Notes

Movements of Radio-Marked California Ridgway's Rails During Monitoring Surveys: Implications for Population Monitoring

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Abstract

The California Ridgway's rail *Rallus obsoletus obsoletus* (hereafter California rail) is a secretive marsh bird endemic to tidal marshes in the San Francisco Bay (hereafter bay) of California. The California rail has undergone significant range contraction and population declines due to a variety of factors, including predation and the degradation and loss of habitat. Call-count surveys, which include call playbacks, based on the standardized North American marsh bird monitoring protocol have been conducted throughout the bay since 2005 to monitor population size and distribution of the California rail. However, call-count surveys are difficult to evaluate for efficacy or accuracy. To measure the accuracy of call-count surveys and investigate whether radio-marked California rails moved in response to call-count surveys, we compared locations of radio-marked California rails collected at frequent intervals (15 min) to California rail detections recorded during call-count surveys conducted over the same time periods. Overall, 60% of radio-marked California rails within 200 m of observers were not detected during call-count surveys. Movements of radio-marked California rails showed no directional bias ($P = 0.92$) irrespective of whether or not playbacks of five marsh bird species (including the California rail) were broadcast from listening stations. Our findings suggest that playbacks of rail vocalizations do not consistently influence California rail movements during surveys. However, call-count surveys may underestimate California rail presence; therefore, caution should be used when relating raw numbers of call-count detections to population abundance.

Keywords: California Ridgway's rail; call-count survey; radiotelemetry; monitoring; endangered species recovery

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Figure 1. Photograph of a California Ridgway's rail *Rallus obsoletus obsoletus*, previously known as the California clapper rail *Rallus longirostris obsoletus*, with chick. The California rail is a secretive marsh bird endemic to and historically abundant in tidal marsh habitat in the San Francisco Bay of California. Trapping of California rails was conducted at Corte Madera Ecological Reserve, Faber Tract, Gallinas Creek, and Laumeister Marsh in the bay between 1 January and 31 March 2013.

Introduction

The California Ridgway's rail *Rallus obsoletus obsoletus* (hereafter California rail; Chesser et al. 2014), previously known as the California clapper rail *Rallus longirostris obsoletus*, is a secretive marsh bird endemic to and historically abundant in tidal marsh habitat in the San Francisco Bay (hereafter bay) of California (Cohen 1895). However, over the past century, the California rail (Figure 1), like other tidal marsh species, has undergone significant range contraction and population declines due to a variety of factors (Takekawa et al. 2006). The combined threats of conversion of tidal marsh to diked lands for agriculture and salt production (San Francisco Bay Area Wetlands Ecosystem Goals Project 1999), urban encroachment (U.S. Fish and Wildlife Service [USFWS] 2013), predation by both native and nonnative predators (Albertson 1995; Foin et al. 1997; Harding et al. 2001), introduction of invasive species (Baye et al. 2004), and contaminants (Schwarzbach et al. 2006; Ackerman et al. 2012; Casazza et al. 2014) have led the California rail to be designated as a state and federally listed endangered species under the California Endangered Species Act (California Department of Fish and Game 1979) and US Endangered Species Act (ESA 1973, as amended), respectively. The subspecies is now restricted mainly to isolated marsh fragments in the highly urbanized bay area, with the vast majority found in the central and southern reaches (California Department of Fish and Game 2008), where it defends small (2–4-ha) territories in areas dominated by mid- and lower-intertidal vegetation, particularly during the breeding season (Rohmer 2010; Overton 2013). Although the subspecies' population dynamics is poorly understood (Liu et al. 2012), recent work has estimated low annual survival rates (27–47%) in south bay salt marshes (Overton et al. 2014).

