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DISTRIBUTION, RELATIVE ABUNDANCE AND STATUS OF THE CALIFORNIA BLACK RAIL IN WESTERN NORTH AMERICA[1]

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Abstract. We conducted breeding season surveys of California Black Rail (*Laterallus jamaicensis coturniculus*) populations in California and western Arizona from 1986–1989. During the course of our field work we developed a method to derive abundance indices and assign abundance values to each study area. We found the bulk of the population (> 80%) confined to the northern reaches of the San Francisco Bay estuary, especially the tidal marshland of San Pablo Bay and associated rivers. Elsewhere, distribution was patchy and subpopulations were small and isolated. Through a review of the literature, discussions with local field ornithologists, and our field work, we determined that the Black Rail population in Western North America is suffering a progressive decline. The causes of this downward trend—all related to habitat loss or degradation—are pervasive and ongoing.

Key words: Black Rail; Laterallus jamaicensis; *California; Arizona; distribution; habitat loss.*

INTRODUCTION

Distribution, abundance, and status of the California Black Rail (*Laterallus jamaicensis coturniculus*) in the western United States has been poorly understood since the first specimen was collected on the Farallon Islands, 48 km west of San Francisco, California on 18 Oct 1859 (Brewster 1907). Subsequently, most published information has been anecdotal and not until the mid-1970s were systematic distributional surveys and population estimates attempted (Jurek 1975, Repking and Ohmart 1977, Manolis 1978).

Black Rails occur only in marshland, a habitat largely destroyed or modified in the western United States since the mid-1800s (Atwater et al. 1979, Zedler 1982, Josselyn 1983, Nichols et al. 1986). Black Rail populations and numbers have declined and will continue to decline as loss and alteration of the habitat continues. Despite this predicament, the official status of the California Black Rail does not ensure its full protection. At present *L. j. coturniculus* is listed as "threatened" by California Department of Fish and Game (California Department of Fish and Game 1989) and is a candidate species under review for listing by the U.S. Fish and Wildlife Service ("Category 1"—U.S. Fish and Wildlife Service 1989). Our research indicates the bulk of the western population is now restricted in distribution and abundance to the tidal marshlands of the northern reaches of the San Francisco Bay estuary, and that several small, fragment subpopulations still exist in southeastern California and western Arizona. This paper documents current distribution, relative abundance, and historic and ongoing threats to the survival of the species in the western United States.

STUDY AREAS AND METHODS

We surveyed Black Rails in three major regions: (1) haline tidal marshland of the San Francisco Bay estuary; (2) haline tidal marshland of the outer coast of California; and (3) fresh water marshland associated with the lower Colorado River and Salton Trough in southeast California and southwest Arizona (Figs. 1 and 2, Table 1). Each marsh was surveyed once only. Other regions that formerly supported breeding populations were not surveyed but are discussed below.

SAN FRANCISCO BAY ESTUARY

The San Francisco Bay estuary encompasses an estimated 12,142 ha of tidal wetlands (Dedrick 1989), approximately 88% of the tidal marshland remaining in California (Nichols et al. 1986). These wetlands are subjected to a wide range of physiographic influences (Atwater et al. 1979, Josselyn 1983, Nichols et al. 1986). The larger physical and ecological gradients of the estuary

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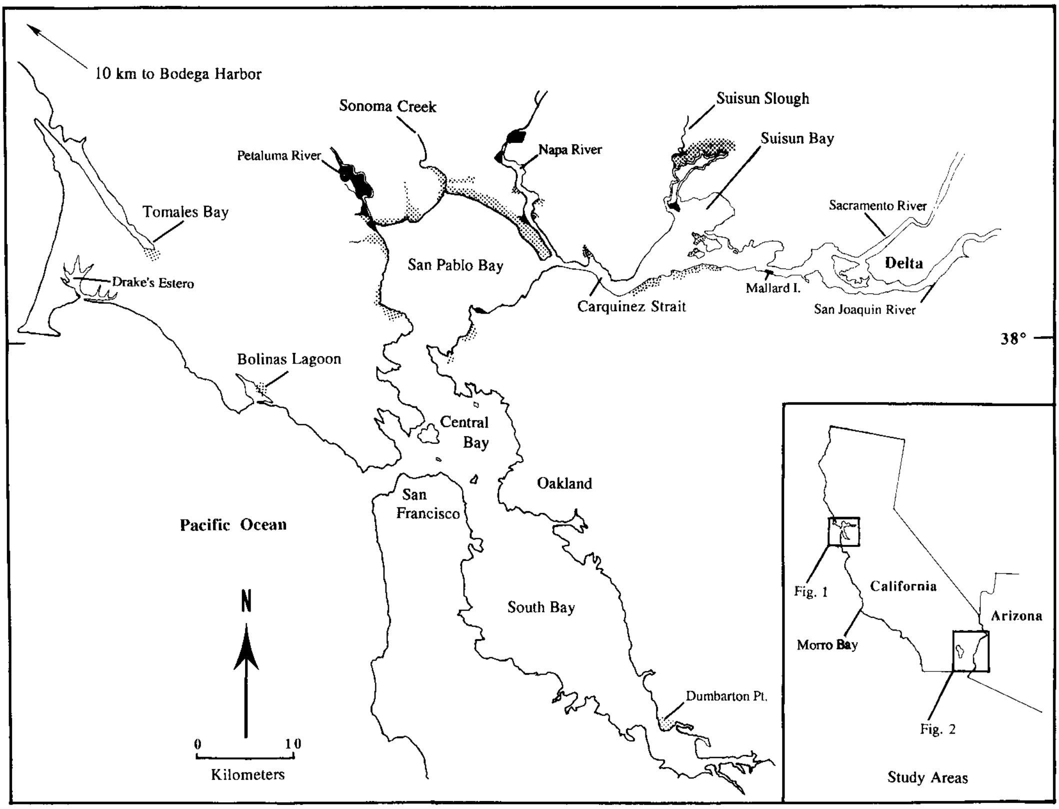

FIGURE 1. Distribution and relative abundance of Black Rails in the San Francisco Bay region. Black shaded areas indicate high abundance of Black Rails; stippled areas indicate low to moderate abundance.

indicate three major subregions (sensu Conomos 1979): (1) South Bay, including "South" and "Central" Bay; (2) North Bay, including San Pablo Bay, Carquinez Strait, and Suisun Bay; and, (3) Delta, tributaries and islands of the Sacramento and San Joaquin rivers, at the head of the estuary (Fig. 1, Table 1). We use "southern reach" to combine the Central and South bays and "northern reach" to combine San Pablo Bay, Carquinez Strait, Suisun Bay, and the Delta but often refer to each subregion individually.

