Received: 15 February 2022 | Revised: 25 October 2022 | Accepted: 25 October 2022
DOI: 10.1002/wsb.1410

OPINION

WILDLIFE SOCIETY BULLETIN Open Access

To improve existing marsh bird survey protocols, we need to evaluate closure assumptions

Auriel M. V. Fournier[1] | **Therin M. Bradshaw**[1] | **Heath M. Hagy**[2] | **Brendan Shirkey**[3]

[1]Forbes Biological Station–Bellrose Waterfowl Research Center, Illinois Natural History Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign, Havana, Illinois 62644, USA

[2]U.S. Fish and Wildlife Service, National Wildlife Refuge System, Stanton, Tennessee 38069, USA

[3]Winous Point Marsh Conservancy, Port Clinton, Ohio 43452, USA

Correspondence
Auriel M. V. Fournier, Forbes Biological Station–Bellrose Waterfowl Research Center, Illinois Natural History Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign, Havana, Illinois 62644, USA.
Email: auriel@illinois.edu

Abstract

Our collective understanding of secretive marsh birds has increased in the past decades due to the development and implementation of the North American Standardized Marsh Bird Monitoring Protocol (hereafter, Protocol). The Protocol proposes call broadcast surveys to increase vocalization and detection rates within 3 standardized survey periods aimed at surveying peak breeding activity for a suite of secretive marsh birds. We noted a trend in the literature linking occupancy modeling with the survey design from the Protocol, despite some evidence that vocalizations decline across survey periods, which could indicate lack of population closure. An underlying assumption of occupancy modeling is closure, and the Protocol was designed to focus on only birds which will remain in an area throughout the breeding season and not migrants that may only be present in the first survey period. Including migrating marsh birds, especially if a large percentage of marsh bird detections are migrants, can bias occupancy estimates and lead to erroneous density and population size estimates that may affect conclusions about habitat resource and bird associations. We urge researchers and managers to carefully consider the analytical and field techniques when designing studies for marsh birds and to not simply pair the biweekly survey design within the Protocol with occupancy modeling and ignore closure assumptions, turnover rates, and potential differences in resource use by migrating and breeding marsh birds. Specifically, we suggest that researchers consider short survey interval times (e.g., ~2 days rather than 2 weeks) or continuous call monitoring using automated recorded devices deployed for 1–2 weeks per survey location when using occupancy analysis on secretive marsh birds. We also call for future study of turnover rates, stopover duration, and vocalization rates during migration and breeding periods to better inform study designs and increase the appropriateness of statistical analysis.

KEYWORDS

call-broadcast surveys, closure, detection, marsh birds, migration

Secretive marsh birds (i.e., bitterns, gallinules, rails, grebes) are an understudied group of birds largely because of the substantial challenges in detecting individuals even when present compared to more conspicuous birds (Conway 2011). Our collective understanding of marsh birds has grown dramatically over the past decade due to the development and implementation of the North American Standardized Marsh Bird Monitoring Protocol (hereafter, Protocol; Conway 2011). The Protocol provides standardized methods for surveying marsh birds during the breeding season and recommends call broadcasts to increase vocalization rates and increase the likelihood of detection. The Protocol has been applied across the United States and Canada to help estimate population size and better understand habitat resource use and selection by marsh birds (Baschuk et al. 2012, Pickens and King 2014, Stevens and Conway 2020). The Protocol has been used in salt and freshwater systems (Woodrey et al. 2012, Harms and Dinsmore 2013) to index population trends for potentially imperiled species (Wiest et al. 2016, Correll et al. 2017), to identify military installations with important habitat resources (Stevens and Conway 2019), to evaluate wetland management regimes (Bradshaw et al. 2020), and to assess the impacts of sea level rise and climate change on wetland bird communities (Steen and Powell 2012, Hunter et al. 2017).

