Science Foundation Chapter 5
Appendix 5.1 – Case Study
California Black Rail (*Laterallus jamaicensis corturniculus*)

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DESCRIPTION OF THE SPECIES

The Black Rail is the smallest member of the avian family *Rallidae* and has a wide-ranging but highly scattered distribution throughout the New World. Of five subspecies, two occur in North America—the Eastern Black Rail (*L.j. jamaicensis*) and the California Black Rail (*L.j. coturniculus*). Throughout its range, the Black Rail is a secretive inhabitant of tidal and freshwater wetlands and rarely ventures out from the cover of dense marsh vegetation. It is more likely to be heard than seen; spontaneous vocalizations tend to be concentrated in the nesting season and are much less common during the rest of the year.

The California Black Rail (CBR), the smaller of the two North American subspecies, has a thinner bill and, unlike the nominate subspecies, is largely non-migratory although capable of sporadic dispersal. Because of its small size (10-15 cm in length; ~30 grams) and furtive behavior, CBR is often referred to as "mouse-like." It is a rather plump, short-necked bird with a stubby bill, longish legs, and large feet. The plumage is slate gray to black, with white barring on the flanks, white speckling on the back, and a chestnut nape and upper mantle. Males and females are alike as are juveniles and adults, although adults have fire engine red eyes, whereas the eyes of immature birds are brown.

The tidal wetlands of San Francisco Bay estuary and the Delta support the preponderance of the population (Manolis 1978, Evens *et al.* 1991, Evens and Nur 2002). Abundance estimates for the estuary range from 12,400 individuals (Veloz et al. 2012) to 14,500 individuals (Evens and Nur 2002). Birds also occur in coastal tidal marshes scattered along the outer central California coast (Bodega Bay south to Morro Bay), in freshwater seeps and swales in the low western Sierra foothills, along the lower Colorado River and Salton Sea at the California-Arizona border, and in northwestern Baja California (Evens *et al.* 1991, Eddleman *et al.* 1994, Aigner *et al.* 1995, Conway and Sulzman 2007, Richmond et al. 2008). Coastal marshes of southern California no longer support breeding populations of CBR, but did historically (Garret and Dunn 1981, Unitt 1984, Lentz 2005).

In the San Francisco Bay estuary, the CBR is associated primarily with emergent tidal marshes, most abundantly within the "pickleweed zone," at or above mean tide level (MTL) and often associated with patches of fine-stemmed bulrush (*Schoenoplectus* spp.). Relatively few nests have been reported (Spautz and Nur 2002), but presence and territoriality during the nesting season (March-June) suggest breeding throughout the tidal marshlands of San Pablo Bay, Carquinez Strait, and Suisun Bay. Nesting is apparently limited to small and discrete habitat patches in the Delta, Central and South bay marshes.

CRITERIA FOR SELECTION OF THE SPECIES

The CBR, a California threatened species (CDFG 2011), is a member of a suite of special status vertebrate species emblematic of the estuary's tidal marsh habitat— such as the salt-marsh harvest mouse (*Reithrodontomys raviventris*), California Ridgeway's rail (*Rallus obsoletus obsoletus*; formerly, California Clapper Rail), San Pablo California vole (*Microtis californicus sanpabloensis*), Suisun shrew (*Sorex ornatus sinuosus*), and three endemic races of song sparrows (*Melospiza melodia maxillaris, M. m. samuelis, and M. m. pusillula*). The historical pressures of agriculture, salt production, and urbanization reduced the former tidal marshlands of the San Francisco Bay estuary by an estimated 78 to 85 percent with a concomitant reduction in tidal marsh dependent species (Nichols *et al*. 1986, Evens *et al*. 1991, Goals Project 1999, Albertson and Evens 2000, Shellhammer 2000).

Conservation concern for the CBR is high because of the linearity and low slope of the preferred habitat, its vulnerability to modification, and its historical loss of preferred habitat (Goals Project 1999). Much of the remaining tidal marsh habitat around the estuary is hardened at the landward edge (e.g., fill, roads, levees, berms, riprap) constraining the marsh plain to a narrow band between upland and bayshore.

