Science Foundation Chapter 5
Appendix 5.1 – Case Study
California Ridgway's Rail (*Rallus obseoletus obsoletus)*

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DESCRIPTION OF THE SPECIES

The clapper rail (*Rallus longirostris*) recently was split into two sister groups (Chesser et al. 2014) on the basis of phylogenetic analyses (Maley and Brumfield 2013). The original grouping is now represented on the East Coast of North America by the Clapper rail (*Rallus crepitans*) and on the West Coast by the Ridgway's rail (*Rallus obsoletus*). The California Ridgeway's rail (*Rallus obsoletus obsoletus*; hereafter California rail) is the largest of 3 Ridgway's rail subspecies which also include *R. o. levipes* (light-footed rail) and *R. o. yumanensis* (Yuma rail) (Eddleman and Conway 1994). The California rail is also the largest resident terrestrial vertebrate that lives solely in San Francisco Bay salt marshes. Formerly present in salt marsh along the California coast from Morro Bay to Humboldt Bay, by the early 1970s the California rail was breeding only in Elkhorn Slough and San Francisco Bay (Gill 1979). Population declines throughout the 19th and 20th centuries were attributed predominately to land conversion, development, and fragmentation of marshlands (USFWS 2013). However, exotic predators such as red fox (*Vulpes vulpes*) and Norway rat (*Rattus norvegicus*) are also implicated in population declines (USFWS 2013).

Tidal inundation of habitats used by California rails that reduce refuge availability and increase susceptibility of nests to flooding (Overton 2014).

California rails are facultative obligates of salt marsh, but do occur in brackish water marshes such as those in Suisun Bay and the mouth of Coyote Creek at lower apparent densities. Suitable vegetative cover, large marsh size, and extensive channelization appear to be the primary factors influencing presence and/or density of California rail populations (DeGroot 1927, Harvey 1988, Foerster et al. 1990, Alberston and Evens 2000). Mid-marsh elevations may also be more strongly associated with large California rail populations than lower or higher elevation marshland (Liu et al. 2012). They are omnivorous and not selective in their diet, but the majority of food items consumed appear to be mollusks and crustaceans (Moffitt 1941, Albertson and Evens 2000, C. Overton, USGS, unpublished data).

California rails are monogamous and highly territorial, particularly during the prolonged breeding season from March through August (Albertson 1995, Zembal et al. 1989, Zembal and Massey 1987, Applegarth 1938). Two types of nests are constructed from wrack and marsh vegetation. The first is built around the stems of cordgrass (*Spartina* spp.; native or invasive) and will often float up the stems with the tide; the second is often woven into branches of gumplant (*Grindela humilis*) and/or perennial pickleweed (*Sarcocornia virginica*) and remains in place even during high flood tides (Schwarzbach et al. 2006, Harvey 1988, Foerster et al. 1990). Both adults tend the nest and care for young, often building platforms for broods to rest on during high tides (Eddleman and Conway 1994). California rails may construct multiple dummy nests, often in close proximity to active nests (Gaines et al. 2003).

CRITERIA FOR SELECTION OF THE GUILD

Like many listed and special status species occupying tidal marshlands of Northern and Central California, threats to the endangered California rail are largely the result of anthropogenic changes to sensitive habitats that have a limited distribution (Goals Project 1999, Albertson and Evens 2000, USFWS 2013). California rails provide a unique case study for effects of climate change in the San Francisco Bay Estuary. Unlike other tidal marsh species in San Francisco Bay, the California rail is closely tied to tidal channels and sloughs for foraging and nesting and typically uses lower elevation habitats more frequently than other sensitive species.

