# Population trends, distribution, and monitoring protocols for the California Black Rail

Final Report

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by

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## DISCLAIMER

**ABSTRACT:** California black rails (*Laterallus jamaicensis coturniculus*) are rare and many local populations are thought to be declining due to loss of wetland habitat. Most remaining California black rails in the U.S. occur in two disjunct regions: the lower Colorado River region and northern California (including Sacramento Valley and the San Francisco Bay area). Despite state and federal concern for black rails, their status and distribution is still poorly known and effective monitoring programs to adequately estimate population trends are currently lacking. We developed and implemented a standardized survey for California black rails throughout remaining habitat in Arizona, and southern and central California. We repeated surveys in areas included in previous survey efforts in the region to provide estimates of population trends for California black rails. We compared number of black rails detected (and temporal variation in numbers detected) between passive (no calls broadcast) and call broadcast surveys. We conducted replicate trials at a subset of survey routes to determine the most effective black rail monitoring protocols for future surveys. We also examined the habitat and vegetative features correlated with current black rail distribution and abundance. We detected 136 black rails in Arizona and southern/central California. The majority (100) were detected at sites along the lower Colorado River, and 21 were detected at three sites along the All-American Canal. Most of the black rails located along the Colorado River were found in wetlands associated with the river between Laguna Dam north to Ferguson and Martinez Lakes. Numbers of California black rails have declined at 10 of the 11 locations where rails are/were most abundant in the region. Population declines were most significant at marshes along the All-American Canal and the mouth of the New River in California (where all rails and rail habitat has been eliminated). Black rails (and all suitable habitat) have also completely disappeared from the southern end of the Coachella Canal and Finney/Ramer Lakes. Marshes associated with the Colorado River from Senator Wash to Mittry Lake support most of the breeding California black rails in the region. Planet Ranch area of the Bill Williams River and the seep marsh along the All-American Canal are also important areas for black rails. Despite the importance of the Imperial Reservoir area for conservation of black rail populations, several marshes in this area have been filled or developed since 1974. These actions need to be curtailed so that black rail populations in the region can persist. Plants that were significantly more common at points with black rails included three-square bulrush, cottonwood, salt grass, seep willow, salt cedar, arrowweed, and mixed shrubs. Plants that were significantly less common at points with black rails included common reed, California bulrush, and cattail. Three-square bulrush showed by far the most obvious association with black rail presence. Call broadcast significantly increased number of black rails detected by 14% compared to passive surveys. However, broadcasting calls of black rails reduced detection probability of other rails and bitterns. We detected more black rails on evening surveys compared to morning surveys, but evenings were often too windy for surveys. Detection probability increased from 05:00-07:00 h and then declined as the morning progressed, but did not vary among time intervals during evening surveys. Average observer detection probability of black rails was 80.6%. We recommend that standardized black rail surveys be repeated annually so that better estimates of black rail population trend can be obtained. Three replicate surveys should be conducted annually at each survey point during defined survey windows (we suggest 21-30 March, 21-30 April, and 21-30 May). Observers can conduct either morning or evening surveys on a route as long as a particular survey route is surveyed during the same period (morning or evening) consistently each year. Standardized black rail survey protocols are presented in an Appendix.

## INTRODUCTION

Although limited in local distribution, California black rails (*Laterallus jamaicensis coturniculus*) were apparently not rare in the early 1900s (Allen 1900). Most populations of California black rails are now threatened with extinction. Local populations are thought to be declining due to loss/degradation of suitable habitat (Evens et al. 1991, Eddleman et al. 1994) and isolation of remaining populations make California black rails vulnerable to extirpation. Because of habitat loss and perceived population declines, California black rails are listed as state endangered in Arizona (Arizona Game and Fish Department 1988) and state threatened in California (California Department of Fish and Game 1989). Consequently, California black rails are considered a priority species in the Draft Lower Colorado River Multi-Species Conservation Plan (Ogden Environmental and Energy Services 1998) and are one of the 10 highest priorities for conservation action among birds in Arizona (Latta et al. 1999). Black rail populations have also declined in the eastern U.S., and Eastern black rails (*L. jamaicensis jamaicensis*) are listed as state threatened in New Jersey (Kerlinger and Wiedner 1991). Hence, black rails are considered a species of national management concern in the U.S. (U.S. Fish and Wildlife Service 1987), are on the National Audubon Society's "*WatchList*", and were previously a Category 1 "candidate" species for federal listing under the Endangered Species Act (U. S. Dept. of Interior 1989).

Remaining California black rails in the U.S. occur in two disjunct regions: the lower Colorado River region and northern California (including Sacramento Valley and the San Francisco Bay area; Evens et al. 1991, Tecklin 1999). The status of California black rails in Mexico is unknown but large populations probably do not exist. Only two previous surveys of black rails have occurred in the lower Colorado River region: 1973-74 (Repking and Ohmart 1977) and 1989 (Evens et al. 1991). California black rail populations in the lower Colorado River region were thought to be declining in 1977 because of habitat destruction (Repking and Ohmart 1977, Edwards 1979). Laymon et al. (1990) believed that much of the California black rail habitat in southern Arizona and California was in danger of being destroyed by water reclamation and flood control measures. Numerous important marshes in the region have been altered or destroyed since the last region-wide distributional survey in 1989 (Evens et al. 1991).

Black rails prefer stable, shallow-water areas and usually occupy the narrow transition zone between upland and emergent vegetation within lower Colorado River wetlands (Repking and Ohmart 1977, Eddleman et al. 1994, Flores and Eddleman 1995). Hence, black rails are more vulnerable to changes in water level than other marsh birds (Flores and Eddleman 1991). Protection of existing, and recovery of historic, habitat is essential to maintain black rail populations in the lower Colorado River region (Evens et al. 1991). Despite state and federal concern for black rails, status and distribution is still poorly known (Flores and Eddleman 1991) and land managers lack the information necessary to manage or recover black rail populations.

A pro-active approach to protecting species is considered more effective, more cost-efficient, and less politically difficult compared to the traditional retroactive approach to species recovery (Green and Hirons 1991, Noss and Cooperrider 1994). Population monitoring is critical to effective species conservation because monitoring allows us to identify problems before populations are threatened with extinction (Goldsmith 1991, Hagan et al. 1992). Traditional avian monitoring programs (e.g., the Breeding Bird Survey of the U.S. Geological Survey) are ineffective at monitoring black rails (Eddleman et al. 1994). Despite the perceived population declines of California black rails, effective monitoring programs to adequately estimate population trends are currently lacking. Moreover, information on current distribution and abundance is not available. Past black rail surveys provided distribution/abundance information (Repking and Ohmart 1977, Evens et al. 1991) and Evens et al. (1991) reported a 30% decline in black rails between 1974 and 1989 on the lower Colorado River. However, these surveys tell us little about current distribution and population trends. Indeed, basic information on distribution, abundance, and population trends are considered conservation needs for black rails (Gustafson 1987, Evens et al. 1991, Kerlinger and Wiedner 1991). In this study, we developed and implemented a standardized survey for California black rails throughout remaining habitat in Arizona and southern and central California. We repeated surveys in areas included in previous survey efforts in the region to provide estimates of population trends for California black rails. We also surveyed other areas that had suitable habitat but were not included in previous survey efforts.

The most commonly-used method to determine presence and abundance of marsh birds in local areas involves the broadcast of recorded calls (also referred to as tape playback; Conway and Gibbs 2001). Indeed, call broadcast surveys have been used to monitor local and regional black rail populations (Jurek 1975, Repking and Ohmart 1977, Manolis 1978, Evens et al. 1991, Flores and Eddleman 1991, Legare et al. 1999, Spear et al. 1999). However, this method is not effective for all marsh birds (Conway and Gibbs 2001) and call broadcast surveys did not increase the number of California black rails detected relative to passive surveys (surveys on which calls are not broadcast) in a previous study on the lower Colorado River (Flores and Eddleman 1991). Moreover, call broadcast surveys have many drawbacks not associated with passive surveys (Conway and Gibbs 2001). Understanding the magnitude of benefits and drawbacks associated with call broadcast surveys is essential prior to implementing a region-wide black rail monitoring program. Hence, we compared number of black rails detected (and temporal variation in numbers detected) between passive and call broadcast surveys. We also conducted replicate trials at a subset of survey routes to determine the most effective black rail monitoring protocols for future surveys by comparing a variety of survey methods. Indeed, development of standardized population surveys and refinement of survey methods are considered high priorities for black rail conservation (Eddleman et al. 1994).

Habitat restoration projects are needed to restore black rail populations in the lower Colorado River region. However, information on the distribution, abundance, and trends associated with preferred black rail habitat in the region is not available. Such information would help land managers along the Colorado River adjust current or implement new management plans that benefit black rails so that California black rails avoid federal listing and possible extirpation. Consequently, we also documented vegetative composition at all of our survey points and examined the features correlated with current black rail distribution and abundance.

## METHODS

We surveyed suitable black rail habitat along the lower Colorado River (Grand Canyon south to the Gila River confluence), at Morro Bay (San Luis Obispo County, California), Big Morongo Canyon (San Bernardino County, California), wetlands throughout the Imperial Valley of California (including areas along the All-American and Coachella Canals, the New River west of Seeley, Fig Lagoon, and around the Salton Sea), and portions of the Gila and Bill Williams Rivers in Arizona. All surveys were conducted from 1 March to 28 July when black rails are most vocal (Todd 1970, Repking and Ohmart 1977, Eddleman et al. 1994). We surveyed Morro Bay, Fig Lagoon, the New River, and a few marshes near Blythe, California in 2001 and all other areas in 2000. Survey sites were chosen by searching for appropriate habitat at locations surveyed during previous black rail surveys (Repking and Ohmart 1977, Evens et al. 1991) and by using aerial photos of the Colorado River taken in 1997. Most surveys were conducted in the morning from 0.5 hours before sunrise until 10:00 h to coincide with the daily survey period used in previous black rail surveys in the region (Todd 1980, Evens et al. 1991, Flores and Eddleman 1991). Some surveys were conducted in the evening (4 hours before sunset until 0.5 hours after sunset).

We established survey points along upland and open water edges of all "suitable" emergent vegetation based on our examination of aerial photographs, available information from previous survey efforts, conversations on possible locations with local biologists and recreational birders, and reconnaissance visits. Distance between adjacent survey points was approximately 50 meters at sites where black rails were discovered during past surveys and 100-150 meters at sites with no previous black rail records. We attempted to locate survey routes in the same locations as previous studies (Todd 1980, Repking 1975, Evens et al. 1991) whenever possible. We recorded exact location of each survey point using a Garmin eMap GPS unit. We also plotted the location of each of our survey points onto aerial photographs and topographic maps to allow standardized replication of our complete survey effort in future years. Periodic re-survey of our points will allow us to detect population declines quickly. We also recorded all Yuma clapper rails (*Rallus longirostris yumanensis*), Virginia rails (*Rallus limicola*), soras (*Porzana carolina*), least bitterns (*Lxyobrychus exilis*), and American bitterns (*Botaurus lentiginosus*) detected during our surveys. Hence, repeating our survey effort in future years will allow us to estimate population trends for all rails and bitterns in the lower Colorado River region.

During our surveys, we used a cassette tape of recorded black rail calls broadcast at a volume of 90 decibels using a portable stereo cassette tape player (Optimus model SCP-88 or model SCP-104) attached to a pair of portable amplified speakers (Optimus model AMX-4). The speakers were taped together, placed on the ground at the marsh edge, and faced out into the marsh. We recorded all rails and bitterns seen and heard during the 6-minute survey period as well as all those detected while moving between survey points (either before or after the 6-minute survey period at each point). We also recorded the type(s) of vocalization given by each bird detected. We recorded temperature, wind speed, and precipitation at the beginning and end of each survey period. Surveys were not conducted when wind speed consistently exceeded 25 kilometers per hour or during periods of heavy rain. Field surveys were conducted by a field crew supervisor (Christina Sulzman) and two technicians (Benjamin Clock and Wendy Jess). Some surveys in Topock Marsh and Havasu National Wildlife Refuge were conducted by Heather Hundt, Jessica Bulloch, Greg Clune, Shawn Goodchild, Erin Schuldheiss, and Joe Kahl of the U.S. Bureau of Reclamation. All field work was supervised by the Principal Investigator, Dr. Courtney J. Conway.

<u>Developing Effective Monitoring Protocols</u>

The most effective monitoring protocol for any organism is one that incorporates a survey methodology in which detection probability is high, temporal variation in detection probability is low, observer variability is low, and extraneous factors that may influence detection probability are eliminated or are accounted for statistically. Hence, we examined a variety of factors that might influence detection probability during black rail surveys. One of the main issues in developing black rail monitoring protocols is whether or not to use call broadcast to elicit vocalizations. Call broadcast is often assumed to increase detection probability of marsh birds, but may increase bias in estimation of population trends (Ribic et al. 1998, Conway and Gibbs 2001). Moreover, passive surveys would provide us a more general monitoring program for the region; one that provides population trend estimates for black rails, Yuma clapper rails, and other marsh birds simultaneously. We wanted to evaluate the benefits and drawbacks of using tapes to monitor black rails prior to implementing annual river-wide surveys. Hence, at each survey point, we conducted both a passive and call broadcast survey.

Passive versus call broadcast surveys

Our 6-minute survey at each point consisted of a 3-minute passive survey segment followed by a 3-minute period of call broadcast. During both of the 3-minute periods, we recorded all rails/bitterns seen or heard calling, whether each individual bird was detected previously during the survey (i.e., at a previous survey point), and the type(s) of vocalization heard. The 3-minute broadcast sequence consisted of three one-minute segments of 30 seconds of black rail calls (15 seconds of "*kickydoo*" calls and 15 seconds of "*grr*" calls) followed by 30 seconds of silence. We separated the 6-minute survey period into 7 segments (the 3 minute passive period, the first 30-second call period, the first 30-second silent period, the second 30-second call period, etc.). We recorded whether each bird was detected during each of the 7 survey segments. This design (3 minutes of passive followed by 3 minutes of call broadcast) allowed us to examine the influence of call broadcast on detection probability.

We compared temporal variation in number of black rails detected between passive and call broadcast surveys on a subset of survey routes which we surveyed multiple times. Temporal variation in numbers detected is an important consideration when choosing survey methods because low variation in detection probability translates into greater power to detect population change. Hence, survey methods that reduce temporal variation in numbers counted are preferred. Call broadcast is assumed to increase the number of birds detected and therefore decrease the number of points with zero counts. Consequently, previous authors have suggested that call broadcast probably decreases temporal variation in detection probability compared to passive surveys in marsh birds (Glahn 1974), yet this assumption had not been tested. Hence, we compared temporal variation in numbers counted between passive surveys and call broadcast surveys using 1) data at all survey points at which we conducted replicate surveys, and 2) only data from points at which $\geq$1 black rail was detected on one or more replicate surveys.

Comparison with previous survey results

We compared our survey results with results from 12 published and unpublished black rail survey efforts. Repking (1975, Repking and Ohmart 1977) surveyed all suitable habitat along the lower Colorado River from Yuma north to Topock Marsh in both 1973 and 1974 (21 March - 14 August). Evens et al. (1991; Laymon et al. 1990) attempted to replicate Repking's (1975) survey effort along the lower Colorado River and also surveyed known areas along the All-American and Coachella Canals and throughout the Imperial Valley in southern California (23 March-23 April 1989). The other 10 survey efforts were much shorter survey efforts of restricted areas known to harbor black rails. Jurek (1975) conducted a 4-day black rail survey (12-16 May) of all seep marshes between Highline and Coachella Canals from the All-American Canal north to Niland in the Imperial Valley. Garrett and Dunn (1981) report black rails detected at Finney and Ramer Lakes in California and along the Bill Williams River in Arizona. Todd (1980) surveyed all suitable habitat between Imperial Dam south to the Gila River on the Arizona side of the lower Colorado River (8-17 May). McCaskie (in Evens et al. 1991) report black rails detected between drops 3 and 4 of the All-American Canal in 1980. Kasprzyk et al. (1987) surveyed the All-American Canal seepage marsh between drops 3 and 4 on 9-13 April and again 14-18 May 1984. Rosenberg et al. (1991) reported records from the Bill Williams River in the early 1980s. Conway and Eddleman (unpublished data) surveyed north Mittry Lake 1985-1987. Flores and Eddleman (1991) surveyed areas near north Mittry Lake 1987-1988. Jackson (1988) surveyed the Coachella Canal and adjacent wetlands between Niland and North Shore 29-30 March and 19-21 April 1988.

By using methods similar to those used by Repking (1975) and Evens et al. (1991), we examined whether black rail populations on the lower Colorado River have increased, decreased, or remained stable over the past 25 years. Such information is vital for making informed decisions regarding status of black rails along the Colorado River, for determining effects of water management decisions on population viability, and for determining whether changes in water management need to be implemented to prevent future population declines. We used linear regression analysis to regress number of black rails detected against year for 11 areas in the region for which $\geq$5 birds were detected during at least one of the 13 survey efforts. Using a meta-analysis approach, we used a one-sample *t*-test to test whether the population change in black rails over the past 25 years across all areas was significantly different than zero.