OTHER INFORMATION ABOUT THE SPECIES

CBR is a sedentary species, establishing and occupying relatively small territories. A radio-telemetry study of birds (n=48) in the Petaluma River found a mean fixed-kernel home range of 0.59 ha, a mean core area of 0.14 ha, and reported average daily movement of 27.6 (±1.8) meters and 38.4 (±5.5) meters during extreme high tides (Tsao *et al*. 2010). Males have significantly larger home ranges and core areas than females (Tsao *et al*. 2010). Abundance indices (average number of detections per hectare) were used to derive regional estimates of total population size in the San Francisco Bay area from 23 sites surveyed in 1988 and replicated in 1996 (Evens and Nur 2002). Although these methods contained considerable uncertainty, the study derived "adjusted abundance estimates" for each region of San Francisco Bay (Table 1).

CBR habitat preferences within the estuary are well understood. The bird is confined to high tidal marsh (mostly above MTL) with a dense cover (>90%) of native halophytes and moist substrate. In San Pablo Bay marshes, CBRs occur in mature, dense stands of perennial pickleweed (*Sarcocornia pacifica*) often in association with alkali bulrush (*Bolboschoenus maritimus*) and alkali heath (*Frankenia salina*) (Evens et al. 1991, Trulio and Evens 2000, Tsao *et al*. 2010). East of the Carquinez Strait, the vertical range and relative abundance of pickleweed decreases from west to east and is supplanted by bulrushes (*Bolboschoenus* and *Schoenoplectus)* and cattails (*Typha*). CBRs are found in these complex associations in Suisun Bay and the lower Delta. Peripheral (fringing) vegetation adjacent to the marsh plain at or above mean higher high water (MHHW) provides important refuge habitat during periods of higher inundation (Evens and Page 1986, Trulio and Evens 2000.) Indeed, CBR presence was positively associated with shorter distances to high-tide refugia in an analysis of CBR-habitat relationships (Tsao *et al*. 2010).

The first California record of CBRs on Southeast Farallon Islands (18 October 1886), 48 kms west of San Francisco, and two or three others from the island in the early 1900s (Ridgeway 1890, Grinnell and Miller 1944, DeSante and Ainley 1980) demonstrate dispersal ability by CBR, a characteristic trait of the *Rallidae* (Taylor 1998). Two dozen coastal California records of birds far from marshes attest further to the dispersal movements of CBR, especially in the post-breeding season. The timing of these few records hints at irruptive or sporadic nomadic behavior, another trait common to the *Rallidae*. The discovery of CBRs in small isolated freshwater seeps sometimes associated with irrigation ditches and natural fed springs in the Sierra foothills demonstrate their dispersal ability, however seep habitats would have been historic in the Central Valley and could have provided a source for the Sierra foothills populations (Aiger *et al.* 1995, Richmond *et al.* 2008, Girard *et al.* 2010).

Table 1. Abundance indices and population estimates of CBR for three geographic regions of the San Francisco Bay area. Abundance index is number of rails detected per effective census area (0.41 ha). Population estimates are shown with and without adjustment for detection probability and amount of suitable habitat (*sensu* Evens and Nur 2002).

Region	Habitat Size (ha)	Mean Abundance Index ± SE	Mean Abundance Index	Sites (n)	Abundance Estimated based on Median[a]	Adjusted Abundance Estimate[b]
San Pablo bay	531	1.25 ±0.345	0.71	13	3930	7100
Suisun & Carquinez	780	1.43 ± 0.320	1.08	5	4080	7200
Outer coast	43	0.46 ± 0.196	0.3	5	163	289

[a] Estimated number of California Black Rails per region based on median abundance index only, not adjusted for detection probability.
[b] Estimated number of California Black Rails per region, incorporating detection probability of 0.33 estimated using the program DISTANCE (Buckland et al. 1993) and assuming that not all habitat is suitable for Black Rails.