We surveyed all marshlands subject to tidal influence or from which April to July breeding season records of Black Rails were available. Census periods were 3 March–30 May 1986, 3–30 May 1987, and 20 April–28 June 1988. Tidal marshlands were located by field reconnaissance and by National Wetland Inventory Maps (U.S. Fish and Wildlife Service 1986). Manolis' study (1978) and our reconnaissance indicated Black Rails occurred almost exclusively in marshland with unrestricted tidal influence, classified as "estuarine, intertidal, emergent, regularly flooded" ("E2EMN") on National Wetland Inventory Maps (Cowardin et al. 1979, USFWS 1986). Consequently, surveys were conducted predominantly in E2EMN marshland and we covered every marsh in San Francisco Bay so designated.

The complex elevational and salinity gradients of the estuary affect the distribution of marsh vegetation and fauna. Common pickleweed (*Salicornia virginica*) and California cordgrass (*Spartina foliosa*) dominate the tidal marsh vegetation in the South and North bays. *Salicornia* occurs at or near mean higher high water (MHHW); *Spartina* extends from mean tidal level (MTL) up to MHHW where it yields to *Salicornia* (Hinde 1954 *in* Atwater et al. 1979). The percent cover of *Spartina* is high in the South Bay but low in the North Bay marshes, whereas the percent cover of *Salicornia* is high in the San Pablo Bay but low in the South Bay (Cuneo 1987). This reflects the distribution of submergent, or youthful, marshes in the South Bay and emergent, mature,

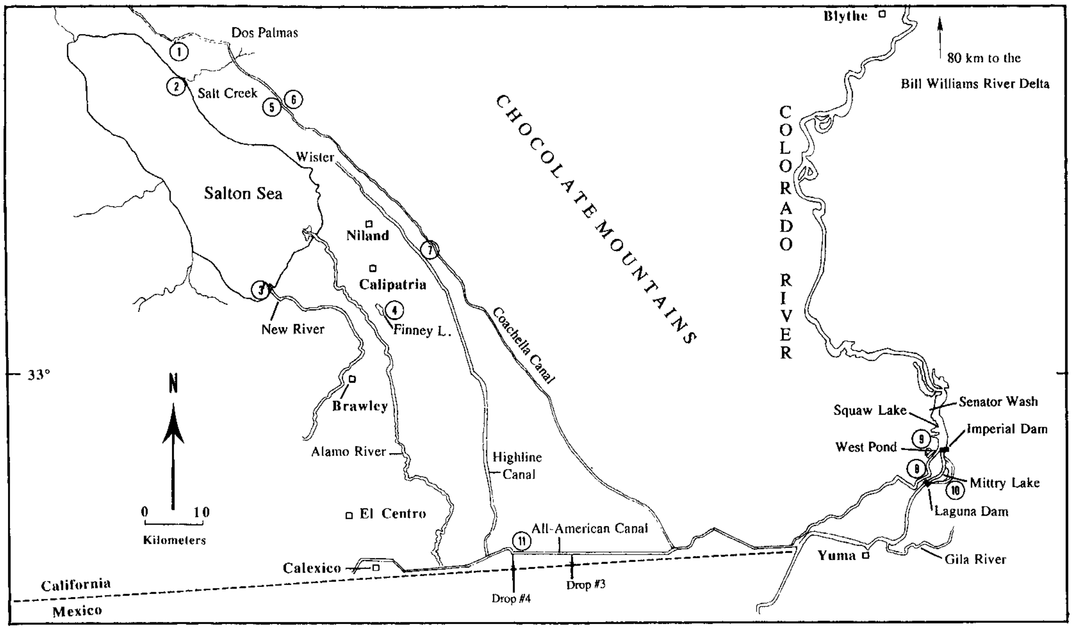

FIGURE 2. Distribution of Black Rails along the lower Colorado River, All-American Canal, Coachella Canal and Salton Sea. Circled numbers indicate sites at which new rails were detected. (1) Coachella Canal at Desert Aire Road; (2) Salt Creek mouth; (3) New River mouth; (4) Finney Lake; (5) Tilly Road marsh, W. of Hot Springs Spa; (6) Coachella Canal Road, below Siphon 19; (7) orchard irrigation seep marsh at the intersection of Montgomery Rd. and Haley Rd. E. of Calipatria; (8) West Pond; (9) Squaw Lake; (10) Mittry Lake; (11) seep marshes between "Drop 3" and "Drop 4" along the All-American Canal.

TABLE 1. Areal extent of marshlands surveyed for Black Rails during this study.

Location	Size (ha)	% of total	Source
San Francisco Bay estuary	12,141	81.6	Dedrick 1989
Southern reach			
South Bay	2,616	17.6	Dedrick 1989
Central Bay	213	1.4	Dedrick 1989
Northern reach			
North Bay			
a) San Pablo Bay	5,531	37.2	Dedrick 1989
b) Suisun Bay and Carquinez Strait	3,780	25.4	Dedrick 1989
c) Sacramento-San Joaquin Delta	NA	NA	Dedrick 1989
Outer coast	543	3.7	
Tomales Bay	219	1.5	Speth 1979
Bolinas Lagoon	98	<1.0	Shuford *et al.* 1990
Morro Bay	226	1.5	Speth 1979
Colorado River and Imperial Valley	<2,190	14.7	
Colorado River	2,060	13.8	Repking and Ohmart 1977
Salton Trough			
Salton Sea	<10	<1.0	This study
Finney Lake	<10	<1.0	This study
Coachella Canal	<100	<1.0	This study
All American Canal	<10	<1.0	This study

marshes in the North Bay (Ranwell 1972 *in* MacDonald 1977, J. Collins, pers. comm.). Other broad patterns of plant distribution and abundance reflect environmental variables in the estuary: (1) diversity of vegetation increases from the Central Bay toward the Delta; (2) in the northern reaches the vertical range and relative abundance of *Salicornia* decreases from west to east; and (3) *Scirpus* spp., cat-tail (*Typha* spp.), and common reed (*Phragmites communis*) supplant *Spartina* east of Carquinez strait (Atwater et al. 1979).

