5-YEAR REVIEW
Salt marsh harvest mouse (*Reithrodontomys raviventris*)

CONTENTS:

GENERAL INFORMATION:

Species: Salt marsh harvest mouse (*Reithrodontomys raviventris*)
Date listed: October 13, 1970
FR citation(s): 35 FR 16047
Classification: Endangered

BACKGROUND:

Most recent status review:
The most recent 5-year review of salt marsh harvest mouse was finalized on February 16, 2010 (2010 5-Year Review; U.S. Fish and Wildlife Service [USFWS, Service] 2010). That review did not result in a change in the status of the species.

FR Notice citation announcing this status review:
FR citation: 84 FR 36116 36118
Title: Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 58 Species in California, Nevada, and the Klamath Basin of Oregon. AGENCY: Fish and Wildlife Service, Interior. ACTION: Notice of initiation of reviews; request for information,
Date of notice: July 26, 2019
Comments received: We received two comment emails in response to the Federal Register Notice. One comment was from the National Park Service (Merkle 2019) noting a capture record from a specific location in the Marin Headlands in the 1990s and advising that the subject area habitat no longer had salt marsh components to support the salt marsh harvest mouse. The other comment expressed general concern about threats to all endangered species and the need to keep them all listed.

ASSESSMENT:

Introduction

This 5-year review was conducted by the USFWS San Francisco Bay-Delta Fish and Wildlife Office (BDFWO). Information for this review was solicited from interested parties through a Federal Register notice announcing this review on July 26, 2019. Additionally, we conducted a literature search and review of information in our files. Based on our inspection of the last 5-year review and new information, we believe the most recent status review is still an accurate representation or assessment of the status of the species, its biology, and the threats affecting it.

The 2010 5-Year Review and the *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Recovery Plan; USFWS 2013) reviewed that multiple factors influence the salt marsh harvest mouse. In this current review of progress toward Recovery Plan recovery criteria (USFWS 2013), because primary population spatial distribution and abundance thresholds prescribed in downlisting criterion E/1 for population occupancy by viable habitat area, marsh complex, and recovery unit have not been achieved (see *Population Spatial Distribution and Abundance* discussion below), we did not review progress toward other criteria. Based on our analysis, the status of the salt marsh harvest mouse (*Reithrodontomys raviventris*) (mouse) remains endangered and we did not revise the recovery priority number of 2C. The priority number of 2C is based on a high degree of threat, a high potential of recovery, and its taxonomic standing as a species. The additional “C” ranking indicates some degree of conflict between the conservation needs of the species and economic development (USFWS 1983).

Recovery Criteria

The Recovery Plan addresses salt marsh harvest mouse population recovery criteria at the geographic scales of recovery unit (and segment), marsh complex, and viable habitat area, listed in Table 1. Refer to the Recovery Plan for marsh complex and viable habitat area descriptions and recovery unit and segment maps. The population metric used in the recovery criteria is capture efficiency. Capture efficiency is calculated as the number of unique captures divided by the number of trap nights (number of traps times the number of nights trapped), times 100.

The Recovery Plan, E/1 downlisting criterion prescribes the following population occupancy thresholds:

For each marsh complex:

- 40 percent of viable habitat areas must have salt marsh harvest mice present at a capture efficiency level of 5.0 or better;
- An additional 50 percent of viable habitat areas must have mice present at a capture efficiency level of 3.0 or better;
- Each marsh complex must be monitored and found to meet the above criteria at least twice, with at least five years between surveys. Some marsh complexes may meet the target after only two surveys while it may take more than two surveys for other marsh complexes (restored marshes which eventually establish suitable habitat) to meet the target. After marsh complexes meet the criteria twice, there is no need to resurvey them, as long as no more than 20 years has passed and there has been no obvious negative change to habitat during that time (i.e., substantial loss of upland transition or high marsh refugia due to sea level rise).

Table 1. Recovery units, marsh complexes, viable habitat areas, recovery unit segments, and respective acreage requirements associated with salt marsh harvest mouse population occupancy recovery criteria (USFWS 2013).

Recovery Unit	Marsh Complex	Min. Acres	Viable Habitat Area	Recovery Unit Segment	Min. Acres
Central/Southern San Francisco Bay	San Rafael Creek-Richardson's Bay, including Corte Madera Creek	400	Corte Madera Marsh (State Ecological Area)	I	150
	Bair-Greco-Ravenswood	1000	Foster City	M	150
			Bair Island	N	150
			Greco-Westpoint and Flood Sloughs	N	150
			Ravenswood Point and Slough	N	150
	East Palo Alto-Guadalupe Slough	1000	E Palo Alto - Cooley Landing - Palo Alto Nature - Mt View to Stevens Creek	O	150
			Stevens Creek to Guadalupe Slough	O	150
	Guadalupe Slough-Warm Springs	1000	one VHA within the marsh complex	P	150
	Calaveras-Mowry-Dumbarton	1000	one VHA within the marsh complex	Q	150
	Hwys 84 to 92 (Coyote Hills-Eden Landing)	1000	Hwy 84 to Coyote Hills Slough	R	150
			Coyote Hills Slough to Hwy 92	S	150
	Hwy 92- Arrowhead Marsh	1000	Cogswell-Hayward Shoreline	T	150
			Oro Loma	T	150
			Roberts Landing	T	150
San Pablo Bay	China Camp to the mouth of the Petaluma River	1000	China Camp to Gallinas Creek and Gallinas Creek	G	150
			Hamilton Air Force Base marshes to Petaluma Point, including Novato Creek	G	150
	Petaluma River marshes	1000	Bahia-Black John Slough-mouth of San Antonio Creek	F	150
			Petaluma Marsh and east of Petaluma River	F	150
			South-east of Petaluma Marsh	F	150
	Mouth of the Petaluma River to the mouth of Sonoma Creek	1000	one VHA within the marsh complex	E	150
	Napa marshes from the mouth of Sonoma Creek to the southern tip of Mare Island	1000	1/6 restored VHA within the marsh complex	D	150
			2/6 restored VHA within the marsh complex	D	150
			3/6 restored VHA within the marsh complex	D	150
			4/6 restored VHA within the marsh complex	D	150
			5/6 restored VHA within the marsh complex	D	150
			6/6 restored VHA within the marsh complex	D	150
	Point Pinole marsh	400	San Pablo Creek marshes and northeast from mouth of San Pablo Creek	H	150
Suisun Bay Area	Western Suisun/Hill Slough	1000	Morrow Island	B	150
			Cordelia Slough (west of railroad tracks)	B	150
			Chadbourne/Upper Wells Slough (W & E of RR tracks)	B	150
			Peytonia	B	150
			Hill Slough complex	B	150
	Suisun Slough/Cutoff Slough	1000	Lower Joice Island	B	150
			Upper Joice Island	B	150
			Rush Landing to Beldon's Landing (east of Suisun and Cutoff Sloughs)	B	150
			Beldon's Landing to Nurse Slough	B	150
	Nurse Slough/Denverton Slough	1000	Bradmoor Is- Little Honker Bay (plus areas along Denverton Slough)	A	150
			Blacklock	A	150
			Upper Nurse Slough	A	150
	Grizzly Island	1500	Grizzly Island West	A	150
			East border of Grizzly Bay, plus Crescent unit	A	150
			Grizzly Island East, including Ponds 1 and 15	A	150
			Simmons-Wheeler Islands	A	150
			Van Sickle Island/Chipps Island	A	150
			Ryer Island	A	150
			Montezuma area	A	150
	Contra Costa County Shoreline	500	Mallard Slough East	C	150
			Concord Naval Weapons Station marshes	C	150
			Hastings Slough to Carquinez Bridge	C	150

Information Acquired Since the Last Status Review

Population and Habitat Distribution and Abundance

<u>Methods</u>

There is currently no USFWS BDFWO range-wide salt marsh harvest mouse monitoring program or protocol nor habitat assessment protocol available to evaluate progress toward recovery population and habitat thresholds. Developing a range-wide robust and coordinated monitoring program and a habitat assessment and modeling protocol are high priorities for the USFWS BDFWO. Given these limitations, we reviewed progress toward recovery criteria as described below.