To monitor population size and distribution of the California rail and other secretive marsh birds, government agencies and conservation organizations have used call-count surveys based on the standardized North American marsh bird monitoring protocol (Conway 2011). Surveyors listen for marsh bird vocalizations and play recorded calls along predetermined survey routes through or adjacent to tidal marshes during the marsh bird breeding season (Conway 2011). The number of detected marsh birds and the distance to them are then estimated and recorded. Throughout the bay, call-count surveys optimized for California rails have been con-

ducted since 2005 (Spautz and McBroom 2005; Wood et al. 2014), and the data collected from these surveys have played a central role in population monitoring analyses (Liu et al. 2012) and in guiding local management actions such as invasive species control (McBroom 2012).

Despite their widespread use, call-count surveys are difficult to evaluate for efficacy or accuracy because they require assumptions that are rarely validated and have a high likelihood of being incorrect (Johnson et al. 2009). Calling rates can change throughout the day and breeding season when surveys are conducted (Conway et al. 1993; Liu et al. 2012) and also differ between the sexes (Legare et al. 1999), thereby biasing estimates of population density and structure. Furthermore, birds may move away from or toward surveyors before or after broadcasting of recorded bird vocalizations (Legare et al. 1999; Lor and Malecki 2002; Bogner and Baldassarre 2002), and such movements would result in under- or overestimation of detectability and local density (Conway and Gibbs 2001).

We compared locations of radio-marked California rails collected at frequent intervals (15 min) to California rail detections recorded during call-count surveys conducted over the same time periods to measure the accuracy of call-count surveys. Specifically, we measured the distance between paired radiotelemetry locations and call-count survey detections in both space and time. We also investigated whether radio-marked California rails moved in response to call-count surveys and discussed the implications such movements would have for estimates of population density and distribution obtained from call-count surveys.

Study Site

We conducted our study in four tidal salt marshes (Corte Madera, Faber, Gallinas Creek, and Laumeister; Figure 2) in the bay. Corte Madera Ecological Reserve (100 ha; 37°94′N, 122°49′W) was formed from the accumulation of sediment by-products of hydraulic gold mining during the mid-1800s. Faber Tract (42 ha; 37°46′N, 122°12′W) was the result of the deposition of dredge material from nearby harbors. Gallinas Creek (136 ha; 38°03′N, 122°50′W) was part of an ongoing habitat restoration project to restore wetland habitat adjacent to Miller Creek and Las Gallinas Creek. Laumeister Marsh (36 ha; 37°47′N, 122°12′W) has been tidal salt marsh for over 110 y, making it one of the oldest remaining marshes in the south bay. Ground cover at all study sites was dominated by *Sarcocornia virginica*, with nearly all escape and refuge cover for California rails provided by *Grindelia stricta* and *Spartina foliosa*.

Methods

Capture and radio-marking

We captured and radio-marked 39 California rails with very-high-frequency transmitters between 1 January and 31 March 2013. Tomahawk® live traps (Tomahawk Live Trap, LLC, Hazelhurst, WI) measuring one of two sizes (107 × 38 × 41 cm or 41 × 13 × 13 cm) were modified by removing the treadle mechanism typically used to trigger the trap and replacing it with a tripwire attached to an externally mounted spring-snap rat trap (Figure 3). The snap-bar of the rat trap was attached to the Tomahawk trap door release mechanism, allowing the live-trap doors to close when pressure on the tripwire triggered the rat trap (Overton 2013). The modified live traps were placed at low tide within well-developed channels and passively caught California rails as they moved and foraged through the marsh. Captured rails were sexed according to culmen length, tarsometatarsus length, and flat wing length (Overton et al. 2009) and then fitted with 9.5-g backpack-mounted very-high-frequency radio-transmitters (model A1120; Advanced Telemetry Systems, Isanti, MN) attached using modified Dwyer harnesses (Dwyer 1972) made of 0.5-cm tubular Teflon™ ribbon (Bally Ribbon Mills, Bally, PA). California rails were monitored intensively for the first week after marking, with repeated attempts at visually observing the bird to verify transmitter fit and acclimatization. Individual age classes could not be determined at the time of year that individuals were captured (Pyle 2008).