REVIEW OF CLIMATE CHANGE EFFECTS ON THE GUILD

CBRs and other marsh species are expected to be negatively impacted by both sea-level rise and changes in the intensity and frequency of storms over the near and long-term (Thorne *et al.* 2012, Thorne *et al.* 2013). The dynamics of tidal marsh response to sea-level rise may allow vertical accretion of the marsh elevation (depending on sediment supply) into areas with open space of sufficiently low relief; however, because of the heavily modified landward edge in the "urbanized estuary," models predict a future net loss of high marsh (Kirwan and Murray 2007, Stralberg *et al.* 2011, Takekawa *et al.* 2012, Thorne 2012). Other climate change impacts to CBR such as changes in precipitation amount and timing, ambient temperature extremes, and changes in water salinity are less well understood (Nur et al. 2012).

Sea-Level Rise

The historical modification of the San Francisco Bay estuary makes it especially susceptible to sea-level rise since there are few areas available for upslope marsh transgression. In addition, many areas are predicted to not maintain their elevation relative to sea-level rise in the later part of the century due to low accretion rates (Stralberg et al. 2011, Takekawa et al. 2012, Veloz et al. 2013). Suspended sediment and measured accretion rates vary from Suisun Bay and around the San Francisco Bay estuary (Stralberg et al. 2011, Takekawa *et al.* 2012, Swanson et al. 2013, Thorne et al. 2013, Veloz et al. 2013). For example, accretion rates are relatively high in south San Francisco Bay (Callaway *et al.* 2012), and those marshes are projected to withstand sea-level rise longer with areas transitioning from high to low marsh vegetation by 2100 (Swanson *et al.* 2013). However, north San Francisco Bay marshes, such as San Pablo Bay, Napa River and

Petaluma River marshes, were projected to maintain high- and mid-marsh habitats dominated by pickleweed (and potentially supporting CBR populations) to 2060, but these marshes were lost by 2100 (Takekawa et al. 2012, Swanson et al. 2013). Projected loss of pickleweed-dominated habitats by mid-century in the northern part of San Francisco Bay estuary will negatively affect the CBR and other high marsh species. Areas where natural marsh building processes are not occurring due to subsidence or other human modifications will lose pickleweed-dominated habitats earlier this century (Thorne 2012, Thorne et al. 2014), impacting those CBR populations sooner. For example, Thorne (2012) found that many areas of San Pablo Bay National Wildlife Refuge (NWR) are subsiding and are not keeping pace with current rates of sea-level rise, which will result in the loss of pickleweed-dominated habitat by 2040-2060. Scenarios of sea-level rise in the San Francisco Bay estuary are fraught with uncertainty, but modeling predicts likely impacts that should be incorporated into conservation and restoration planning (Veloz et al. 2013). Understanding how these marshes will respond to sea-level rise are key information gaps for management of high marsh species that include the CBR.

Storms

Global climate models (GCMs) have yet to converge on future scenarios for storms (Bengtsson et al. 2006; Stephens 2011). However, Sea Level Height (SLH), a metric of extremes, has increased 20-fold in the San Francisco Bay estuary since 1915 (Cayan *et al.* 2008). More frequent and intense El Niño events, as a result of warming in the central Pacific Ocean (Lee and McPhaden 2010) are predicted to bring more storm episodes to the area. In addition to changes in storm frequency, ongoing sea-level rise will create more SLH extremes if land elevation does not keep pace with relative sea-level rise.