Population Data and Analysis

In our current analysis of the population status, we reviewed new information about the spatial distribution and abundance of mice based on reported mouse survey results. We used USFWS Section 10(a)(1)(A) recovery permit reported mouse survey results from 2010 through 2019 from the USFWS (Marriott 2018, 2019, 2020; Tertes No Date, 2017, 2019), California Department of Fish and Wildlife (Barthman-Thompson 2020), California Department of Water Resources (2015, 2016), DiDonato (2019), and East Bay Regional Park District (Riensche 2015, 2017), and limited survey data analysis from Smith (2021) to analyze and describe population distribution and abundance.

When compiling the mouse survey data, we noted several inconsistencies that impeded trend analysis and complicated comparison against recovery criteria thresholds and between sites.

With regard to survey design and implementation, we found that across sites: surveys have been performed at different times of year; not all surveys had equal trapping pressure (number of traps and/or trap nights) with some surveys using 180, 400, or in a few specialized research surveys over 2,000 trap nights; not all sites or bays had equal trapping pressure across years; and some sites were surveyed more than once during a single year. Survey effort appears to be concentrated at sites that are owned, managed, or under regulatory requirement to monitor for salt marsh harvest mice, by one or more governmental agencies and data was not available for up to 24 (49 percent) of the 49 viable habitat area locations. Additionally, and in separate analysis of a longer-term set of mouse survey data that includes the data we used, Smith (2021) used ANOVA testing to determine that month, bay, and effort each have a significant effect on capture per unit effort results. Smith (2021) found that at a rangewide scale: capture per unit effort results are significantly higher in January than all other months, followed by February, March, April, July, and November, which are not significantly different from each other; and capture per unit effort results are positively correlated with trapping effort, so that months with more trapping sessions tend to have higher capture per unit effort values. All of these considerations will be taken into account as the USFWS BDFWO develops a monitoring program for the species.

With regard to survey result reporting, we found that the USFWS BDFWO Section 10(a)(1)(A) recovery permit annual reporting standards did not require information at a resolution to allow extraction of data for our analysis. For this reason, some annual summary survey results that did not report survey- and site-specific trap nights and captures were not included in our summary or analysis. The BDFWO is currently working to amend reporting requirements to meet our analysis needs.

Habitat Data and Analysis

Relative to the limitations described in the *Methods* section introductory paragraph above, we did not have reported habitat assessment information necessary to analyze habitat distribution and abundance. Rather, in our presentation of habitat status, we only note a general association between positive mouse survey results (occupancy) and habitat suitability at survey locations. We present population survey metrics by survey site, which may represent a geographically proximate viable habitat area or a portion thereof, but we do not quantify habitat for survey sites. Accordingly, in assessing progress toward population thresholds, we are not able to indicate whether associated geographic unit-required habitat thresholds (i.e., for each viable habitat area) have been met, so we do not further discuss habitat spatial distribution and abundance in this review. These habitat assessment considerations will be taken into account as the USFWS BDFWO develops a monitoring program for the species and its habitat.

Population Spatial Distribution and Abundance

We present the results of our analysis in two ways: First, we compare mouse survey data against the Recovery Plan E/1 population occupancy downlisting criterion; then we summarize annual survey results to review some indication of population trend, by site.

Comparing Mouse Survey Data Against Recovery Plan E/1 Population Occupancy Downlisting Criterion

We compared site-specific mouse survey data against the Recovery Plan E/1 population occupancy downlisting criterion capture efficiency thresholds of at least 5.0 or at least 3.0 for two surveys separated by at least five years (Tables 2a-2c). For sites where more than one survey was conducted in a single year, a range of capture efficiencies is indicated. While we attributed survey sites to geographically proximate viable habitat areas, as discussed above, we did not have habitat assessment information necessary to evaluate whether survey sites qualify as a Viable Habitat Area (noted in Tables 2a-2c). For this reason, we were not able to evaluate the other part of the Recovery Plan E/1 population occupancy downlisting criterion threshold; quantifying the proportion of viable habitat areas for each marsh complex that meet the capture efficiency thresholds (see Recovery Criteria section, above). Therefore, while any survey site may have met one of the capture efficiency population occupancy thresholds, the site may not meet viable habitat area criteria.

We found that across all three recovery units and a total of 17 marsh complexes and 49 viable habitat area locations, only five survey sites had a capture efficiency of at least 5.0 for two surveys separated by at least five years and only eight sites had a capture efficiency of at least 3.0 for two surveys separated by at least five years (Tables 2a-2c). These sites were among those with relatively higher trapping effort. Rangewide, these capture efficiency values fall considerably below the E/1 population occupancy downlisting criterion for any marsh complex, representing only 16 percent of survey sites (and potential viable habitat areas) that met or exceeded either of the capture efficiencies. The eight survey sites and corresponding Recovery Unit that had capture efficiency thresholds of at least 5.0 at one site and at least 3.0 at another site for two surveys separated by at least five years, include: Eden Landing in the Central/Southern San Francisco Bay Recovery Unit; California Department of Fish and Wildlife (Napa/Petaluma)/Sonoma Creek 1/Strip Marsh West/Tubbs Island Setback/Lower Tubbs Island and Napa Sonoma Marsh in the San Pablo Bay Recovery Unit; and Peytonia Sloough, Hill Slough Wildlife Area, Lower Joice Island, Grizzly Island Wildlife Area, and Ponds 1-15 in the Suisun Bay Area Recovery Unit.

Only two marsh complexes, the Highways 84 to 92 (Coyote Hills-Eden Landing) Marsh Complex in the Central/Southern San Francisco Bay Recovery Unit and the Mouth of the Petaluma River to the mouth of Sonoma Creek in the San Pablo Bay Recovery Unit, would meet the threshold of at least 40% of viable habitat areas having a capture efficiency of at least 5.0 for two surveys separated by at least five years, if the survey sites exceeding that threshold were determined to also meet the viable habitat area criteria.

Summarizing Annual Mouse Survey Results to Review Population Trend, by Site

We also summarized annual mouse survey capture efficiencies by survey site to review some indication of population trend, by site (Tables 3a-3c). We describe this as an indication of population trend because relative to the data limitations described above in the *Population Data and Analysis* section, we note that the values presented in Tables 3a-3c may not represent true trends. In Tables 3a-3c, we present capture efficiencies for individual surveys; for sites where more than one survey was conducted in a single year, a capture efficiency is indicated for each survey. We do not present values for the timing, the number of trap nights, or the number of captures for each survey in this review.

While capture efficiency values in Tables 3a-3c fluctuate annually for almost every surveyed site, some possible trends appear. Excluding sites with two or fewer years of data, there appear to be positive population trends from 2010 to 2019 for several sites, including: Eden Landing in the Central/Southern San Francisco Bay Recovery Unit; Napa Sonoma Marsh in the San Pablo Bay Recovery Unit; and Grizzly Island East, Ponds 1-5, and Goodyear Slough in the Suisun Bay Area Recovery Unit. There also appear to be negative population trends at several sites, including: Sonoma Creek 1/Strip Marsh West (formerly Sonoma Baylands)/Tubbs Island Setback/Lower Tubbs Island in San Pablo Bay Recovery Unit; and Hill Slough Wildlife Area/Ponds 1 and 2 (and Ponds 4/4a and Areas 8 and 9), Bradmoor Island/California Water Association, Denverton, Lower Joice Island/Joice Island Unit, and East Border of Grizzly Island plus Crescent Unit in the Suisun Bay Area Recovery Unit. It is noted, however, that for several of the Suisun Bay Area Recovery Unit, sites listed as having apparent negative population trends from 2010 to 2019, the lower value in 2019 followed what appears to have otherwise constituted a positive trend through 2018.

Population Spatial Distribution and Abundance Conclusion

Our analysis above suggests that there are both positive and negative salt marsh harvest mouse population trends between 2010 and 2019 at the sites we assessed. Our comparison of capture efficiencies against the Recovery Plan E/1 population occupancy downlisting criterion thresholds also indicates that mouse capture efficiencies between 2010 and 2019 fell considerably short of the downlisting threshold for each of the 14 marsh complexes. We also identified that multiple aspects of survey design, implementation, and reporting should be improved to make the data more compatible with analyzing recovery progress in the future, including that relevant survey data was not available for up to 24 (49 percent) of the 49 viable habitat area locations.