Substantial effort toward understanding California rail population change and habitat requirements has been undertaken by a wide variety of interested parties (e.g., Point Blue Conservation Science, US Fish and Wildlife Service, California Department of Fish and Wildlife, East Bay Regional Parks District, State Coastal Conservancy, Invasive Spartina Project, and U.S. Geological Survey). Although populations have roughly stabilized since approximately 2005 (McBroom 2012, Liu et al. 2012), low abundance, limited distribution, and apparent restricted niche occupied by California rails suggest management options to mitigate effects of climate change may be limited. Nevertheless, the California rail remains an icon of San Francisco Bay salt marshes; widely sought after by naturalists and the only top consumer that is a year-round resident in the salt marsh food web. As such, California rails serve as indicators of the overall health of the San Francisco Bay ecosystem.

OTHER INFORMATION ABOUT THE SPECIES

California rail populations are fragmented but widespread throughout the intertidal salt marshes of San Francisco Bay. Population abundance recovered from a few hundreds of individuals in the early 1990s to nearly two thousand in the early 2000s (Albertson and Evans 2000, Liu et al. 2012). Between 2005 and 2011, coincident with habitat modification to remove invasive *Spartina* (*Spartina foliosa × alterniflora*), California rail populations declined to just over one thousand (Liu et al. 2012). This decline occurred predominately in the South Bay where invasive *Spartina* infestation was greatest although North Bay populations declined to a lower extent (Liu et al. 2012). A large bay-wide decline in California rail detections in 2008, even in areas unaffected by invasive *Spartina* eradication, highlights the sensitivity of this species to annual variation in ecological conditions.

REVIEW OF CLIMATE CHANGE EFFECTS ON THE SPECIES

Our framework for assessing the impacts of climate change on California rails stem from two principal assertions: 1) The primary cause of declining populations of California rails in San Francisco Bay is low survival and reproductive success; and 2) vegetation cover which provides escape cover from predation and nesting substrate appears to be limited during the winter and periods of increased tidal inundation (Overton et al. 2014). The presence of invasive *Spartina*, which grew taller, had greater stem density, and senesced less than native *Spartina foliosa* (Callaway and Josselyn 1992) increased California rail survival rates which declined following herbicide application to survival comparable that in natively vegetated marshland, and were among the lowest recorded for any rail species (Overton et al. 2014). To the extent that these patterns hold true throughout the San Francisco Bay Estuary, any changes to tidal inundation patterns or the extent and structure of intertidal vegetation are likely to have the large impacts to California rail survival and reproduction. These impacts could result could result from global climate changes, regional climate patterns such as El Niño/Southern Oscillation (ENSO), or local weather patterns.

The effects of tide and vegetation structure on California rail survival is becoming clearer (Overton et al. 2014), but the nesting ecology of California rails is still poorly understood. Estimates of fecundity are low (1.9-2.5; Schwarzbach et al. 2006) yet consistent with contemporary population declines (Liu et al. 2012). Flooding appears to have been a minor risk in many marshes during years with moderate tide levels (Schwarzbach et al. 2006), but may increase during storms, following eradication of invasive *Spartina* and sea-level rise. The 28-30 day incubation period of California rails is longer than that of conspecifics (Eddleman and Conway 1998) and ensures that at least one cycle of "spring" high tides is experienced during incubation. The risk to California rail nests posed by tidal inundation is moderated by the choice of nesting site and the structural characteristics of vegetation where the nest is placed. Climate projections suggest that the San Francisco Bay region will experience reduced precipitation and changes to the timing of water flow through the Sacramento-San Joaquin Delta in addition to increased salinity in portions of the estuary (Chapters 2, 3, and 4). Both increased salinity and increased inundation time affect height of salt marsh vegetation (Woo and Takekawa 2012) and reduce the value of existing habitats as tidal refuge or as nesting substrate. Expansion of saltier waters could result in expansion of suitable California rail habitats through Suisun Marsh and upstream into current freshwater habitats within the Delta. Furthermore, increased variability in weather patterns and extremes resulting in more severe flooding and drought cycles are likely to occur. As such, there may not be sufficient resilience in California rail demographic rates to adjust to any increased pressure resulting from climate change. To the extent that marshes shift toward lower elevation and/or shorter vegetation structure, California rail survival, and likely recruitment, will be reduced. To the extent that suitable salt marsh vegetation expands up the Estuary, increase in the potential distribution of California clpper rails is possible. Both beneficial and detrimental impacts to California rail habitat are likely to occur under projected climate change scenarios and a management framework to compensate for these contraindicating effects is urgently needed.

