m); 4 = *intense noise (probably can't hear some birds beyond 25m);* 9 = *not recorded.*
Beaufort scale: 0=*smoke rises vertically;* 1=*wind direction shown by smoke drift;* 2=*wind felt on face; leaves rustle; 3=leaves & small twigs in constant motion and light flag extended; 4=raises dust and loose paper -- small branches are moved;* 5=*small trees with leaves sway --crested wavelets on inland waters*
Sky: 0=*clear or a few clouds;* 1=*partly cloudy or variable sky;* 2=*cloudy or overcast;* 3=sand or dust storm; 4=*fog/smoke;* 5=*drizzle;* 6=*snow;* 7=snow/sleet; 8=*showers*
Distance Aide: 0 = *none;* 1 = *range finder;* 2 = *distance bands on aerial photo;* 3 = *surveyor flags tied to vegetation*

Appendix 5. Example of a completed datasheet for a survey that followed the Standardized North American Marsh Bird Monitoring Protocol.