Table 2a. Comparison of site-specific salt marsh harvest mouse survey capture efficiencies against the Recovery Plan E/1 population occupancy downlisting criterion thresholds for the Central/Southern San Francisco Bay Recovery Unit (meeting or exceeding a threshold indicated with green highlight; blank cells mean no survey was conducted or data was unavailable).

Marsh Complex	Viable Habitat Area (VHA)	Recovery Unit Segment	Survey Site Name (VHA acreage requirement not evaluated)	CE ≥ 3.0 in 2 surveys separated by ≥ 5 years from 2010 through 2019?	CE ≥ 5.0 in 2 surveys separated by ≥ 5 years from 2010 through 2019?
San Rafael Creek-Richardson's Bay, including Corte Madera Creek	Corte Madera Marsh (State Ecological Area)	I	Bothin Marsh	no	no
Bair-Greco-Ravenswood	Foster City	M		no	no
	Bair Island	N		no	no
	Greco-Westpoint and Flood Sloughs	N		no	no
	Ravenswood Point and Slough	N		no	no
East Palo Alto-Guadalupe Slough	East Palo Alto- Cooley Landing- Palo Alto Nature-Mountain View to Stevens Creek	O		no	no
	Stevens Creek to Guadalupe Slough	O		no	no
Guadalupe Slough-Warm Springs	one VHA within the marsh complex	P		no	no
Calaveras-Mowry-Dumbarton	one VHA within the marsh complex	Q	DE SFBNWR - Calaveras, LaRiviere, Dumbarton, Mayhew's Landing	no	no
Hwys 84 to 92 (Coyote Hills-Eden Landing)	Hwy 84 to Coyote Hills Slough	R		no	no
	Coyote Hills Slough to Hwy 92	S	Eden Landing	yes	yes
Hwy 92- Arrowhead Marsh	Cogswell-Hayward Shoreline	T	Hayward - Interpretive Trail	no	no
	Oro Loma	T	Hayward - Oro Loma	no	no
	Roberts Landing	T		no	no

Table 2b. Comparison of site-specific salt marsh harvest mouse survey capture efficiencies against the Recovery Plan E/1 population occupancy downlisting criterion threshold for the San Pablo Bay Recovery Unit (meeting or exceeding a threshold indicated with green highlight; blank cells mean no survey was conducted or data was unavailable).

Marsh Complex	Viable Habitat Area (VHA	Recovery Unit Segment	Survey Site Name (VHA acreage requirement not evaluated)	CE ≥ 3.0 in 2 surveys separated by ≥ 5 years from 2010 through 2019?	CE ≥ 5.0 in 2 surveys separated by ≥ 5 years from 2010 through 2019?
China Camp to the mouth of the Petaluma River	China Camp to Gallinas Creek and Gallinas Creek	G	China Camp State Park	no	no
	Hamilton Air Force Base marshes to Petaluma Point, including Novato Creek	G		no	no
Petaluma River marshes	Bahia-Black John Slough-mouth of San Antonio Creek	F		no	no
	Petaluma Marsh and east of Petaluma River	F		no	no
	South-east of Petaluma Marsh	F		no	no
Mouth of the Petaluma River to the mouth of Sonoma Creek	one VHA within the marsh complex	E	CDFW (Napa/Petluma); Sonoma Creek 1; Strip Marsh West (formerly Sonoma Baylands); Tubbs Island Setback; Lower Tubbs Island	yes	yes
Napa marshes from the mouth of Sonoma Creek to the southern tip of Mare Island	1/6 restored VHA within the marsh complex	D	Mare Island	no	no
	2/6 restored VHA within the marsh complex	D	Napa Sonoma Marsh	yes	no
	3/6 restored VHA within the marsh complex	D	Fagan Marsh	no	no
	4/6 restored VHA within the marsh complex	D		no	no
	5/6 restored VHA within the marsh complex	D		no	no
	6/6 restored VHA within the marsh complex	D		no	no
Point Pinole marsh	San Pablo Creek marshes and northeast from mouth of San Pablo Creek	H	Point Pinole, Giant Marsh	no	no

Table 2c. Comparison of site-specific salt marsh harvest mouse survey capture efficiencies against the Recovery Plan E/1 population occupancy downlisting criterion threshold for the Suisun Bay Area Recovery Unit (meeting or exceeding a threshold indicated with green highlight; blank cells mean no survey was conducted or data was unavailable).

Marsh Complex	Viable Habitat Area	Recovery Unit Segment	Survey Site Name (VHA acreage requirement not evaluated)	CE ≥ 3.0 in 2 surveys separated by ≥ 5 years from 2010 through 2019?	CE ≥ 5.0 in 2 surveys separated by ≥ 5 years from 2010 through 2019?
Western Suisun/Hill Slough	Morrow Island	B	Goodyear Slough	no	no
	Cordelia Slough (west of railroad tracks)	B		no	no
	Chadbourne/Upper Wells Slough (west and east of railroad tracks)	B		no	no
	Peytonia	B	Peytonia Slough Eco Reserve	yes	no
	Hill Slough complex	B	Hill Slough Wildlife Area, Ponds 1&2 (& Ponds 4/4a, Areas 8, 9)	yes	yes
Suisun Slough/Cutoff Slough	Lower Joice Island	B	Lower Joice Island (& Joice Island Unit)	yes	yes
	Upper Joice Island	B		no	no
	Rush Landing to Beldon's Landing (east of Suisun and Cutoff Sloughs)	B		no	no
	Beldon's Landing to Nurse Slough	B		no	no
Nurse Slough/Denverton Slough	Bradmoor Island- Little Honker Bay (plus all areas along Denverton Slough)	A	Bradmoor Island; CA Waterfowl Assoc, Denverton	no	no
	Blacklock	A	Blacklock	no	no
	Upper Nurse Slough	A		no	no
Grizzly Island	Grizzly Island West	A		no	no
	East border of Grizzly Bay, plus Crescent unit	A	Grizzly Island Wildife Area, Crescent	yes	yes
	Grizzly Island East, including Ponds 1 and 15	A	Ponds 1-15	yes	no
	Simmons-Wheeler Islands	A		no	no
	Van Sickle Island/Chipps Island	A	Van Sickle Island	no	no
	Ryer Island	A	Ryer Island	no	no
	Montezuma area	A	Montezuma Wetlands	no	no
Contra Costa County Shoreline	Mallard Slough East	C	McAvoy Harbor, Bay Pointe	no	no
	Concord Naval Weapons Station marshes	C		no	no
	Hastings Slough to Carquinez Bridge	C	McNabney Marsh, Mt. View Sanitary	no	no

Table 3a. Annual salt marsh harvest mouse survey capture efficiencies, by survey site for the Central/Southern San Francisco Bay Recovery Unit (blank cells mean no survey was conducted or data was unavailable).

Marsh Complex	Viable Habitat Area (VHA)	Recovery Unit Segment	Survey Site Name (qualification for VHA criteria not evaluated)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
San Rafael Creek-Richardson's Bay, including Corte Madera Creek	Corte Madera Marsh (State Ecological Area)	I	Bothin Marsh								0.00		
Bair-Greco-Ravenswood	Foster City	M											
	Bair Island	N											
	Greco-Westpoint and Flood Sloughs	N											
	Ravenswood Point and Slough	N											
East Palo Alto-Guadalupe Slough	East Palo Alto- Cooley Landing- Palo Alto Nature- Mountain View to Stevens Creek	O											
	Stevens Creek to Guadalupe Slough	O											
Guadalupe Slough-Warm Springs	one VHA within the marsh complex	P											
Calaveras-Mowry-Dumbarton	one VHA within the marsh complex	Q	DE SFBNWR - Calaveras, LaRiviere, Dumbarton, Mayhew's Landing								1.25	0.25	
Hwys 84 to 92 (Coyote Hills-Eden Landing)	Hwy 84 to Coyote Hills Slough	R											
	Coyote Hills Slough to Hwy 92	S	Eden Landing			8.25	10.0	4.37	5.50		9.63		11.85
Hwy 92- Arrowhead Marsh	Cogswell-Hayward Shoreline	T	Hayward - Interpretive Trail						0.50		1.33		
	Oro Loma	T	Hayward - Oro Loma						0.00		3.33		
	Roberts Landing	T											

Table 3b. Annual salt marsh harvest mouse survey capture efficiencies, by survey site for the San Pablo Bay Recovery Unit (blank cells mean no survey was conducted or data was unavailable).