OTHER STRESSORS

Several authors have indicated a positive link between California rail population density and marsh area (Garcia 1995, Liu et al. 2012). However, most marshes in San Francisco Bay are insufficiently large to provide the conditions which apparently promote increased California rail density. Although increase in California rail density is greater in small marshes, for a given increase in marsh area, than larger marshes, smaller marshes still have lower density than larger marshes (Liu et al. 2012). Since most marshes in San Francisco Bay are less than 50 ha, California rail populations in these areas are more at risk of local extinction due to lowered population size. The potential for inverse density dependence (i.e. Allee effect) to accelerate impacts due to climate change should be recognized. As population size drops, individual California rail survival probability may decrease due to increased exposure rate to predators (i.e. inverse density dependence). This could accelerate population change and drive small populations extinct. If marshland characteristics change and reduce the population of California rails, increased variability in population growth rates could result (Gilpin and Soule 1986). Although California rails can be highly mobile and redistribute to virtually any location within their range (Casazza et al. 2008), the frequency of such occurrences is exceedingly uncommon, suggesting that increased isolation and fragmentation of populations is likely to result as marshland is lost to sea-level rise and concomitant habitat change. Reduced spatial interdependency among populations is likely to affect both individual population viability within a single marsh and increase the consequences of catastrophes (e.g. oil spills) for the entire species (Hanski 1982).

However, an alternate (if interim) situation may also occur. Conversion of existing high and mid-marsh habitats to low marsh habitats as a result of sea-level rise may alter existing vegetation communities leading to vegetation structure of greater overall height as tidal inundation patterns become more favorable for native monocot vegetation, i.e. *Spartina foliosa*. While conversion of short mid-marsh vegetation to taller low-marsh vegetation may create increased nesting, refuge, and foraging opportunities for California rails in the near term, senescence of monocots during the winter may still result in seasonal bottlenecks to population dynamics creating an ecological trap that could exacerbate population declines. In addition, conversion of low-marsh vegetation to mudflat and homogenization of habitat types could reduce the ability for California rail populations to respond to random, large perturbations (i.e. catastrophes). Vegetation type conversion would place an increase risk during El Nino cycles, particularly those occurring in conjunction with storm events, when water levels can increase dramatically. Under such situations, likely outcomes include increased nest failure and reduced survival, particularly during the winter. In order to maintain resilience of California rail populations it is suggested that managers maintain heterogeneous marsh structure, and maintain or increase the number or size of marshes in San Francisco Bay (USFWS 2013).

ENTIRE LIFE CYCLE AND INFLUENCES FROM OUTSIDE THE ESTUARY

While California rails remain resident within San Francisco Bay throughout the year, this does not suggest that influences from outside the Bay do not affect California rail populations. In 2008, California rail populations declined dramatically throughout San Francisco Bay (Liu et al. 2012). In the same year, apparent declines were noticed in the light-footed Ridgway's rail surveys in Southern California as well (R. Zembal, *pers. comm.*). While a mechanism that would result in synchronous population dynamics between the two conspecifics has not been formally evaluated, very large scale climate or ocean patterns could be operating to influence both subspecies. Furthermore, changes in the predator community occur in the winter when vegetation and tides create the most extreme conditions for refuge cover used by rails. Climate-induced changes to the distribution and abundance of seasonal predators (e.g. short-eared owls, *Asio flammeus*) could propagate through the food web to impact California rails.

