Chapter 1

THE SALT MARSH HARVEST MOUSE IN THE EMERYVILLE CRESCENT MARSH

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The East Bay shoreline from the Bay Bridge approach in Emeryville northwards to the Richmond city limits (see map, p. vi) is currently under consideration for some form of development program. The present study is directed toward determining the status of the salt marsh harvest mouse, Reithrodontomys raviventris, within this area in the hope that it will aid in rational decisions for future programs and add to the available information on the species.

The salt marsh harvest mouse (SMHM) is an unusual mammal endemic to the salt marshes of the San Francisco Bay region. It is physiologically and behaviorally adapted to the rigorous conditions of the salt marsh environment. The species has the ability to tolerate high salt concentrations, which allows it to subsist on saltwater and saline marsh vegetation (Fisler, 1965). The SMHM has also adapted to tidal fluctuations through its strong swimming ability and non-aggressive behavior towards its own species while crowded on marsh patches above high tides (Fisler, 1965). A subspecies of R. raviventris, R. r. halicoetes, inhabits more brackish marshes in San Pablo and Suisun Bays, while the former is confined to salt marshes in San Francisco Bay proper (FIGURE 1).

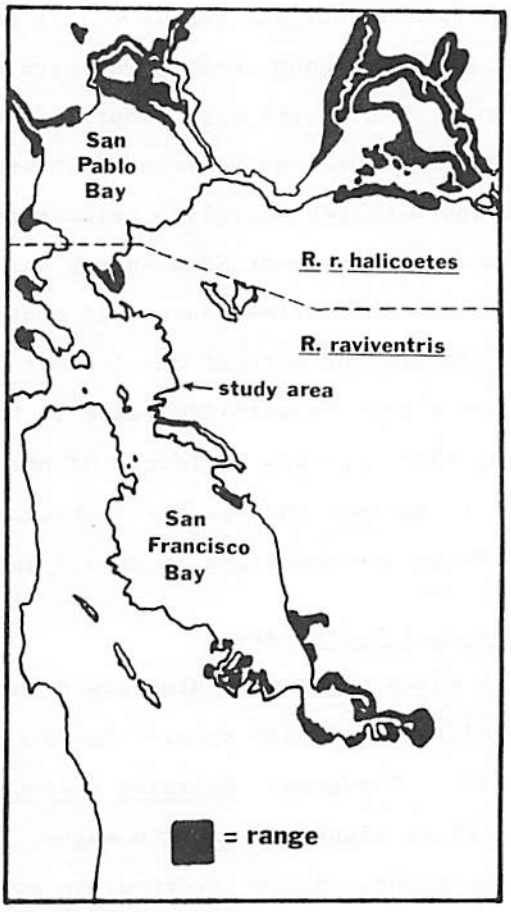

FIGURE 1. Present distribution of the Salt Marsh Harvest Mouse in the San Francisco Bay region. Adapted from Fradkin, 1979.

The SMHM is presently on both the federal and state of California list of endangered species. It is considered endangered because much of its naturally restricted habitat has been

altered or destroyed, and it has been reduced to small disjunct populations throughout its range. The disappearance of nearly sixty percent of the original marshlands of the bay has resulted primarily from human activity such as filling, diking, and water pollution (Fradkin, 1977). The southern subspecies, R. raviventris, is considered the most threatened, since development has been heaviest in the central and southern portions of the bay. R. raviventris ranged throughout the salt marshes which originally encircled much of San Francisco Bay (Fisler, 1965). Although data on its present distribution are incomplete, there are recognized populations in relatively undisturbed marshland at Corte Madera, San Pablo Creek, South Oakland and San Leandro area, the Dumbarton and Alviso marsh complex, and the Palo Alto-Redwood City marshes (Fisler, 1965).

The East Bay shoreline has two substantial salt marshes, the Hoffman Marsh and the Emeryville Crescent Marsh (see map, p. vi). The Hoffman Marsh is enclosed by earth fill except for canals on its east and west sides. Tidal channels weave through an established covering of pickleweed, Salicornia. Smaller patches of marsh, some open to the bay, occur to the northwest. The accompanying report by Mark Oddi describes the Hoffman Marsh area in detail. The Emeryville Crescent Marsh fringes the L-shaped shoreline between the Emeryville Marina spit and Bay Bridge toll plaza. The present SMHM survey was conducted solely in this area because, in comparison to the Hoffman Marsh, it contains the most favorable SMHM habitat, would be most affected by current development proposals, and, in light of conservation goals, has a greater wildlife value in terms of species and habitat diversity. In addition, this area has no record of previous SMHM surveys, although the species' presence is assumed (Bodega Bay Institute, 1978). Two previous SMHM surveys in the Hoffman Marsh are described in detail in the discussion of local distribution.