The Protocol has been used in academic research and by state and federal agencies to assess the impacts of wetland management and restoration on secretive marsh birds (O'Neal et al. 2008, Benson et al. 2018). Moreover, it has been implemented on a geographic scale in the past decades that is not frequently seen in bird monitoring, with dozens of states implementing multi-year repeated surveys following the Protocol and archiving the data for public accessibility within the Avian Knowledge Network (www.avianknowledge.net). Implementing the Protocol across parts of the United States and Canada has resulted in significant investment in person-hours and other resources to create data that have been used to document broad patterns in marsh-bird resource selection, estimate population size, and index wetland quality (Monfils et al. 2020).

The Protocol includes 3 standardized survey periods within subsequent 2 week periods during which a site is to be revisited, and the timing of those periods is standardized nationally with the assumption that the peak of each species' breeding activity will be captured in at least one survey period. Standardization allows for data to answer questions at a variety of spatial scales. Conway and Gibbs (2005) recommended the first survey begin after the passage of migrants, but before the initiation of breeding. Conway and Gibbs (2005) recommendation is complicated by the differing migratory and breeding timings of the different target species, highlighting the challenge and limitation of a standardized protocol that covers a suite of species that are often generalized as a singular group, which can result in nuances among species being lost. At many latitudes, some marsh bird species are actively nesting while others are still migrating, making a single optimal survey period for all species infeasible (Rehm and Baldassarre 2007). Conway (2011) acknowledges the potential bias of detecting migrants, but we are not aware of any previous work to evaluate the effect of detecting migrants on study results.

In our work in Ohio and Illinois, we have observed many survey points that have multiple detections of marsh birds in the first survey period, but no detections in subsequent survey periods (a ratio of 4:1 from survey period 1 to period 3; Bradshaw et al. 2020). At one site in Illinois used extensively by breeding and migrating marsh birds, we recorded multiple detections of Sora (*Porzana carolina*) and Virginia Rail (*Rallus limicola*) during the first survey period but recorded no detections in the later survey periods and failed to find any nesting Virginia Rails and only found Sora nests in 2 of 7 years after intensive nest searching (Fournier et al. 2021). As a result, we attributed the higher number of detections in the first survey period versus later periods to detection of migrants in the first survey period.

To determine if our anecdotal observations were part of a wider pattern, we reviewed all published papers that cited Conway (2011), as reported by Google Scholar on July 9, 2021. Of those 381 publications, the vast majority ($n = 372$; 97.6%) did not report the number of detections by survey period. In the 9 publications that reported detections by survey period, we found declining trends across survey periods for all species except Common Gallinule (*Gallinula galeata).* Declining trends in detections across survey periods were as common or more common than steady detections in all species except Virginia Rail and Common Gallinule (Figure 1, Table 1).

Although use of the Protocol is widespread, few of the publications we reviewed documented trends in detections across the 3 survey periods nor did they discuss potential implications on the analysis and results (Bradshaw et al. 2020). Although surprising, this could be because 1) there were roughly the same number of detections among survey periods in most of the studies where detections were not reported, 2) previous authors failed to notice the disparity in detections among survey periods during their data analysis, or 3) the authors assumed differences were insufficient to affect results of their analyses (Bolenbaugh et al. 2011). Regardless, underlying mechanisms leading to potential disparities in marsh bird detections among Protocol survey periods could have consequences on data interpretation and an examination of the issue is warranted. To better understand the potential causes of having more detections in the first survey period versus later survey periods and help researchers adjust study designs and analyses, we propose 3 hypotheses to explain declining detections over the 3 survey periods:

H1: Migrating individuals vocalize and are detected during the first survey period but are absent from subsequent survey periods, and breeding individuals vocalize at a constant rate throughout all 3 survey periods. Since migrants are vocalizing and detected in the first survey period, the number of detections of individual birds is higher in the first survey period when the migrants are present than the later survey periods when only locally breeding individuals are present.

H2: Migrating individuals are either not present or not vocalizing and thus not being detected during the first survey period. Breeding individuals are present throughout all survey periods, but vocalization rates decline across the survey periods as they move through territory establishment, nest initiation, and incubation.