FACTORS THAT MAY AFFECT SPECIES RESILIENCE

How Can Resilience by Increased or Maintained

The structure and function of marshlands are a direct consequence of the tidal dynamics and sediment supply available to build and/or maintain marshes. Scenario models included within this update (Chapter 2 in this report) recognize that suspended sediment supply in San Francisco Bay may continue to decline and accelerate transition of marshland to lower elevation ecotypes. Even if marshes were able to maintain characteristics, elevated water levels would reduce the suitability of existing vegetation to provide refuge cover. The potential impact of short-term storm events on California rail should also be recognized. Scenarios that incorporated a 2045 storm event coinciding with winter king tides predicted sea levels that reached 75 cm higher at the Golden Gate Bridge than non-storm king tides occurring in 2000 due to combined effects of sea level rise and storm surge (Chapter 3, this report). Under these scenarios local inundation in other regions of the Bay may be more severe due to increased tidal range (e.g. South Bay), proximity to watershed runoff (e.g. Petaluma River), or local wind patterns that result in significant wind-driven waves (2 m or more). The impact to the California rail during these periods may be severe as intertidal refuge habitats are inundated and birds are forced to search for alternative cover in upland-transition ecotones or occupy suboptimal cover within the marsh with increased predation risks. If these changes progress, California rail survival and nest success will likely be reduced. Either demographic process could be critical for the small fragmented populations in the remaining marshlands surrounding San Francisco Bay which may already be near maximum reproductive capacity (Schwarzbach et al. 2006). It remains unclear whether California rails have a relatively r- or K- selected life history since both survival and fecundity appear low. As such, the undetermined sensitivity of populations to changes in either survival or recruitment rates confuses where the focus of conservation efforts should be placed (Martin and Wilson 2011). Further confounding appropriate management actions is uncertainty on the effectiveness of intervention strategies to improve demographic rates. Reduced reproductive success due to contaminant exposure for example may be a more intractable problem than insufficient nesting substrate or predation risks (Schwarzbach et al. 2006).

LIKELY CLIMATE CHANGE IMPACTS AND RISKS

Magnitude and Likelihood of Effects, Bottlenecks, and Other Stressors

Climate change scenarios indicate that tide levels will increase and the amount and timing of precipitation occurring in the San Francisco Estuary will change. Both of these patterns will influence the distribution and characteristics of marshland vegetation and affect California rail populations. California rail survival and reproductive output are likely to be reduced as marsh area is lost due to drowning and/or insufficient sediment supply or as vegetation communities shift in response to changes in inundation frequency and duration (Bockelmann et al. 2002). Increase in the frequency or severity of droughts and storms may also influence vegetation characteristics resulting in lower quality habitats for California rails. The effects of these changes may be most pronounced during the winter when California rail populations already experience a bottleneck in survival rates (Overton et al. 2014). Reduction in marshes that increase fragmentation or isolation of remnant California rail populations may increase susceptibility of the entire species to catastrophes or reduce the spatial buffering that connected populations provide and lead to increased risk of extinction (Hanski 1982, Gilpin and Soule 1986).

MANAGEMENT ACTIONS TO BE CONSIDERED

- Retain existing, actively restore, or promote establishment of habitat features that provide tidal refuge for California rails.

  Projections of sea-level rise suggests that the specific locations that currently provide tidal refuge habitat are likely to change as upland margins become refuge habitat and existing refuge habitat becomes intertidal habitat. While it is possible that the projected climate impacts outlined above could be moderated by existing marsh condition, future limitation of refuge cover may not be evident in all marshes. It is unlikely that many current marshes have adequate potential to migrate upslope or have sufficient internal habitat complexity to continue provision of tidal refuge in San Francisco Bay in response to increasing tide levels. Projects which conserve existing tidal refuge, and/or create refuge where this limiting factor is suspected may reduce at least the near term risks to affected populations. Particular attention to climate-smart transition zone and high marsh restoration that takes advantage of locally adapted plant species, which tolerate drought and salinity changes, may be necessary to provide adequate cover for California rails in the future.