Description of Survey Area

Salt marsh vegetation displays a zonation pattern which is directly related to the tolerance of each species to water and saline conditions (Bodega Bay Institute, 1978). Cordgrass, Spartina foliosa, tolerates regular tidal submersion where it grows along the water's edge. Pickleweed, Salicornia, a succulent-stemmed halophyte, occurs in the intermediate zone, often in extensive pure stands (Fisler, 1965). The higher areas are characterized by gumplant, Grindelia cuneifolia, which is interspersed with lower growing species such as saltgrass (Distichlis spicata), iceplant (Mesembryantheum), and sea lavender (Limonium californicum). Local topography and tidal height influence the amount of gradation between zones (Fisler, 1965).

Five distinct areas of the Emeryville Crescent Marsh are recognized: the northern and southern halves of the Sculpture Marsh, the Shellmound Marsh, the Neck, and the Duck Club Marsh (Bodega Bay Institute, 1978; FIGURE 2). The Sculpture Marsh borders Interstate 80 and is bisected by the Temescal Creek outfall. Two spits around the mouth of the creek extend outward into the bay and are covered with upland vegetation. This vegetation type, which includes gumplant, coyotebush, arroyo willow, and a variety of herbaceous plants and grasses, also occurs between the pickleweed zone and the highway. The Salicornia zone averages 100 meters wide in the northern section. The construction of driftwood sculptures here has created an extensive trampled area with pools of standing water between the upland and Salicornia zones. Sculptures extend into the Southern Sculpture Marsh for nearly three-fourths of its length. Past the sculptures, the Salicornia zone widens to roughly 175 meters.

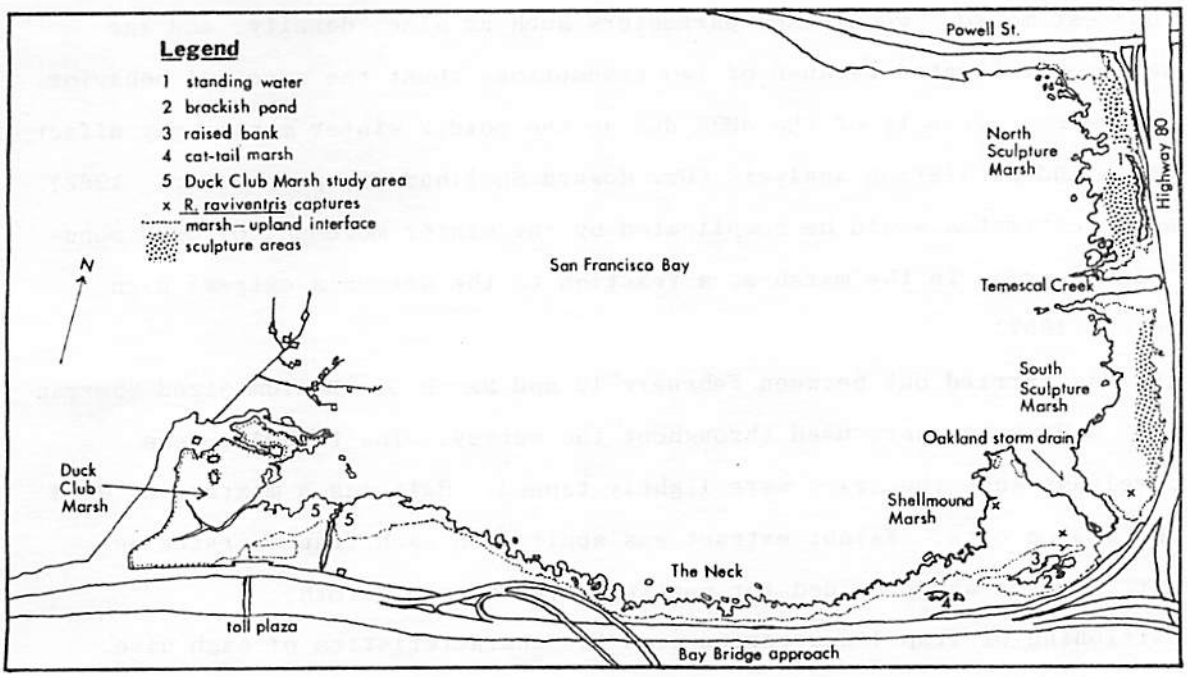

FIGURE 2. The Emeryville Crescent Marsh.
Adapted from an aerial photograph, SFB-38-14, 6/17/80, Army Corps of Engineers.