The marshes of the Delta, Suisun Bay, and Carquinez Strait have been more extensively affected by man than those of San Pablo Bay and its tributaries. Most have been diked or drained and are bordered by levees, although in Suisun Bay some levees have been breached, allowing the marshes to be restored to restricted tidal action. The Delta marshes are dominated by common tule (*Scirpus acutus*), Olney's bulrush (*S. olneyi*), cat-tail, and common reed above MTL, and by dense stands of tules (*S. acutus*, and *S. californicus*) below MTL. In Suisun Bay and Carquinez Strait, the plant communities are a diverse mosaic of *Scirpus* spp., *Distichlis spicata, Juncus* spp., *Triglochin maritima, Salicornia virginica, Jaumea carnosa, Frankenia grandiflora*, and *Grindelia humilis.*

Fromt our own reconnaissance and previous surveys (Manolis 1978), we suspected that the marshes of San Pablo Bay and its tributaries held larger numbers of rails than other regions of San Francisco Bay. We separated these marshes by their position relative to the bay shore and its tributaries and distinguished two types: (1) those bisected by a creek, river, or large slough, and (2) those not bisected by a channel. The width of bayshore marshes from the landward margin to the tidal flat varied from <100 m to >500 m. The landward margins of most were bounded by man-made levees and most had been modified with ditches for mosquito abatement. These marshes are dominated by *Salicornia,* but some have small patches of *Scirpus* which perhaps indicate freshwater seeps or result from intrinsic geomorphic processes (J. Collins, pers. comm.).

Tidally-influenced marshes also extend along the creeks, rivers, and sloughs draining into San Pablo Bay. Marshes along the minor tributaries (Napa Slough, Sonoma Slough, Tolay Creek, South Slough) tend to be linear and <100 m wide; they also are bounded by man-made levees and mosquito abatement ditches. *Salicornia* is the dominant vegetation, but there is a higher relative frequency of *Scirpus* than in the bayshore marshes. Several of these marshes contain small islands of upland vegetation that may act as refugia for rails during flooding. Wider (>200 m) marshes are located along the Petaluma and Napa rivers; although dominated by *Salicornia,* they have taller and denser stands of *Salicornia,* a higher diversity of plant species, and a higher elevation than other San Pablo Bay marshes (Atwater et al. 1979). Alkali health (*Frankenia grandiflora*) is a fairly common associate of *Salicornia* in these marshes.

The remnant marshes of the Central Bay are small (<100 m wide) and discrete with *Salicornia* dominant. There is little emergent marsh above MHHW and the fringing upland vegetation occurs as a narrow band, often ruderal, or is non-existent (Evens and Page 1983, Shellhammer 1989). In the South Bay upper marsh vegetation varies from *Salicornia* monoculture, to a 50% *Salicornia*/50% *Scirpus* marsh, to *Spartina*-dominated.

OUTER COAST

Published avifaunal reviews (Garrett and Dunn 1981, Unitt 1984) indicate that southern California coastal marshland no longer supports breeding populations of Black Rails. Since only three areas (Tomales Bay, Bolinas Lagoon, and Morro Bay; Table 1) of outer coastal marshland in northern California are known to have supported breeding season populations of Black Rails recently, we surveyed only from Bodega Harbor to the Morro Bay region. The census periods for outer coast surveys were 2–16 May 1986 and 23–24 April 1987.

Outer coast marshes are characterized by a dense *Salicornia*—dominated high marsh assemblage, with *Distichlis spicata* and *Jaumea carnosa* as subdominants (MacDonald 1977). *Grindelia stricta, Juncus* spp. and *Frankenia grandifolia* are also common.

COLORADO RIVER AND SALTON TROUGH

The interior marshlands of Imperial County, California, and Yuma County, Arizona, are in three geographic groups: (1) along the Colorado River, mostly linear parcels extending approximately 300 km from the Bill Williams River Delta south to Imperial Dam, and a single 326 ha parcel that extends from Imperial Dam south to Laguna Dam; (2) the Salton Trough marshlands, including man-made "wildlife management units" (e.g., Wister Unit on the Salton Sea, and Finney Lake) where water levels are regulated to encourage use by migratory waterfowl, and other marshland at tributary mouths of Salt Creek and the New River; and (3) "seep" marshland along the All-American and Coachella canals. The All-American Canal is a man-made, concrete-lined, aqueduct that runs west from below Laguna Dam to Calexico, California. Rare seeps, accounting for only about 10 ha of marsh habitat along 130 km of canal, occur outside the lining. The Coachella Canal flows northwestward from its confluence with the All-American Canal to Coachella, California. Several seep marshes are associated with the northern section of this distribution canal (Fig. 2).

Colorado River marshes were surveyed 23 March–23 April 1989, Salton Sea marshes and All-American and Coachella canals 10–19 April 1989. We found five dominant plant taxa or groups at our survey sites. In descending order, they were: (1) three-square bulrush (*Scirpus olneyi*); (2) cat-tails (*Typha angustifolia, T. domingensis*); (3) California bulrush (*Scirpus californicus*); (4) native shrubs and trees including arrowweed (*Tesseria sericea*), coyote bush (*Baccharis* sp.), willow (*Salix* sp.), and cottonwood (*Populus fremontii*); (5) exotics including tamarisk (*Tamarix chinensis*) and giant reed (*Arundo donax*). We recognized five types of habitat based upon general hydrology: seep, pond, slough, lake front, and river front.

DETECTING BIRDS AT CENSUS STATIONS

Each study area in San Francisco Bay and the outer coast was surveyed from an array of census stations selected by one of two methods. (1) For tidal areas on the outer coast and in San Pablo and Suisun bays, census stations were located along transects across the elevational gradient of the marsh ("transect" stations). (2) For areas where rails were not expected (e.g., in the Central and South Bay and non-E2EMN marshland elsewhere in San Pablo and Suisun bays) census stations were selected in the most promising habitat, as defined by vegetation type, marsh elevation, and proximity to channel banks or uplands ("selected" stations). To avoid the possibility of missing rails because of our selection criteria, about 30% of the selected stations were deliberately located in habitat that did not fit the criteria listed above.

Transect or selected stations were always at least 100 m apart and 50 m from upland habitat or open water (although tidal channels were included within some stations). In general, the number of stations per study area was determined by the size of the marsh, with smaller marshes covered more thoroughly than larger ones. In non-tidal (i.e., non-E2EMN) marshes, stations were usually on the edge of the upland and therefore had an effective census area approximately one-half that for stations full tidal marshes. Ninety percent of the survey points were transect stations, 10% were selected stations.