Low sea level pressure (SLP) is associated with regional storm events that include high wind speeds and substantial rainfall in the San Francisco Bay and Delta (Bromirski *et al.* 2008) and are capable of raising water levels >1 cm mb^{-1} (Chelton and Davis 1982; Bromirski *et al.* 2003) resulting in a local increase in tidal conditions. Recent studies have documented the importance of Pacific Ocean "atmospheric rivers" (ARs) that transport large amounts of water vapor to the coast and can result in storms and flooding for the San Francisco Bay area (Dettinger 2011, Ralph and Dettinger 2012). In the near-term, the timing of storm events and flooding can put CBR in serious risk of site-level reproductive failure and a decrease in population viability if nest inundation occurs or young birds are at risk. Even single storm events that coincide with naturally high tides (e.g., spring high tides) can pose serious risks to CBR reproduction and survival. Repeated reproductive failure could create population bottlenecks that reduce long-term population viability (van de Pol *et al.* 2010, Nur et al. 2012). In addition, these stochastic storm events can put adults and juveniles at risk of drowning, stress, and predation when sufficient cover habitat is not available.

Recent studies examined the potential impacts of storms on tidal marsh habitats and the CBR in the northern reaches of San Francisco Bay estuary. Two storms occurred in the San Francisco Bay estuary in January 2010 and March 2011 resulting in regional flooding and higher than expected tides. Using water level logging at three San Pablo Bay marsh sites (Petaluma marsh, Coon Island, and San Pablo Bay NWR] it was determined that during the storm episodes the duration of marsh inundation was 2 and 3 times greater than average for that time of year, respectively. At peak storm surges, over 65% in 2010 and 93% in 2011 of the plant communities in these marshes were under water and therefore unavailable to CBRs (Table 2; Thorne *et al.* 2013). Storms during the breeding season, like the one in March 2011, can have negative consequences for CBR and other marsh breeding birds and mammals.

The USGS Western Ecological Research Center assessed marsh inundation levels for CBR home ranges on the Petaluma River in 2005 and 2006. A storm in April of 2006, an El Niño year, increased MHHW during the breeding season sufficiently to flood dominant marsh vegetation species (*Sarcocornia pacifica, Bolboschoenus maritimus*, and *Grindelia stricta*) by approximately 20% to 40% (Takekawa *et al.* in press). In addition, the increase of water level in April of 2006 increased the frequency of tide levels above mean CBR nest height and increased risk of nest failure (Spautz and Nur 2002), when compared to the previous year. Population viability modeling indicated that increasing the frequency of extreme storm events from one in 10 years to three in 10 years would result in a Petaluma River marsh population decline of 52% by mid-century. Despite increased inundation of tidal marsh habitat during the stormier breeding season of 2006, home range extent overlapped at Black John Marsh (32%) and at Petaluma Marsh (87%) between the two study years, suggesting that the black rails were not changing their location for nesting based on water levels (Takekawa *et al.* in press). Thus, storms during the CBR incubation period (March-May; Eddleman *et al.* 1994) pose a great threat to established nests (van de Pol *et al.* 2010; Nur et al. 2012).

Table 2. Percent of marsh vegetation flooded during storms across three marsh sites in San Pablo Bay. During the March 2011 storm, 80-90% of the available habitat was inundated and therefore functionally unavailable for wildlife. The Max SLH was highest at Petaluma Marsh during both storm episodes. During the March 2011 storm, over 90% of the vegetative habitat was underwater during the Max SLH at all sites. Mean higher high water (MHHW) and maximum sea level height (SLH) were determined from water level loggers deployed in 2nd order channels (Thorne et al. 2013).

	Jan-10 % inundated			Mar-11 % inundated		
	MHHW	MHHW	Max SLH	MHHW	MHHW	Max SLH
Region	Non-Storm	Storm	Storm	Non-Storm	Storm	Storm
Coon Island	41	56	65	7	81	94
Petaluma Marsh	47	74	79	16	93	98
San Pablo Bay NWR	54	65	72	23	90	96

Storm events vary in severity and longevity across the San Francisco Bay estuary with differences in wind, wave action and precipitation amounts. Little is understood about how this varies spatially and how it may effect CBR populations. CBR may alter their behavior during storms, which could include changes in the timing of nesting, home range location, or nest elevation. Such behavioral shifts could make it possible for CBR populations to persist in the face of predicted increases in the frequency of inundation from high water storms.

OTHER STRESSORS

The impacts of climate change discussed in this case study pose a significant threat to San Francisco Bay estuary tidal marsh inhabitants. More proximate threats are itemized below.