H3: Migrating individuals are present during the first survey period but do not vocalize and are not detected; however, a behavioral consequence of increased rail densities from the presence of migrants, is that breeding individuals vocalize at a higher rate (i.e., increased territoriality with more perceived nest-site competitors present) in survey period 1 when migrants are present.

The validity of each of the hypotheses will have different effects on the appropriateness of statistical techniques available and for interpretation of results from past studies. Moreover, given the wide acceptance and use of the Protocol to study marsh birds, the alternative hypotheses may necessitate different study designs, analytical techniques, or other methods that are more appropriate for each research question, in contrast with a long-term monitoring program that the Protocol was designed to facilitate (Conway and Gibbs 2005). Our objective is to document variation in number of detections across the 3 survey periods of the Protocol that likely occur but are seldom mentioned in marsh-bird studies, outline support for various hypotheses of the change in detections, and initiate a conversation about how to improve the Protocol and subsequent uses of marsh-bird data collected

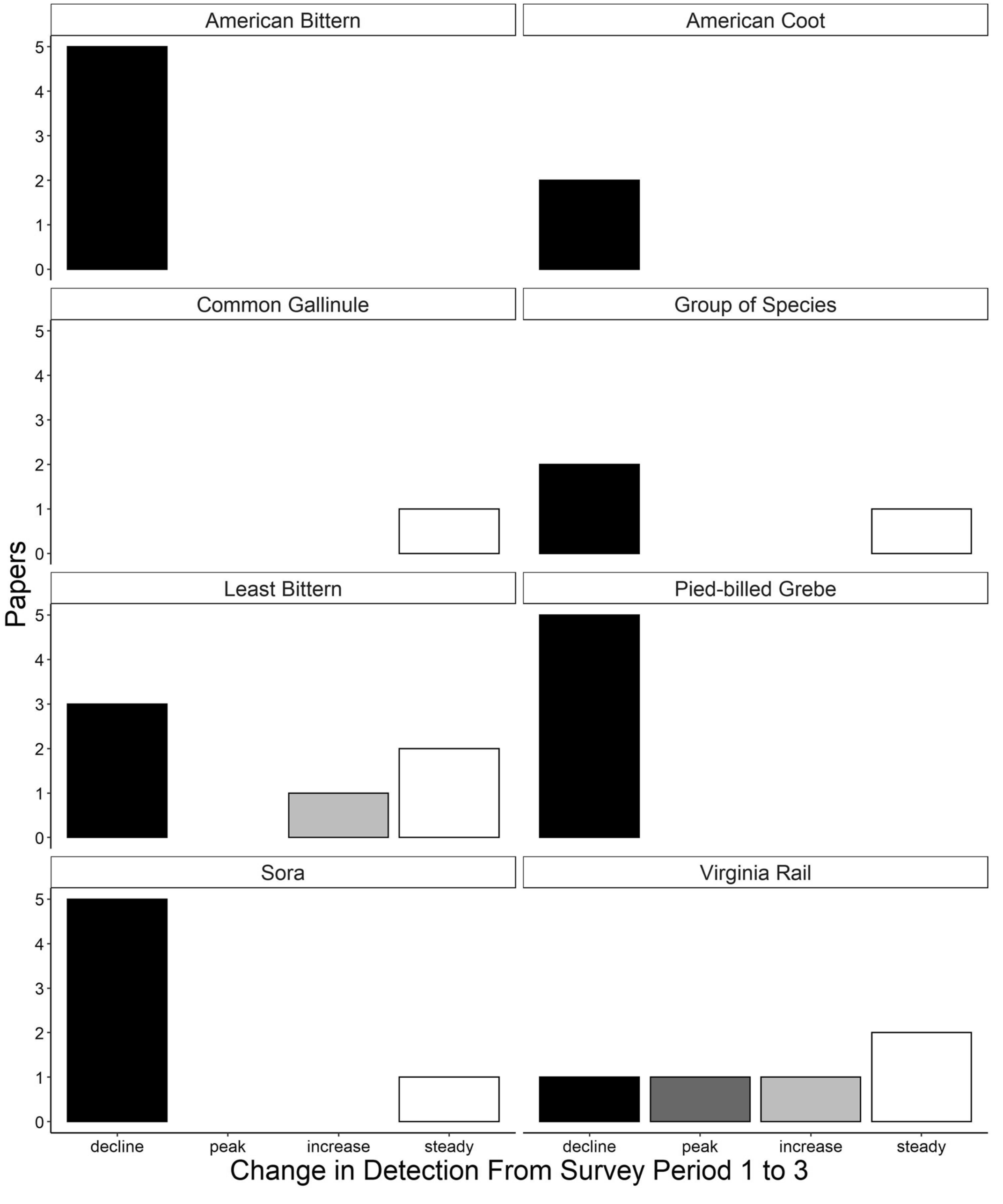

FIGURE 1 Number of studies that reported the number of detections across the 3 survey periods from the Conway (2011) protocol for each species and the direction of change of detections (decline = fewer detections in the latter 2 periods then the first period, peak = highest detections in the second survey period, steady = roughly the same across survey period, increase = more detections in the latter 2 periods).

using its methodologies. Our hope is that by highlighting the importance of noting directional change of detections over the survey periods and potential issues for data interpretation, we will spur further examination of the Protocol across the continent and continue to improve coordinated survey efforts to improve monitoring and management efforts for marsh birds.