<u>Incidental black rail detections from previous years</u>

In an effort to better document, record, and eventually verify incidental and historical records of black rails in the lower Colorado River region, we contacted biologists and amateur birders throughout Arizona and southern California. We also posted a request for black rail records on the CALBIRD internet discussion board.

<u>Morning versus evening surveys</u>

We compared the effectiveness of morning versus evening surveys for detecting black rails by conducting paired morning and evening surveys (either on the same day or on consecutive days) on 17 survey routes (226 points surveyed during both morning and evening) known to contain black rails. Evening surveys were conducted 4 hours before sunset until 0.5 hour after sunset. We varied the order in which we conducted the paired morning and evening surveys so that we did not always conduct one survey prior to the other. Paired morning-evening surveys were conducted either on the same or consecutive days. We included repeat detections of individual rails detected at more than one station prior in this analysis because we were interested in whether black rails were more vocal during morning or evening periods. We compared the mean number of black rails detected per point between morning and evening surveys using paired *t*-tests. We compared the proportion of survey points at which we detected black rails between morning and evening surveys using a chi-square analysis. We also analyzed the entire dataset to examine the effectiveness of morning versus evening surveys (not restricted to just the 452 paired surveys) and used chi-square analysis to compare proportion of survey points at which we detected black rails.

Diurnal changes in black rail detection probability

Detection probability can differ between morning and evening periods, but can also differ among hourly time intervals within both the morning and evening survey period. Understanding how detection probability varies with time of day is important prior to developing standardized monitoring protocols so that effective survey windows can be established. Hence, we summarized the proportion of points at which at least one black rail was detected across five one-hour time periods in the morning (05:00-06:00, 06:00-07:00, 07:00-08:00, 08:00-09:00, 09:00-10:00) and four one-hour time periods in the evening (16:30-17:30, 17:30-18:30, 18:30-19:30, 19:30-20:30). We compared proportion of points with black rails detected across these time intervals using chi-square analyses. We conducted the analysis using 1) all survey data ($n = 2385$ morning survey points, 373 evening survey points), and 2) only data from survey routes along which at least one black rail was detected sometime during the season ($n = 1443$ morning survey points and 254 evening survey points).

Effects of broadcast volume on number of birds detected

We compared the effect of call broadcast volume on detection probability of black rails by conducting two replicate surveys (one using 90 dB volume and the other using 70 dB volume at 1 meter in front of the speaker) on consecutive days along 20 survey routes (including 310 points) known to contain black rails. We alternated the order in which we conducted the paired 70 dB and 90 dB survey so that we did not always conduct one survey prior to the other. We did not remove repeats of individual birds detected at more than one station prior to this analysis because we were interested in whether higher broadcast volume elicits more vocalizations from black rails. We compared the mean number of black rails detected per point between 90 dB and 70 dB surveys using paired *t*-tests. We compared the proportion of survey points at which we detected black rails between 90 dB and 70 dB surveys using a chi-square analysis. We repeated the analysis for each of three survey segments: the 3-minute passive segment, the 3-minute call broadcast segment, and individuals detected before or after each 6-minute survey period.

Observer bias

At 228 points we had two observers independently record all rails and bitterns detected so that we could estimate observer bias associated with our survey efforts. We used these data to estimate observer detection probabilities (i.e., observer bias) of black rails and compare these probabilities between passive and call broadcast surveys. We don't believe that having observers record detections of all 6 species reduced their detection probability of black rails because the observers were trained to identify and tally these species simultaneously. Observer #1 and observer #2 conducted observer bias trials at 88 survey points and observer #1 and observer #3 conducted observer bias trials at 140 survey points. Observer #2 and observer #3 did not conduct any observer bias surveys together due to logistical constraints associated with other aspects of the study. We estimated the proportion of black rails vocalizing that observer #1 detected (observer detection probability) as:

$$\frac{\textit{(total \# of black rails that observer \#1 detected)}}{\textit{[(total \# of black rails that observer \#1 detected)+(total \# of black rails that only observer \#2 detected)]}}$$

Hence, we obtained 4 estimates of detection probability for black rails: observer #1 with observer #2, observer #1 with observer #3, observer #2 with observer #1, and observer #3 with observer #1. We averaged these 4 estimates for an overall estimate of observer detection probability for black rails. We compared observer detection probability of black rails between passive and call broadcast segments using 2x2 contingency table analysis.

Habitat correlates of black rail distribution

Habitat loss is considered the main factor causing past population declines and limiting population recovery of black rails (Evens et al. 1991, Eddleman et al. 1994). Hence, we recorded vegetation characteristics within a 50-meter-radius semi-circle at each survey point. We recorded the percent coverage of each emergent plant and non-marsh vegetative community (e.g., upland, bare ground, and open water). We compared the proportion of each emergent plant/vegetation community between points at which we detected black rails and those lacking black rails using *t*-tests. We conducted the analysis using 1) all survey data, and 2) only data from survey routes along which at least one black rail was detected sometime during the season. Data from future surveys will also allow us to correlate black rail population trends with changes in abundance of emergent habitat in the region. Quantifying habitat at each survey point will also allow us to identify areas in which habitat restoration projects can be used to reverse local declines in black rails. Replicating this effort on future surveys will provide information on trends in black rail habitat in the lower Colorado River region and help land managers adjust current or implement new management plans that benefit black rails so that populations might increase to the point of de-listing.

## RESULTS

We conducted surveys at 1722 distinct points and detected a total of 136 black rails in areas along the lower Colorado River, and at Morro Bay and throughout Imperial Valley in California (Table 1). We conducted a single survey at 1410 points and 2-11 replicate surveys (total of 1158 surveys) at 260 points. Including our replicate surveys, we conducted a total of 2828 6-minute black rail surveys. We recorded black rails on 675 of our 2828 surveys. Of the 1012 black rail detections (including those from replicate surveys at sites known to have black rails present), we saw a black rail on only 4 surveys and all 4 of these birds were also detected aurally. Of 1012 black rail detections, 418 were thought to be within 50 meters of the observer and 452 were thought to be birds already heard from a previous survey point (429 of the remaining 560 black rail detections were thought to be birds already counted on a previous round of surveys since we did up to 11 replicate surveys on routes with black rails). We also detected 418 Yuma clapper rails, 220 Virginia rails, 99 soras, 242 least bitterns, and 11 American bitterns (duplicate responses excluded) even though we did not broadcast calls of any of these marsh birds (Table 1).

The majority (100) of black rails detected were at sites along the lower Colorado River, and 21 were detected at three sites along the All-American Canal. We detected just 6 black rails at 2 sites near the Coachella Canal, 5 rails at one location along the New River, and 4 rails at

Table 1. Number of survey points and marsh birds detected at each survey location in 2000.

| Location | Points | Black Rail | Clapper Rail | Virginia Rail | Sora | Least Bittern | American Bittern |
|---|---|---|---|---|---|---|---|
| **ARIZONA** | | | | | | | |
| *Colorado River* | | | | | | | |
| Gila River near Highway 95 | 15 | 0 | 0 | 0 | 0 | 11 | 0 |
| Gila Gravity Main Canal Seeps below Laguna Dam | 30 | 0 | 0 | 9 | 3 | 3 | 0 |
| Mittry Lake | | | | | | | |
| Mittry Lake proper | | | | | | | |
| North Mittry[6] | 12 | 5 | 3 | 7 | 2 | 1 | 0 |
| South Mittry[7] | 29 | 13 | 2 | 12 | 0 | 2 | 0 |
| Teal Alley | 17 | 0 | 7 | 5 | 4 | 0 | 0 |
| Gila Gravity Main Canal Seepage South[5] | 20 | 2 | 9 | 13 | 4 | 0 | 0 |
| Gila Gravity Main Canal Seepage North[4] | 34 | 4 | 2 | 7 | 2 | 0 | 0 |
| N. of Imperial Dam Road | 23 | 5 | 6 | 10 | 3 | 0 | 0 |
| Old Colorado River Channel | 8 | 0 | 0 | 2 | 1 | 0 | 0 |
| Imperial Reservoir, Arizona Side | 72 | 7 | 2 | 0 | 0 | 3 | 0 |
| Arizona Channel (large island N. of Senator Wash) | 56 | 5 | 22 | 1 | 1 | 24 | 0 |
| River Shoreline between Imp Dam/Martinez Lake | 30 | 2 | 10 | 1 | 1 | 7 | 0 |
| Martinez Lake | 29 | 1 | 4 | 0 | 1 | 16 | 0 |
| Imperial National Wildlife Refuge | 88 | 2 | 1 | 7 | 15 | 10 | 0 |
| Adobe Lake | 11 | 0 | 0 | 0 | 0 | 5 | 0 |
| Cibola Lake | 44 | 0 | 5 | 0 | 0 | 21 | 0 |
| Palo Verde Drain | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| CRIT Lands S. of Parker | 55 | 1[3] | 2 | 1 | 0 | 3 | 0 |
| Bill Williams River (Bill Williams Natl. Wildl. Refuge) | 64 | 15 | 0 | 5 | 0 | 0 | 0 |
| Tamarisk Inn – Lake Havasu | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Topock Gorge | 48 | 0 | 15 | 15 | 2 | 4 | 0 |
| Topock Marsh | 73 | 0 | 19 | 13 | 1 | 3 | 0 |
| Three-mile Lake | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Grand Canyon | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| **CALIFORNIA** | | | | | | | |
| *Colorado River* | | | | | | | |
| West Pond Area | | | | | | | |
| West Pond proper | 46 | 15 | 7 | 23 | 6 | 6 | 0 |
| Unnamed areas | 41 | 4 | 7 | 13 | 1 | 10 | 1 |
| Hurricane Ridge Marsh | 10 | 1 | 1 | 0 | 0 | 2 | 0 |
| Imp. Irr. Dist. Housing | 17 | 3 | 0 | 5 | 0 | 0 | 0 |
| Imperial Reservoir | | | | | | | |
| California Side | 5 | 0 | 61 | 18 | 34 | 11 | 0 |
| Squaw Lake | 18 | 4 | 8 | 0 | 5 | 5 | 0 |
| Senator Wash | 29 | 7 | 12 | 2 | 4 | 12 | 0 |
| Small island[8] | 15 | 2 | 3 | 0 | 0 | 4 | 0 |
| Ferguson Lake | 32 | 2 | 1 | 2 | 1 | 15 | 0 |
| Walter's Camp - Picacho State Recreation Area | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| Taylor Lake | 21 | 0 | 0 | 0 | 0 | 6 | 0 |
| Palo Verde Oxbow | 24 | 0 | 0 | 0 | 0 | 10 | 0 |
| Big Hole, Blythe | 13 | 0 | 0 | 0 | 0 | 1 | 0 |
| Goose Flats[9] | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| South of Hall Island[9] | 19 | 0 | 1 | 0 | 0 | 1 | 0 |
| CRIT lands S. of Earp | 19 | 0 | 4 | 0 | 2 | 1 | 0 |
| CRIT lands N. of Earp | 26 | 0 | 2 | 5 | 6 | 1 | 0 |
| *All-American Canal seep marshes* | | | | | | | |
| Mission Wash | 18 | 2 | 0 | 10 | 0 | 0 | 0 |
| Between drops 3 and 4 | 30 | 19 | 2 | 0 | 0 | 2 | 0 |
| *Coachella Canal seep marshes* | | | | | | | |
| Trilly Road | 5 | 3 | 0 | 1 | 0 | 0 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Mineral Hot Springs Spa[1] | 8 | 3 | 0 | 2 | 0 | 0 | 0 |
| Desert Aire Road | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dos Palmas | 35 | 0 | 0 | 2 | 0 | 1 | 0 |
| *Salton Sea area* | | | | | | | |
| Finney/Ramer Lakes | 18 | 0 | 1 | 0 | 0 | 1 | 0 |
| Alamo River mouth | 4 | 0 | 0 | 0 | 0 | 1 | 0 |
| New River mouth, Bruchard Bay, SSNWR | 10 | 0 | 0 | 8[2] | 0 | 0 | 0 |
| Wister Unit, Imperial WMA | 191 | 0 | 157 | 4 | 0 | 18 | 7 |
| SSNWR Hazard Tract | 48 | 0 | 16 | 2 | 0 | 9 | 0 |
| SSNWR Unit 1 and Union Tract | 66 | 0 | 24 | 3 | 0 | 10 | 3 |
| Salt Creek mouth | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| Salton Sea State Rec. Area | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bombay Beach Marsh | 9 | 0 | 3 | 8 | 0 | 2 | 0 |
| Big Morongo Canyon | 22 | 0 | 0 | 4 | 0 | 0 | 0 |
| New River - Curtis Rd.[9] | 14 | 5 | 1 | 3 | 3 | 0 | 0 |
| Fig Lagoon[9] | 11 | 0 | 1 | 0 | 3 | 0 | 0 |
| Morro Bay[9] | 84 | 4 | 0 | 9 | 2 | 0 | 0 |
| Total for Arizona | 795 | 62 | 109 | 108 | 40 | 113 | 0 |
| Total for California | 927 | 74 | 312 | 124 | 67 | 129 | 11 |
| **TOTAL** | **1722** | **136** | **421** | **232** | **107** | **242** | **11** |

[1]numbers are from survey #2, no birds detected in survey #1
[2]4 adults and 4 young
[3]heard previous day from marsh S. of Earp on California side of River
[4]also known as North YPG slough, all marsh South of Imperial Dam Road and North of old access road that runs west to east between South end of YPG housing area and the Old River Channel
[5]also known as South YPG slough, all marsh extending from alluvial fan North to old access road that runs west to east between South end of YPG housing area and the Old River Channel
[6]area South of alluvial fan to dredge ramp
[7]area South of dredge ramp next to Mittry Lake
[8]south of Martinez Lake, north of large island
[9]surveyed in March/April 2001.

Morro Bay. No black rails were found in areas surrounding the Salton Sea. Most of the black rails located along the Colorado River were found in wetlands associated with the river between Laguna Dam north to Ferguson and Martinez Lakes. Only 16 of the 100 counted along the Colorado River occurred north of this area (15 of which were along the Bill Williams River). The greatest concentrations of black rails (accounting for 61% of all black rails detected) were found in the areas of Mittry Lake (including YPG slough; 29 birds), West Pond (15 birds), between drops 3 and 4 of the All-American Canal (19 birds), and the Planet Ranch area of the Bill Williams River (14 birds).

Based on the results of our replicate surveys at locations with black rails and our experimental methods trials, we developed a standardized black rail survey protocol (Appendix 1). This survey protocol is designed to help local managers and agency biologists conduct black rail surveys so that the data produced can be pooled regionally for greater analytical power to detect population trends.

Passive versus call broadcast surveys

Call broadcast significantly increased number of black rails detected compared to passive surveys (Table 2). However, the effect size (the relative increase in number of black rails detected with call broadcast) was small. Considering all points at which at least one black rail was detected, we detected an average of 0.90 birds per point during the 3 minute passive portion of the survey and an average of 1.03 birds per point during the 3-minute call broadcast portion of the survey (Table 2). This amounts to a 14% increase in the number of black rails detected using call broadcast surveys compared to passive survey methods. However, detection probability of other rails and bitterns was lower on the call broadcast segment of the surveys compared to the passive segment (Table 2). Within the call broadcast period, detection probability of all species (except soras) was higher during the three 30-second silent periods compared to the three 30-second call broadcast periods (Table 3). The number of new black rails detected declined with time throughout the 6-minute survey period (Fig. 1). Temporal variation in numbers counted at survey points on which we did replicate surveys was higher on call broadcast surveys compared to passive surveys (Table 4). Variation was greater on call broadcast surveys even when we restricted our analysis to only those survey points at which $\geq$1 black rail was detected on one or more surveys.

Comparison with previous survey results

Numbers of California black rails have declined at 10 of the 11 locations where rails are/were most abundant in the lower Colorado River region (Fig. 2). The mean slope of population change in these 11 locations was -0.581 + 0.222 ($t = 2.62$, $df = 10$, $P = 0.026$). Population declines were most significant at the All-American Canal and the mouth of the New River (Fig. 2). Black rails (and all suitable habitat) have completely disappeared from the southern end of the Coachella Canal, Finney/Ramer Lakes, and the mouth of the New River (Fig. 2).