- Invasive plants are altering the community structure of tidal marshes in San Francisco Bay. Two species in particular—*Spartina alterniflora*, and *Lepidium latifolium*—are of ecological concern because of their ability to alter the vegetative community, to change edaphic conditions, and to displace native plants and animals. *Lepidium* has invaded high marsh zones (especially in Suisun Bay) and non-native *Spartina* has invaded the lower mash elevations (especially in the central and south bays). Concurrently, several control efforts are underway to arrest or reverse the colonization of tidal marshes by non-native halophytes with a goal of tidal marsh recovery. Continued colonization by these invasive plants poses a threat to CBR to the extent that they might alter high marsh habitat. Other invasive marsh plants are also of concern, e.g., *Atriplex prostrata, Apium graveolens, Juncus gerardii,* and *Polyypogon monspeliensis* (Grewell *et al*. 2012). Vegetation management projects meant to control these invasive plants also pose a direct stressor to sensitive resident species (Evens *et al*. 2010), including CBR.
- Predation is always a stressor, exacerbated in marshes with reduced vegetative cover, especially along the upland edge (Evens and Page 1986). Nonnative predators—feral cats, black rat (*Rattus rattus*)and Norway rats (*Rattus norvegicus*), and perhaps red fox(*Vulpes vulpes*)—add to the predation pressure posed by native animals such as skunks (*Mephitidae spp*.), raccoons (*Procyon lotor*), northern harriers (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicensis*). Furthermore, at several known sites adjacent to tidal marshes around the urbanized estuary, citizens have established feeding stations for feral cats. These undoubtedly subsidize cats as well as other mesopredators, thereby increasing "background" predation pressure. Also, rip rap and other structures placed adjacent to marshlands provide habitat for rats, which are likely to be egg predators of CBR. Rats are known egg predators of the California Ridgeway's Rail (Albertson & Evens 2000).
- Intrusion into marshlands by humans, including researchers, has the potential to alter habitat (create trails) and cause mortality of adults and chicks or to disturb nests. CBRs are hesitant to flush, and there have been instances of "take" due to trampling. (See "Walking in the Marsh: methods to increase safety and reduce impacts to wildlife and plants." http://www.sfbaynerr.org/ctp/documents/1305649171Walking%20In%20the%20Marsh.pdf
- Fragmentation of tidal habitat has been an historical stressor on CBR and other marsh-dependent species. The restoration of tidal marshes throughout the San Francisco Bay estuary may be starting to arrest and even reverse this trend, however upland transition zone loss remains a concern.
- Stochastic events—earthquakes, floods, erosion associated with storm surges, and landslides—are ongoing potential stressors.
- Pesticides and other contaminants such as Hg have been found to have increased concentrations over historic levels in the eggs of San Francisco Bay estuary nesting birds (e.g. Lonzarich *et al*. 1992, Ackerman and Eagles-Smith 2007, Tsao et al. 2009). Although levels of contaminants in CBR eggs are unknown, it likely mirrors that of other vertebrates that forage in marsh substrate.
- Grazing and other land-use practices on the upland edge of the marsh may reduce peripheral vegetative cover and reduce the quality and availability of high-tide refugia.

LIFE CYCLE AND INFLUENCES FROM OUTSIDE THE ESTUARY

The following life cycle information is summarized from Eddleman et al. (1994); see also Nur et al. (2012) for a summary of demographic information for CBR in the San Francisco Bay estuary. Age at first breeding is presumed to be one year (adult plumage is attained with the preformative molt), and little is known about longevity. In San Francisco Bay, CBRs nest within high elevation tidal marsh. Mean clutch size is reported as 6.0 $\pm$1.3 SD, n=86, range 3-8. Known egg-laying phenology spans March 10 to July 6, with an apparent peak in April-May. Second or replacement clutches may account for later nesting. Both sexes incubate.

Chicks are precocial, but remain near the nest site for a day or two after hatching. CBRs are generally sedentary, and show strong site fidelity; however, as in other *Rallidae*, they are capable of dispersal.