Radiotelemetry

Every 3 d at each study site between 12 February and 2 April 2013, radio-marked California rails were located by two observers every 15 min over a period of 2.5 h before and after sunrise or sunset by using handheld three-element Yagi antennas and telemetry receivers (model R4500SD; Advanced Telemetry Systems) from the perimeter of the study marshes. Observers simultaneously measured the azimuth toward the strongest signal location by using a handheld compass from three to six locations recorded with handheld global positioning system units. Azimuths to the bird's signal and distance to the bird were analyzed using LOAS version 4.0 (Ecological Software Solutions, LLC, Hegymagas, Hungary).

Call-count surveys

The periods of frequent radiotelemetry described above coincided with marsh bird call-count surveys based on methods described in Conway (2011). Call-count surveys were conducted by observers other than those who conducted radiotelemetry. Listening stations were placed approximately 200 m apart and primarily located at marsh edges, levees bordering and within marshes, and boardwalks within the marsh. The number of listening stations established at each marsh varied due to site size, configuration, and accessibility. All study sites had four listening stations, except for Gallinas, which had only three. Standardized prerecorded vocalizations with a total duration of 5 min were provided by the Invasive Spartina Project (www.spartina.org) in conjunction with the USFWS and played from an mp3 player with portable speakers after 5 min of passive listening. Multiple bird species were included in the vocalizations and broadcast in the following order, with 1 min of vocalizations for each species: California black rail *Laterallus jamaicencis coturniculus*, California rail, sora *Porzana carolina*, Virginia rail *Rallus limicola*, and American bittern *Botaurus*