Because of their paucity and small size, we were able to survey all the marshes of the Colorado River north of the U.S. border and the Salton Trough. This thorough coverage allowed a comparison with other studies for the Colorado River (Repking and Ohmart 1977), the Coachella Canal (Jurek 1975, Jackson 1988), and around the Salton Sea (McCaskie 1979, pers. comm.). All stations were selected. Because of the linearity of the marshes, especially those along the Colorado River, each effective survey was often an approximate half circle.

At all sites and stations vocal responses were elicited by the observer using a portable cassette recorder to broadcast a 1.5 min recording of Black Rail calls. The tape consisted of 1 min of repetitive "*grr*" calls recorded at Corte Madera Marsh, Marin County, California in June 1983, followed by 0.5 min of "*kic-kic-kerr*" calls (Repking and Ohmart 1977). Except in linear habitat, the calls were broadcast from the center of each census station. Maximum sound pressure 1 m from the source was approximately 90 db. Each station was surveyed once by a single observer. The number of rails at each station was determined by the sum of the responses detected from a different compass direction (>30°) within 30 m of the observer (i.e., station radius = 30 m) during a 5 min period. All calls coming from one compass direction during the 5 min listening period were considered to represent a single rail unless two calls were heard simultaneously. Calls from different compass directions (>30% apart) were considered to represent different rails. Average number of detections per census station was equated to an abundance index for each study area. All census were conducted between dawn and 09:30 Pacific Standard Time. As background noise severely limits an observer's ability to detect Black Rail vocalizations, we canceled censuses when wind speed exceeded approximately 25 km/hr.

Observers were trained to estimate the distance of Black Rail vocalizations during a blind test using tape recorded calls early in the season, as suggested by Kepler and Scott (1981). An effective 30 m census radius was chosen after field testing determined that the observer's ability to estimate distance accurately declined beyond that distance. This plot radius also conforms with other studies (Evens et al. 1986, Swift et al. 1988).

HABITAT SAMPLING

At all census stations we made visual estimates of total percent vegetative cover, percent cover by each common species, and average vegetation height within a 30 m radius of the center. Each marsh was also classified according to hydrology type and tidal influence. In San Francisco Bay and on the outer coast each marsh was classified according to tidal influence and the occurrence of water courses within the marsh (after Collins and Resh 1985). In all subregions each marsh was classified according to its location in relation to a major waterway (e.g., "river mouth" or "bayshore") or its general hydrological character (e.g., "seep").

Complete habitat data are presented elsewhere (Evens et al. 1989, Laymon et al. 1990) and are beyond the scope of this paper. However, data from censuses in similar emergent plant communities and from similar hydrology types were merged to provide abundance rankings for each general habitat type reported here.

RESULTS

SAN FRANCISCO BAY ESTUARY

We detected 497 rails at 1,168 stations (plus an additional 111 rails outside stations) in 78 marshlands of the San Francisco Bay estuary. All but two (99.6%) of the total detections were in the northern reaches (Fig. 1), where rails were detected at 32% of all stations surveyed (36% of 816 transect stations and 4.5% of 112 selected stations). Overall, we found moderate abundances in the northern reach (0.53 rails/station) and low abundances in the southern reach (0.04 rails/station). Broken down into subregions and ranked by detection rates, rails were found at 37% of the 663 stations in the marshlands associated with San Pablo Bay (including tributaries), at 20% of the 244 stations in the Carquinez Strait and Suisun Bay, at 5% of 21 stations in the Sacramento-San Joaquin Delta, and at < 1% of 174 stations in the South Bay (Table 2). No rails were detected at 66 stations in the Central Bay.

NORTHERN REACH

Sacramento–San Joaquin River Delta. We surveyed the delta marshlands less thoroughly than other regions of San Francisco Bay, covering only 20 transect stations in two habitat types. Ten stations were located at approximately 0.5 km intervals on "bench islands" (elongated, planar, and elevated marshlands located mid-river) dominated by dense stands of *Typha,* and 10 in a broad *Salicornia*/*Scirpus* marsh at Big Break where three birds were reported in the past (Winter and Manolis 1978). No Black Rails were detected at either site. We elicited two responses at a selected station on Bacon Island where birds had been discovered several weeks prior (P. Dietrich, pers. comm.). They called from a small *Scirpus*/*Salix* patch along the edge of a wider *Scirpus* stand on a bench island at the south end of Bacon Island. This and similar bench islands are classified as "palustrine, emergent, semipermanent tidal" on National Wetland Inventory maps (UFSWS 1986).

Suisun Bay and Carquinez Strait. We detected Black Rails at 27.6% of 170 stations in tidal E2EMN marshes with unrestricted tidal flow but at only 2.7% of 74 stations in "estuarine, emergent, irregularly flooded, diked/impounded" habitat ("E2EMPh" *sensu* USFWS 1986). Overall, we detected moderate abundances (0.30 rails/station) in this subregion. High abundances (1.56 rails per station) were detected at one site, East Mallard Island, a narrow outboard, island marsh with unrestricted tidal flow and a mosaic plant community measured and estimated as 40% *Juncus,* 30% *Scirpus,* 10% *Triglochin,* < 10% *Grindelia,* < 10% *Distichlis,* and < 10% *Typha.* Moderate abundances (0.29–0.80 rails per station) were found at five other marshes, each of which was subjected to unrestricted tidal flow, had a continuous upland transition zone, and supported a mosaic plant community of *Salicornia, Scirpus, Juncus, Grindelia, Distichlis, Typha, Jaumea,* and *Atriplex.* Two marshes that were *Salicornia*-dominated had low abundances (< 0.17 rails per station) and the rails tended to be associated with "fingers" or islands of *Scirpus* or with the *Salicornia*/*Scirpus* ecotone along the landward edge.

San Pablo Bay and tributaries. We detected

TABLE 2. Types of census stations and abundance rankings for areas surveyed for Black Rails, 1986–1988. N = total number of stations; A = number of transect stations; B = number of selected stations; C = % of stations with rails; D = number of rails per station; E = number of rails per tidal station ("E2EMN"—USFWS 1986); F = number of rails per station with restricted tidal flow ("non-E2EMN"—USFWS 1986); G = abundance rank (high = >0.90 rails per transect station; moderate = 0.25–0.90 rails per transect station; low = <0.25 rails per transect station.)