*Mittry Lake area.* Number of black rails detected between Laguna Dam and Imperial Dam was much lower than numbers reported by Todd (1980). Our numbers were similar to those reported by Repking and only slightly lower than those reported by Evens et al. (1991; Table 5, Fig. 2). Comparison among studies are difficult here because Mittry Lake is very large, many

Table 2. Results of paired *t*-tests comparing the average number of marsh birds detected during an initial 3-minute passive survey and a subsequent 3-minute call broadcast survey. The call broadcast included both *kickydoo* and *grr* calls of California black rails. Only points at which at least one bird was detected were included in the analysis for each species.

| | black rail n = 624 | clapper rail n = 540 | sora n = 105 | Virginia rail n = 748 | least bittern n = 552 |
|---|---|---|---|---|---|
| passive | 0.97 ± 0.03 | 1.34 ± 0.05 | 0.82 ± 0.06 | 1.12 ± 0.03 | 0.97 ± 0.03 |
| call broadcast | 1.10 ± 0.03 | 1.08 ± 0.05 | 0.63 ± 0.06 | 0.97 ± 0.03 | 0.70 ± 0.03 |
| | $t = 3.72$, $P<0.001$ | $t = 4.53$, $P<0.001$ | $t = 1.80$, $P=0.08$ | $t = 3.59$, $P<0.001$ | $t = 6.25$, $P<0.001$ |

Table 3. Results of paired *t*-tests comparing the average number of marsh birds detected during the three 30-second calling periods and the three 30-second interstitial silent periods during the 3-minute call broadcast survey period. The call broadcast included both *kickydoo* and *grr* calls of California black rails. Only points at which at least one bird was detected during the call broadcast survey segment were included in the analysis for each species.

| | black rail n = 516 | clapper rail n = 357 | sora n = 56 | Virginia rail n = 509 | least bittern n = 324 |
|---|---|---|---|---|---|
| silent segments | 1.17 ± 0.03 | 1.39 ± 0.05 | 0.53 ± 0.08 | 1.10 ± 0.04 | 0.89 ± 0.03 |
| call segments | 0.82 ± 0.03 | 1.11 ± 0.05 | 0.74 ± 0.08 | 0.80 ± 0.03 | 0.72 ± 0.04 |
| | $t$ = 10.02, P<0.001 | $t$ = 5.19, P<0.001 | $t$ = 1.49, P=0.14 | $t$ = 6.36, P<0.001 | $t$ = 3.39, P=0.001 |

Table 4. Results of paired *t*-tests comparing temporal variation in number of black rails counted between passive surveys and call broadcast surveys at 260 survey points at which we conducted replicate surveys.

| | temporal variation in # BLRAs detected (± SE) | temporal variation in # BLRAs detected (± SE)[1] |
|---|---|---|
| passive surveys | 0.36 ± 0.03 | 0.65 + 0.04 |
| call broadcast surveys | 0.41 ± 0.03 | 0.73 + 0.04 |
| | $t$=2.5, $P$=0.012 | $t$=2.6, $P$=0.011 |

[1]includes only those survey points where ≥1 black rail was detected during one or more replicate surveys

Table 5. Comparison of number of black rails detected (and number of points surveyed where reported) in this study and previous studies in the lower Colorado River region on southwestern Arizona and southeastern California.

| Reference: | Repking 1975 | | Jurek 1975 | Garrett & Dunn 1981 | Todd 1980 | | McCaskie[3] | Kasprzyk et al. 1987 | Conway & Eddleman unpubl. | | Flores & Eddleman 1991 | | Jackson 1988 | Laymon et al 1990 | | this study | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year of survey: | 1973 | 1974 | 1975 | 1977 | 1980 | | 1980 | 1984 | 1985-87 | | 1987-88 | | 1988 | 1989 | | 2000 | |
| | | | | | pts | birds | | | pts | birds | pts | birds | | pts | birds | pts | birds |
| **ARIZONA** | | | | | | | | | | | | | | | | | |
| marsh near Yuma territorial prison | 0 | | | | | | | | | | | | | | | | |
| Gila/Colorado River confluence | 0 | | | | | | | | | | | | | | | | |
| Gila River at Highway 95 | | | | | | | | | | | | | | | | 15 | 0 |
| Gila Gravity Main Canal seeps below Laguna dam | | | | | | | | | | | | | | | | 30 | 0 |
| Mittry Lake | | | | | | | | | | | | | | 146 | 44 | | |
| Mittry Lake proper | 9[1] | 10 | | | | | | | | | | | | | | | |
| South Mittry Lake | | | | | 19 | 1 | | | | | | | | | | 29 | 13 |
| North Mittry Lake | | | | | 38 | 39 | | | 9 | 3[7] | | | | | | 12 | 5 |
| Teal Alley | | | | | 5 | 0 | | | | | | | | | | 17 | 0 |
| Gila Gravity Main Canal seepage[2] | | | | | | | | | | | | | | | | | |
| North end | 5[1] | 5 | | | 36 | 14 | | | | | 11 | 2[7] | | | | 34 | 4 |
| South end | 4[1] | 7 | | | 15 | 6 | | | 11 | 3[7] | 11 | 3[7] | | | | 20 | 2 |
| North of Imperial Dam road[2] | | | | | 10 | 12 | | | | | | | | | | 23 | 5 |
| Old Colorado River channel | | | | | 34 | 8 | | | | | | | | | | 8 | 0 |
| Imperial Reservoir, Arizona side | 14 | 9 | | | | | | | | | | | | | 0 | 72 | 7 |
| Arizona Channel, large island, N of Senator wash | 14 | 3 | | | | | | | | | | | | | | 56 | 5 |
| River shoreline betw. Imp. Dam & Martinez Lake | 0 | 0 | | | | | | | | | | | | | | 30 | 2 |
| Martinez Lake | | | | | | | | | | | | | | 20 | 0 | 29 | 1 |
| Imperial National Wildlife Refuge | 0 | 8 | | | | | | | | | | | | | 0 | 88 | 2 |
| Adobe Lake | | | | | | | | | | | | | | | | 11 | 0 |
| Palo Verde Drain | | | | | | | | | | | | | | | | 15 | 0 |
| Cibola Lake | | | | | | | | | | | | | | 34 | | 44 | 0 |
| CRIT lands south of Parker | | | | | | | | | | | | | | | | 55 | 1[9] |
| Parker II near Poston | 0 | | | | | | | | | | | | | | | | |
| Bill Williams River | | | | 1 | | | | | | | | | | 34 | 0 | 4 | 0 |
| Upper Bill Williams River | | | | | | | | | | | | | | | | 60 | 15 |
| Blankenship Bend | 0 | | | | | | | | | | | | | | | | |
| Tamarisk Inn - Lake Havasu | | | | | | | | | | | | | | | | 4 | 0 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Topock Gorge (Castle Rock to Topock marsh) | 0 | | | | | | | | | | | | | 48 | | 48 | 0 |
| Topock marsh (Havasu National Wildlife Refuge) | 0 | | | | | | | | | | | | | 66 | | 73 | 0 |
| Three-mile Lake | | | | | | | | | | | | | | | | 7 | 0 |
| Grand Canyon | | | | | | | | | | | | | | | | 11 | 0 |
| **CALIFORNIA** | | | | | | | | | | | | | | | | | |
| West Pond area | | | | | | | | | | | | | | 103 | | | |
| West Pond proper | 16[1] | 22 | | | | | | | | | | | | | 19 | 46 | 15 |
| un-named areas[11] | 1 | 6 | | | | | | | | | | | | | 2 | 41 | 4 |
| Hurricane Ridge marsh[12] | | | | | | | | | | | | | | | | 10 | 1 |
| Hidden marsh | | | | | | | | | | | | | | | 1 | | |
| Imperial Irr. Dist. housing complex | 4 | 4 | | | | | | | | | | | | | | 17 | 3 |
| Imperial Reservoir | | | | | | | | | | | | | | 54 | | | |
| California side | 2 | 1 | | | | | | | | | | | | | 0 | 5 | 0 |
| Squaw lake | 10 | 6 | | | | | | | | | | | | | 8 | 18 | 4 |
| Senator wash | 21 | 10 | | | | | | | | | | | | | 0 | 29 | 7 |
| small island[8] | 1 | 0 | | | | | | | | | | | | | | 15 | 2 |
| Ferguson lake | 5 | 5 | | | | | | | | | | | | | | 32 | 2 |
| California shoreline | 0 | 0 | | | | | | | | | | | | | | | |
| Walter's camp- Picacho SRA | | | | | | | | | | | | | | 7 | | 13 | 0 |
| Taylor lake | | | | | | | | | | | | | | 18 | | 21 | 0 |
| Palo verde oxbow, NW of Cibola National Wildlife Refuge | | | | | | | | | | | | | | 24 | | 24 | 0 |
| Goose flats, south of Blythe | | | | | | | | | | | | | | 20 | | 2 | 0 |
| Big hole, Blythe | | | | | | | | | | | | | | 12 | | 13 | 0 |
| South of Hall Island | | | | | | | | | | | | | | | | 19 | 0 |
| CRIT lands south of Earp | | | | | | | | | | | | | | | | 19 | 0 |
| CRIT lands north of Earp | | | | | | | | | | | | | | 14 | | 26 | 0 |
| All-American Canal seep marshes | | | | | | | | | | | | | | | | | |
| Pond northwest of Laguna dam | | | | | | | | | | | | | | | 1 | 0 | 0 |
| Mission wash | | | | | | | | | | | | | | 11 | 1 | 18 | 2 |
| Between drops 3 and 4 | | | | | | | ~80 | 30[13] | | | | | | 37 | 17 | 30 | 19 |
| Coachella Canal seep marshes | | | | | | | | | | | | | | | | | |
| South of Niland, west of canal | | | | | | | | | | | | | | | | | |
| Siphon 5 @ Flowing Well Rd. and Beal Rd. | | | 2 | | | | | | | | | | | | 0 | 0 | 0 |
| Siphon 4; Stanley Rd and Nider Rd. | | | 5 | | | | | | | | | | | | 0 | 0 | 0 |
| Haley Rd. and Montgomery Rd.[6] | | | 5 | | | | | | | | | | | 20 | 1 | 0 | 0 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Siphon 1, Mammoth Wash | | | 2 | | | | | | | | | | | | 0 | 0 | 0 |
| Between Mammoth Wash and Titsworth Rd. | | | 3 | | | | | | | | | | | | 0 | 0 | 0 |
| 1 mile south of Titsworth Rd. | | | 3 | | | | | | | | | | | | 0 | 0 | 0 |
| Between Niland and north shore | | | | | | | | | | | | | | | | | |
| Siphon 19[4] | | | | | | | | | | | | | 1 | | 3 | 0 | 0 |
| Siphon 21 | | | | | | | | | | | | | 0 | | | | |
| Trilly Rd., west of Mineral Hot Springs Spa | | | | | | | | | | | | | 4 | 18 | | 5 | 3 |
| Desert Aire Road | | | | | | | | | | | | | | | | 1 | 0 |
| Dos Palmas (=Hot spring spa?) | | | | | | | | | | | | | 6 | | | 35 | 0 |
| Mineral Hot springs spa (=Trilly Rd?) | | | | | | | | | | | | | | 10 | 3 | 8 | 3 |
| Fountain-of-Youth spa sewage pond | | | | | | | | | | | | | 0 | | | | |
| Small marshes west of Salt Creek | | | | | | | | | | | | | 0 | | | | |
| Salton Sea area | | | | | | | | | | | | | | | | | |
| Finney/Ramer lakes | | | | 7 | | | | | | | | | | 33 | 1 | 18 | 0 |
| Alamo River mouth | | | | | | | | | | | | | | 10 | | 4 | 0 |
| New River mouth, Brouchard Bay, SSNWR | | | | | | | | | | | | | | 30 | 13 | 10 | 0 |
| Wister Unit, Imperial WMA | | | | | | | | | | | | | | 95 | | 191 | 0 |
| SSNWR, Hazard Tract | | | | | | | | | | | | | | 20 | | 48 | 0 |
| SSNWR, Union Tract/Unit 1 | | | | | | | | | | | | | | | | 66 | 0 |
| Whitewater River mouth | | | | | | | | | | | | | | 25 | | 0 | 0 |
| Salt Creek | | | | | | | | | | | | | | 10 | 1 | 11 | 0 |
| Salton Sea State Rec. Area | | | | | | | | | | | | | | | | 5 | 0 |
| Bombay Beach Marsh | | | | | | | | | | | | | | | | 9 | 0 |
| Big Morongo Canyon | | | | | | | | | | | | | | | | 22 | 0 |
| New River - Curtis Rd.[10] | | | | | | | | | | | | | | | | 14 | 5 |
| Fig Lagoon[10] | | | | | | | | | | | | | | | | 11 | 0 |
| Morro Bay[10] | | | | | | | | | | | | | | 20 | 6 | 84 | 4 |
| Total for Arizona | 46 | 42 | | | | | | | | | | | | 348 | 44 | 795 | 62 |
| Total for California | 60 | 54 | | | | | | | | | | | | 591 | 77 | 927 | 74 |
| TOTAL | 106 | 96 | | | | | | | | | | | | 939 | 121 | 1722 | 136 |

[1]average of 3 replicate surveys
[2]commonly referred to as YPG slough, divided into N. and S. by old access road running east/west from YPG housing area to old Colorado River channel
[3]in Evens et al. 1991/Laymon et al. 1990
[4]2.5 hectare marsh 2 kilometers N of Spa Rd
[5]0.1 hectare marsh 1 kilometers E of canal
[6]between siphon 1 and 2
[7]average of weekly replicate surveys, March-June
[8]south of Martinez Lake, north of large island
[9]heard previous day from marsh S. of Earp on California side of River
[10]surveyed in March/April 2001.
[11]includes small marshes southwest of Imperial Dam on both sides of Imperial Dam Rd.
[12]south of Squaw Lake
[13]38 in Kenney and Bransfield 1988.

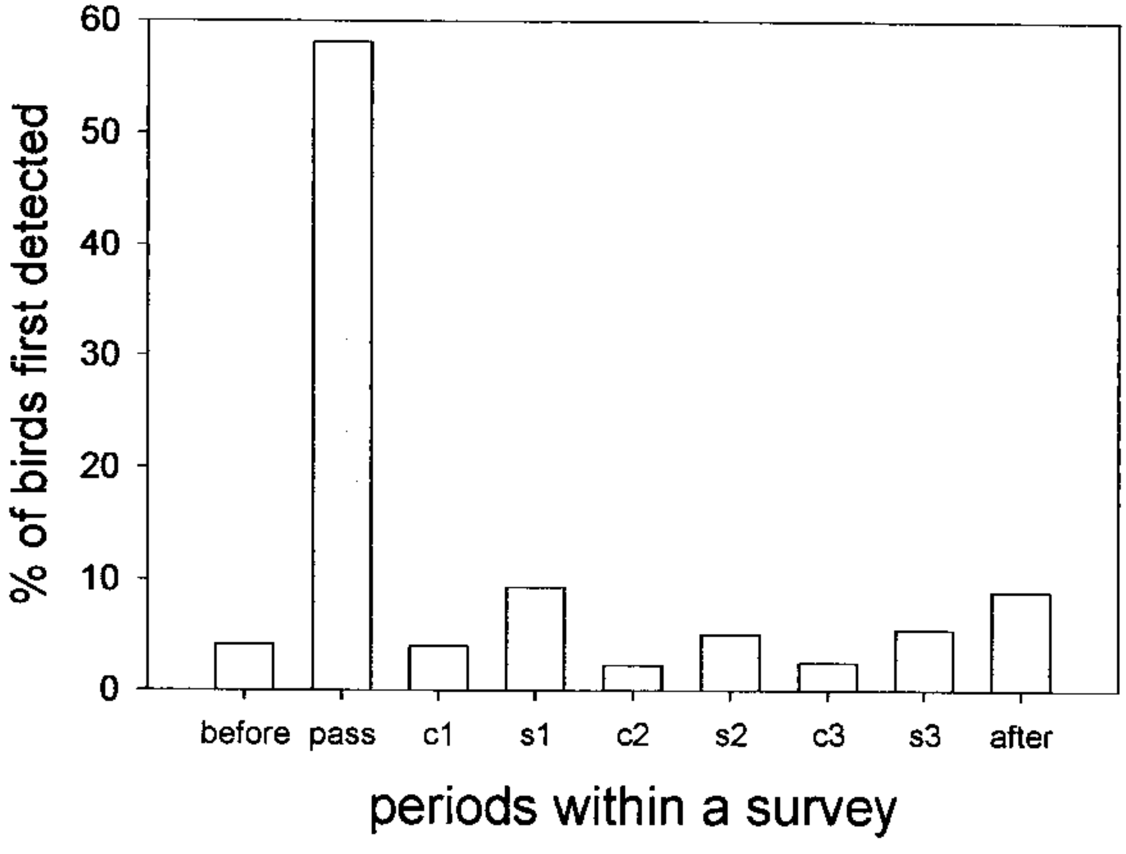


Figure 1. Percent of birds first detected during each of 9 periods during our standardized surveys: before the observer initiated the 6-minute survey, during the 3-minute passive segment of the survey (pass), during the first 30 seconds of call broadcast (c1), during the subsequent 30 seconds of silence (s1), during the second 30 seconds of call broadcast (c2), during the subsequent 30 seconds of silence (s2), during the third 30 seconds of call broadcast (c3), during the final 30 seconds of silence (s3), and after the 6-minute survey period.