Marsh Complex	Viable Habitat Area	Recovery Unit Segment	Survey Site Name (qualification for VHA criteria not evaluated)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
China Camp to the mouth of the Petaluma River	China Camp to Gallinas Creek and Gallinas Creek	G	China Camp SP					7.0					
	Hamilton Air Force Base marshes to Petaluma Point, including Novato Creek	G											
Petaluma River marshes	Bahia-Black John Slough-mouth of San Antonio Creek	F											
	Petaluma Marsh and east of Petaluma River	F											
	South-east of Petaluma Marsh	F											
Mouth of the Petaluma River to the mouth of Sonoma Creek	one VHA within the marsh complex	E	CDFW (Napa/Petluma); Sonoma Crk 1; Strip Marsh W (formerly Sonoma Baylands); Tubbs Island Setback; Lower Tubbs Island	6.06	0.91	2.13	2.68	7.18	4.86	5.82	5.41	1.35	4.17
Napa marshes from the mouth of Sonoma Creek to the southern tip of Mare Island	1/6 restored VHA within the marsh complex	D	Mare Island									0.34	
	2/6 restored VHA within the marsh complex	D	Napa Sonoma Marsh		4.75		8.33		8.25			7.0	
	3/6 restored VHA within the marsh complex	D	Fagan Marsh		12.33								
	4/6 restored VHA within the marsh complex	D											
	5/6 restored VHA within the marsh complex	D											
	6/6 restored VHA within the marsh complex	D											
Point Pinole marsh	San Pablo Creek marshes and northeast from mouth of San Pablo Creek	H	Point Pinole, Giant Marsh									0.0	

Table 3c. Annual salt marsh harvest mouse survey capture efficiencies, by survey site for the Suisun Bay Area Recovery Unit (blank cells mean no survey was conducted or data was unavailable).

Marsh Complex	Viable Habitat Area	Recovery Unit Segment	Survey Site Name (qualification for VHA criteria not evaluated)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Western Suisun/Hill Slough Marsh Complex	Morrow Island	B	Goodyear Slough						12.99	3.06, 5.0, 16.75	1.39, 3.89	7.78, 14.44, 12.50, 11.39	6.39, 2.78, 1.94, 23.89
	Cordelia Slough (west of railroad tracks)	B											
	Chadbourne/Upper Wells Slough (west and east of railroad tracks)	B											
	Peytonia	B	Peytonia Slough Eco Reserve	4.43		1.75	10.0		10.10				
	Hill Slough complex	B	Hill Slough Wildlife Area, Ponds 1&2 (& Ponds 4/4a, Areas 8, 9)	3.25	6.12	6.90	7.00	9.43		10.80	1.30	7.50	2.50
Suisun Slough/Cutoff Slough Marsh Complex	Lower Joice Island	B	Lower Joice Island (& Joice Island Unit)	6.75	2.50			14.94	5.49	6.39, 5.0, 11.55	7.78, 0.83, 2.78, 2.5	23.61, 7.78, 6.39, 5.0, 2.22, 10.28	1.17, 0.83, 1.67
	Upper Joice Island	B											
	Rush Landing to Beldon's Landing (east of Suisun and Cutoff Sloughs)	B											
	Beldon's Landing to Nurse Slough	B											
Nurse Slough/Denverton Slough Marsh Complex	Bradmoor Island- Little Honker Bay (plus all areas along Denverton Slough)	A	Bradmoor Island; CA Waterfowl Assoc, Denverton			3.50		7.34	6.75	2.84			
	Blacklock	A	Blacklock						1.11				
	Upper Nurse Slough	A											
Grizzly Island Marsh Complex	Grizzly Island West	A											
	East border of Grizzly Bay, plus Crescent unit	A	GIWA Crescent	15.60	2.0	6.50	7.0	9.25	8.0	8.0		15.0	5.75
	Grizzly Island East, including Ponds 1 and 15	A	Ponds 1-15	4.50	3.75	7.18	3.94, 3.75	9.0, 3.79		6.25			
	Simmons-Wheeler Islands	A											
	Van Sickle Island/Chipps Island	A	Van Sickle Island	4.25									
	Ryer Island	A	Ryer Island				16.50						
	Montezuma area	A	Montezuma Wetlands		2.47		6.40		5.87		1.67		2.47
Contra Costa County Shoreline Marsh Complex	Mallard Slough East	C	McAvoy Harbor, Bay Pointe								1.50		
	Concord Naval Weapons Station marshes	C											
	Hastings Slough to Carquinez Bridge	C	McNabney Marsh, Mt. View Sanitary							4.17			

New Information about Threats Relative to Respective Listing Factors

The 2010 5-Year Review and the Recovery Plan reviewed that habitat loss due to human actions continued to be the greatest threat to the salt marsh harvest mouse. Since the 2010 5-Year Review and the Recovery Plan were completed, new information about threats has become available and is briefly summarized below. This review of new information about relevant threats is organized relative to the respective listing factor (Five Factors) outlined in section 4(a)(1) of the Act and associated with the threat; not all factors are discussed here.

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Habitat Loss and Fragmentation

Habitat Loss:

Several marsh restoration projects that may increase habitat for the salt marsh harvest mouse are in various stages of implementation. New marsh restorations in the South Bay include work at Island Ponds in Alviso, parts of Eden Landing, and as of 2020, a portion of Outer Bair Island. The South Bay Salt Pond Restoration Project has projects that also recently started. In the North Bay, the Dixon and Cullinan Ranch restoration projects have been initiated. At Sonoma Creek marsh, marsh/upland ecotones were built as well as high tide refuge islands. Past restoration projects include Lower Tubbs, Tolay Creek, and Sonoma Baylands (Albertson 2020). Restoration projects in the Suisun Bay Area include work at Hill Slough, Chipps Island, Arnold Slough, and Bradmoor Island (Estrella 2019) and Lower Walnut Creek. We have not attempted to quantify suitable habitat for these restorations because, as explained below in the *Recommendations for Future Actions section,* we have not yet established standardized suitable habitat assessment protocol, and some of these restorations are not complete or mature enough to evaluate habitat suitability for the salt marsh harvest mouse (see also, *Loss of Ecotones* section, below).

Habitat Fragmentation

We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding habitat fragmentation in response to our Federal Register Notice announcing this 5-year review.

Habitat Disturbance and Degradation

Dikes/Levees

Four publications reviewing potential implications of dikes/levees in salt marsh harvest mouse habitat are summarized below. The research for all four publications was conducted at Suisun Marsh in Solano County, California. The Smith *et al* (2014) publication suggests that behavioral flexibility of the salt marsh harvest mouse may allow it to adapt to using diked wetlands. The Smith *et al* (2019) publication also suggests that salt marsh harvest mice make use of diked wetlands and that as climate change and sea level rise are predicted to threaten coastal marshes, a recovery strategy for salt marsh harvest mice could incorporate managed wetlands. The Jones *et al* (2021) publication, which was written with a focus on waterfowl management, suggests impounded brackish marshes experience a decline in plant species richness and altered functional dominants and potential salinization of soil as compared to tidal marshes. They add that such changes may require careful management to balance native plant diversity, ecosystem processes, and waterfowl requirements. We note that such changes and management may cause potential adverse effects to habitat for some other tidal marsh wildlife species and that Jones *et al* (2021) do not specifically discuss potential effects to the salt marsh harvest mouse. We also add that when considered in combination, the publications summarized in this section suggest that some carefully managed diked wetlands may be beneficial for the salt marsh harvest mouse, including those managed for waterfowl.