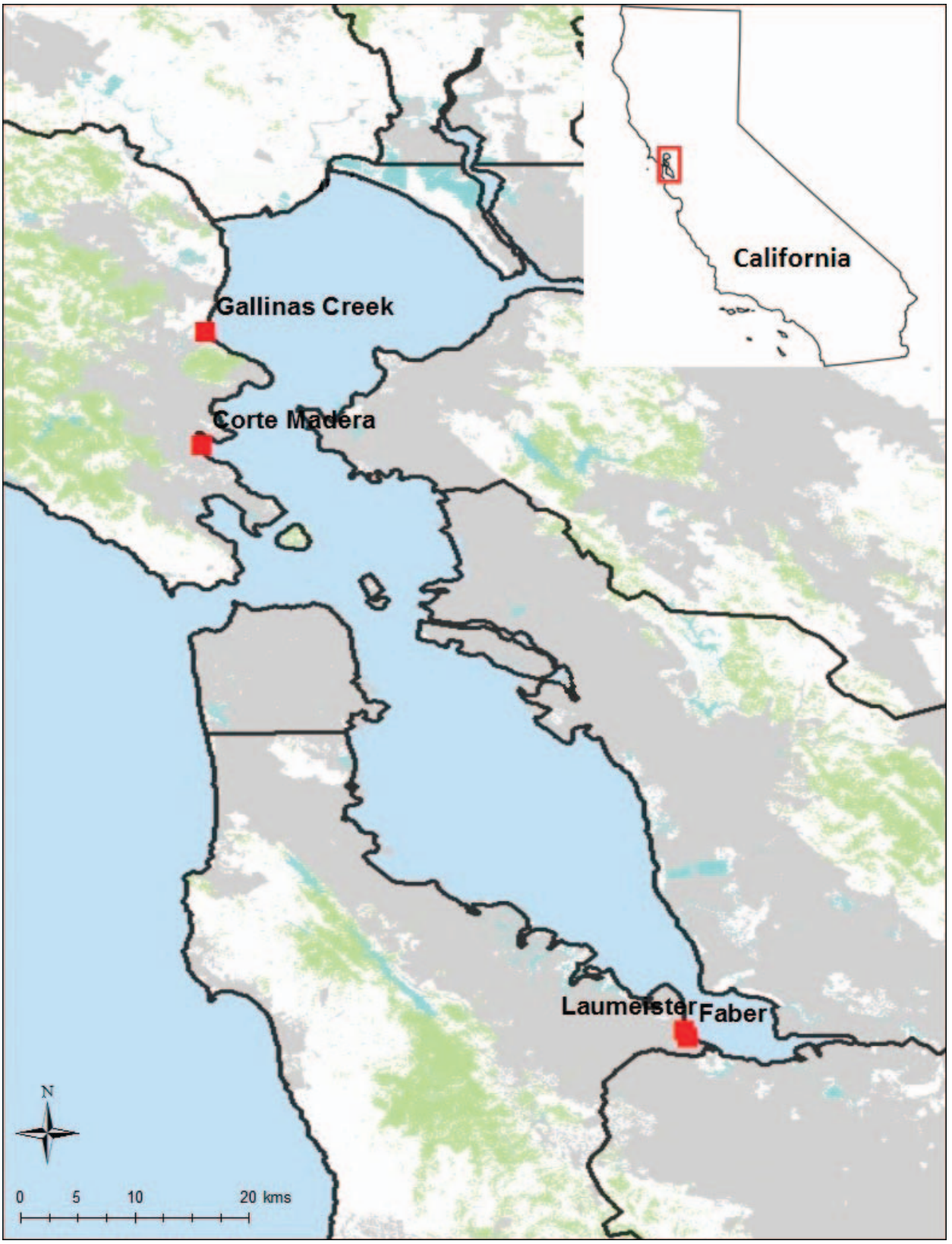

Figure 2. Location of Corte Madera Ecological Reserve, Faber Tract, Gallinas Creek, and Laumeister Marsh in San Francisco Bay, California, where California Ridgway's rails *Rallus obsoletus obsoletus* were captured during 2013.

Figure 3. Photograph of a Tomahawk live trap (107 × 38 × 41 cm) modified by removing the treadle mechanism typically used to trigger the trap and replacing it with a tripwire attached to an externally mounted spring-snap rat trap. The snap-bar of the rat trap was attached to the Tomahawk trap door release mechanism allowing the live-trap doors to close when pressure on the tripwire triggered the rat trap. The modified live traps were placed at low tide within well-developed channels and passively caught California Ridgway's rails *Rallus obsoletus obsoletus* as they moved and foraged through the marsh. Trapping was conducted at Corte Madera Ecological Reserve, Faber Tract, Gallinas Creek, and Laumeister Marsh in San Francisco Bay, California, between 1 January and 31 March 2013.

lentiginosus. All California rails detected from a listening station were recorded with the time, estimated direction, and estimated distance from the listening station. In addition, the approximate location of each California rail, or pair of California rails, was plotted on a field map of the site. California rails detected during transit between listening stations as well as before or after the 10-min survey period were also recorded.

Analysis

We compared locations of radio-marked California rails to California rail detections during call-count surveys with ArcGIS 10.1 (ESRI, Redlands, CA) and the Data Management tools module (bearing distance to line, feature vertices to points). We used additional Data Management tools (points to lines, split lines at vertices) to measure movements of radio-marked California rails in response to broadcast rail vocalizations. We considered a telemetry location and a call-count detection to be the same individual if the two occurred within 60 m and 10 min of each other (Legare et al. 1999; Figure 4a). In contrast, we considered telemetry locations and call-count detections as separate individuals when they occurred greater than 60 m (Figure 4b) or 10 min (Figure 4c) apart. If a telemetry location and call-count detection occurred within 10 min of each other but greater than 60 m apart, we considered these detections to be separate individuals. Call-count detections were not compared with any telemetry location more than 10 min apart because more proximate locations were available for comparison. We developed two rose diagrams (one each for passive and active surveys) grouping directional movement of California rails into 20° bins during call-count surveys with R 3.0.2 (R Development Core Team 2012). Rayleigh's test of uniformity was conducted with these data to investigate the mean direction of movement of California rails during passive and active call-count surveys and