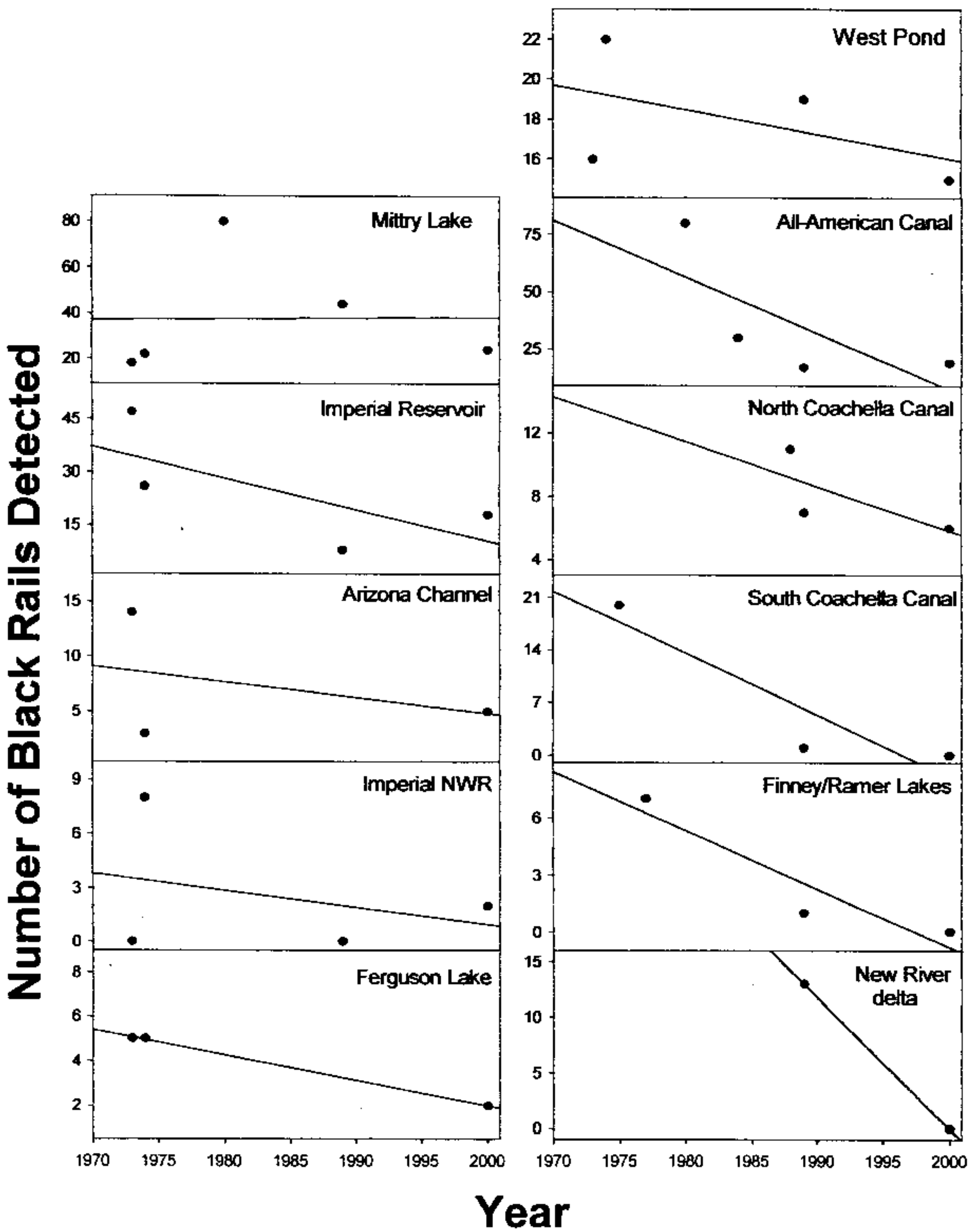


Figure 2. Population trends of black rails at locations in Arizona and southern California, 1973-2000. Lines represent simple linear least squares regression of number of black rails detected vs year for each location.

portions have difficult access, and previous studies failed to sufficiently document survey effort (e.g., number or location of survey points).

*Imperial Reservoir.* Number of black rails detected in marshes associated with Imperial Reservoir (Squaw Lake, Senator Wash, Arizona Channel, etc.) was lower compared to surveys in 1973-74 (Repking and Ohmart 1977), but was similar to numbers detected in 1989 (Evens et al. 1991) (Table 5, Fig. 2).

*Colorado River above Imperial Reservoir.* Black rails detected in marshes upriver of Imperial Reservoir (Arizona Channel, Imperial National Wildlife Refuge, Ferguson Lake) were slightly lower than those reported from previous surveys (Table 5, Fig. 2).

*Bill Williams River.* Past survey efforts in the Bill Williams River have been inadequate to allow meaningful comparisons with our numbers. The first known record of black rail on the Bill Williams River was on 18 April 1979 approximately 2 miles upriver from the delta (Edwards 1979, Garrett and Dunn 1981, K. Rosenberg, pers. comm.). This record was thought to represent a northern range extension, but lack of standardized surveys prevent adequate conclusions. The second record was fall of 1982 (D. Krueper). Additional records exist for 1982-1983 in an area approximately one mile from the Arizona Highway 95 bridge (C. Hunter). In mid-June 1986, S. Laymon heard 2 black rails at night in a small pond south of the Bill Williams River road 4.3 miles southeast of Highway 95. In 1986, J. Rorabaugh detected black rails at 3 survey points on 21 May 1.7-2.4 miles southeast of Highway 95 during a nighttime roadside elf owl survey. In 1987, J. Rorabaugh recorded 4-8 black rails at 4 survey points at 2 locations (1.7-2.4 miles and 3.9-4.1 miles southeast of Highway 95) during a 6.6 mile nighttime (21:24-01:38 h) elf owl survey route on 6-7 May between Highway 95 and Mineral Wash. In 1989, no black rails were recorded out of 34 points surveyed (Laymon et al. 1990). B. Raulston detected no black rails during January and February call broadcast surveys at 5 points conducted in 1994 in the delta, but detected 4 black rails (1.7-2.4 miles southeast of Highway 95) in 1997 during a call broadcast survey. No black rails were detected in this same area (and other areas throughout the Bill Williams River) during passive morning point count surveys in 1993-1995 (Lynn and Averill 1996). In 2000, we counted 15 black rails (60 points surveyed) along the Bill Williams River. We detected only one bird at the location where past observers had recorded black rails (1.7-2.4 miles southeast of Highway 95). Most of the black rails we detected (14) were in the Planet Ranch area (approximately 14 kilometers southeast of Highway 95). The Planet Ranch population represents one of the largest current concentrations of black rails along the lower Colorado River. The Planet Ranch area was not surveyed during any of these previous survey efforts so we cannot necessarily conclude that black rail numbers have increased along the Bill Williams River.

*West Pond.* Our results represent a small decline in birds detected compared to Repking and Ohmart (1977) and Evens et al. (1991) (Table 5, Fig. 2).

*All-American Canal.* Black rail numbers along the All-American Canal have declined dramatically since 1980, but have remained relatively stable since the last survey in 1989 (Table 5, Fig. 2).

*Coachella Canal.* Black rail numbers have declined drastically since 1989. We detected only 6 black rails in 2 marshes (Trilly Road marsh and the Hot Mineral Spa area). All other marshes along the Coachella Canal that contained black rails during the 1989 survey (Evens et al. 1991) were no longer present.

*Salton Sea area.* Black rail numbers have declined drastically since 1989. No black rails were found in marshes surrounding the Salton Sea that previously harbored black rails (e.g., Finney and Ramer Lakes, New River mouth, Whitewater River delta) (Table 5, Fig. 2).

*Morro Bay*. We detected 4 birds on 2 survey occasions covering 68 survey points. Six black rails were detected on 12 May 1981 (McCaskie 1981), but a focused survey of the population on Morro Bay has not been conducted since the 1970s. Previous estimates of the black rail population at Morro Bay in 1983 was 25 to 75 birds (Marantz 1985).

Incidental black rail detections from previous years

*Arizona*

Black rails have been heard in the backwater behind Imperial National Wildlife Refuge housing (10-23 February 1995, 20 June 2000). We failed to detect black rails in that marsh during our formal survey efforts but we did record one incidental detection in late June 2000 (our field crew stayed in housing above this wetland). Black rails were detected in seep marshes along the Gila Gravity Main Canal south of Mittry Lake in the mid-1980s (R. Todd; B. Henry), but we failed to find birds in any of these seep marshes. At least one of these seep marshes was being filled at the time of our survey and others were being filled in 2001. Other locations where recent black rail records exist but at which we failed to detect birds include: south side of Adobe Lake near the river entry (10 May 1995), northeast side of Palo Verde Point backwater (Imperial National Wildlife Refuge, 1 April 1997; C. Kennedy; A. Miller), and behind Tamarisk Hotel (Havasu National Wildlife Refuge; May 1997). We detected 2 black rails in the farm fields on Imperial National Wildlife Refuge (west of the refuge headquarters; a.k.a. Cormorant Pond); previous records from Martinez Lake/Imperial National Wildlife Refuge include: 2 birds in December 1972, 3 in December 1973, 8 in spring 1974, 2 in January 1977, 1 in April and December 1977, 1 in February 1978, 3 in March 1978, 1 in April 1978, 3 in May 1978, 5 in June 1978, 1 on 1 May 1995 (Edwards 1979, J. Record). No black rails were detected at Imperial National Wildlife Refuge during passive morning point count surveys in 1993-95 (Lynn and Averill 1996). Black rails were detected in several locations in the Grand Canyon: river mile 249.3 (16 November 1999), river mile 246 south side (spring, summer, and fall, 1998 and 1999), river mile 252.5 south side (16 November 1999; S. Grimm). We failed to detect black rails at some of these locations in the Grand Canyon in 2000. Other records exist from locations not included in our survey effort: island near the northwest corner of Island Lake (1 June 1995), west end of Island Lake (7 July 1995), and south Walker Lake (1997; R. McKernan).

*California*

Locations where recent black rail records exist but at which we failed to detect birds include: just west of Parker Dam, 1 kilometer west-northwest of Headgate Rock Dam on Colorado River Indian Tribal Lands (22 May 2001; B. Raulston), Picacho State Recreation Area between the upper and lower docks (21 June 1995; P. Jorgensen), Picacho State Recreation Area at the mouth of Sortan Wash, far west end of Ferguson Lake (1998; A. Miller), in the New River along highway 78 just west of Brawley (B. Principe), Whitewater River delta (1986-1992), Wister Unit of the Imperial Wildlife Area off Ruddy Duck Road (spring 1993), Salt Creek, Coachella Canal south of Highline Canal approximately 2 kilometers north of Highway 78 (1994; R. McKernan). Black rails were previously reported at a marsh in the vicinity of Seeley (Garrett and Dunn 1981), but this marsh has since been destroyed (Evens et al. 1991). An unverified black rail record exists for Oso Flaco Lake in southern San Luis Obispo County (T. Edell).

Historical records also exist in many locations in southern California that no longer have suitable black rail habitat: Carrizo Marsh in Anza-Borrego Desert State Park (May 1974; P. Jorgensen), Little Lake, Inyo County (1964; Garrett and Dunn 1981), marsh near Calipatria adjacent to Salton Sea (5 January 1947; Laughlin 1947), and past breeding records from the 1930s at Hueneme, Ventura County and Chino, San Bernardino County (Garrett and Dunn 1981). Black rails once inhabited tidal and freshwater marshes in San Diego County (including mouth of the Sweetwater River, Mission Bay, Tijuana River estuary, Los Peñasquitos Lagoon, San Elijo Lagoon, Sorrento Valley, and Carrizo Marsh), but seemingly now are extirpated from San Diego County and all coastal marshes in central coastal and southern California, with the exception of Morro Bay (Unitt 1984, Garrett and Dunn 1981, Evens et al. 1991).

*Mexico*

We did not conduct any black rail surveys in Mexico. Black rail records exist from the early 1900s for Sangre de Cristo, San Ramón, San Telmo, and San Quintín, although some of these areas no longer have suitable habitat (Grinnell 1928, Wilbur 1987). Black rails have been recorded as far south as San Ignacio Bay in Baja California and the coast of Sinaloa (Tecklin 1999). However, no recent records are listed in accounts of the birds of Baja California and Sonora (Wilbur 1987, Russell and Monson 1998). Wilbur (1987) states that black rails have never been recorded along the Colorado River in Mexico, but recent records are now available for this region: one black rail heard just southwest of El Doctor (5 June 1998; K. Garrett), and one heard on the northeast edge of the Cienega de Santa Clara (~1.25 kilometers northwest of where La Flor del Desierto Canal empties into the Cienega; 14 May 1998, L. Piest). O. Hinojosa-Huerta detected 15 black rails on recent call broadcast surveys in the Cienega de Santa Clara.

Morning versus evening surveys

We detected more black rails on evening surveys (0.78 black rails per point) compared to the corresponding paired morning surveys (0.64 black rails per point; $t = 1.96$, $n = 225$, $P = 0.051$). The difference was most pronounced during the call broadcast segment of the survey ($t = 2.28$, $n = 225$, $P = 0.023$). The proportion of survey points at which we detected black rails was also greater during evening surveys (0.535) compared to the corresponding paired morning surveys (0.358; $\chi^2 = 5.26$, $P = 0.022$). When we analyzed the entire data set, the proportion of points at which we detected black rails was also higher during evening surveys compared to morning surveys ($\chi^2 = 22.1$, $P < 0.001$). The proportion of points at which we detected black rails was also higher during evening surveys when we restricted our analysis to only those routes which had black rails ($\chi^2 = 13.9$, $P < 0.001$). However, evenings were often too windy for surveys, so we frequently had to cancel evening survey plans.

Diurnal changes in black rail detection probability

The proportion of points at which we detected black rails differed among hourly time periods in the morning for both the entire data set and the restricted analysis (Fig. 3). Detection probability increased from 05:00-06:00 h to 06:00-07:00 h and then declined as the morning progressed (Fig. 3). In contrast, the proportion of points at which we detected black rails did not differ among hourly time periods in the evening (Fig. 3). Hence, the peak in vocalization

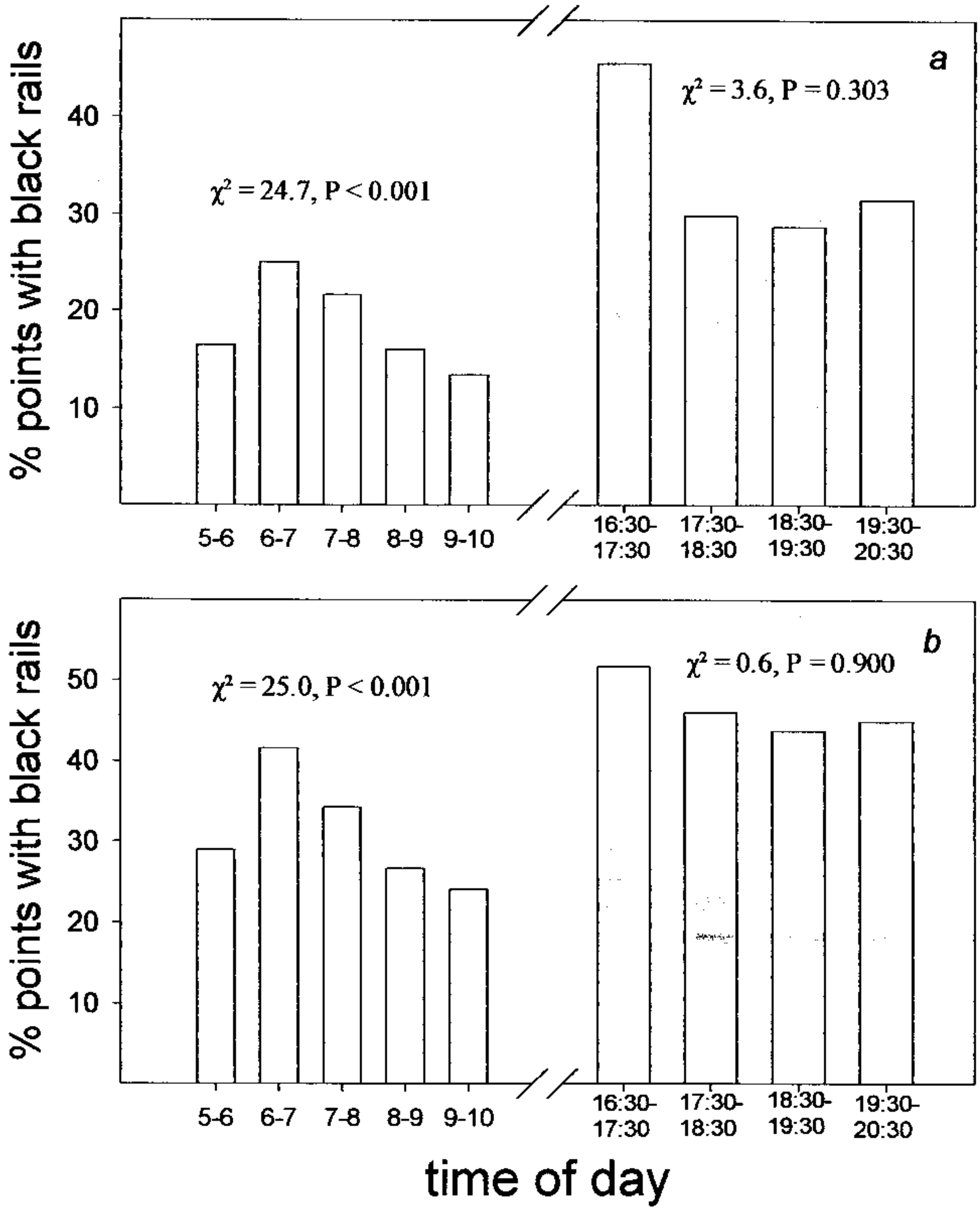


Figure 3. Proportion of survey points at which we detected black rails among one-hour time periods for both morning and evening surveys: a) includes all survey points, b) includes only those survey points along routes where at least one black rail was detected.

probability was narrower during morning surveys.

