# Conserving the Endangered Salt Marsh Harvest Mouse in the Modern San Francisco Estuary

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Recent research on the salt marsh harvest mouse (*Reithrodontomys raviventris*) has greatly improved our understanding of the ecology of the mouse and our abilities to effectively manage it. Modern research techniques such as genetic analyses and powerful statistical analyses are providing managers with valuable new information that allows us to understand the status of populations of mice throughout the Estuary. Additionally, many of the knowledge gaps that exist in our understanding of the life history of the species have recently been addressed. Armed with these new tools and new data, managers are now more prepared to tackle some of the challenges they will face in conserving this endangered species in the face of future threats such as climate change and associated sea level rise. In this poster cluster we provide an overview of some of recent improvements to research and management techniques, and present data that will aid in the future management of the species.

**Student Award Competition**: Yes

**Keywords:** salt marsh harvest mouse, genetics, statistical analysis, management, conservation, habitat

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# The Salt Marsh Harvest Mouse (SMHM; *Reithrodontomys raviventris*) Workgroup: Identifying Recovery Needs and Data Gaps

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The Salt Marsh Harvest Mouse (SMHM; *Reithrodontomys raviventris*) is a federally and state endangered species endemic to a variety of marsh habitats in San Francisco Bay. Despite several pivotal studies conducted in the 1960-1980's there remains a general lack of understanding about their ecology, genetics, and long-term trends. A SMHM workgroup was initiated to facilitate coordination and standardize measurement protocols and identification techniques. This group also serves to inform the Tidal Marsh Recovery Implementation Team, and is comprised of State, Federal, University, and NGO partners/collaborators. In 2016 the Workgroup established 3 priority working groups to help address priority needs: 1) develop a standard suite of protocols, 2) a uniform database, and 3) identify SMHM recovery needs.

**Keywords:** endangered species, standard protocols, database

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# Salt Marsh Harvest Mouse Survey Bias, New Results for China Camp State Park

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China Camp State Park is within the range of the Northern subspecies of the salt marsh harvest mouse (*R. raviventris halicoetes*). New information on vegetation and habitat use by salt marsh harvest mice has been published, particularly from work done in the Suisun Marsh. However, many surveys focus on tidal marshes dominated by pickleweed (*Salicornia pacifica*) and salt marsh harvest numbers captured can be very low. In the Suisun Marsh surveyors take into consideration vegetation height, thatch layer, and structure of vegetation when selecting survey locations. In August 2014 the Department of Fish and Wildlife and the Department of Water Resources conducted a survey at China Camp State Park. We targeted two muted tidal marshes west of Turtle Back Hill which had taller vegetation and were not inundated during high tides. These marshes had never been surveyed as North San Pedro Road was considered a barrier for the mouse. Over three nights a total of 21 individual salt marsh harvest mice, 11 western harvest mice (*R.megalotis*), 8 voles (*Microtus californicus*), 8 deer mice (*Peromyscus maniculatus*), and 6 house mice (*Mus musculus*) were captured. We believe our surveys show that larger numbers of salt marsh harvest mice are present at China Camp than previous survey efforts found. Future survey efforts should not be limited to pickleweed and should include tall vegetation and muted tidal wetlands as these types of wetlands may be all that remain as tidal areas become flooded out due to sea level rise.

**Keywords:** salt marsh harvest mouse, *Reithrodontomys raviventris*, muted tidal, China Camp

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# Nest Variation in the Salt Marsh Harvest Mouse Offers Potential Resilience to Climate Change

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For 3 years researchers conducted radio telemetry on the northern subspecies (*Reithrodontomys raviventris halicoetes*) of the salt marsh harvest mouse. Through the course of the study, researchers often located mice in nests. The nests came in many varieties, both in nesting material and nest locations. The variation in nests suggests the salt marsh harvest mouse may not be as specialized as previously believed. This offers a glimpse of hope for the salt marsh harvest mouse's ability to adapt in the face of climate change.

**Keywords:** Endangered, Climate Change, Salt Marsh Harvest Mouse

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# Drivers of Longterm Trends for Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*) at Crescent Unit, Suisun Marsh

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Federally and CA State endangered salt marsh harvest mouse (SMHM, *Reithrodontomys raviventris*) is endemic to marshes and adjacent habitats in the San Francisco Bay and Delta. Despite several pivotal studies conducted in the 1960-1980's there remains a general lack of understanding of population trends and variability marsh habitats. Here, we examine a long-term dataset to understand population trends, and compare population estimates with capture indices for SMHM. We also examined potential drivers of population trends, including physical (weather, temperature, inundation patterns, rainfall) and biological parameters (vegetation). From 2000-2016 small mammal surveys were conducted by CA Dept. Fish and Wildlife at Crescent Unit, Grizzly Island Wildlife Area in Suisun Marsh. Crescent Unit is an extensive marsh which receives most of its water in the form of precipitation, as water management is minimal, and the area is not fully tidal. Vegetation is predominantly pickleweed (*Salicornia* spp) with some annual grass and bare ground due to salt scalding. Small mammal surveys were conducted annually and each SMHM captured was given a unique fur clipped pattern to distinguish individuals. Since the SMHM recovery metric uses a capture index, we compared this to mark-recapture population estimates. In general, the capture index and population estimates had similar patterns of population fluctuations. Winter through early spring precipitation had the strongest correlation to SMHM abundance for the following summer (June), indicating that increased precipitation during the winter and spring time periods resulted in decreased population abundance. Other parameters such as inundation, temperature, and vegetation did not have a strong correlation on SMHM population abundance.