- Predator management adjacent to marshlands with limited tidal refugia

  Anthropogenically subsidized predators, particularly mammalian predators, pose a unique risk in areas wherein tidal refugia is limited to levee faces. Increased predator access and hunting success is thought to be a major reason for low survival rates during the winter. The urban-marsh interface which represents much of the boundary of marshland in San Francisco Bay is a highly productive habitat for predators that are either directly (e.g. feral cat feeding stations), or indirectly (e.g., denning sites for foxes, diurnal refuge for raccoons), supported by the human environment. The impact of mammalian predators may be less in marshes when refuge is dispersed throughout the marsh plain rather than concentrated at the upland edges. Sufficient and appropriate upland transition habitats may also reduce hunting success for some predators. Very dense plantings may preclude access by larger predators (e.g. red foxes), while multiple planting clusters may reduce the likely of predators encountering California rail. Specific characteristics (size or other physical characteristics and/or spatial arrangement or other intrinsic characteristics) of upland transition habitat which promote secure refuge habitats need to be better understood and may be best suited for investigation in an adaptive management framework.

  Upland edge transition habitat may remain a poor substitute for dispersed refuge habitat within the marsh plain if mammalian predation of California rails is facilitated by habitat structure and ease of marsh access at the marsh edge. Furthermore, raptor predation appears to be the dominant cause of mortality for California rails (USGS, unpublished data). It remains unclear what quantity or structure of tidal refuge habitat is ultimately needed to increase California rail survival rates.

UNCERTAINTY AND KNOWLEDGE GAPS

The characteristics of salt marsh vegetation and surrounding lands that promote survival and reproduction of the California rail are just beginning to be understood. Much more needs to be learned about environmental correlates to California rail demographic rates, predator ecology, and habitat availability to develop more effective management actions that target particular life history stages and processes. Major uncertainties, as outlined above, relate to the habitat conditions which promote survival and successful reproduction by California rails and therefore, the rail's ultimate response to climate change. Habitat needs are likely to vary in space, due to differences in tidal inundation and constituent plant species, as well as temporally, due to seasonal senesce and tidal inundation. More effective management of California rail populations and habitats will require a broader understanding of not only characteristics of beneficial habitat, but also on how those characteristics can be achieved through restoration design. Direct study of California rail individuals or populations in the San Francisco Bay Estuary has been limited to a few South Bay marshes and many of these investigations were conducted as long as 40 to 50 years ago. Current information on reproductive ecology in particular is urgently needed. For example, the influence of nest site selection on nest success has not been studied since the 1970s and the propensity for California rails to renest or double brood like East Coast clapper rails (Kozicky and Schmidt 1949, Blandin 1963) remains unclear.

Population dynamics in the North Bay appear different than those in the South Bay (Liu et al. 2012) and may suggest different factors limiting population growth with potentially different responses to climate change. The importance and degree of connectivity among fragmented salt marshes are also important to understand. Synchrony in population dynamics can destabilize metapopulations and lead to extinction, it remains unknown how the fragmented marshes of San Francisco Bay are connected and how this supports or degrades the species persistence.

Additional validation of California rail abundance and survival rates is needed to inform management options. Much of our recent knowledge on California rails stems from widespread population surveys and radio-telemetry methods. These methods have yet to be validated with independent estimates though considerable theoretical work has been completed which enhances the usability of information from both surveys (Liu et al 2012) and radio-telemetry locations (Overton 2014). With regard to existing population survey information, we can be confident in the direction of population trajectories, but less certain about absolute population size which is important for evaluating progress toward recovery objectives for species delisting (USFWS 2013). This is particularly problematic given the need to contrast marshes or regions (USFWS 2013) where population index values potentially represent very different proportions of the attendant population. Survival rates have been estimated via radio-telemetry studies twice since the early 1990s (Albertson 1995, Overton et al. 2014). Both survey and telemetry-derived information suggest California rail populations have limited dispersal and low survival rates, particularly during the winter. Alternative techniques to assess this information may discover important mechanisms driving population dynamics within the San Francisco Estuary.

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