Effects of broadcast volume on number of birds detected

The number of black rails detected was higher on 90 dB surveys compared to 70 dB surveys (Fig. 4), but the difference was not significant. The number of black rails detected on paired 70 dB and 90 dB surveys was very similar during the passive and call broadcast segments of the survey (Fig. 4b and 4c, respectively), but we tended to detect more black rails while traveling between survey points during 90 dB surveys (Fig. 4a). The proportion of survey points at which we detected black rails did not differ ($\chi^2 = 0.11$, $P = 0.736$, $n = 574$) between 70 dB (125 of 287 points) and 90 dB (121 of 287 points) surveys. On 9 of the routes we detected more black rails during the 70 dB survey, on 9 routes we detected more black rails on the 90 dB survey, and on 2 routes we detected the same number of black rails on the two surveys.

Observer bias

We conducted 228 observer bias trials during which 2 observers independently recorded birds detected during the same survey. During their 88 observer bias surveys, observer #1 detected 11 black rails that observer #2 missed, observer #2 detected 13 black rails that observer #1 missed, and there were 65 black rails that both observers detected. Hence, observer #1 detected 76 (observer detection probability = 85.4%) and observer #2 detected 78 (observer detection probability = 87.6%) of the 89 birds that vocalized during the double-observer surveys. During their 140 observer bias surveys, observer #1 detected 17 black rails that observer #3 missed, observer #3 detected 28 black rails that observer #1 missed, and there were 44 black rails that both observers detected. Hence, observer #1 detected 61 (observer detection probability = 68.5%) and observer #3 detected 72 (observer detection probability = 80.9%) of the 89 birds that vocalized during the double-observer surveys. The two observers detected the same number of black rails at 75% of the 228 survey points. Most (51%) of the discrepancies were not whether a black rail was detected at a particular point, but how many individuals were detected. Average observer detection probability of black rails across all 3 observers was 80.6%. Observer detection probability of black rails was similar during the passive (average across all 3 observers = 79.5%) and call broadcast (average across all 3 observers = 79.3%) segments ($\chi^2$=0.12 and 0.15 for observer #1 versus #2, and #1 versus #3, respectively).

Seasonal variation in calling behavior and detection probability

Seasonal peak in number of black rails detected varied among survey locations (Fig. 5). Although we recorded peak counts for many routes in late June through late July, we also conducted more replicate surveys during this period and just as many of those replicate counts were similar or lower than counts from March and April (Fig. 5). For example, although the peak in number of black rails detected was mid-July at Hidden Shores and North Mittry Lake-A, survey results during mid-July resulted in moderate or low counts compared to other surveys on other routes (e.g., West Pond, Water Tower Marsh; Fig. 5). Hence, we found no consistent seasonal peak in detection probability across locations; high daily variation in detection probability of black rails overwhelms or masks any seasonal pattern in peak calling activity. Most of the birds detected from March through June (~80%) gave the *kicky-doo* call (Fig. 6). *Grr* and *churt* calls were less common March through June. In July, the *grr* and *churt* calls became more frequent

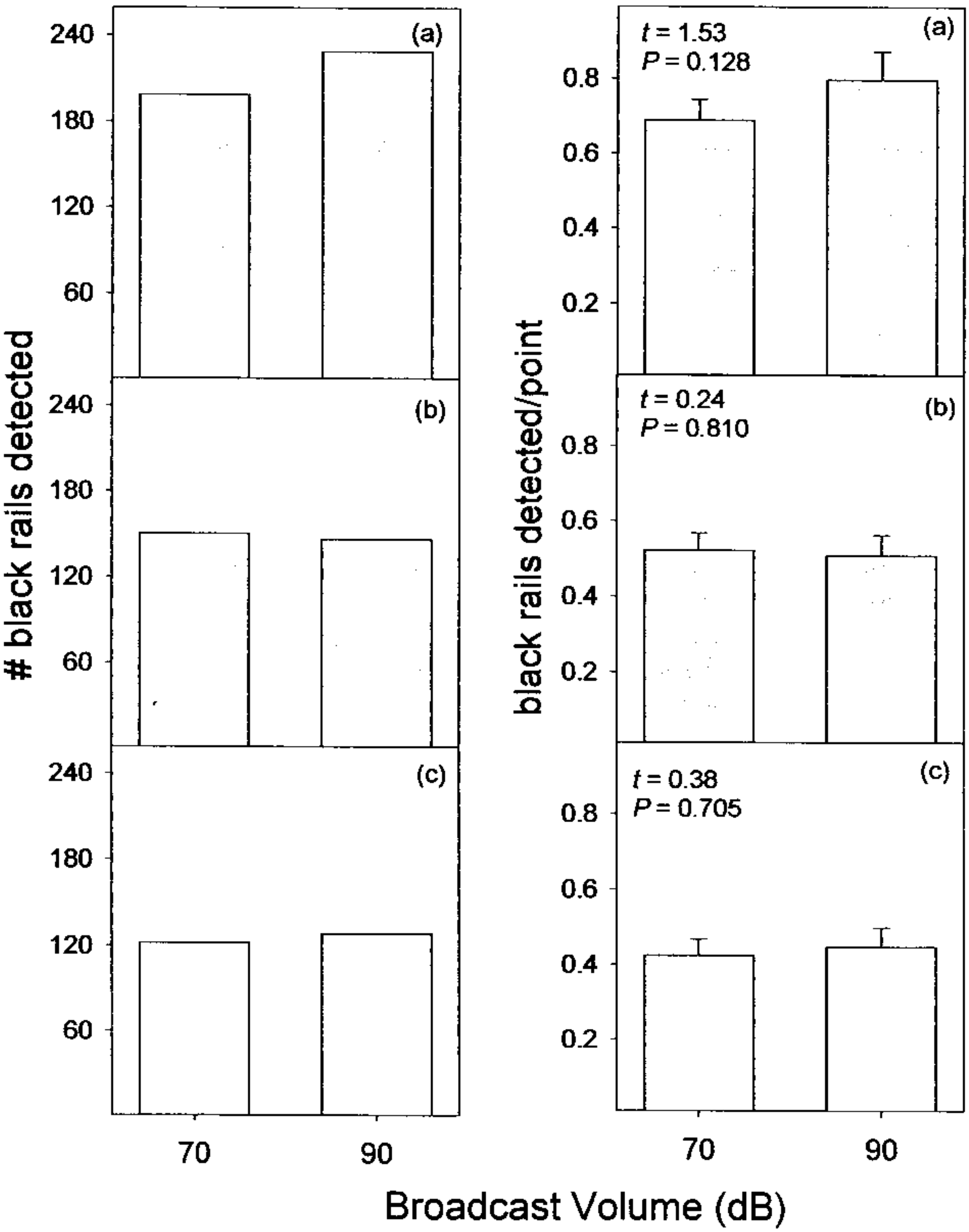


Figure 4. Total number of black rails detected and mean number of black rails per point at 228 survey points during paired 70 dB and 90 dB replicate surveys: survey consisted of two segments: a) before or after our 6-minute survey period, b) during our 3-minute passive survey segment, c) during our 3-minute call broadcast survey segment.

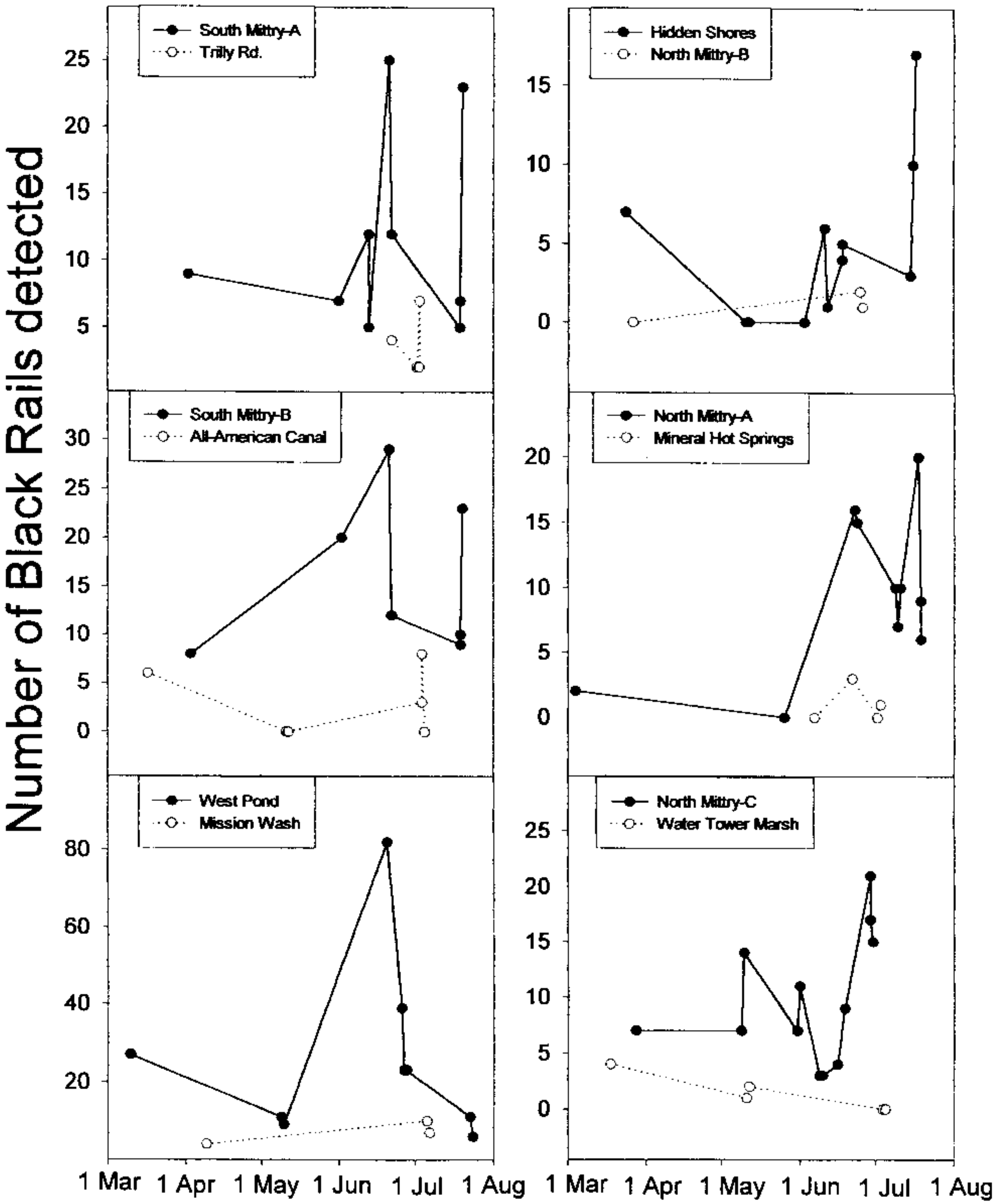


Figure 5. Seasonal peak in number of black rails detected at 12 locations in Arizona and southern California. Points represent number of black rails detected during replicate surveys, March through July 2000.

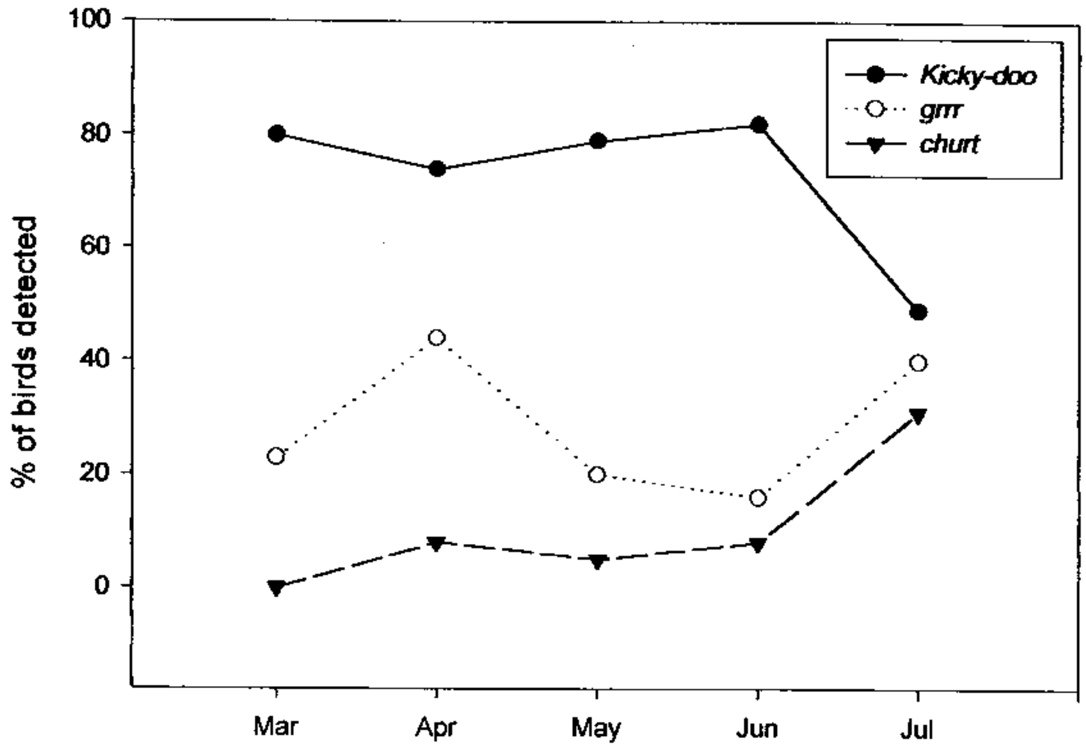


Figure 6. Seasonal variation in the proportion of each black rail detected that elicited each of three calls (*kicky-doo*, *grr*, and *churt*) during our surveys.

and the *kicky-doo* call (given by only 55% of birds detected) became less frequent (Fig. 6).

Habitat correlates of black rail distribution

Points at which black rails were detected differed significantly in vegetative composition compared to points at which we failed to detect black rails (Table 6). Our results were similar whether we limited our analysis to include only points on survey routes that had black rails or when we analyzed all 1600 points. Plants that were significantly more common at points with black rails included three-square bulrush (*Scirpus olneyi*), cottonwood (*Populus fremontii*), salt grass (*Distichlis spicata*), seep willow (*Baccharis glutinosa*), salt cedar (*Tamarisk chinensis*), arrowweed (*Tessaria sericea*), and mixed shrubs (Table 6). Plants that were significantly less common at points with black rails included common/giant reed (*Phragmites australis* and *Arundo donax*), California bulrush (*Scirpus californicus*), and cattail (*Typha domingensis*). Upland and open water were also less common at points with black rails (Table 6). Three-square bulrush showed by far the most obvious association; survey points with black rails average 13% coverage by *S. olneyi* whereas points lacking black rails averaged only 2% coverage by *S. olneyi* (Table 6).

Plants associated with black rail presence (three-square bulrush) were relatively rare compared to those that were less frequently associated with black rails (narrowleaf cattail and California bulrush; Table 7). Three-square bulrush was the dominant plant species at only 40 of the 1600 survey points (Table 7). Although three-square bulrush is relatively rare, we detected black rails at 48% of the 214 points that contained *S. olneyii*. Black rails may not be present at all locations with three-square bulrush; we failed to detect black rails at 50% of the 40 survey points which had >50% *S. olneyii*.(Table 7). Black rails may have been present at some of these points but failed to vocalize during our survey. Alternatively, black rails may be absent from these locations for one of several reasons: the areas are suitable but black rails are absent due to regional population declines, or the areas are not suitable due to the absence of more subtle habitat features.