Smith *et al* (2014) examined how northern salt marsh harvest mice (*Reithrodontomys raviventris halicoetes*) cope with both natural (daily tidal fluctuations) and anthropogenic (modification of tidal regime) changes in natural tidal wetlands and human-created diked wetlands, and investigated the role of behavioral flexibility in utilizing a human-created environment in the Suisun Marsh. They found that the majority of the time mice remain in vegetation above the water during high tides. They found no difference in space used by mice during high tide as compared to before or after high tide in either tidal or diked wetlands. They also found no detectable difference in diurnal or nocturnal movement rates in tidal wetlands. However, they did find that diurnal movement rates for mice in diked wetlands were lower than nocturnal movement rates, especially during the new moon. They concluded that this change in movement behavior in a relatively novel human-created habitat indicates that behavioral flexibility may facilitate the use of human-created environments by salt marsh harvest mice.

Smith *et al* (2019) conducted research to determine the value of tidal wetlands relative to those managed for waterfowl. They performed periodic surveys for rodents, including the salt marsh harvest mouse, in managed and tidal wetlands over five years at Suisun Marsh. They used capture-mark-recapture analyses to estimate demographic parameters and abundance for the three most common rodents; the northern salt marsh harvest mouse (*R. r. halicoetes*), the western harvest mouse (a sympatric native species; *R. megalotis*), and the house mouse (a sympatric invasive species; *Mus musculus*). They found that wetland type had no effect on detection, temporary emigration, or survival for any of these species. However, fecundity and population growth for all three species were affected by an interaction of season and wetland type, although none of the parameters was consistently superior in either habitat type. Estimated abundance of salt marsh harvest mice and house mice was similar in both wetland types, whereas the western harvest mouse was more abundant in managed wetlands. Salt marsh harvest mice also showed no affinity for any microhabitat characteristics associated with tidal wetlands. They also found that managed wetlands in Suisun Marsh support salt marsh harvest mice and house mice equally, and abundances of western harvest mice were greater than in tidal wetlands, suggesting managed wetlands may be superior in terms of supporting native rodents. They suggest that as climate change and sea level rise are predicted to threaten coastal marshes, these results suggest the recovery strategy for salt marsh harvest mice could incorporate managed wetlands.

Smith and Kelt (2019) conducted research about the implications of waterfowl management on the diet of the salt marsh harvest mouse, which is thought to feed primarily on pickleweed (*Salicornia pacifica*), although its diet is poorly understood, and a large proportion of remaining habitat for the mouse is managed for non-pickleweed vegetation to provide habitat for waterfowl. They used two sets of cafeteria trials to test food preferences of the salt marsh harvest mouse when offered a variety of plants and invertebrates. They found that in a set repeated menu, and unique seasonal menus, salt marsh harvest mice showed strong preferences for food types commonly grown for waterfowl, and also for non-native plants; in contrast, pickleweed was the most preferred food during only some of the set and some of the seasonal trials. They suggest their results show that salt marsh harvest mice have a more flexible diet than previously thought, and should allow land managers in areas such as the Suisun Marsh to promote the growth of plants that provide foods that are preferred by both waterfowl and salt marsh harvest mice.

Jones *et al* (2021) compared patterns of plant diversity and species presence, abundance, and community composition at several spatial scales among tidal wetlands along an estuarine salinity gradient and managed wetlands that were formerly tidal. They found that managed impounded wetlands had decreased alpha and gamma diversity (alpha diversity [at plot-, patch-, and site-scale] and gamma diversity [at region-scale] represent the effective number of species) of rare plant species, with less than 60 percent of the species richness found in tidal brackish wetlands at several spatial scales. They found little change in the overall pattern of alpha, beta (beta diversity is the effective number of compositional units; patches, sites, and regions) and gamma diversity for common species in impounded wetlands; however, dominant tidal brackish species, primarily perennial rhizomatous graminoids, were replaced with management target plants and non-native annual grasses in impounded wetlands. Such species replacement led to over 60 percent of impounded sites being classified as containing novel plant assemblages and an additional 25 percent were classified as containing tidal saline plant assemblages, suggesting potential soil salinization. Along the estuarine gradient, they found patchiness and codominance of common plant species drove high diversity and turnover in tidal brackish wetlands, while it remained unclear whether tidal fresh or brackish wetlands maximize rare plant diversity. They concluded that with reduced species richness, altered functional dominants, and novel or saline assemblages, impounded brackish wetlands may require careful water management to balance native plant biodiversity, associated ecosystem processes, and waterfowl requirements.

Loss of Ecotones
Several of the restoration projects mentioned above in the *Habitat Loss* section incorporate ecotones, which may help minimize this threat. Specifically, the South Bay Salt Pond Restoration Project is incorporating ecotones into pond design in the current Phase 2 implementation, Sonoma Creek West includes ecotones, and Cullinan Ranch East includes ecotones as well as within-marsh mounds/islands (Albertson 2021). Similar to what we explain in the *Habitat Loss* section, above, we have not attempted to quantify suitable ecotone habitat for these restoration projects because, we have not yet established standardized suitable habitat assessment protocol for the species, and some of these restoration projects are not complete or mature enough to evaluate habitat suitability for the salt marsh harvest mouse.

Disturbance
We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding habitat disturbance in response to our Federal Register Notice announcing this 5-year review.

Salinity Changes

We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding salinity changes in response to our Federal Register Notice announcing this 5-year review.

Invasive Species

We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding invasive species in response to our Federal Register Notice announcing this 5-year review.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

In the 2010 5-Year Review this factor was not considered to be a threat to the salt marsh harvest mouse. We have not acquired/are not aware of any information about Factor B that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding Factor B in response to our Federal Register Notice announcing this 5-year review.

Factor C: Disease or Predation

Disease

We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding disease in response to our Federal Register Notice announcing this 5-year review.

Predation

We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding predation in response to our Federal Register Notice announcing this 5-year review.

Factor D: Inadequacy of Existing Regulatory Mechanisms

Federal Protections

We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding federal protections in response to our Federal Register Notice announcing this 5-year review.

State and Local Protections

We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding state and local protections in response to our Federal Register Notice announcing this 5-year review.

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence

Risk of Small Populations

See discussion immediately below under the *Risk of Extirpation Due to Small Populations: Within- and Across-Population Genetic Diversity Information* section.

Risk of Extirpation Due to Small Populations: Within- and Across-Population Genetic Diversity Information

Two important publications investigating genetic diversity are summarized below. Encouraging findings in Statham *et al* (2016) were for no evidence of hybridization between the salt marsh harvest mouse and the western harvest mouse and support for the subspecies designations between the northern and southern subspecies of salt marsh harvest mouse. Concerning findings in Statham *et al* (2016) and Statham and Sacks (2019) include confirming the lowest genetic diversity in the species range among the southern subspecies, which inhabits a comparatively reduced and fragmented portion of the overall range and some evidence of genetic drift among isolated and small populations in the range of the northern subspecies. These investigations represent part of ongoing research toward the Recovery Plan Action 4.3.1, which is to conduct a salt marsh harvest mouse population genetic analysis to determine: the genetic effective population size; the genetic relationships among presumed populations; the magnitude of gene exchange between marshes and subpopulations within marshes; and the extent of inbreeding occurring within populations. This is a Recovery Plan, Priority 1 Action and continuing and completing this research is considered a high priority for the USFWS BDFWO.

Statham *et al* (2016) investigated the possibility of salt marsh harvest mouse hybridization with the morphologically similar western harvest mouse in areas of co-occurrence and the phylogeography and genetic structure of the salt marsh harvest mouse, including support for currently recognized subspecies designations. Their analyses using mitochondrial DNA (mtDNA) cytochrome b sequences and 11 microsatellites from 142 mice indicated complete and substantial separation of the salt marsh harvest mouse and the western harvest mouse, with no evidence of hybridization (Figures 1 and 2). They also identified a deep genetic division within the salt marsh harvest mouse consistent with the current northern (*R. r. halicoetes*) and southern (*R. r. raviventris*) subspecies designations (Figure 2). The authors identified the lowest genetic diversity within the southern subspecies, which inhabits a much reduced and highly fragmented portion of the species range. They suggest their confirmation of the genetically distinct subspecies highlights the importance of determining the status and genetic composition of relict salt marsh harvest mouse populations in the remaining patches of marshland in the central San Francisco Bay where the two subspecies may occur, as well as developing better tools for the field discrimination of species, particularly in the range of the southern subspecies.