Influences from outside the estuary are generally not relevant. However, a recent study using DNA analysis found that populations discovered in the Sierra Nevada Foothills appear linked with San Francisco Bay estuary populations via migration patterns (Girard et al. 2010).

FACTORS THAT MAY AFFECT SPECIES RESILIENCE

Factors that can increase resilience of CBR populations include maintaining current and increasing habitat extent and increasing connectivity between areas for dispersal. In addition, increasing marsh structural complexity by providing different vegetation types at various elevations for refugia could increase resiliency especially with rising sea levels and increased frequency of storm surges. Reducing adult and juvenile mortality due to predation and drowning will increase resiliency. Recently restored marshes that are adjacent and/or proximate to existing occupied marshes have been colonized by CBRs shortly after revegetation (e.g., Napa-Sonoma marsh "2A", Sonoma Baylands Wetland Demonstration Site, Carl's Marsh, Muzzi Marsh, Giacomini Marsh Wetland Restoration Site; J. Evens. Pers. Obs.) illustrating that proximity to established CBR populations could increase resilience. Additionally, restoration of historic marshlands and adjacent slopes for refugia is likely to increase resilience of the species.

LIKELY CLIMATE CHANGE IMPACTS AND RISKS

Rates of predation and drowning are believed to be greater during high marsh inundation, as animals are forced to move out of the habitat to adjacent uplands (Evens and Page 1986). This may occur more often with the increase of mean sea level and changes in storm frequency or intensity. CBR may be forced to move into sub-optimal habitat where they will be more prone competition, predation, and exposure. The predicted increases in inundation frequency and water depth in the San Francisco Bay estuary over the next century are expected to have negative impacts on the demography of CBR. CBR may be exposed to increased intraspecific competition if they are forced to move into new and occupied habitats.

MANAGEMENT ACTIONS TO BE CONSIDERED

- Provide upland and vegetated island refugia (either natural or constructed) for high water events from storms to reduce drowning and predation risk
- Restore movement corridors to increase dispersal capability
- Restore and preserve upland open space where marsh migration could occur to increase future potential habitat
- Decrease predation rates on marsh species by removing human structures (posts, poles, barns, rip rap, etc.) that are used as perches in and adjacent to the marsh to improve CBR survival
- Increase the monitoring of wildlife population abundance to assess bay-wide trends and improve estimates of total abundance for the estuary
- Develop detailed landscape-level population viability models to predict the probability of extinction or estimate minimum viable population numbers under different sea-level rise scenarios to inform planning efforts for the species

- Increase understanding of food and foraging requirements and how those may change with changes in inundation frequency and depth to assess impacts to CBR viability.

UNCERTAINTY AND KNOWLEDGE GAPS

Uncertainty

It is uncertain how quickly sea-level rise will occur since it is dependent on atmospheric warming and CO_2 emissions. Marsh accretion rates into the future may vary due to changing sediment availability and plant responses and it is therefore hard to project marsh persistence or drowning and impacts to CBR habitats.

It is uncertain if all marshes will keep pace with sea-level rise at the same rate. Some populations of CBR may be more susceptible to drowning and reproductive failure then others.

More information is needed on the factors that contribute most to reproductive success for CBR, including breeding rates and territory requirements. Little is known about dispersal ability and habitat requirements during the non-breeding season.

Knowledge Gaps

Other than habitat preferences, information is needed on nearly all aspects of the biology of this species. Primary research needs include the effects of contaminants on mortality and reproduction, effects of inter- and intraspecific competition, and population viability (Eddleman *et al*. 1994). Information is needed about CBR population estimates and trends across the estuary. Specific information on nesting phenology in San Francisco Bay estuary marshes would be helpful in terms of understanding reproductive success. A better understanding of the major factors influencing adult and juvenile survival during high tides and storms is also needed. In addition, little is understood on dispersal timing, distance, and frequency within and out of the San Francisco Bay estuary.

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