Location	N	A	B	C	D	E	F	G
San Francisco Bay								
Southern reach								
South Bay	174	18	156	0.6	0.01	0.01	0.00	low
Central Bay	66	19	47	0.0	0.00	0.00	0.00	none
Northern reach								
San Pablo Bay	663	599	64	36.8	0.64	0.68	0.08	mod
Carquinez/Suisun	224	197	47	20.1	0.30	0.41	0.03	mod
Delta	21	20	1	4.8	0.10	0.00	2.00	low
Outer coast								
Tomales Bay	20	20	0	25.0	0.30	0.30	–	mod
Drake's Bay	5	5	0	0.0	0.00	0.00	–	none
Bolinas Lagoon	18	0	18	5.6	0.11	0.11	–	low
Morro Bay	20	0	6	30.0	0.30	0.30	–	mod
Interior								
Colorado River	577	0	577	8.7	0.13	NA	NA	low
Salton Trough								
All American Canal	48	0	48	18.7	0.37	NA	NA	mod
Coachella Canal	48	0	48	10.4	0.17	NA	NA	low
Salton Sea	213	0	213	3.3	0.07	NA	NA	low
Finney Lake	23	0	23	4.3	0.04	NA	NA	low

Black Rails at 40.1% of 599 transect stations in E2EMN marshlands with unrestricted tidal flow and at 6.3% of 64 selected stations in E2EMPh marshes with restricted tidal flow. Overall, rails were detected in moderate abundances (average 0.64 rails/station), but were much more abundant at tidal sites (0.68 rails/station) than at sites with restricted tidal influence (0.08 rails/station).

Marshes along the bay shore supported moderate abundances (average 0.46 rails/station) with detections at 29.5% of 332 stations. Along the bay shore, rails were detected at 50.6% of the 83 stations (average 0.88 rails/station) at slough, creek, or river mouths, but at only 22.5% of the 249 stations (average 0.31/station) in bayshore

TABLE 3. Comparison of occurrence of Black Rails at tidal and diked marshes in subregions of the northern reaches of San Francisco Bay. N = number of transect stations; A = percent of stations with rails; B = number of rails per station; C = abundance ranking.

Location	N	A	B	C
San Pablo Bay				
Tidal marsh				
Wide riverside	196	63.3	1.22	High
River mouths	83	50.6	0.88	Mod
Strip marsh	101	26.7	0.39	Mod
Wide bayshore	219	21.5	0.30	Mod
Non-tidal marsh	50	8.0	0.08	Low
Suisan Bay and Carquinez Strait				
Tidal marsh	149	28.2	0.43	Mod
Non-tidal marsh	48	2.01	0.02	Low

TABLE 4. Comparisons of numbers of Black Rails found on surveys of the lower Colorado River.

Location	1973[a]	1974[a]	1980[b]	1989[c]
California				
West Pond	16	22		23
Imperial Reservoir	2	1		0
Squaw Lake	10	10		8
Senator Wash	21	10		0
Other riverine sites	11	15		0
Arizona				
Mittry Lake	18	22	80	44
Imperial Reservoir	14	9		0
Other riverine sites	14	3		0
Imperial NWR	0	8		0
Total	106	100		75

[a] Repking and Ohmart (1977).
[b] Arizona Game and Fish (1980).
[c] This study.

marshes not at mouths. In several bayshore marshes, rails were distributed sparsely through the *Salicornia,* but clustered around *Scirpus* islands.

Marshes along tributaries supported high abundances (average 1.00 rails/station) with detections at 53.2% of 267 stations, the smaller, narrower riverside marshes had low or moderate abundances (average of 0.38 rails/station) with rails detected at 25.4% of 71 stations, and in the larger, broader (> 100 m) marshes rails were detected at 63.3% of 196 transect stations in high abundance (average 1.22 rails per station). The highest abundances of Black Rails for the San Francisco Bay estuary were found in the larger, wide riverside marshes of the Napa and Petaluma rivers; in the Petaluma Marsh rails were detected at 84.4% of 45 stations (average 1.60 rails/station) and at the Fagan Slough marsh along the Napa River Marsh at 85.0% of 20 transect stations (average 2.10 rails/station).

At five marshes and four remnant marsh parcels with restricted tidal influence, we found rails only at Upper Tolay Creek marsh where they were detected at 25.0% of 12 stations, and at Lower Tubbs Island where one bird was flushed but did not respond to the tape.

Southern reach. The two rails found in the southern reach were both heard on 16 June 1988 in a *Salicornia*-dominated tidal marsh with *Scirpus* patches at the east end of Dumbarton Bridge.

Outer coast. We detected low abundances (average 0.22 rails per station) at three outer coastal marshes: 6 at Tomales Bay, 6 rails at Morro Bay, and 2 at Bolinas Lagoon. All were undiked with unrestricted tidal influence.

Colorado River and Salton Trough. We surveyed a total of 906 selected stations in southeastern California and western Arizona (Fig. 2) and detected 116 Black Rails: 75 (64.6%) along the Colorado River; 18 (15.5%) in seeps along the All American Canal; 14 (12.1%) at Salton Sea; 8 (6.9%) in seeps and springs associated with the Coachella Canal, and 1 (0.9%) at Finney Lake.

Colorado River. We found low abundances (0.13 rails/station) at 8.7% of 557 stations along the Colorado River (Table 2). All birds were found between the Imperial Dam and Laguna Dam upstream from Senator Wash (Fig. 2). At the 50 stations within this area we found high abundances (1.5 rails/station); 90% of the rails were at seeps from dams and canals and 10% along sloughs behind the Imperial Dam. They were present at 26.5% of the seep stations (n = 170) and 3.2% of the slough stations (n = 157), but none was detected at pond stations (n = 48), lake front stations (n = 179), or river front stations (n = 23). Wherever Black Rails were present, the substrate was moist to wet but without deep (> 10 cm) standing water, and water levels were free from the daily and weekly fluctuation experienced in the main channel.