**Keywords:** endangered species, mark-recapture, population estimate, capture index, abundance

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# Characterizing Adaptive Immunogenetic Variation in the Endangered Salt Marsh Harvest Mouse, *Reithrodontomys raviventris*

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Adaptive genetic loci reflect selective responses to environmental variation that may be critical to population and species survival, while neutral loci reflect the influence of general demographic effects. Neutral loci are often used to characterize endangered populations, forming the basis of conservation plans; however, it is also important to consider functional adaptive loci, such as immune system loci at the major histocompatibility complex (MHC). As the most variable loci in vertebrate genomes, MHC can provide detailed information on population distinctions and viability. In this first study of adaptive genetic diversity in the salt marsh harvest mouse, we sequenced the MHC Class II DRB locus. Hair from mice was collected from 12 sites across Suisun, San Pablo, and San Francisco Bays. DNA from individuals was cloned and sequenced at the functionally diversifying MHC locus (n=56) and sequenced at the functionally conserved mitochondrial cytochrome b locus (cytB, n=104), used as a neutral reference locus. Patterns of genetic diversity show regional differentiation at both loci, particularly between northern and southern regions, corresponding to subspecies designations. In the southern subspecies, patterns of genetic diversity between MHC and cytB are similar, while in the northern subspecies MHC is more diverse. Northern populations are functionally differentiated at the MHC locus with six unique alleles as compared to only one in southern populations. Selection tests indicate positive selection acting on the MHC locus (dN/dS=6.29, p=0.006 at antigen binding sites), suggesting that there is still enough diversity at this locus to respond to selection. However, supertype analysis (based on binding sites under positive selection) shows that southern populations have only half the supertype diversity found in northern populations, indicating limited adaptive potential. We recommend adaptive immunogenetic data be used along with neutral genetic data to prioritize conservation efforts and most effectively manage and recover endangered species.

**Keywords:** immunogenetics, conservation genetics, endangered species, adaptive genetic variation, habitat fragmentation

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# Managing the Salt Marsh Harvest Mouse in the Built Environment

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Worldwide, about 50% of wetlands have been lost. In the San Francisco Bay Estuary (SFBE) less than 10% of historical tidal wetlands remain, and those comprise a fragmented mosaic of natural and anthropogenically altered wetlands. Globally, only 5 species of vertebrates, and only one mammal, the endangered salt marsh harvest mouse (SMHM, *Reithrodontomys raviventris*), are restricted to coastal wetlands. SMHM is a unique wetland-adapted rodent endemic to the marshes of the SFBE. Conventional conservation practices have favored a push toward tidal restoration as a recovery action for SMHM. However, tidal wetlands are vulnerable to sea level rise and tidal restoration is slow and costly. Understanding and maximizing the value of alternative habitat types can improve conservation of SMHM. We investigated the relative value of historical tidal and anthropogenic diked wetlands for SMHM. We found that both support similarly sized populations and similar numbers of reproductive females, but diked wetlands had higher densities of juveniles. Habitat use is similar between wetland types, home ranges are not significantly different and microhabitat use was similarly flexible. Finally, preferred food plants occur at high densities in diked wetlands. This study – the first of its kind – greatly improves our understanding of the habitat requirements of SMHM. Diked wetlands have high habitat value for SMHM, possibly superior to tidal habitat; this result triples the acreage of "good" SMHM habitat in the SFBE. It also illustrates the importance of understanding the value of anthropogenic habitats for conservation of endangered mammals as historical habitat patches dwindle.

**Student Award Competition**: Yes

**Keywords:** salt marsh harvest mouse, managed wetlands, tidal restoration, habitat management

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# Diet Preferences of the Salt Marsh Harvest Mouse

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Historically it was assumed that Salt Marsh Harvest Mice (*Reithrodontomys raviventris*, SMHM) ate predominately pickleweed (*Salicornia pacifica*) and therefore were only found in habitat with pickleweed. However, based on the cafeteria trials of local species performed during this diet study, the data collected suggests that they actually eat a wide range of food, including invasive and non-native species. Some of the most consumed species in the study were non-native, showing that the salt marsh harvest mouse can be very adaptive when it comes to its food requirements. This study suggests that a change in criteria for the species' habitat requirements is necessary. They can and are found in areas without pickleweed which was incorrectly thought to be necessary for viable habitat. New habitat and/or potential habitat destruction could be managed better if the habitat criteria were expanded to include areas without pickleweed.

**Keywords:** SMHM, Salt Marsh Harvest Mouse, Pickleweed, invasive, conservation, management

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