TABLE 1 Literature that reports detections in the US and Canada across the survey periods for marsh birds surveyed under the Conway (2011) protocol for each species and the direction of change of detections (decline = fewer detections in the latter 2 periods then the first period, peak = highest detections in the second survey period, steady = roughly the same across survey period, increase = more detections in the latter 2 periods, mixed = inconsistent or variable trends).

Species	Detections over time	Location	Citation
American bittern	Decline	Upper Midwest	Bolenbaugh et al. (2011)
American bittern	Decline	New York	Rehm and Baldassarre (2007)
American bittern	Decline	Minnesota	Saunders et al. (2019)
American bittern	Decline	Louisiana	Valente et al. (2011)
American bittern	Decline	Manitoba	Hay (2006)
American coot	Decline	Upper Midwest	Bolenbaugh et al. (2011)
American coot	Decline	Louisiana	Valente et al. (2011)
Common gallinule	Steady	Upper Midwest	Bolenbaugh et al. (2011)
Common gallinule	Mixed	Louisiana	Valente et al. (2011)
Emergent guild[a]	Decline	Illinois	Bradshaw et al. (2020)
King rail	Steady	Louisiana	Valente et al. (2011)
Least bittern	Steady	Upper Midwest	Bolenbaugh et al. (2011)
Least bittern	Decline	Missouri	Darrah and Krementz (2010)
Least bittern	Steady	Manitoba	Hay (2006)
Least bittern	Decline	Eastern Canada	Jobin et al. (2013)
Least bittern	Increase	New York	Rehm and Baldassarre (2007)
Least bittern	Steady	Louisiana	Valente et al. (2011)
Open water guild[b]	Decline	Illinois	Bradshaw et al. (2020)
Pied-billed grebe	Decline	Upper Midwest	Bolenbaugh et al. (2011)
Pied-billed grebe	Decline	Iowa	Harms and Dinsmore (2014)
Pied-billed grebe	Decline	Manitoba	Hay (2006)
Pied-billed grebe	Decline	New York	Rehm and Baldassarre (2007)
Purple gallinule	Steady	Louisiana	Valente et al. (2011)
Sora	Decline	Upper Midwest	Bolenbaugh et al. (2011)
Sora	Decline	Iowa	Harms and Dinsmore (2014)
Sora	Decline	Manitoba	Hay (2006)
Sora	Steady	New York	Rehm and Baldassarre (2007)
Sora	Decline	Minnesota	Saunders et al. (2019)
Sora	Decline	Louisiana	Valente et al. (2011)
Virginia rail	Steady	Upper Midwest	Bolenbaugh et al. (2011)
Virginia rail	Decline	Iowa	Harms and Dinsmore (2014)
Virginia rail	Steady	Manitoba	Hay (2006)