A Chi-square test of differences in rail distributions among the five hydrological categories of habitat showed a significant difference (χ^2 = 94.51 > critical value χ^2, 4 df = 9.49, v = 0.40). A posthoc analysis of all pairwise contrasts showed seeps were used more frequently than expected by chance when compared to all other hydrological categories of habitat (seep vs. pond Z = 7.82; seep vs. slough Z = 6.36; seep vs. river Z = 7.82; critical value for Z with 4 df [S] = 3.08). Of the 50 stations at which we found Black Rails, 64% were dominated by three-edged bulrush (*Typha angustifolia*), 20% by cat-tail (*Typha domingensis*), 10% by tall bulrush (*Scirpus californicus*), and 6% by bushes and trees, including arrowweed (*Tessaria sericea*), coyote bush (*Baccharis* sp.), and willow (*Salix* sp.).

Salton Trough. Away from the Colorado River, abundances were low (0.12 rails/station) overall, with a total of 41 rails present at only 6.6% of 332 stations in the Salton Trough (Fig. 2). Of these, 63.4% of the rails were associted with seeps and springs along the All-American and Coachella canals, 34.1% were from the Salton Sea shore (1 at mouth of Salt Creek, 13 at New River Mouth), and 2.4% were at Finney Lake. Of rails detected along the canals, 69.2% were associated with the All-American Canal, 30.8% with the Coachella Canal. One half (50.0%) of the detections along the canals were in a small (approximately 4.2 ha) seep marsh on the south side of the All-American Canal with a mosaic of cattail, willow, tamarisk, *Salicornia,* and *Phragmites* with no single species dominant (Site 11. Fig. 2). The remainder were at other seep marshes along the All-American canal (19.2%) and the Coachella Canal (30.7%).

DISCUSSION

PATTERNS OF DISTRIBUTION AND ABUNDANCE

In the early 20th Century ornithologists thought *L. j. coturniculus* was confined to Pacific Coast salt marshes from Tomales Bay and San Francisco Bay south to San Diego Bay (Wheelock 1910, Grinnell and Miller 1944). References to

Black Rails north of Tomales Bay (38°N), as at Puget Sound and Humboldt Bay (Bowles 1906, Grinnell et al. 1918, Gabrielson and Jewett 1940, Jewett et al. 1953), were based on sight records and are considered hypothetical (Jewett et al. 1953) or are disregarded (AOU 1957, AOU 1983). There are breeding records early in the century from coastal marshes in San Diego, Los Angeles, and Santa Barbara counties, but because of habitat loss associated with urbanization, the Black Rail has been extirpated as a breeding species on the southern California coast since the 1950s (Manolis 1978, Garrett and Dunn 1981, Unitt 1984). A small breeding population still survives at Morro Bay in San Luis Obispo County (Manolis 1978; McCaskie 1981; Wier, pers. comm.). There are a few recent breeding season records from Mexico where the Black Rail is considered "probably a rare resident in the NW corner of Baja California" (Wilbur 1987).

SAN FRANCISCO BAY ESTUARY

There is scant documentation that *L. j. coturniculus* bred in San Francisco Bay prior to 1970, probably due to the species' secretive habits and well concealed nests. Wheelock (1910) mentioned that the Black Rail nested in marshes at Alviso in the southern reaches of the bay, but the reference was either overlooked or discounted by Grinnell and Miller (1944) and the AOU (1983). In the South Bay, a set of eggs was collected near Newark, Alameda County, in April 1911 (Kiff 1978), possibly from the same marsh where two rails were detected (June 1988) during our study. At least one Black Rail was collected at Palo Alto on 24 May 1930 (Manolis 1978). In the Central Bay, a juvenile was found dead at "Manzanita" (now Richardson Bay), Marin County, on 11 August 1929 (Kibbe 1929), a specimen was taken at Larkspur on 13 April 1949 (California Academy of Sciences #61077), and one bird was calling near the mouth of Corte Madera Creek, Marin County, in June 1983 (Evens and Page 1983). The August and April records may represent migrants. The first breeding season record of a Black Rail in the northern reaches of San Francisco Bay was near Benicia at Southhampton Bay on 2 April 1958 (Manolis 1978). Calling birds were heard in the Southhampton Bay marsh in May 1975 and June 1976, and an abandoned nest, reportedly of a Black Rail, was found at Pinole in fall 1976 (Manolis 1978). During spring and summer surveys in 1977, Manolis found the species in several San Pablo and Suisun bay marshes but not in central or south San Francisco Bay marshes. We found Black Rails widely distributed in spring and summer in the northern reaches and nearly absent in the southern reaches, confirming the distributional pattern found by Manolis' 1977 study. We also found Black Rails to be particularly abundant in the marshes of San Pablo Bay and its tributaries, and in certain areas in Suisun Bay and Carquinez Strait. Although there are breeding season records from the Delta (*in* Manolis 1978; Laymon and Shuford 1979; P. Deitrich and A. M. Green, pers. comm.), we believe Black Rails are patchily distributed on mid-river islands, perhaps sporadically as water levels allow. Given the sparsity of available habitat, and an absence of rails at 95% of stations surveyed ($n = 21$), the population in the Delta must be small.

Although there are numerous non-breeding season (August through March) records of Black Rails in the central and south bay marshes, their numbers are apparently not sustained through the spring. Predation by raptors, herons, egrets, and perhaps even gulls during winter high tides (J. Morlan, pers. comm.; LeValley and Evens 1982; Evens and Page 1986; authors' unpubl. data) may eliminate many rails from the marshes of the southern reaches. The impact of predation on rails is probably exacerbated by the absence of transitional habitat between the marsh and upland due to the extensive system of levees and dikes that separate uplands and marshlands in the South Bay. A lack of suitable high marsh habitat may also account for the absence of breeding season records (Manolis 1978).

Prior to European settlement of the San Francisco Bay area beginning in 1850 and the subsequent modification of the estuary, a two- or three-mile band of tidal marsh bordered much of the South Bay, and bands of tidal marsh four or five miles wide bordered the north shores of San Pablo and Suisun bays. By 1950 approximately 85% of the historic marshlands had been diked and filled for conversion to agricultural land, salt evaporation ponds, and uses for various other human endeavors (Atwater et al. 1979, Nichols et al. 1986, Dedrick 1989). Concurrent with the destruction of the historic marshlands, human activity increased the sediment load and contributed to the inadvertent creation of new marshes. A large fraction of present marshlands originated since 1850 (Dedrick 1989). The net loss of tidal marsh has been greatest in the southern reach and the Delta (Josselyn 1983, Dedrick

1989); we suspect the destruction of tidal marsh there was accompanied by a near disappearance of the Black Rail. The species is now confined mostly to the most pristine remnants of historical tidal marshlands, mainly along the large tributaries of northern San Pablo Bay and along the shoreline of San Pablo Bay, Carquinez Strait, and Suisun Bay.