## DISCUSSION

Passive versus call broadcast surveys

Call broadcast increased vocalization probability of black rails, but significantly lowered vocalization probability of non-target species. Hence, the use of call broadcast methods to elicit response of target marsh bird species has a cost in that call broadcast causes a reduction in detection probability of other species. Previous studies have demonstrated that call broadcast increases vocalization probability of other rails (Conway and Gibbs 2001), but effectiveness of call broadcast on California black rails in a previous study was equivocal (Flores and Eddleman 1991). Detection probability was higher during interstitial silent periods compared to periods of call broadcast. Hence, if call broadcast is used for marsh bird surveys, surveys should include intermittent passive periods to allow birds to respond to broadcasts and allow observers to hear calling birds. The use of call broadcast increases temporal variation in detection probability compared to passive surveys. Higher temporal variation in detection probability diminishes our ability to detect population change. Previous authors have suggested that call broadcast lowers temporal variation in detection probability (Glahn 1974), yet our results refute this common assumption (also see Conway and Gibbs 2001).

Table 6. Results of independent sample *t*-tests comparing % ground coverage between survey points at which California black rails were and were not detected.

| | points with BLRAs n = 243 | points[1] lacking BLRAs n = 380 | *t* | *P* | points[2] lacking BLRAs n = 1380 | *t* | *P* |
|---|---|---|---|---|---|---|---|
| *Populus fremontii* | 1.8 ± 0.4 | 0.5 ± 0.2 | 3.4 | 0.001 | 0.4 ± 0.1 | 5.5 | 0.000 |
| *Distichlis stricta* | 0.6 ± 0.2 | 0.1 ± 0.1 | 3.5 | 0.000 | 0.2 ± 0.1 | 2.7 | 0.007 |
| Common/Giant reed[3] | 11.2 ± 1.4 | 25.9 ± 1.5 | 6.6 | 0.000 | 11.4 ± 0.6 | 0.1 | 0.919 |
| *Baccharis glutinosa* | 5.8 ± 0.6 | 3.4 0 ± .4 | 3.3 | 0.001 | 3.0 ± 0.2 | 4.4 | 0.000 |
| *Scirpus californicus* | 4.4 ± 0.9 | 6.8 ± 0.8 | 1.9 | 0.058 | 5.7 ± 0.4 | 1.2 | 0.247 |
| *Scirpus olneyi* | 13.1 ± 1.3 | 1.9 ± 0.4 | 10.1 | 0.000 | 2.2 ± 0.3 | 13.2 | 0.000 |
| mixed shrub | 0.9 ± 0.2 | 0.4 ± 0.1 | 2.0 | 0.049 | 0.3 ± 0.1 | 4.1 | 0.000 |
| *Tamarix chinensis* | 13.9 ± 1.0 | 10.3 ± 0.7 | 3.1 | 0.002 | 9.6 ± 0.4 | 4.4 | 0.000 |
| *Tessaria sericea* | 5.7 ± 0.7 | 2.1 ± 0.4 | 5.0 | 0.000 | 1.6 ± 0.2 | 8.4 | 0.000 |
| *Typha domingensis* | 35.5 ± 1.9 | 38.8 ± 1.6 | 1.3 | 0.196 | 52.1± 0.9 | 7.2 | 0.000 |
| Upland | 1.7 ± 0.3 | 3.7 ± 0.5 | 2.9 | 0.004 | 3.4 ± 0.3 | 2.7 | 0.007 |
| Open water | 4.0 ± 0.6 | 5.6 ± 0.6 | 1.9 | 0.060 | 6.6 ± 0.4 | 3.0 | 0.003 |

[1]restricted to points on those survey routes that had at least one black rail detected.
[2]all points included.
[3]includes common reed (*Phragmites australis*) and giant reed (*Arundo donax*).

Table 7. Vegetative composition of the 1600 survey points and the plant species associated with black rail presence. Proportion of the 1600 survey points that contained each plant species within a 50-meter radius at which we detected black rails.

| Vegetation type | No. points with >1% coverage by veg. type | % of points with ≥1% coverage with black rails | No. points with ≥50% coverage by veg. type | % of points with ≥50% coverage with black rails |
|---|---|---|---|---|
| *Populus fremontii* | 70 | 37.1 | 1 | |
| *Distichlis stricta* | 38 | 36.8 | 0 | |
| Common/Giant reed[1] | 481 | 15.6 | 161 | 13 |
| *Baccharis glutinosa* | 338 | 28.1 | 15 | 13 |
| *Scirpus californicus* | 307 | 13.4 | 75 | 12 |
| *Scirpus olneyi* | 214 | 48.1 | 40 | 50 |
| mixed shrub | 60 | 36.7 | 0 | |
| *Tamarix chinensis* | 982 | 19.6 | 53 | 32 |
| *Tessaria sericea* | 231 | 35.5 | 11 | 45 |
| *Typha domingensis* | 1403 | 14.2 | 842 | 9 |
| Upland | 255 | 11.0 | 24 | 0 |
| Open water | 504 | 11.3 | 37 | 0 |

[1]includes common reed (*Phragmites australis*) and giant reed (*Arundo donax*).

Comparison with previous survey results

The number of breeding black rails in the region has declined. Declines have been most dramatic in southern California. Highest black rail densities associated with the lower Colorado River in 1974-75 were at West Pond, north Mittry, YPG slough, Senator Wash, and Ferguson Lake (Repking and Ohmart 1977). Locations with the highest black rail densities were similar in 2000 with the exception of Ferguson Lake.

*Mittry Lake area.* Population change at Mittry is difficult to determine. Repking and Ohmart (1977) detected 18 and 22 black rails in 1973 and 1974, respectively. Todd (1980) detected 80 black rails and Evens et al. (1991) detected 44 birds. Todd (1980) appears to have surveyed the interior areas of Mittry Lake much more intensively than Repking and Ohmart (1977) and Evens (et al. 1991). Our results (24 birds) represent a decline compared to 1980 and 1989 surveys, but our numbers are similar to those reported by Repking and Ohmart (1977). Artificially prolonged flooding of the Mittry Lake area in 1983 which silted in suitable black rail habitat may explain the recent declines.

*Imperial Reservoir.* Number of black rails have declined since early 1970s (Fig. 2). Severe floods of 1983 on the lower Colorado River and high water flows in 1984-1986 may have contributed to these declines. The Imperial Reservoir marshes (in combination with West Pond and Mittry Lake), represent the only remaining viable black rail population south of San Francisco Bay (although the 15 birds we detected on Bill Williams River may represent another). Most Colorado River marshes upstream of Imperial Reservoir are subject to water level fluctuations that limit their suitability for black rails. For example, daily water level fluctuations in the Parker Division were $\geq$1 meter, but only 0.1 meter at Imperial Reservoir and the daily fluctuations were most extreme during spring (Repking 1975). Water levels in Imperial reservoir are relatively stable and allow black rails to utilize the riverine marshes there. These marshes are critical to black rail population viability in the region and need to be maintained.

*Bill Williams River.* We detected 15 black rails in the Bill Williams River and our effort represents the first thorough black rail survey in this area. Rosenberg et al. (1991) suggested that black rails colonized the Bill Williams River in 1982 via immigration from the population near Imperial Dam. Their conclusion was based on knowledge of the water regime and vegetative communities of the Bill Williams River prior to the high water releases from Alamo Dam (fall 1978 through spring 1981). They believe that if black rails had been present in the Bill Williams River marshes prior to this time they would have been detected. Hence, this may be the one area in the region where black rail numbers have increased but we lack good comparative survey data to make reliable statements on population trajectories at Bill Williams.

*West Pond.* Our results from West Pond were lower than all other previous surveys (Fig. 2). West Pond burned in February 1974 (6.8 hectaresof mostly three-square bulrush; Repking 1975) which may have caused some loss of optimal habitat.

*All-American Canal.* Number of black rails along the All-American Canal has declined substantially since 1980, but has remained relatively stable since 1984 (Fig. 2). Imperial County Irrigation District installed pumps in the seepage marsh on the All-American Canal between drops 3 and 4 to return seep water to the canal. This effort reduced the size and quality of this marsh (Laymon et al. 1990). Continued threats to this marsh exist; the U.S. Border Patrol has an interest in removing this marsh because illegal immigrants hide in the vegetation.

*Coachella Canal.* We detected black rails in 2 seep marshes associated with the Coachella Canal in our 2000 survey effort (Table 1). All other marshes along the Coachella Canal that contained black rails during the 1989 survey (Evens et al. 1991) were no longer present. A large portion of the Coachella Canal has been rebuilt and lined with concrete causing many seep marshes which contained black rails in 1989 to disappear. For example, the old earthen Coachella Canal between Titsworth and Flowing Wells (south of Niland) was replaced with a new concrete-lined canal between 1975 and 1989 eliminating most of the black rail habitat along this portion of the canal (Laymon et al. 1990).

*Salton Sea area.* Black rails are no longer present in the Salton Sea area; we failed to detect any black rails in marshes associated with the Salton Sea. Surveys for California black rails in 1999 in the Salton Sea area also failed to detect any birds (Shuford et al. 2000). Habitat at Finney Lake, Whitewater River delta, and the New River delta that once supported breeding black rails has been completely altered or destroyed and has not supported black rails in many years (M. Patten, pers. comm.). For example, the marsh at the mouth of the New River where 13 black rails were detected in the summer of 1989 was destroyed by the Army Corp of Engineers in the fall of 1989 (Evens et al. 1991). Finney Lake has been bulldozed and graded periodically to increase waterfowl habitat (Evens et al. 1991) and these modifications appear to have eliminated black rail habitat.

Incidental black rail detections from previous years

Many areas with recent black rail records have since been destroyed and no longer support suitable black rail habitat. For example, Carrizo Marsh in Anza-Borrego Desert State Park was severely altered by a hurricane in 1976 and no black rails have been heard since (Unitt 1984, P. Jorgensen, pers. comm.). Other incidental records may reflect dispersing birds rather than small breeding populations; rails are known for their dispersal tendencies and high degree of vagrancy outside their breeding range.

Potential black rail habitat exists along the Colorado River delta in Mexico but no known records existed in 1991 (Evens et al. 1991). However, the lack of historical records may reflect the lack of visitation by ornithologists rather than the lack of birds. Recently, several observers have reported isolated black rails in marshes associated with the delta (Cienaga de Santa Clara and El Doctor). Surveys to document abundance and distribution of black rails in the Colorado River delta in Mexico are needed.

Morning versus evening surveys

Our results suggest that detection probability of black rails is higher during evening surveys compared to morning surveys. However, survey conditions were more optimal during the morning period and we often had to cancel evening surveys due to moderate wind. For other species of marsh birds, evening surveys have proven more effective in some studies (Rabe and Rabe 1985, Tacha 1975, Johnson and Dinsmore 1986), whereas morning surveys have proven better in others (Cashen 1998). Eastern black rails in Florida vocalized more readily during morning surveys (63% vocalization probability) compared to evening surveys (37% detection probability; Legare et al. 1999). For California black rails, Repking (1975) found morning surveys to be more effective, Flores and Eddleman (1991) reported that black rails were slightly more responsive during evening surveys, and Spear et al. (1999) and Tecklin (1999) reported no difference between morning and evening survey results.

Diurnal changes in black rail detection probability

Daily peak in vocalization probability was brief during morning surveys compared to evening surveys; number of black rails detected varied among one hour time periods during morning surveys, but less so during evening surveys. In contrast, daily peak in vocalization probability was shorter in the evening compared to the morning in the San Francisco Bay population (Spear et al. 1999). We conducted more evening surveys later in the season (June and July) due to logistical constraints and weather. Hence, our conclusions based on duration of diurnal peak in vocalization probability may have differed had we been able to conduct more evening surveys in March-May.

Effects of broadcast volume on number of birds detected

Broadcast volume showed little effect on detection probability of black rails. All survey efforts, including future black rail survey efforts, should attempt to standardize all aspects of survey methods. However, even moderate temporal and spatial variation in broadcast volume that will inevitably occur when using call broadcast surveys will probably not sacrifice the explanatory power of black rail survey results.

Observer bias

Few survey efforts make any attempt to estimate detection probability. For strictly vocal surveys such as ours, detection probability is the product of vocalization probability (the probability that an individual bird that is within the sampled area vocalizes during the survey period) and observer detection probability (the probability that the observer hears and records an individual bird that vocalizes during the survey period; Conway and Gibbs 2001). No previous authors have estimated observer detection probability associated with marsh bird survey efforts. Observer detection probability was relatively high (80.6%) and did not differ between passive and call broadcast survey segments. We measured observer detection probability using the double-observer method (Nichols et al. 2000). Measuring observer detection probability in this way is possible because all black rails were detected aurally. However, if one observer tends to mistakenly record a bird when none actually called, their own detection probability will be biased high and the detection probability of the other observer will be biased low.

Observer detection probability on marsh bird surveys is probably very high (Erwin et al. 2002, this study) because marsh bird calls are relatively easy to identify and densities are often low. In contrast, vocalization probability is often relatively low in black rails (20-50%; Legare et al. 1999) and other marsh birds (40% for Yuma clapper rails, 31% for American bitterns, and 13% for least bitterns; Conway et al. 1993, Conway and Gibbs 2001). Hence, replicate surveys are needed in local areas to assure high probability of detecting resident birds. The cumulative probability of detection with $x$ replicate surveys is $(1-(1-p)^x)$, where $p$ is the detection probability associated with a single survey. For example, if vocalization probability is 50% and observer detection probability is 80.6% (hence $p = 0.5 \times 0.806 = 0.403$), then we would need to conduct 5 replicate surveys to ensure >90% detection probability of a resident black rail. In contrast, if vocalization probability is only 20% we would need to conduct 13 replicate surveys to obtain 90% detection probability. The increase in overall detection probability gained by increased number of replicate surveys must be tempered by the fact that birds may become habituated to call broadcast with more frequent replicate surveys. Moreover, using observer detection probability (measured via the double-observer method; Nichols et al. 2000) as a surrogate for detection probability on marsh bird surveys is inadequate because vocalization probability is much lower than observer detection probability even with call broadcast.

Seasonal variation in calling behavior and detection probability

We were unable to document one consistent seasonal peak in detection probability of black rails; seasonal peak in number of birds counted was not consistent among areas within the lower Colorado River region (Fig. 5). Seasonal changes in detection probability of black rails have been reported in some studies (Legare 1996, Spear et al. 1999) but not in others (Tecklin 1999, Tomlinson and Todd 1973). Some studies have reported two seasonal peaks in numbers of marsh birds detected; one in early breeding when adult vocalization probability is highest and another later in the season coinciding with when juvenile birds begin calling (Conway and Gibbs 2001).

Our results suggest that vocal repertoire of black rails is relatively constant across the breeding season; proportion of black rails detected that gave *kicky-doo*, *grr*, and *churt* calls was surprisingly constant from March through June. However, *kicky-doo* calls were less common in July and *grr* and *churt* calls were more common. *Grrs* are usually given at close range (within 5 meters) in response to call broadcast (Tecklin 1999). Repking and Ohmart (1974) also reported that the *kicky-doo* call was more common and the *grr* call less common in March and April compared to June-August in 1973, but this pattern was not repeated the following year (Repking 1975). *Grrs* can be heard from only about 30 meters away whereas *kicky-doo* can be heard from over 100 meters away (Tecklin 1999). The *kicky-doo* (or *kic-kic-kerr*) is thought to be the call of the male (Reynard 1974, Wilbur 1974, Legare et al. 1999). Perhaps the observed increase in *grr* and *churt* calls in August reflect juvenile birds beginning to vocalize. An increase in numbers of black rails detected in late summer is often observed (Flores and Eddleman 1991, Legare et al. 1999, Spear et al. 1999) and may reflect the onset of vocal development in hatch-year birds (Spear et al. 1999). However, fledging dates do not appear to be very synchronized within the regional population; hatching dates of 6 nests at Mittry Lake were between 18 April and 23 July (Flores and Eddleman 1993). Both sexes incubate the clutch (Flores and Eddleman 1993) and hence both sexes may be less vocal during incubation.

Habitat correlates of black rail distribution

In general, the plants that we found associated with black rail presence were those associated with stable, shallow water (three-square bulrush) and/or with the upland/wetland interface (e.g., seepwillow, arrowweed, saltgrass, cottonwood). In contrast, plants that were more common at points lacking black rails were those associated with comparatively deeper water (cattail, California bulrush). Our results reaffirm results of previous studies of black rail habitat use. Similar to our results, Repking and Ohmart (1974) reported that three-square bulrush, salt grass, salt cedar, and arrowweed were associated with local black rail presence. But in contrast to our results, Repking and Ohmart (1974) reported that *Phragmites* and cattail were also associated with black rail presence. In 1973-74, black rail presence was strongly associated with *S. olyneyii*; 94% of areas where black rails were detected had three-square bulrush, and all vegetative transects that contained *S. olneyii* had black rails (Repking 1975). Three-square bulrush dominated the majority (64%) of the 50 sites at which black rails were detected during 1989 surveys, and black rails were detected at 33% of the 95 sites that were dominated by three-square bulrush (Laymon et al. 1990). Daily water level fluctuations of 1 meter are thought to prevent use by black rails (Repking 1975) and *S. olneyii* is most common in shallow or saturated soil situations on gentle slopes (Repking and Ohmart 1977). Hence, the association between black rails and three-square bulrush may simply reflect similar requirements for shallow, stable water conditions. The majority of sites (73%) at which black rails were detected in northern California were areas with water depths ≤3 centimeters (Tecklin 1999). All 5 nests located at Mittry lake were placed in areas with <2.5 centimeters water depth (Flores and Eddleman 1993). *S. olneyii* is also restricted to shallow water/moist soil.