Figure 1. Map of sampling locations within the San Francisco Bay area. Sampling locations are indicated with a red pentagon. Coarse outline of the salt marshes is indicated with a yellow line. (Figure and description *from* Statham *et al* (2016)).

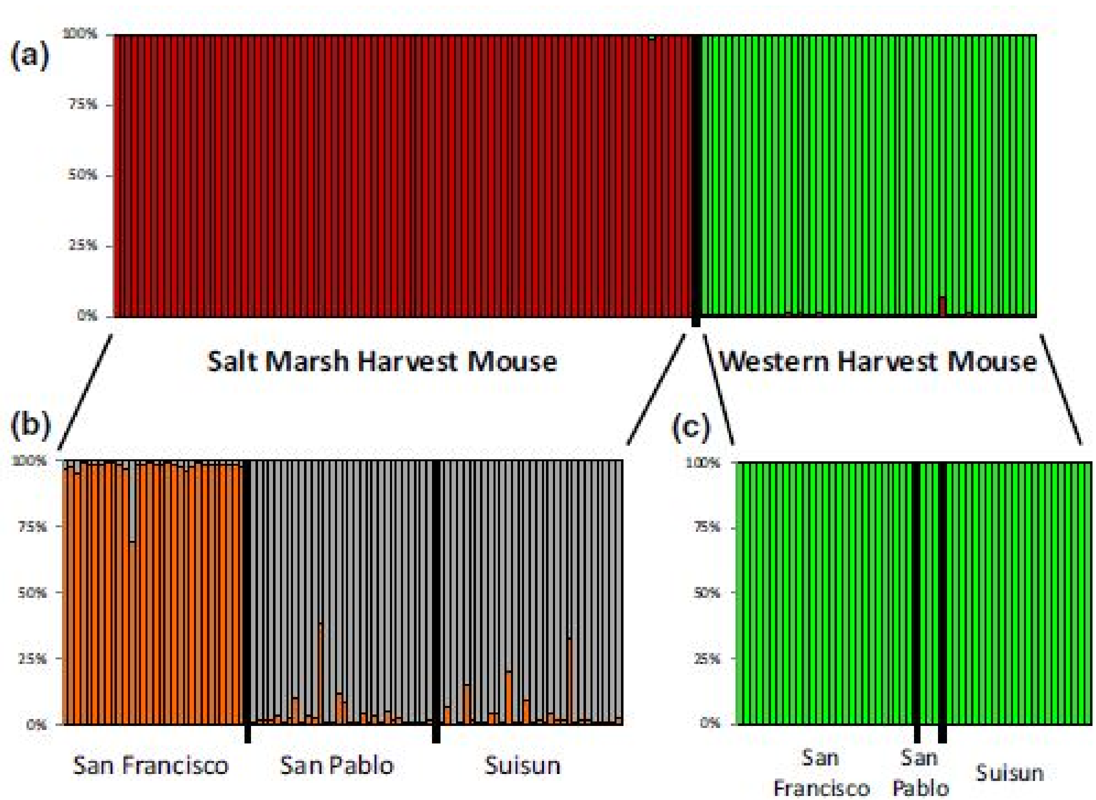

Figure 2. Harvest mouse genetic subdivision as evident from microsatellite loci and cluster analysis using the program STRUCTURE. All analyses were performed without prior information regarding the population of origin or putative species. a) Genetic cluster analysis of all harvest mice (based on five microsatellite loci) separated animals into two groups, salt marsh harvest mouse and western harvest mouse, consistent with the species assignment from mtDNA analyses. b) Cluster analysis of the salt marsh harvest mouse (based on eight microsatellite loci) separated animals from the south bay from those in the two northern bays, consistent with previously described subspecies. c) There was no evidence of population subdivision within the western harvest mouse dataset (based on analyses of six microsatellite loci). (Figure and description *from* Statham *et al* (2016)).

Statham and Sacks (2019) investigated the genetic diversity and genetic relationship among salt marsh harvest mice from 26 trapping locations across the Suisun Bay Area Recovery Unit, which included multiple sites in each of the recovery unit's marsh complexes (Figure 3). Their main findings included:

(1) The Suisun Bay Area Recovery Unit supports multiple populations of salt marsh harvest mice with the most genetically distinct population at Ryer Island and additional distinct populations along the Contra Costa County shoreline (at Point Edith and McNabney Marsh). Additionally, mice from the northern marshes of Suisun Bay were distinct from those on Ryer Island and the Contra Costa County shoreline (Figures 3 and 4);

(2) On the Contra Costa County shoreline, the mice at McNabney Marsh were differentiated from those at neighboring Point Edith, which is likely due to genetic drift caused by geographic isolation and/or small population size (Figures 3 and 4).

(3) Salt marsh harvest mice located in the northern marshes of Suisun Bay constitute a single population and geographic distance between locations was the best predictor of genetic

distance. This area covers the majority of four Suisun Bay Area Recovery Unit marsh complexes (Figures 3 and 4).

(4) Based on the landscape genetic analysis of salt marsh harvest mice from across Suisun Bay, the best explanation for the subdivision observed was that water and elevation constrain gene flow and mouse movement. This information can be used to help to locate other potentially distinct populations and also highlights how isolated many other marshes are, especially around the central part of the Central/Southern San Francisco Bay Recovery Unit, which has implications for any relict populations of mice remaining there.

(5) Their study also established the existence of the salt marsh harvest mouse at three new locations, genetically verified the continued occurrence at two rarely surveyed locations, and reported negative survey results for one location.