The apparent lack of suitability of many contemporary San Francisco Bay marshes for nesting Black Rails is not easily explained, but several factors may account for the pattern of distribution and abundance we observed. Marshes of the northern reaches are higher in elevation (above MHHT), have more emergent marsh vegetation, have a lower rate of subsidence relative to mean tidal level, receive a much higher inflow of fresh water, and are larger than the marshes of the southern reaches (Atwater et al. 1979, Conomos 1979, Josselyn 1983, Cuneo 1987, Moffatt et al. 1987, Rozengurt et al. 1987, Dedrick 1989). Low marsh elevation could account for the absence of breeding Black Rails in the South Bay (Manolis 1978), but marsh elevation alone does not explain the localized patterns of rail abundance we observed in the North Bay. In the northern reaches rail numbers were: much higher in tidal marshes than in marshes with restricted tidal flow; generally higher in marshes along large tributaries than along smaller tributaries or along the bay shore; much higher in bayshore marshes located at the mouths of creeks, rivers, or sloughs than in bayshore marshes not bisected by water courses. In addition to elevation, the presence or absence of rails in the marshes of San Francisco Bay may be related to: periodicity and degree of flooding, marsh age (maturity) and size, degree of channelization, soil and water salinity, and plant composition. Many of these factors interact and their relationship to one another may be critical to habitat suitability.

OUTER COAST

Outer coastal marshes have suffered many of the same impacts as those in San Francisco Bay and their total area is estimated to be only 25% of their extent prior to the arrival of Europeans (Speth 1969, Zedler 1982). Tomales Bay, Bolinas Lagoon, and Morro Bay are the only Pacific coastal sites outside of San Francisco Bay where Black Rails are now known to breed. Reports by Brooks (1938) and Grinnell and Miller (1944) indicate they were formerly abundant in the southern reaches of Tomales Bay, but diking and conversion of more than half of the tidal lands to agricultural pasture in 1945 eliminated much of the habitat. Breeding was confirmed near Inverness in 1966 (Audubon Field Notes 21:73, 1967). We found only seven individuals during the breeding season but numbers may be appreciably higher in winter (Evens and Page 1986). The first record at Bolinas Lagoon was a calling Black Rail on 11 March 1979 (Laymon 1979); subsequent breeding season records involve only a few birds in limited habitat (Shuford et al. 1989). The first breeding season report at Morro Bay was in 1961 (Audubon Field Notes 15:439, 1961); six individuals still survived in limited high marsh habitat as recently as 1987 (Weir 1987).

COLORADO RIVER

Black Rails were discovered only fairly recently away from the coast. Phillips et al. (1964) do not include the species in their list of Arizona birds. A breeding population along the lower Colorado River was first documented in 1969 (Snider 1969). Repking and Ohmart (1977) surveyed the Colorado River from Needles, California, to Yuma, Arizona, in spring 1973 and 1974 and found 100 to 106 rails. We found only 75 rails in the same region during the same season in 1989; numbers found were similar to those of Repking and Ohmart at West Pond and Squaw Lake. At Mittry Lake our results represent a 100% increase over Repking and Ohmart's estimate, but only 55% of the number on a 1980 survey (Arizona Fish and Game 1980). Mittry Lake, which we estimate supports 58.7% of the Black Rail population associated with the Colorado River, is dependent primarily on seep water from the Gila Canal. We had no rails at six sites where Repking and Ohmart found them in the 1970s, although the sites where we detected rails in 1989 had maintained relatively stable water levels since their surveys. Those sites which had had rails in 1973 and 1974 but not in 1989 had experienced high water levels during the above average annual precipitation from 1983–1986 and low levels during the subsequent drought years (Laymon et al. 1990). No rails were detected at Bill Williams River Delta, Arizona, where a small population was reported in the past (Garrett and Dunn 1981; S. Laymon, pers. obs.). Overall, our estimate of the number of Black Rails along the lower Colorado River was 30% lower than the numbers estimated in 1973 and 1974 (Repking and Ohmart (op. cit.).

SALTON TROUGH

The other interior sites where rails occur (Salton Sea, All-American Canal, Coachella Canal, and Finney Lake) lie in the Salton Trough which extends northwestward for 140 miles from the Gulf of California and includes the Imperial and Coachella valleys. Remnant shorelines around the margin of the trough indicate the shoreline of the ancient Lake Cahuilla (Sharp 1976). Geological and archaeological evidence suggests that Lake Cahuilla was fringed by extensive marshlands until ca. 500 years ago (Bean 1972, Chartkoff and Chartkoff 1984, Sharp 1976); its shores receded during the Holocene drying (Chartkoff and Chartkoff 1984), but small remnant marshes persisted along the ancient shoreline. Black Rail populations that persist in these marshes are probably relictual.

The Coachella Valley was flooded by an overflow from the Colorado River from 1905 to 1907 to form the Salton Sea. The All-American Canal and its distributaries (including the Coachella Canal) were completed in 1942. The first published record from the Coachella or Imperial valley was of a rail collected at the Salton Sea in January 1947 (Laughlin 1947). By 1980 the species was described as "sporadic and unpredictable" in the area, with most records in summer (Garrett and Dunn 1981).

Potential Black Rail habitat along the All-American Canal (seep-fed marsh adjacent to a 1.5 km section of the canal between hydro plants #3 and #4, Fig. 2) has been surveyed several times during the past decade. Estimated numbers have declined progressively: ca. 80 birds in 1980 (G. McCaskie, pers. comm.), 30 to 50 in 1984 (Kasprzyk et al. 1984), 38 in April 1984 (USFWS 1988), and 18 in April 1989 (this study). The decline is apparently related to loss of habitat. Since 1908 the Imperial County Irrigation District has installed pumps in the marsh to return seep water to the main canal; as a result, the marsh is smaller and the rail population has declined an estimated 79% (Laymon et al. 1990).