Development of standardized black rail survey methods

Our region-wide survey can be easily repeated in future years to monitor population status of black rails in the region (location of each of our survey points is listed in Appendix 2). The rarity of visual detections during our surveys highlights the difficulty in surveying black rails; standardized vocal survey methods are needed (Appendix 1). Length of the survey period often varies greatly among local marsh bird survey efforts (Conway and Gibbs 2001). When designing a survey protocol, survey duration must be standardized. Longer survey duration increases detection probability, but limits the number of points an observer can visit each day. Detection probability of black rails declines dramatically as the morning progresses (Fig. 3) and number of new black rails detected declined throughout our 6-minute survey period (Fig. 1). Hence, we believe that a relatively short survey period is more efficient for monitoring population change compared to one of longer duration. We recommend a 3-minute initial passive survey segment followed by a 3-minute call broadcast segment. A passive segment allows detection of other marsh birds (which provides efficient use of monitoring resources given that other marsh birds are declining) and a call broadcast segment maximizes black rail detections.

A large proportion of the black rails we detected were within 50 meters of the survey point. Short spacing between adjacent survey points will increase detection probability, but will limit the amount of area that an observer can cover in one day. Short distance between adjacent survey points also results in increased observer bias because individual birds can be heard at multiple survey points and each observer must make subjective decisions regarding which birds are new individuals. Individual birds also move toward the tape source making individual birds difficult to distinguish if points are close together. Hence, we recommend 100 meter spacing between adjacent survey points for regional monitoring of population trends.

Unlike eastern black rails which vocalize mostly at night (Reynard 1974, Kerlinger and Wiedner 1991), California black rails vocalize primarily near dawn and dusk. Evening surveys had greater detection probability than morning surveys and hourly variation in detection probability was lower during evening surveys. However, windy weather often prohibited black rail surveys during the evening. For future black rail surveys, we recommend that observers identify particular surveys routes as either morning or evening survey routes taking the results mentioned above into consideration. Morning survey routes should always be conducted during the morning hours (dawn until four hours after sunrise) and evening routes always conducted during the evening hours (4 hours before sunset until dark). Including both morning and evening surveys into a standardized monitoring protocol will provide added flexibility and potential survey hours for field personnel. Broadcast volume doesn't appear to have a large influence on numbers of black rails detected, but we recommend attempting to standardize broadcast volume (at 90 dB) and tape quality.

Seasonal peak in vocalization probability varied among routes with no apparent consistent period of maximum response. Our failure to detect a clear seasonal peak in vocalization probability is due to large temporal (day-to-day) variation in detection probability. Low vocalization probability (even with call broadcast) and high daily variation in vocalization probability of black rails (this study; Spear et al. 1999) necessitates replicate surveys. Too many replicate surveys are not good because rails may habituate to call broadcast and detection probability may decline with time. Standardized surveys should target the pre-hatching period which is typically May in coastal California (Spear et al. 1999) and late March through mid-June in southern Arizona (Flores and Eddleman 1993). Replicate surveys should be completed prior to the time when juveniles begin vocalizing. Hence, we recommend surveys be conducted from 21 March through 30 May, and we recommend at least three replicate surveys each year (Appendix 1). Restricting annual surveys to March-May will help ensure that we monitor trends of adult black rails (juveniles probably begin vocalizing in June and July).

Management/Conservation Implications

Black rails were listed as hypothetical in Arizona by Phillips et al. (1964), and black rail presence on the Colorado River was not verified until 1969 (Snider 1969, Tomlinson 1970). However, the fact that black rails were not documented on the Colorado River prior to 1969 is not sufficient proof that black rails only recently colonized Arizona marshes. Indeed, relatively large local black rail populations are frequently not recorded in areas were they occur. For example, a breeding population in the Sacramento Valley (with at least 184 birds) was only recently "discovered" (in 1994) yet has apparently existed for many years (Tecklin 1999), and two "relatively large" local populations were recently "discovered" (1988) in New Jersey (Kerlinger and Sutton 1989). Moreover, black rails are more difficult to detect compared to other rails because their vocalizations are not as loud.

Degradation and elimination of suitable habitat has caused considerable decline in California black rail populations and significant reduction in distribution in southern California and Arizona (also see Wilbur 1974, Garrett and Dunn 1981, Gustafson 1987, Jackson 1988). Declines have been most dramatic in the Imperial Valley of California where marshes that once supported breeding black rails have been altered or destroyed. Observed declines in eastern black rail populations are also the result of elimination and degradation of wetland habitat (Kerlinger and Wiedner 1991). Black rails have relatively narrow habitat breadth and require very stable, shallow water emergent marshland conditions (Flores and Eddleman 1991). Black rails are often associated with seep marshes in the lower Colorado River region (Laymon et al. 1990) because these marshes tend to maintain extremely stable, shallow water conditions. Black rails are present in the main stem of the Colorado River only at Imperial Reservoir because the large amount of water above Imperial Dam results in more stable water levels relative to emergent marshes up-river (Repking and Ohmart 1977).

Marshes associated with the Colorado River from Senator Wash to Mittry Lake support most of the breeding California black rails in southern Arizona/California. Planet Ranch area of the Bill Williams River and the seep marsh along the All-American Canal are also important areas for black rails in the region. The closest known self-sustaining breeding population is in San Francisco Bay (the population at Morro Bay appears too small to be self-sustaining). Repking (1975) argued that to maintain black rail populations along the lower Colorado River, shallow water emergent marsh areas in the vicinity of Imperial Dam must be preserved. Despite the importance of the Imperial Reservoir area for conservation of black rail populations, several marshes in this area have been filled or developed since 1974 (e.g., elimination of ponds west of

Yuma Proving Ground entrance, expansion of Hidden Shores development, recent filling of Hurricane Ridge marsh just south of Squaw Lake, recent filling of seep marshes associated with Gila Gravity Main Canal south of Laguna Dam, proposed elimination of the seep marsh along the All-American Canal). These actions need to be curtailed so that black rail populations in the region can persist. Indeed, the goals of the Lower Colorado River Multi-Species Conservation Plan for black rails include the enhancement of existing habitat, restoration of unsuitable habitat, and the establishment of additional breeding locations within the lower Colorado River area.

Laymon et al. (1990) believed that the outlook for maintaining California black rails in southern Arizona/California was bleak. They suggested that insufficient habitat was available to maintain the species in perpetuity and that any further habitat loss could lead to rapid local extinction in the region. Since 1989, additional breeding habitat has been destroyed. Hence, land managers need to preserve existing marshes and restore unsuitable areas immediately. Low nest predation and high adult survival in quality marsh habitat (e.g., Mittry Lake; Flores and Eddleman 1993) suggests that availability of suitable shallow, stable-water emergent habitat limits black rail distribution and population size. Hence, habitat restoration may be the best approach to species recovery and prevention of further declines. Indeed, restoration of degraded marsh habitat is a management priority for conservation of California black rails (Gustafson 1987). Recovery of black rail populations through habitat restoration may be possible; black rails appear willing and able to find and use constructed or restored wetlands (Tecklin 1999). However, marsh restoration/creation efforts that were supposed to fully compensate for the substantial impacts to California black rails (and Yuma clapper rails) associated with lining the Coachella Canal (Coachella Valley County Water District 1977) have been ineffective; black rail populations in the Imperial Valley have declined dramatically since the 1970s.

Research needs

Studies of genetic relatedness among populations of California black rails (in the lower Colorado River, Salton trough, Colorado River delta, San Francisco Bay, and Sacramento valley), and between these populations and eastern black rails, are needed to better understand extent of gene flow and degree of isolation of disjunct populations. The populations of black rail along the lower Colorado River and in the Imperial Valley are considered to be most similar to the populations inhabiting brackish and salt marshes in the San Francisco Bay region (Rosenberg et al. 1991). However, the taxonomic and distributional status of black rails in the Lower Colorado River region is still poorly understood (Rosenberg et al. 1991). Prescribed fire may be a management tool that benefits California black rails but we need to rigorously evaluate the usefulness of fire as a tool for restoring/enhancing black rail habitat.

## MANAGEMENT RECOMMENDATIONS

Conservation and management efforts should be implemented immediately to prevent further declines in populations of California black rails. Alteration and elimination of wetland areas continues in the region and these activities should be curtailed to prevent further black rail declines. Efforts should also be made to restore existing wetland habitats to boost populations of black rails. Possible methods for restoring and/or creating black rail habitat have not been evaluated. Studies are needed to evaluate potential methods for improving black rail habitat in the region. Prescribed fire is one management tool that has been suggested to possibly benefit black rails, but needs to be critically and fully evaluated. Creation of new wetlands with features optimal for black rails may also be a way to help maintain and increase black rail populations in the region. Whether or not black rails will use created wetlands needs to be tested in a pilot study. Marshes and shorelines with high numbers of black rails (eastern shoreline of Mittry Lake, seep marsh along the All-American Canal between drops 3 and 4, West Pond, marshes between Imperial Dam and Martinez Lake, upper Bill Williams River marshes) should not be altered in any way (including no increases in decreases in water level). We recommend that standardized surveys be repeated annually so that better estimates of population trend can be obtained and managers can more closely monitor status and trends of black rails, and black rail habitat, in the region. Annual black rail surveys should be combined with current Yuma clapper rail survey efforts in the region to make most efficient use of volunteer and agency monitoring efforts.

## SUMMARY

We detected 136 black rails in southern Arizona and southern California. The majority (100) were detected at sites along the lower Colorado River, and 21 were detected at 3 sites along the All-American Canal. Most of the black rails located along the Colorado River were found in wetlands associated with the river between Laguna Dam north to Ferguson and Martinez Lakes. Numbers of California black rails have declined at 10 of the 11 locations where rails are/were most abundant in southern Arizona and southern California. Degradation and elimination of suitable habitat has caused considerable decline in California black rail populations and significant reduction in distribution in southern California and Arizona. Population declines were most significant in marshes along the All-American Canal and the mouth of the New River in California. Black rails (and all suitable habitat) have completely disappeared from the southern end of the Coachella Canal, Finney/Ramer Lakes, and the mouth of the New River. Declines have been most dramatic in the Imperial Valley of California where marshes that once supported breeding black rails have been altered or destroyed. Marshes associated with the Colorado River from Senator Wash to Mittry Lake support most of the breeding California black rails in southern Arizona/California. The Planet Ranch area of the Bill Williams River and the seep marsh along the All-American Canal are also important areas for black rails in the region. Despite the importance of the Imperial Reservoir area for conservation of black rail populations, several marshes in this area have been filled or developed since 1974. These actions need to be curtailed so that black rail populations in the region can persist. Substantial amounts of black rail breeding habitat in the region have been destroyed since 1989. Hence, land managers need to preserve existing marshes and restore unsuitable areas immediately. Habitat restoration may be the best approach to species recovery and prevention of further declines. Plants that were significantly more common at points with black rails included three-square bulrush, cottonwood, salt grass, seep willow, salt cedar, arrowweed, and mixed shrubs. Plants that were significantly less common at points with black rails included common reed, California bulrush, and cattail. Three-square bulrush showed by far the most obvious association with black rail presence.

Call broadcast significantly increased number of black rails detected by 14% compared to passive surveys. However, detection probability of other rails and bitterns was lower on the call broadcast segment of the surveys compared to the passive segment. We detected more black rails on evening surveys (0.78 black rails per point) compared to the corresponding paired morning surveys, but evenings were often too windy for surveys. Detection probability increased from 05:00-06:00 h to 06:00-07:00 h and then declined as the morning progressed. Detection probability did not vary among time intervals during evening surveys. Average observer detection

probability of black rails across all 3 observers was 80.6%. We recommend that standardized surveys be repeated annually so that better estimates of population trend can be obtained. Three replicate surveys should be conducted annually at each survey point during defined survey windows (we suggest 21-30 March, 21-30 April, and 21-30 May). Observers can conduct either morning or evening surveys on a route as long as each survey route is surveyed during the same period (morning or evening) consistently each year. We present a standardized black rail survey protocol designed to help local managers and agency biologists conduct annual black rail surveys in the region.

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Appendix 1. Standardized survey protocols for California black rails.

## STANDARDIZED CALIFORNIA BLACK RAIL MONITORING PROTOCOLS

**Introduction**

The amount of emergent wetland habitat in North America has declined sharply during the past century (Tiner 1984). 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), but adequate monitoring programs to determine status and estimate population trends are lacking. The U.S. Fish and Wildlife Service has identified Black Rails as a species of special concern because they are relatively rare and basic information on status and trends in most areas is not available (U. S. Fish and Wildlife Service 1987). California black rails are state listed in California and Arizona. Because rails consume a wide variety of aquatic invertebrates, marsh bird populations may be affected by accumulation of environmental contaminants in wetland substrates (Odom 1975, Klaas et al. 1980, Eddleman et al. 1988, Gibbs et al. 1992, Conway 1995). 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. Black rails also have high recreational value; black rails are highly sought-after by recreational birders.

Implementing standardized survey efforts will allow us to monitor black rail populations to estimate population trends. Continued monitoring will also allow resource managers to evaluate whether management actions or activities adversely impact wetland ecosystems and/or black rail population trends. Any management action that alters water levels, reduces mudflat/open-water areas, alters invertebrate communities, or reduces/changes the amount of emergent plant cover within marsh habitats could potentially affect habitat quality for black rails.

During surveys for black rails, observers will also record species of secondary concern that are also under-sampled by other monitoring programs, e.g., other rails, bitterns, coots, moorhens, grebes, herons, egrets, Forster's Terns (*Sterna forsteri*), Common Snipe (*Gallinago gallinago*), Northern Harriers (*Circus cyaneus*), Belted Kingfishers (*Ceryle alcyon*), Willow Flycatchers (*Empidonax traillii*), Marsh Wrens (*Cistothorus palustris*), Red-winged and Yellow-headed Blackbirds (*Agelaius phoeniceus* and *Xanthocephalus xanthocephalus*), Common Yellowthroats (*Geothlypis trichas*). Agencies or individuals intending to conduct standardized black rail surveys should follow standardized continental marsh bird survey methods which include broadcasting calls of all rails/bitterns that breed in their region. These standardized protocols can be found in Conway and Gibbs (2001) or by contacting Dr. Courtney J. Conway (cconway@ag.arizona.edu). The protocols listed here are similar to the continental survey methods and are intended for individuals/agencies who only want to broadcast black rail calls rather than following the continental survey protocols. However, we recommend adopting a multi-species monitoring protocol so that cooperators get more information for the effort invested in monitoring.

### PARAMETERS TO BE ESTIMATED

*Density/abundance indices*

Abundance is the total number of birds within a defined area of interest. Density is abundance divided by area, or the number of birds/hectare of emergent habitat within a wetland during one season. Surveys rarely count all individuals present in the sampling area because detection probability is typically less than 100%. However, number of birds responding during standardized surveys will provide an index to abundance that will allow comparisons among wetland basins and habitat types. Abundance indices will also allow examination of the effects of management actions (e.g., wetland restoration) on marsh birds by comparing changes in abundance indices between managed and un-managed sites both before and after activities have occurred. Indices also allow comparison among other areas in the region to determine the relative importance/quality of local habitats to regional marsh bird populations. The value of an abundance index relies on 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). 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). Validation of indices based on call broadcast surveys for black rails will be obtained by incorporating methods for estimating detection probability into survey protocols. In the meantime, we will assume number of birds responding during standardized surveys provide a useful index to abundance.

*Population trend*

Population trend is the percent annual change in population size. Population trend estimates allow managers to determine whether local or regional marsh bird populations are declining. Managers can establish *a priori* population trend thresholds or trigger points below which immediate management action will be taken. Such actions can prevent local extinctions by identifying population problems before they become severe. We will estimate population trends of black rails by using weighted linear regression to analyze annual changes in the number of individuals detected per survey point. Few estimates of black rail (or any marsh bird) population trends currently exist, and reliable estimates of population trends will probably require >5 years of survey data. We will estimate population trends for black rails during the breeding season.

*Trends in habitat availability*

We will also estimate trends in emergent habitat availability. Trends in habitat availability are the percent annual change in the amount of each major wetland habitat type. Information on emergent habitat availability will allow us to: 1) correlate changes in black rail numbers with changes in habitat availability to identify potential causes of observed population changes (Gibbs and Melvin 1993), 2) identify emergent habitats that need protection, and 3) design management actions in ways that either improve or minimize adverse effects to preferred habitat of black rails.