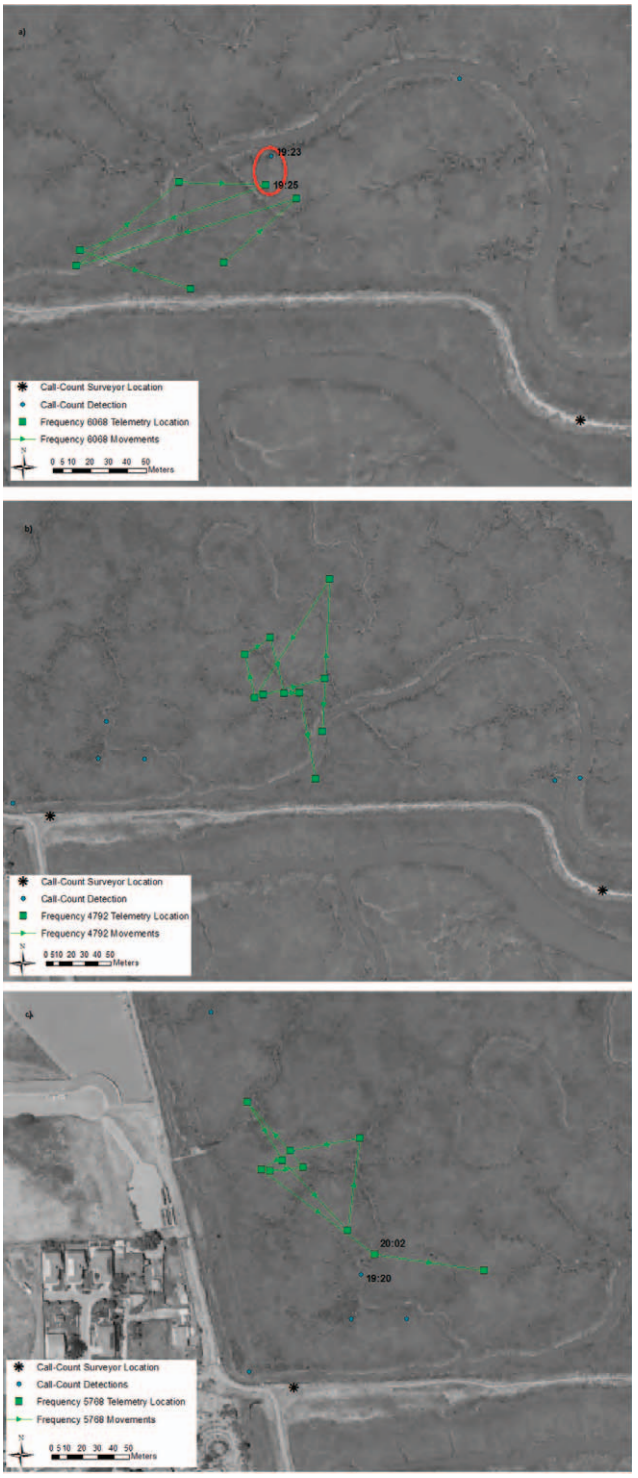

Figure 4. Examples of radio-marked California Ridgway's rails *Rallus obsoletus obsoletus* that were either detected or missed during call-count surveys. A telemetry location and call-count detection that occurred within 60 m and 10 min of each other were considered to be the same individual California rail (**a**; circled in red). A telemetry location and call-count detection that occurred within 10 min of each other but were more than 60 m apart were considered to be two distinct individual California rails (**b**). A telemetry location and call-count detection that were within 60 m of each other but occurred more than 10 min apart were also considered to be two distinct individual California rails (**c**). Radiotelemetry and call-count surveys were conducted at Corte Madera Ecological Reserve, Faber Tract, Gallinas Creek, and Laumeister Marsh in San Francisco Bay, California, between 12 February and 2 April 2013.

to determine whether mean direction of movement differed between the two call-count survey types. Data are reported as mean ± standard deviation.

Results

In total, we recorded 486 radiotelemetry locations (Table S4, *Supplemental Material*) in 39 bouts, with an average error of 57 ± 65 m. Radio-marked California rails were detected at the same locations between call-count surveys, indicating little movement by individuals between adjacent marshes or areas within a marsh. This finding was consistent across all four study sites and over the entire study period.