Marshes fed by seeps and natural springs along the Coachella Canal were surveyed for Black Rails in 1975 (Jurek 1975), in 1988 (Jackson 1988), and in 1989 (this study). In 1975 Jurek detected 20 rails at 8 of 11 sites along the section of the canal south of Niland. There was no surface water at the three marshes without rails. We visited all the sites Jurek surveyed and found only one rail at one site, a small marsh which benefited from the surface run-off from irrigation of a nearby citrus orchard. Since Jurek's survey the canal has been lined with concrete to eliminate seeps, the marshes have dried and almost all the rail habitat has been eliminated. In 1988 Jackson detected 11 rails at 8 sites on surveys of marshes along the unlined portion of the canal north of Niland. In 1989 we also detected 8 rails, and estimated a total population of 14 (Laymon et al. 1990) in the areas Jackson (1988) surveyed. If the Bureau of Reclamation's plans to line this section of the canal do not provide water to maintain the seep marshes north of Niland, the rail habitat will be eliminated.

Prior to our study, there were no systematic surveys for Black Rails around the Salton Sea, but they had been noted at several localities since the mid-1970s (Garrett and Dunn 1981). Thirteen of the 14 rails we found at the Salton Sea were at the mouth of the New River in a small marsh fed by seepage from a drainage canal. Several months after our survey the Army Corps of Engineers bulldozed the area, which eliminated all of the rail habitat (Laymon et al. 1990). Finney Lake, where we located one rail, was the only other location we surveyed in 1989; up to seven rails had been reported in the past (Garrett and Dunn 1981). The lake is bulldozed and graded seasonally as part of a waterfowl management program. Undisturbed rail habitat around the Salton Sea is rare or nonexistent, because marshland is subjected to frequent modifications by the Department of Fish and Game, the Bureau of Reclamation, and the Army Corps of Engineers. As a result, Black Rails can be expected to occur only sporadically in the future.

OTHER SITES

Black Rails were reported from two other interior sites: Carrizo Marsh in the Anza-Borrego Desert (Unitt 1984) and a marsh near Seeley, California (Garrett and Dunn 1981), but can no longer be expected since both marshes have been destroyed. There is potential habitat along the Colorado River delta in Mexico, but these marshes have been much reduced and degraded, coverage by ornithologists is minimal, and there are no records available (S. Wilbur, pers. comm.). Coastal marshes of Baja California have been only cursorily explored, but it is likely that they support isolated populations as indicated by a 1990 winter record at Bahia San Quintin (R. W. Erickson and A. Barron, pers. comm.).

ONGOING AND FUTURE THREATS

Massive loss of habitat associated with the historic and ongoing pressures of agricultural practices, salt production, and urbanization has drastically reduced Black Rail habitat in the western United States. In San Francisco Bay, many of the same factors that have caused other marsh-dependent species—California Clapper Rail (*Rallus longirostris obsoletus*), Salt-marsh Harvest Mouse (*Reithrodontomys raviventris*), soft bird's beak (*Cordylanthus mollis*), Jepson's pea (*Lathyrus jepsonii*)—to be classified as threatened or endangered, and several others—Salt Marsh Common Yellowthroat (*Geothlypis trichas sinosa*), Suisun Song Sparrow (*Melospiza melodia maxillaris*), San Pablo Song Sparrow (*M.m. samuelis*), Salt Marsh Vagrant Shrew (*Sorex vagrans halicoetes*), Ornate Salt Marsh Shrew (*Sorex ornatus salicornicus*), Suisun Ornate Shrew (*S.o. sinuosus*)—to be listed as candidates (USFWS 1989), also negatively influence the Black Rail population. The tidal marsh habitat that remains continues to be lost and degraded through the continuing pressures of urbanization and land-use practices. The remnant tidal marshlands of San Fransico Bay, the largest refuge for the California Black Rail, occupy only 15% or less of their historic area (Dedrick 1989), yet even in such diminished capacity comprise 90% of all remaining California tidal marshes (MacDonald 1977). Marshlands of San Francisco Bay and Tomales Bay still occupied by Black Rails have been degraded by the loss of the zone of peripheral halophytes which form a natural vegetative transition between the marsh and upland and provide high tide refugia for rails. Livestock grazing and diking have reduced or eliminated this transition zone in most of the marshes around the bay and on the outer coast (USFWS 1979, Evens and Page 1983), resulting in rail susceptibility to heavy predation by herons, egrets, and raptors during high tides (Evens and Page 1986). Other pressures that threaten to alter or degrade San Francisco Bay habitat include continued diversion of freshwater inflow from the North Bay (Rozengurt et al. 1987, Williams and Josselyn 1987), a progressive rise in sea level (Williams 1985, Moffatt and Nichol et al. 1987), and contamination by toxic agents shown to have had adverse biological effects on other birds in the estuary (Ohlendorf et al. 1986, Ohlendorf and Fleming 1988, Phillips and Spies 1988). Indeed, a significant oil spill occurred in Carquinez Strait during the course of this study. These cumulative impacts put the remnant populations of Black Rails in the San Francisco Bay estuary at risk.

Habitat destruction continues in the Salton Trough; water conservation practices are eliminating marshlands along the major irrigation canals, and those along the Colorado River are becoming increasingly fragmented. Black Rails in the region have a small overall population size, very small average subpopulation sizes, and a patchy distribution. Along the Colorado River there are four subpopulations with an average size of 18.75 individuals (range = 1–44). In the Salton Trough there are nine subpopulations with an average size of 5.2 individuals (range = 1–17). Models predict that 10 to 25 breeding pairs are necessary to avoid stochastic extinction and sustain a population (Richter-Dyn and Goel 1972, Roth 1974, Shaffer 1981). Only one of the interior subpopulations is large enough to reach the ten pair threshold. None has enough for the 25 pair threshold. Even if we assume an average of 1.5 individuals from each pair that responded during our surveys, only 3 of 13 subpopulations reach the ten pair limit and only the Mittry Lake subpopulation reaches the 25 pair limit. On the outer coast the three subpopulations average 5.0 individuals (range = 2–7) and none reaches the minimum threshold. Given the isolation of the populations and an apparent absence of significant dispersal and immigration, models predict that sustained existence in the interior and outer coast marshlands is tenuous.

Protection and careful management of rail habitat along the Colorado River and in the Salton Trough will be necessary to sustain these populations. Outer coast habitats are protected by law, but may succumb to stochastic threats. The large marshes of northern San Francisco Bay, especially those of San Pablo and Suisun Bays and their tributaries, are the last refuge for a viable population. Black Rail distribution and abundance should be considered carefully in management decisions concerning San Francisco Bay.

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