(Continues)

TABLE 1 (Continued)

Species	Detections over time	Location	Citation
Virginia rail	Increase	New York	Rehm and Baldassarre (2007)
Virginia rail	Peak	Minnesota	Saunders et al. (2019)

[a]least bittern (*Ixobrychus exilis*), American bittern (*Botaurus lentiginosus*), black rail (*Laterallus jamaicensis*), king rail, sora, Virginia rail, and yellow rail (*Coturnicops noveboracensis*).

[b]American coot (*Fulica americana*), common gallinule, and pied-billed grebe (*Podilymbus podiceps*).

In our review, we noticed that an implicit link has formed between the Protocol and occupancy modeling as the latter has quickly proliferated in published literature over the last 15 years (Rush et al. 2009, Darrah and Krementz 2010, Tozer 2016, Wiest and Shriver 2016, Glisson et al. 2017). Analyzing call broadcast data with occupancy models is not dictated by the Protocol, as it does not contain analytical recommendations. However, researchers have paired the repeated biweekly survey design advocated in the Protocol with occupancy modeling and made violating basic analytic assumptions commonplace. We are especially concerned about the impacts of those assumption violations in mid-latitude and southern states where fewer individuals breed for some of the secretive marsh birds (e.g. Sora, Virginia Rail, among others). An underlying assumption of occupancy modeling is closure, which in our context means that only the population of interest (locally breeding individuals) are being detected in each survey period, and migrating individuals, which may only be present but will not stay at the local site to attempt to breed (and thus are not local), are not being detected. Considerable discussion has already occurred in the literature over other forms of violations of the closure assumption, primarily focused on the movement of individuals within the local area such that they are present within their home range during the period of interest but may not be available within the survey plot to be detected at all times (Kendall et al. 2013, Hayes and Monfils 2015, Latif et al. 2015). The type of assumption violation that would occur if migrant individuals were detected during a survey targeted at locally breeding individuals differs from a violation caused by individuals moving around the local area, since it results in individuals outside of the sample population of interest being detected as if they are members of that sample population. The detection of migrants on a survey targeting at locally breeding birds is concerning since detecting migratory birds during the first survey window could bias detection probabilities low and consequently inflate occupancy estimates. Moreover, migratory birds may be selecting habitat resources differently than breeding birds which could add variation and potentially mask relationships that would be informative to wetland managers.

The vocalization rate and response rate to call broadcasts of migratory individuals compared to locally breeding individual marsh birds is not well studied, with often conflicting reports in the literature on whether or not a given species does vocalize during migration (Glahn 1974, Kaufmann 1989, Conway and Gibbs 2005, Rehm and Baldassarre 2007). Data to support any conclusions are often limited, perhaps in part because the birds are difficult to detect in the first place, and when a species is known to vocalize during migration it is unknown whether migrant individuals and locally breeding individuals using the same site will vocalize at similar rates or respond to stimuli (call broadcast) in a similar way. If migrants are being detected during the first survey period, the impact on resulting inference could bias results towards migrants or increase error around estimates; either one is a significant concern.

Migratory birds may select different habitat resources than breeding individuals, and selection differences may result in more generalized findings of resource use or introduce variation that masks actual patterns of resource selection by breeding birds, the latter of which seems to be a common theme in marsh bird habitat resource selection literature (Johnson and Dinsmore 1986, Harms and Dinsmore 2013, Pickens and King 2013, Fournier et al. 2018, Wilson et al. 2018). Including migratory bird detections could also bias studies towards quantifying habitat selection of migrants, which could result in management mismatches. Management mismatch is a significant concern given the common practice of drawing down water levels in late spring and summer to promote vegetation germination, which can also remove water from under marsh bird nests increasing the risk of predation (Schmidt 2022).