We recorded 143 California rail detections (Table S5, *Supplemental Material*) during 12 call-counts (three per study site). One radio-marked California rail at Corte Madera was detected twice during a single call-count survey; no other radio-marked California rails were detected more than once during a survey. Paired telemetry locations and call-count detections were separated by an average of 34 ± 14 m and 3.5 ± 0.002 min. Radio-marked California rails that were detected during call-count surveys were, on average, 150 ± 60 m from surveyors, whereas those that were not detected were 244 ± 123 m from surveyors. Overall, 59% (16 of 27) of radio-marked California rails present within 200 m of surveyors were not detected during call-count surveys.

Movements of radio-marked California rails showed no directional bias regardless of whether or not playbacks were broadcast from listening stations. Rose diagrams displaying California rail movements during passive surveys (without playbacks; Figure 5a, n = 249) and active surveys (with playbacks; Figure 5b, n = 181) showed a similar response, with California rails exhibiting a tendency to move in random directions during both types of call-count surveys. Results from Rayleigh's test of uniformity (passive surveys: R = 0.018, P = 0.92; active surveys: R = 0.021, P = 0.92) confirmed that the distribution of California rail directional movements during the two types of call-count surveys showed no significant difference from a random, uniform distribution.

Discussion

Our findings indicate an overall underestimation of California rail presence due to low probability of detection for call-count surveys in tidal salt marshes throughout the bay and suggest that population abundance in marsh complexes may be greater than uncorrected counts reported in previous studies (Liu et al. 2012). Nearly 60% of radio-marked California rails within 200 m from surveyors were not detected during call-count surveys. However, our study encompassed only a few areas and did not include study sites with low