## FIELD PROCEDURES, METHODS, PROTOCOLS

*Areas included in surveys*

Surveys should be conducted in all emergent marshes within the breeding range of the black rail that are >0.5 hectares in total area and that have shallow water (<2 centimeters) or moist soil conditions. Observers should not place survey points or survey routes only in areas/marshes where they know black rails exist. Such an approach is a biased sampling design that will always lead to perceived population declines (if you place samples in areas where density is highest then only declines can occur). Hence, we need an "area-based" sampling frame rather than a "marsh-based" sampling frame (i.e., we need to survey all potential habitat each year). Emergent habitat is not perennial and changes spatially over time - we want a sampling design that allows for that. By sampling "all emergent marshes within a defined area" observers will have to add or remove survey points as emergent habitat increases, decreases, or shifts within their defined management area. Survey routes should include as many survey points as needed to cover an area of interest.

*Location of survey points*

Fixed, permanent survey points will be chosen and marked with inconspicuous markers in the field. If possible, locations of all survey points should also be plotted on maps of each wetland using a GPS. Point spacing in previous studies has varied from 40 meters to 800 meters (Conway and Gibbs 2001). The more survey points included in an area, the more precise the resulting estimates of local population change. For black rail surveys, distance between adjacent survey points is 100 meters (50 meter intervals can be used in smaller areas in order to obtain a sufficient number of survey points). Survey points in ponds should be located either on the upland-emergent interface or on the open water-emergent interface, whichever will allow easier access and travel between survey points. Some marshes may be more effectively surveyed by boat (with survey points on the open water-emergent interface) and others more effectively surveyed on foot (with survey points on the upland-emergent interface). Many black rail survey efforts place survey points at the interface between emergent marsh and upland. This approach minimizes travel time between adjacent points, reduces trampling vegetation within the marsh, eliminates noise associated with boat engines, and may increase the distance at which observers can hear vocalizing birds due to increased elevation relative to the marsh vegetation. Each survey point receives a unique identification number. The number of survey points per marsh will be correlated with marsh size. Points should be in a 100 meter grid system in larger marshes (hence, 1 point per 1 hectare of marsh). Include at least one survey point in all marshes >0.5 hectares within the management area. Additional survey points can be added in small marshes that are linear in shape as long as they are 100 meters apart.

*Timing of surveys*

Survey routes can be either morning or evening survey routes. Observers can conduct either morning or evening surveys on a route as long as each survey route is surveyed during the same period (morning or evening) consistently each year. Morning surveys begin 30 minutes before sunrise (first light) and must be completed by 4 hours after sunrise. Evening surveys begin 4 hours before sunset and must be completed by dark. Including both morning and evening surveys into a standardized monitoring protocol will provide added flexibility and potential survey hours for field personnel. Conduct 3 surveys annually during the presumed peak breeding season for black rails in your area. Each of the 3 replicate surveys will be conducted during a 10-day window, and each of the 10-day windows will be separated by 20 days. Seasonal timing of these 3 replicate survey windows is based on migration and breeding chronology. Marsh birds are typically most vocal during courtship and egg-laying periods, although peaks in black rail vocalization tendency are not consistent across marshes. The first survey should be conducted when migratory passage is over, but prior to breeding. In the Lower Colorado River region, the first black rail survey should be between 21-30 March, the second survey 21-30 April, and the third survey 21-30 May. Restricting annual surveys to March-May will help ensure that we monitor trends of adult black rails (juveniles probably begin vocalizing in June and July). Three surveys are needed to confirm seasonal presence/absence of marsh birds in a wetland with 90%

certainty (Gibbs and Melvin 1993). Three replicate surveys per year is warranted, because timing of breeding cycle probably varies throughout the breeding range and will seldom be known by personnel conducting surveys. Finally, including 3 replicates per season will provide us with data on temporal and spatial variation in numbers counted (parameters needed to conduct reliable power analyses once enough preliminary data are available). The 3 survey windows increase our probability of conducting at least one survey during the peak seasonal response period of other marsh bird species in a local management area. One observer should expect to survey approximately 15-25 survey points each morning or evening survey period, depending on travel times between survey points.

*Survey methods*

Standardized survey methods for marsh birds have recently been developed to aid agencies developing marsh bird monitoring programs (Ribic et al. 1999, Conway and Gibbs 2001). These protocols include broadcasting calls of all rails and bitterns that commonly breed in your region and should be followed if at all possible. Because many marsh birds are secretive, seldom observed, and vocalize infrequently, we will use broadcast calls to elicit vocalizations during vocal surveys (Gibbs and Melvin 1993, Conway and Gibbs 2001). But because we want to estimate detection probability, evaluate the usefulness of call broadcast for future survey efforts, and survey secondary species, we will also record birds during a passive period prior to playing tapes.

At each survey point, observers will record all species detected (both black rails and other marsh bird species) during both a 3-minute passive period prior to broadcasting recorded calls, and during a period in which a cassette tape of pre-recorded vocalizations is broadcast into the marsh. The cassette tape includes two California black rail calls (*kicky-doo* and *grr*) and is broadcast using a portable cassette player (e.g., SONY Sports Series CFD-980) attached to an amplified speaker. The tape should be obtained from the Cornell Laboratory of Ornithology's Library of Natural Sounds (contact Andrea Priori at 607-254-2404). Order tapes well in advance; the Cornell Lab may require 2-3 months to fill your order. The 3-minute tape should include 3 sets of exactly 30 seconds of calls interspersed with 30 seconds of silence. The 30 seconds of calls should consist of calls interspersed with 5 seconds of silence. For example, an entire survey tape might look like this:

3 minutes of silence
- 5 seconds of *kicky-doo*
- 5 seconds of silence
- 5 seconds of *kicky-doo*
- 5 seconds of silence
- 5 seconds of *kicky-doo*
- 5 seconds of silence

30 seconds of silence
- 5 seconds of *kicky-doo*
- 5 seconds of silence
- 5 seconds of *kicky-doo*
- 5 seconds of silence
- 5 seconds of *kicky-doo*
- 5 seconds of silence

30 seconds of silence
    5 seconds of *grr*
    5 seconds of silence
    5 seconds of *grr*
    5 seconds of silence
    5 seconds of *grr*
    5 seconds of silence
30 seconds of silence

Each individual bird detected (both black rails and individuals of other species) during the survey period will be entered on a separate line on the field data form (Figure 1). Observers should record when each individual is detected: during any of the 1-minute passive periods, and/or during any of the 1-minute call broadcast periods. Recording all the segments during which an individual bird is detected is extremely important so that we can determine whether tapes are effective at eliciting additional responses for each of the primary species. These data will help us determine whether or not to use tapes during surveys in future years. Hence, observers must make a decision as to whether each vocalization heard at a survey point is a new individual for that point or is an individual that vocalized previously from that survey point. Observers should also estimate whether each response is within or beyond 50 meters of the survey point. Recording those individuals that are detected within 50 meters of each survey point will provide minimum density indices for each species in each habitat type. 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 cassette recorder should be placed upright on the ground (or on the bow of the boat), and sound pressure should be 90 dB at 1 meter in front of the speaker. Use a sound-level meter to adjust volume of the cassette player at the beginning of each survey. Observers should stand 2 meters to one side of the speaker while listening for vocal responses. Observers should point the speaker toward the center of the marsh and should **not** rotate the speaker during the call broadcast survey. An additional 1 minute passive period may be added to the end of the call broadcast segment if observers believe that such a protocol will significantly increase total detections. If a final passive period is included in a local survey, observers should record any birds detected during this additional segment in a separate column (e.g., the "*Comments*" column). Surveys should only be conducted when wind speed is <20 kilometers/hour, and not during periods of sustained rain or fog.

*Filling out the data sheet*

Prior to the beginning of the survey, write down the day, month, and year at the top of the data sheet. Also write the full name of all observers present during the survey. If more than one observer, write down who recorded the data and who identified calling birds. Write down the name of the marsh, the name of the management area, and other location information (distance and direction to nearest town, county, state). Make notes of weather conditions, and whether (and when) weather changes during the course of the morning or evening survey period.

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 a bird is detected, write the name of the species in the third column. You can use the 4-letter acronym for the species or write the full species name. A list of 4-letter AOU species acronyms is attached to this protocol. Put a tick in each column in which that individual is detected based on vocalizations and put a "v" in each column in which the individual is detected visually. For example, if an individual Virginia Rail calls during the first minute of passive listening, put a tick in that column. Regardless of whether that individual calls once or many times during the first minute, you only put one tick in the first column. If that same individual bird also calls during the second minute of the passive period , then put a tick in that column also. Likewise, if that same individual bird also calls during the first 30 seconds of call broadcast, then put a tick in that column. Hence, if an individual bird is calling constantly throughout the survey period, you will have a tick in every column for that individual. If the individual is heard **and** seen, put both a tick and a "v" in the appropriate column. If you hear a call of the same species but from a different individual (or from an individual of another species), you start a new line on the data sheet and follow the same protocol for this individual bird. The difficulty is determining whether a call is coming from a new individual or an individual detected earlier at each survey point. Observers must make this decision without seeing the bird by using their best judgement. Follow the same procedure at subsequent survey points. If an individual detected at one survey point is thought to be an individual that was already detected at a previous survey point, fill out a new line for this individual but write "yes" in the "repeat" column. The number of lines filled out on the data sheet will differ among survey points and will correspond to the total number of individual marsh birds detected at each point. If no birds are detected at a survey point, record the point number and starting time, and write "no birds" in the *Comments* column. A sample data sheet is included as an example of what survey data might look like. Also record the level of background noise during the survey at each survey point. This information will be used as a covariate in trend analyses because level of background noise varies spatially and temporally and influences detection probability. Categorize background noise at each point on a scale from 0 to 4 (0= no background noise, 1=faint background noise, 2=moderate background noise (probably can't hear birds beyond 100 meters), 3=loud background noise (probably can't hear birds beyond 50 meters), 4=intense background noise (probably can't hear birds beyond 25 meters).

*Habitat measurements*

Natural changes in water level and management activities (e.g., dredging, wetland restoration efforts, prescribed burning, etc.) can lead to dramatic changes in marsh vegetation. Patterns of distribution and local population trends of marsh birds can often be best explained by local changes in wetland habitat. Consequently, quantifying the proportion of major habitat types (e.g., % cattail, bulrush, *Phragmites/Arundo*, *Spartina*, *Salicornia*, grasses, open water, mudflat, shrub, upland) surrounding each survey point each year can help identify the cause of observed changes in marsh bird populations. Habitat will be quantified at 2 scales: observers should visually estimate the proportion of each major habitat type within a 50-meter-radius circle around each survey point, and aerial photographs should be used to periodically (e.g., every 3 years) determine the amount of each major habitat type on the management area. To control for the seasonal progression of annual growth in emergent plants, observers should quantify habitat within the 50-meter radius circles during the first two weeks of July each year. As an example, visual estimates of proportions of each habitat at a survey point might look like this: 15% water, 10% California bulrush, 20% three-square bulrush, 5% cattail, 20% shrubs, 10% mudflat, 20% upland.

*Personnel and Training*

All observers should have the ability to identify all common calls of black rails and other marsh bird species in the region. Observers should practice call identification at marshes (outside the management area if necessary) where the primary species are frequently heard calling. All observers must pass a vocalization identification exam each year prior to conducting surveys. This exam should be a cassette tape requested from Cornell Laboratory of Ornithology's Lab of Natural Sounds. The tape should be new each year and observers should not have heard the exam tape prior to taking the exam. All observers should also be trained to accurately determine whether marsh bird calls are within 50 meters, and to identify all species of emergent plants on the management area.

*Equipment/materials*

Where possible, fixed survey points will be permanently marked with inconspicuous markers (e.g., 4 ft PVC pipe pounded into the ground) and numbered. Portable GPS units should be used to mark survey points onto aerial maps. GPS coordinates of each permanent survey point should be recorded and saved for reference in future years. Cassette tapes will be obtained from Cornell Lab of Ornithology, and new tapes should be ordered if tape quality declines. Cassette recorders should be high quality and batteries should be changed frequently (before sound quality declines). Observers should always carry replacement batteries on all surveys. A sound level meter with $\pm 5$ dB precision (e.g., EXTECH sound level meter, $99 from Forestry Suppliers, Inc.) should be used to standardize broadcast volume. A small boat/canoe may be useful for surveying larger wetland habitats adjacent to open water, reducing travel time between survey points. A spare tape player should be kept close-by in case the primary unit fails to operate. A prototype field data form for use on vocal surveys is included below.

DATA COLLECTION, ANALYSIS, SUMMARY AND ROUTINE REPORTING

A. Field data. Field data will be manually entered in the field on a data form (see blank form below) and transferred weekly to an electronic form. At each survey point, observers should record: name of observer, name of data recorder (if different from observer), name of wetland, date, survey point #, start time, species of each individual detected, the tape periods during which the individual was detected, and whether the individual bird was within 50 meters of the survey point. Each individual bird detected should be recorded on a new line on the data form. An overview map of the management area with all survey points numbered on the map should be developed for field personnel conducting surveys. All data forms should be reviewed by the supervisor within 24 hours of each survey so that mistakes can be identified and corrected promptly. Copies of original data forms should be stored in two separate locations.

B. Data entry/Database management. Data will be entered into a common spreadsheet program (EXCEL, Lotus, QuattroPro, dBase, etc) as soon after collection as possible, preferably within 1 week of data collection. Timely data entry limits mistakes, reduces probability of loss of data, and helps identify potential sampling biases and logistical problems that might be corrected in future surveys. Completed surveys will be printed out after entry into the spreadsheet and compared to original data forms to assure data quality. Electronic spreadsheets containing field data will be backed up weekly.

C. Data reporting. An annual report should be completed each year. After each season, survey data should be summarized and summaries should include the mean number of individuals detected per survey point during both passive and tape broadcast periods for each marsh bird species. Summaries should identify locations on the management area with seasonal concentrations of marsh birds. After several years, survey data can be used to estimate population trends of black rails and other marsh birds on the management area using regression analyses. Survey data will also allow comparison of birds detected during initial passive periods and during call broadcast to evaluate the usefulness of using call broadcast surveys to monitor marsh birds. These comparisons will allow improvement of field methods in future years. On a regional basis, estimates of population trend from areas undergoing management activities can be compared to population trends from areas that have not been subject to management activities to evaluate the long-term effectiveness of management efforts. Survey data collected using the protocol described above will help our efforts to develop the most rigorous monitoring program possible for California black rails and other conspecific marsh birds. Please send any survey data to the address below. For assistance obtaining tapes, additional information, or questions regarding standardized marsh bird survey methods, please contact:

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Date:
Marsh:
Observer:

| survey station # | time start | Species | Responded During: | | | | | | | | | <50 m | repeat | noise | comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | passive segment | | | call broadcast segment | | | | | | | | | |
| | | | 1st min | 2nd min | 3rd min | 30 sec calls | 30 sec silence | 30 sec calls | 30 sec silence | 30 sec calls | 30 sec silence | | | | |
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Date: 24 March 2001

Marsh: West Pond, Imperial Co., California
Observer: Robert Thomas

| survey station # | time start | Species | Responded During: passive segment | | | call broadcast segment | | | | | | <50 m | repeat | noise | comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1st min | 2nd min | 3rd min | 30 sec calls | 30 sec silence | 30 sec calls | 30 sec silence | 30 sec calls | 30 sec silence | | | | |
| 1 | 0650 | BLRA | 1 | | 1 | | 1 | 1 | | 1 | | yes | | 1 | |
| | | VIRA | | | | | 1 | | | | | yes | | | |
| | | VIRA | | 1 | | | | | 1 | | | no | | | |
| | | PBGR | 1 | | | 1 | 1 | 1 | 1 | 1 | | no | | | |
| | | PBGR | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | no | | | |
| 2 | 0710 | | | | | | | | | | | | | 3 | no birds |
| 3 | 0728 | SORA | | | 1 | 1 | 1 | | | 1 | | yes | | 0 | |
| | | BLRA | | 1 | 1 | | | | | | | no | yes | | |
| | | SORA | | | | | 1 | | | | | no | | | |
| | | MAWR | v | v | v | v | v | | | | | no | | | |
| 4 | 0743 | SORA | 1 | | | | | 1 | | 1 | | yes | yes | 1 | |
| | | AMCO | | | | | | 1 | 1 | | 1 | no | | | |
| | | AMBI | | v | | | | | | | v | yes | | | |
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List of AOU 4-letter species acronyms for marsh birds detected during California black rail surveys.

| | |
|---|---|
| BLRA | black rail |
| SORA | sora |
| VIRA | Virginia rail |
| CLRA | clapper rail |
| AMCO | American coot |
| COMO | common moorhen |
| PBGR | pied-billed grebe |
| AMBI | American bittern |
| LEBI | least bittern |
| GNBH | green-backed heron |
| GTBH | great blue heron |
| FOTE | Forster's tern |
| COSN | common snipe |
| NOHA | northern harrier |
| BEKI | belted kingfisher |
| WIFL | willow flycatcher |
| MAWR | marsh wren |
| RWBL | red-winged blackbird |
| YHBL | yellow-headed blackbird |
| COYE | common yellowthroat |