Call type has been suggested as a way to differentiate between migrant and breeding individuals, although no study has specifically sought to examine this and data which do exist are anecdotal (Kaufmann 1989, Rehm and Baldassarre 2007). Some information suggests that call type could be used to differentiate between different phases of the nesting period (Bogner and Baldassarre 2002, Robertson and Olsen 2014), although we are not aware of any work that demonstrates that specific calls are not used during migration. The lack of robust studies examining call type differentiation makes assessing the effect of our H1 on the pattern of high detections in survey period one challenging, and further research is needed into the utility of call type to differentiate between migrant and locally breeding individuals. If this hypothesis is supported, the way that we analyze data from the Protocol would need to be adjusted, either through identification of a specific call type only used by locally breeding individuals or through sub-setting of data collected under the Protocol (e.g., using the second and third survey periods data only to make inferences about breeding individuals).

The second hypothesis, changes in vocalization rate of locally breeding individuals among survey periods because of changes in reproductive phenology, fits well within the broader understanding of avian vocalization (Best 1981, Skirvin 1981, Selmi and Boulinier 2003), but the literature on differential vocalization rates among marsh birds is limited. Further research is needed to better understand the role of call type in differentiating between migrating and breeding individuals, as that could be of great utility in future marsh bird surveys and a potential revision of the Protocol. Unfortunately, this research would not help address the nuance needed in analyzing existing datasets. Based on our experiences in the field, we find broad empirical support for this hypothesis unlikely, although the consequences of this hypothesis on the Protocol would be minimal as period-specific detection probabilities could be used to account for changing vocalization rates.

The third hypothesis, that locally breeding individuals are vocalizing more in the first survey period since there is a higher density of birds present due to migrants, has not been explored in marsh birds in the published literature as far as we can tell. We are not aware of any marsh bird specific literature that suggests a behavioral response to density impacts vocalization rate or responsiveness to call broadcast. We (A. Fournier) have observed Sora vocalizing throughout the night during peak fall migration in Missouri when there are dozens, if not hundreds, of individuals in the same wetland, but how this compares to spring migration and whether it's a true response to density dependence is unknown. We suspect H3 to be the least likely of the 3 proposed hypotheses, but it would be useful to document support or lack thereof. If H3 is supported, then a covariate could be used to explain the change in vocalization rate and thus detection of locally breeding birds in each survey period, although the exact categorization of that would need to be carefully thought out to be appropriate for the species and study context.

Until potential mechanisms are better understood, data collected from sites where migrants may be abundant during the first survey period should be examined carefully and in instances where there are dramatic differences in the number of detections in the first survey period versus latter periods, consideration should be given to analytical methods other than occupancy analysis and others where closure assumptions may be grossly violated. Other analytical options include data subsetting to ensure the population of interest (e.g., locally breeding individuals) for the research question or monitoring objective is being targeted. In places where migrants are abundant during the first survey period, those data might be better used outside of an occupancy modeling framework focused on locally breeding individuals, and instead could be useful for assessing the rail use-days of a given site during migration. For example, duck use-days are a commonly used metric used to monitor waterfowl abundance over time, estimate energy requirements used for conservation planning, and compare wetland management techniques by aggregating abundance over time into a single metric (Osborn et al. 2017, Soulliere et al. 2017). Rails often use the same habitat resources as migrating waterfowl and having a similar metric would allow for evaluation of tradeoffs for each guild in wetland management decisions.

Another option for dealing with H1 would be to repeatedly survey within each survey period outlined in the Protocol at a frequency likely to encompass the stopover duration of migrating marsh bird species of interest. Repeated surveys can be important for difficult to detect species to facilitate estimation of detection probability, and using a short between-survey interval (e.g., 1–2 days) would substantially reduce the likelihood of violating the closure assumption (although it would not completely eliminate this risk). Additionally, double observer methods (Moore et al. 2004) could be used to allow for estimation of detection and occupancy without having surveys on different days. Finally, using continuous-detection methods (e.g., automated recording units, Stewart et al. 2020) for short periods (e.g., 1–2 weeks) would allow data sub-setting at various intervals to examine for detection trends, estimate detection probabilities, and address other questions. All of these methods would require deviation from the Protocol, but they could be implemented in a complementary approach to supplement utility of the data collected within the generalized framework and still made available to the larger marsh bird management community through AKN.