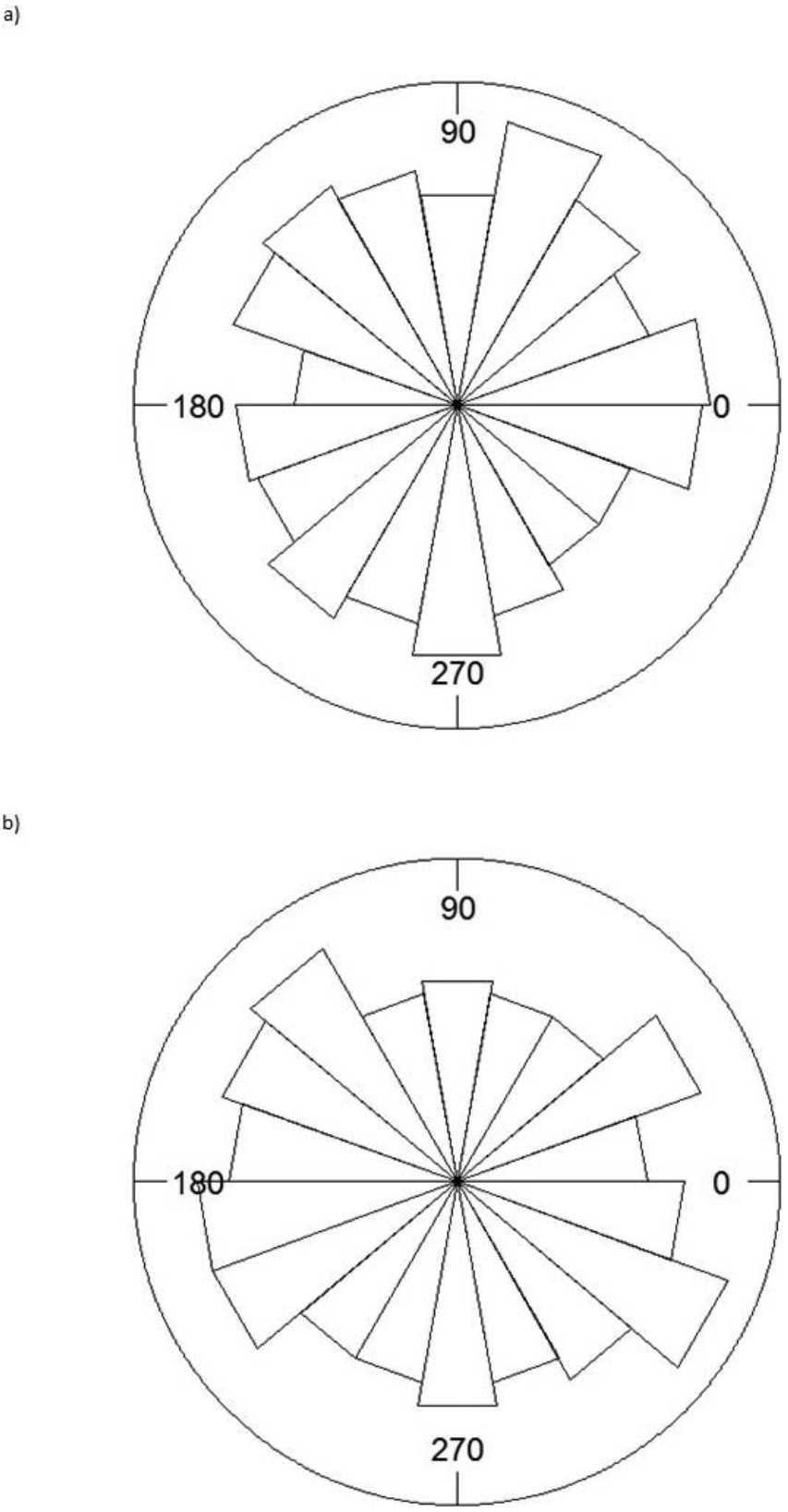

Figure 5. Directional movements of radio-marked California Ridgway's rails *Rallus obsoletus obsoletus* during passive surveys (**a**; $R = 0.018$, $P = 0.92$) and active surveys (**b**; $R = 0.021$, $P = 0.92$) across all sites showed no difference from a random, uniform distribution for radiotelemetry and call-count surveys conducted at Corte Madera Ecological Reserve, Faber Tract, Gallinas Creek, and Laumeister Marsh in San Francisco Bay, California, between 12 February and 2 April 2013.

California rail density; therefore, we are not suggesting that California rail population estimates based on call-count surveys be adjusted by this particular measurement of error. However, a similar yet broader study with larger sample sizes across a wider range of study sites might provide further insight to an appropriate adjustment. In practice, California rail surveys conducted in the bay are used only as an index for population trends, not as an estimate of abundance or density, and the index value is not biased by undercounting individuals as would abundance or density estimates (Johnson 2008).

To our knowledge, this is the first study to use radiotelemetry to investigate the accuracy of call-count surveys in detecting the endangered California rail in the bay; other studies have measured the effectiveness of call-count surveys in detecting other marsh bird species. Legare et al. (1999) found that 40–65% of eastern black rails *Laterallus jamaicensis jamaicensis* responded during call-count surveys, which is comparable to our results. Their study also found that responses from male black rails peaked at 60 m from playback location, which was the cut-off that we used to determine whether a vocalizing and radio-marked California rail was the same individual. Bogner and Baldassarre (2002) detected radio-marked least bitterns *Ixobrychus exilis* only during a quarter of call-count surveys, which is less than during our study but may be due to differences in species behavior.

Factors affecting detectability are often issues of concern in studies using call-count surveys. Such studies commonly use a distance of 200 m from surveyors as the limit at which marsh birds can reliably be detected (Liu et al. 2012; McBroom 2012), and the differences between distance to detected and undetected radio-marked California rails in our study support this approach. Radio-marked California rails that were detected during call-count surveys were within 200 m from surveyors, whereas California rails that were not detected were farther than 200 m away. Furthermore, the use of playbacks seemed to show no consistent influence on movements of radio-marked California rails during call-count surveys, as they were neither attracted to nor repelled by playbacks. Similarly, Legare et al. (1999) found that black rails were equally likely to move toward playbacks as they were to remain in the same location. However, our results conflict with those from studies that have documented attraction to playbacks, such as with least bitterns where playback elicited short flights toward playback locations and defensive behavior (Bogner and Baldassarre 2002; Lor and Malecki 2002). Any consistent movement by marsh birds toward or away from playbacks would violate an assumption of distance sampling and result in a biased estimate of marsh bird density (Conway and Gibbs 2001). Previous studies (Liu et al. 2009; Henkel et al. 2013) have used distance sampling analysis to calculate bay-wide population estimates for the California rail, and our finding that California rails were not responding directionally to playbacks suggested that this method could be used with distance sampling. Other factors that have been shown to affect the detection rate of California rails during call-count surveys include time of day and tide level (Liu et al. 2012; Lehmicke et al. 2013), but these factors were not taken into account in our limited study.