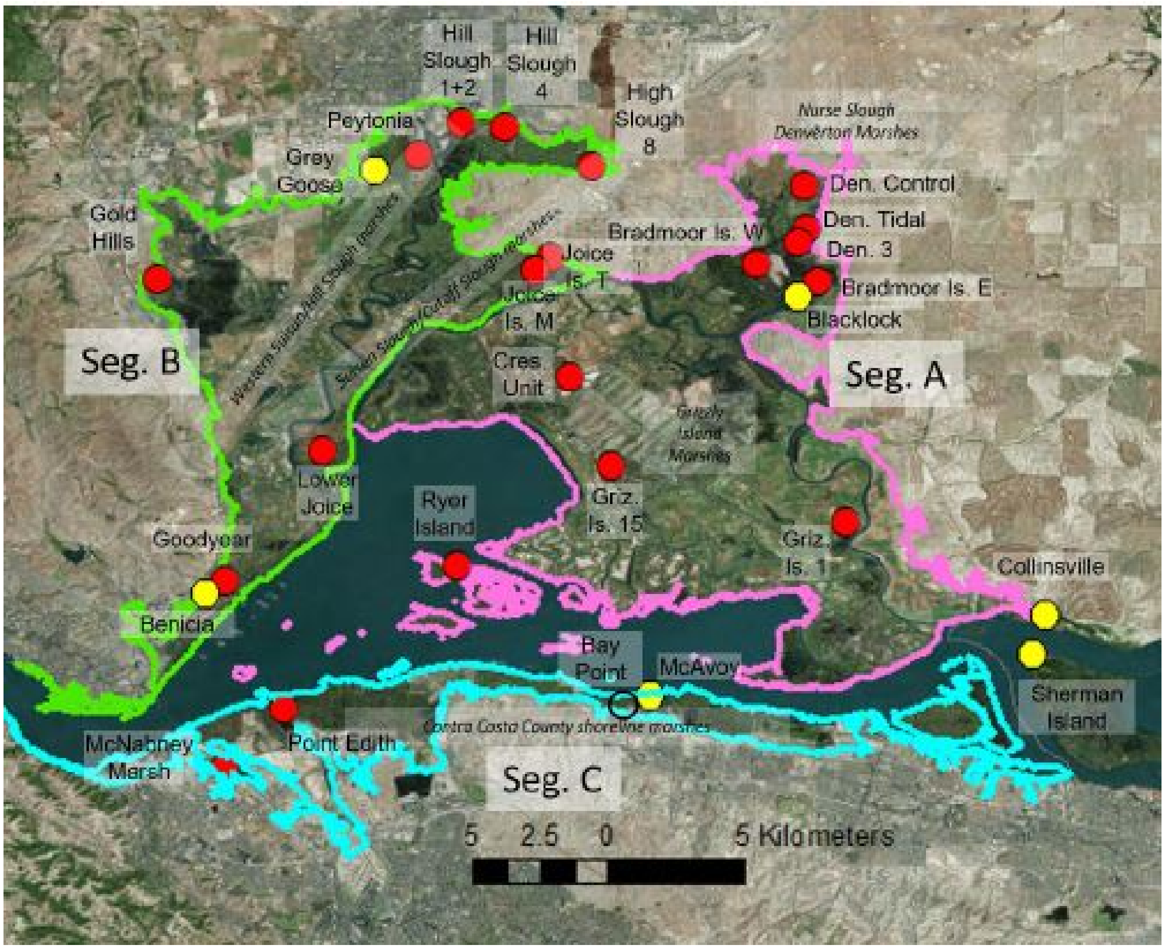

Figure 3. Salt marsh harvest mouse trapping locations within the Suisun Bay Area Recovery Unit. *Note*: Red circles indicate trapping locations where 10 or more salt marsh harvest mice were caught; yellow circles indicate where three or fewer mice were caught. No salt marsh harvest mice were trapped at Bay Point (indicated with an open circle). Pink outlining indicates Suisun Bay Area Recovery Unit Segment A, green indicates Segment B, and blue indicates Segment C. Source: Data compiled by University of California, Davis in 2019. (Figure and description *from* Statham and Sacks (2019)).

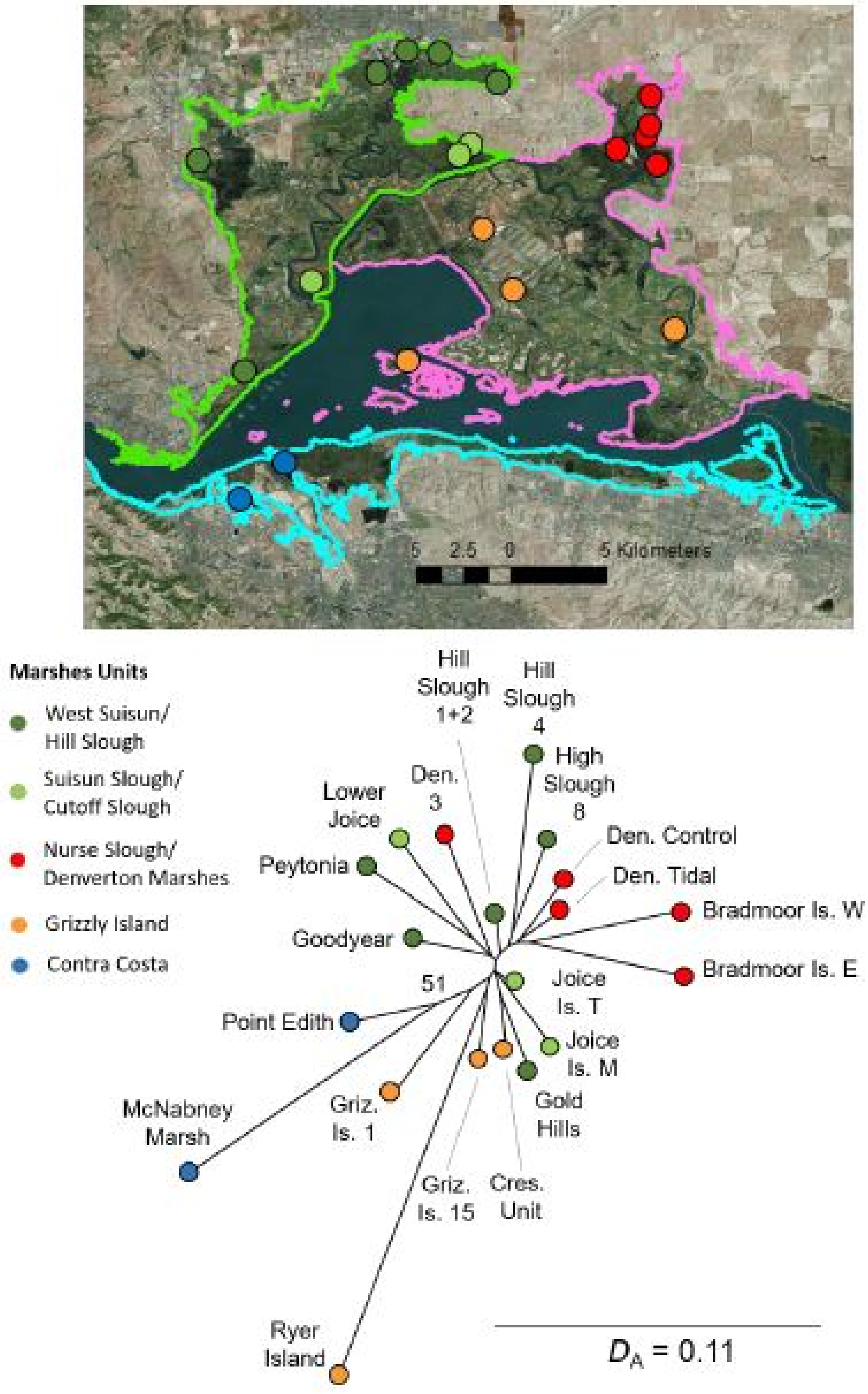

Figure 4. Population tree of salt marsh harvest mouse sampling locations across the Suisun Bay Area Recovery Unit, based on locations with more than 10 individuals. *Note*: Distance is Nei's DA. The value at the node of Point Edith and McNabney Marsh is bootstrap support based on 200 replicates. Source: Data compiled by University of California, Davis in 2019. (Figure and description *from* Statham and Sacks (2019)).

Contaminants
We have not acquired/are not aware of any information that has become available since the most recent status review. Additionally, we did not receive any information from the public regarding contaminants in response to our Federal Register Notice announcing this 5-year review.

Global Warming and Climate Change:

<u>*Sea-Level Rise*</u>
In the 2010 5-Year Review, the local effect of sea-level rise associated with global climate change, was identified as the most central threat to the long-term survival of the salt marsh harvest mouse. Sea-level rise (SLR) is expected to increasingly threaten tidal marsh habitat extent and condition (Thorne *et al* 2018, Thorne *et al* 2019). Research has been conducted to model effects of potential sea-level rise to coastal and estuarine habitat. Some information that has become available since the 2010 5-Year Review is summarized below.

Thorne *et al* (2108) used a comprehensive scenario approach to evaluate both the vertical and horizontal response of tidal wetlands to projected changes in the rate of SLR across 14 estuaries along the Pacific coast of the continental United States through 2110 (Figure 6). Throughout the U.S. Pacific region, they found that tidal wetlands are highly vulnerable to end-of-century submergence, with resulting extensive loss of habitat. The SLR values for each scenario varied by region; SLR values for California were, low (+44 cm; 17.3 in), moderate (+93 cm; 36.6 in), and high (+166 cm; 65.4 in). Using higher-range SLR scenarios, all high and middle marsh habitats were lost, with 83 percent of current tidal wetlands transitioning to unvegetated habitats by 2110. The projected high and middle marsh habitat area lost was greater in California and Oregon (100 percent) but still severe in Washington, with 68 percent submerged by the end of the century. The only wetland habitat remaining at the end of the century was low marsh under higher range SLR rates. Tidal wetland loss was also likely under more conservative SLR scenarios, including loss of 95 percent of high marsh and 60 percent of middle marsh habitats by the end of the century. Horizontal migration of most wetlands was constrained by coastal development or steep topography, with just two wetland sites having sufficient upland space for migration and the possibility for nearly 1:1 replacement, making SLR threats particularly high in the Pacific region and generally undocumented, as compared to other coastal regions of the U.S. They concluded that with low vertical accretion rates and little upland migration space, Pacific coast tidal wetlands are at imminent risk of submergence with projected rates of rapid SLR. Figure 5 illustrates projected percent habitat area under the three SLR scenarios.