Lastly, if Protocol methods are amended to deal with H1 biases, then migrating individuals will likely still be present in the dataset and potential biases in resource selection analysis may still be an issue. At an absolute minimum, researchers should acknowledge this issue and present trends in detections by survey period to help illustrate the degree to which potential biases exist. Superior study designs would use multiple survey methods (e.g., ARUs, repeated surveys during a short-interval) within each of the Protocol survey periods to allow both data sub-setting to reduce the influence of migrating birds and allow period-specific detection probabilities to be generated. Tradeoffs in disturbance would need to be considered with more frequent surveys, especially given the use of call broadcasts. Further refinement of how we collect, analyze, and interpret data from the Protocol would present the opportunity for better understanding of habitat conservation and management on breeding marsh birds and present the opportunity for some species to assess their habitat use and response to management during late migration. We see a need for additional work focused on the turnover rate of marsh birds at sites during migration, including whether it is the earlier or later arriving individuals at a site which choose to remain and breed locally. We also advocate that assessment of detections in survey period one are primarily local breeders verses migrating individuals, and how to best take advantage of data when there are significant migrants being detected.

RESEARCH IMPLICATIONS

Use of the Protocol has greatly improved our understanding of secretive marsh bird breeding ecology across North America in the past 2 decades, and we anticipate it will continue to further our knowledge of marsh birds. We recommend summary information and raw data be presented in the results of papers and reports, including the number of detections in each survey period by species. We laid out 3 potential mechanisms that could cause patterns in detections among survey periods in the Protocol but predict the detection of migrants in surveys targeted at locally breeding individuals (H1) is the most likely and has the biggest potential impacts on the inference made from those studies. We strongly recommend future study to better understand whether the population targeted with the Protocol is the one being surveyed, and if it is, why we see these sharp changes in detections among survey periods using call-back surveys on radio- or GPS-marked birds We also caution that in mid-latitude and southern states, detections from the first survey period for later migrating species should be interpreted with caution until mechanisms underlying detection processes are better understood. In the face of a wide range of threats (e.g., wetland loss, climate change, habitat fragmentation), our ability to understand the impacts of management on secretive marsh birds, as well as other wetland fauna, is crucial to supporting multispecies management of wetlands and allowing for informed discussions of tradeoffs in wetland management strategies. This means taking a crucial next step in our collective effort to ensure we are surveying the population that we intend by adjusting our analytical methods or the Protocol itself to deal with the implicit link with occupancy analyses and violated closure assumptions.

ACKNOWLEDGMENTS

We thank hundreds of individuals and dozens of agencies and organizations for work collecting data that was used or referenced in this manuscript. The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service. Any use of trade, product, website, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government. In kind support was provided by the Illinois Natural History Survey, Winous Point Marsh Conservancy, and United States Fish and Wildlife Service. We thank A. Behney (Associate Editor), A. Knipps (Editorial Assistant), A. Tunstall (Copy Editor) and J. Levengood (Content Editor) and the anonymous reviewers for constructive comments that improved our manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ETHICS STATEMENT

No ethical information provided.

DATA AVAILABILITY STATEMENT

There are no data associated with this paper.

ORCID

Auriel M. V. Fournier http://orcid.org/0000-0002-8530-9968

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Associate Editor: A. Behney.

How to cite this article: Fournier, A. M. V., T. M. Bradshaw, H. M. Hagy, and B. Shirkey. 2022. To improve existing marsh bird survey protocols, we need to evaluate closure assumptions. Wildlife Society Bulletin e1410. https://doi.org/10.1002/wsb.1410