To address the conservation issues surrounding the California rail and other obligate tidal marsh species, the USFWS created the Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (USFWS 2013). Recovery goals for these sensitive species include "securing self-sustaining wild populations of each covered species throughout their full ecological, geographical, and genetic range; ameliorating or eliminating, to the extent possible, the threats that caused the species to be listed or of concern and any future threats; and restoring and conserving healthy ecosystem function supportive of tidal marsh species" (USFWS 2013). Call-count surveys, such as those conducted during our study, have been used to monitor progress toward these recovery goals for the California rail in the bay since 2005 (Spautz and McBroom 2005; Wood et al. 2014). Therefore, it is of significance to the conservation of this endangered species that the effectiveness of call-count surveys in monitoring population trends is investigated thoroughly. This is the first attempt we are aware of to use radiotelemetry to do so, and our findings suggest that although call-count surveys constitute a useful method to monitor population trends, improvements that increase detection probability could be considered to provide a more accurate index of population size.

Supplemental Material

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Table S1. Table of California Ridgway's rail *Rallus obsoletus obsoletus* locations as estimated by radiotelemetry. For each estimated California Ridgway's rail location, the following are listed: easting (in Universal Transverse Mercator [UTM]), northing (in UTM), bird identification, date, study site, and time. To protect the specific location data of this state and federally endangered species, easting and northing figures listed here represent relative distances (m) from average easting and northing across all radiotelemetry locations. Radiotelemetry was conducted at Corte Madera Ecological Reserve, Faber Tract, Gallinas Creek, and Laumeister Marsh in San Francisco Bay, California, between 12 February and 2 April 2013.

Found at DOI: http://dx.doi.org/10.3996/092014-JFWM-069.S1 (36 KB XLSX).

Table S2. Table of California Ridgway's rail *Rallus obsoletus obsoletus* detections during call-count surveys. For each California rail detection, the following are listed: study site, station identification, survey start time, estimated compass bearing from surveyor to detection, estimated distance from surveyor to detection (m), and the minute(s) of the call-count survey (passive or active) during which the detection(s) occurred. Specific location data have been removed to protect this state and federally endangered species. Call-count surveys were

conducted at Corte Madera Ecological Reserve, Faber Tract, Gallinas Creek, and Laumeister Marsh in San Francisco Bay, California, between 12 February and 2 April 2013.

Found at DOI: http://dx.doi.org/10.3996/092014-JFWM-069.S2 (18 KB XLSX).

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Found at DOI: http://dx.doi.org/10.3996/092014-JFWM-069.S3; also available: http://www.prbo.org/refs/files/12002_ LeonardLiu2009.doc (2942 KB DOC).

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Found at DOI: http://dx.doi.org/10.3996/092014-JFWM-069.S4; also available: http://www.southbayrestoration.org/documents/technical/CLRA2005-11FinalReportPRBO.pdf (4353 KB PDF).

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Found at DOI: http://dx.doi.org/10.3996/092014-JFWM-069.S6; also available: http://www.fws.gov/sacramento/es/Recovery-Planning/Tidal-Marsh/Documents/20131210_TMRP_Vol1.pdf (45.6 MB PDF).

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Found at DOI: http://dx.doi.org/10.3996/092014-JFWM-069.S7; also available: http://www.pointblue.org/uploads/assets/2013_CCR_annual-report_Point_Blue_2014_ 01_07 (160 KB PDF).

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