Additionally, Thorne *et al* (2019) found that avian predator numbers and activity in tidal marshes increased with high-tide events and that increased flooding, as is expected with sea-level rise, will increase avian predator pressure on wildlife prey, including salt marsh harvest mice. They found that there was higher predation pressure from ardeids (egrets and herons) than raptor species. Their study highlights the importance of predator–prey interactions and the amplification of predation pressure under flooded conditions, which has implications for population persistence, especially in small, fragmented habitats under sea-level rise.

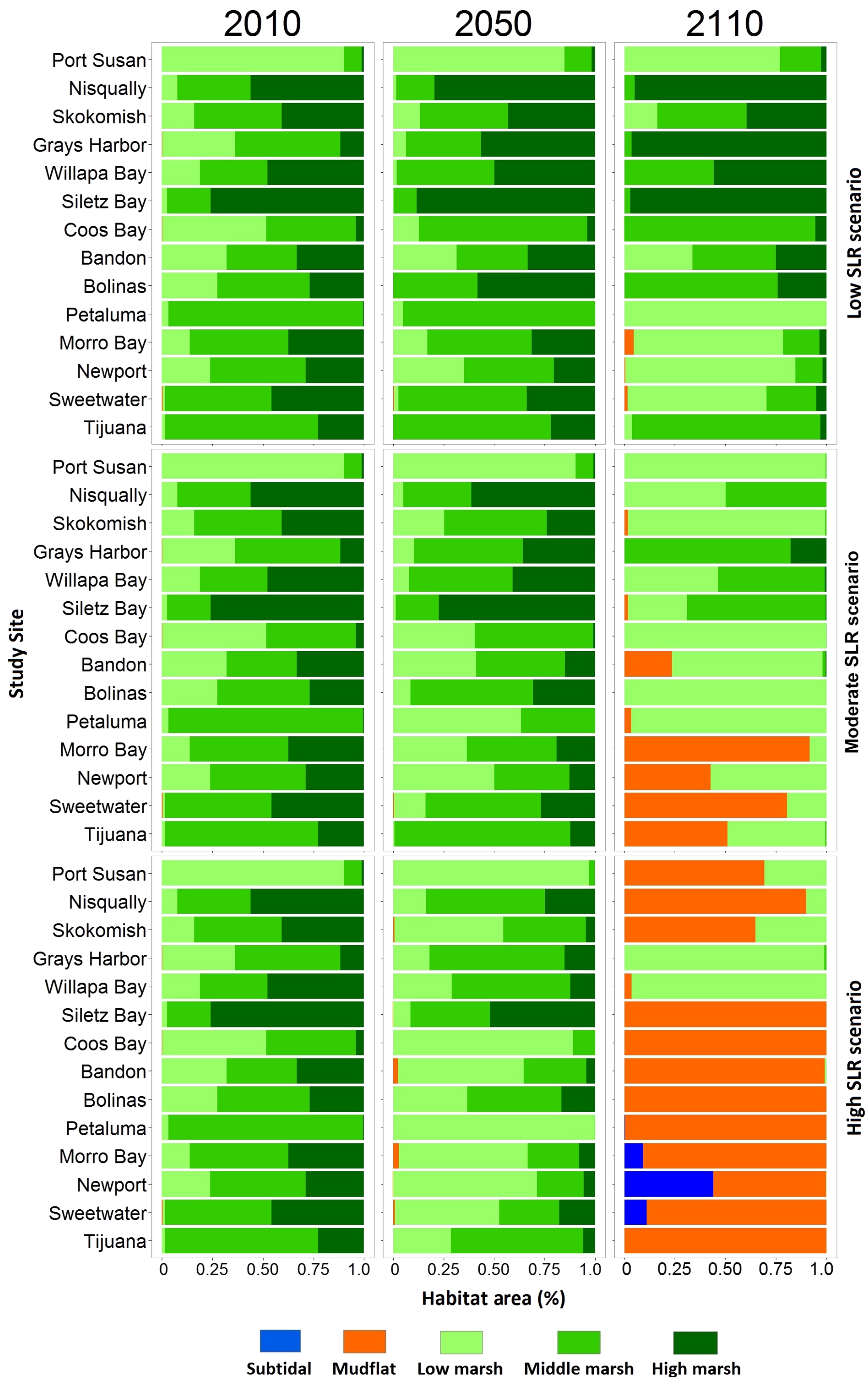

Figure 5. Modeled percent habitat area projections under three SLR scenarios (SLR values for California are, low (+44 cm; 17.3 in), moderate (+93 cm; 36.6 in), and high (+166 cm; 65.4 in)). Bolinas and Petaluma are San Francisco area and Bay locations, respectively. Under moderate and high SLR scenarios, all study sites are projected to undergo substantial loss of elevation over the coming century. By 2050, under moderate and high SLR scenarios, there is a gradual loss of high marsh habitats with an expansion of middle and low marsh habitats. Under moderate SLR scenarios by 2110, there is a loss of middle and high marsh habitats and submergence of tidal marsh, with a conversion to intertidal mudflat and open water at 36% of the study sites. Under high SLR scenarios, there is a total loss of all middle and high marsh habitats and submergence at 86% of the study sites, with three study sites going partly subtidal. (Figure and description *from* Thorne *et al* 2018).

Conclusion:

After reviewing the best available scientific information, we conclude that salt marsh harvest mouse remains an endangered species. The evaluation of threats affecting the species under the factors in 4(a)(1) of the Act and analysis of the status of the species in our 2010 5-Year Review remains an accurate reflection of the species' current status. The species' status remains endangered and we did not revise the recovery priority number of 2C. The priority number of 2C is based on a high degree of threat, a high potential of recovery, and its taxonomic standing as a species. The additional "C" ranking indicates some degree of conflict between the conservation needs of the species and economic development (USFWS 1983).

RECOMMENDATIONS FOR FUTURE ACTIONS:

Since the time when the 2010 5-Year Review was completed, the Recovery Plan has been finalized. The Recovery Plan identifies short- and long-term components of the recovery strategy. In addition to the Recovery Plan strategies and recommendations for future actions from the 2010 5-year Review, the following actions are recommended over the next five years:

1) **Develop a salt marsh harvest mouse range-wide, long-term, population monitoring plan and program.** This effort would be designed to specifically address needs for evaluating the status and distribution and recovery progress of the species relative to the Recovery Plan. It will include standardized protocols for survey design and implementation and data collection, reporting, and analysis.

2) **Develop standardized salt marsh harvest mouse habitat assessment and modeling protocol.** Habitat assessment and modeling protocol is necessary to evaluate the suitability of habitat, estimate the extent and configuration of current habitat, and project the extent and configuration of habitat into the future. The protocol would be used in estimating mouse and habitat status and distribution and measuring progress toward recovery criteria.

3) **Develop tidal marsh restoration guidelines, with emphasis on the Recovery Plan focal species, including salt marsh harvest mouse**. The proposed tidal marsh restoration guidelines would update and expand upon the *Design Guidelines for Tidal Wetland Restoration in San Francisco Bay* (Philip Williams & Associates, Ltd. and Faber 2004). The effort should: (A) access and analyze focal species, vegetation, and topographic survey data from tidal marsh restorations and natural marshes; (B) evaluate the performance of multiple habitat and system/function measures and restoration design elements for the focal species; (C) prescribe tidal marsh restoration features and values that will best benefit the focal species into the future; (D) recommend monitoring data collection and reporting protocol and standards for evaluating the same habitat benefits to the focal species; and (E) work with all partners, including land managers, tidal marsh experts, and other interested parties.

4) **Continue research in support of Recovery Plan Action 4.3.1 to conduct a salt marsh harvest mouse population genetic analysis to determine: the genetic effective**

population size; the genetic relationships among presumed populations; the magnitude of gene exchange between marshes and subpopulations within marshes; the extent of inbreeding occurring within populations. This is a Recovery Plan Priority 1 Action that has been underway for several years. Continuing and completing this research is considered a high priority for the USFWS BDFWO.

Field Supervisor Approval

Donald Ratcliff, Project Leader, San Francisco Bay-Delta Fish and Wildlife Office, U.S. Fish and Wildlife Service

Approve DONALD RATCLIFF Digitally signed by DONALD RATCLIFF Date: 2022.01.14 10:48:57 -08'00' Date 12/28/2021

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