The Shellmound Marsh lies westward from the Oakland Storm Drain to the narrow portion of the marsh known as the Neck. Extensive stands of Salicornia of varied height and condition grow in the Shellmound Marsh. A raised sandy bank, running parallel to the bay across the Salicornia zone, supports Grindelia and associated plants. Tall stands of Salicornia, a brackish pond, and a cattail marsh lie between this bank and the upland vegetation bordering the highway. Stands of Spartina predominate in the Neck. The Duck Club Marsh, lying in the embayment formed by the Duck Club Spit, is largely a mixture of cordgrass and pickleweed and appears to be flooded frequently by tides.

The wide Salicornia zone at the southern end of the South Sculpture Marsh was surveyed for SMHM. In the Shellmound Marsh, the raised bank and stands of Salicornia on either side were surveyed, and higher areas supporting Grindelia and thick Salicornia along the outer edge toward the bay were also trapped. Two patches of relatively pure Salticornia along the southeastern edge of the Duck Club Marsh were surveyed. These areas were chosen because of their relatively large stands of pure Salicornia and dense upland vegetation, features considered favorable for SMHM.

Methods

The main goal of the live-trapping survey was to determine the presence of the salt marsh harvest mouse. Population parameters such as size, density, and age structure were not evaluated because of two assumptions about the species' behavior. First, the decreased activity of the SMHM during the colder winter months may affect capture success and population analysis (Dr. Howard Shellhammer, pers. corr., 1982). Second, density estimates would be complicated by the winter movement of SMHM populations to higher areas in the marsh as a reaction to the season's extreme high tides (Johnston, 1957).

Trapping was carried out between February 12 and March 3. Medium-sized Sherman live traps, 3" x 3" x 9", were used throughout the survey. The treadles were adjusted to release when the traps were lightly tapped. Bait was a mixture of wild bird seed and rolled oats. Walnut extract was applied to each trap entrance as an attractant. Cotton was provided for nesting material and warmth.

The positioning of trap lines varied with the characteristics of each site. An effort was made to place traps above nocturnal high tide levels to avoid drowning captures. Trap lines consisted of a straight series of thirty traps spaced at intervals of approximately 8 to 10 meters. Sixty traps were set each night. Captures were not marked and only one trap-related death occurred, that of a house mouse.

The following measurements and observations of captures were recorded: body length, tail length, ear length, hind foot length, tail to body ratio, diameter of tail 2 cm from body, sex, reproductive status, tail shape and coloration, body coloration, activity, and a habitat description of the trap locality.

Results

Ten house mice, Mus musculus, and two rats were caught in the Duck Club Marsh after two trap nights (TABLE 1). Three trap nights in the South Sculpture Marsh resulted in the capture of 22 house mice, 1 California vole, Microtus californicus, and 1 R. raviventris. The SMHM, a male, was captured in tall Salicornia averaging 34 cm that was roughly twenty meters from upland vegetation. Trap lines were set in the Shellmound Marsh for four nights. Capture results totaled 27 house mice, 4 voles, and 2 R. raviventris. A mature male was captured in Salicornia averaging 30 cm in height that was 25 meters from the raised sandy bank. Another male was captured in tall, thick Salicornia, averaging 42 cm, that was roughly 135 meters from the raised bank. The trap was located 4 meters from a Spartina-lined tidal inlet at the bay's edge. The low SMHM capture success of this study is attributed to the species' decreased activity during winter and the small number of traps used.) Measurements and observations of captured SMHM are given in TABLE 2).

Discussion

The salt marsh harvest mouse is the only rodent able to spend its entire life within the salt marsh environment. The fibrous material from pickleweed and other marsh vegetation compose the bulk of its diet; seeds and grasses are eaten to a lesser extent. Tall, thick Salicornia, which is submerged by the highest tides, is considered optimal habitat for R. raviventris (Wondellock et al., 1976). The species commonly occurs throughout Salicornia stands, but generally avoids Spartina and Spartina-Salicornia mixtures, which offer less cover and are flooded daily by tides (Fisler, 1965). Fisler (1965) observed R. raviventris venturing into the marsh-grassland interface during the spring. The mice are seldom found away from thick vegetative cover, which provides protection from predators such as owls, hawks, egrets, and herons (Fisler, 1965). The partially diurnal activity of R. raviventris, which increases its exposure to predators, emphasizes the importance of cover Fisler, 1965).

Table 1 Capture results, live trapping survey in the Emeryville Crescent Marsh, 1982.

	Duck Club Marsh			Shellmound Marsh					S. Sculpture Marsh			
	2/25	3/8	Total	2/12	2/17	2/23	2/27	Total	2/18	2/22	3/3	Total
house mice, *Mus musculus*	8	2	10	3	12	5	7	27	4	7	11	22
voles, *Microtus*	0	0	0	2	0	0	2	4	0	0	4	4
rat, unidentif.	2	0	2	0	0	0	0	0	0	0	0	0
R. raviventris	0	0	0	0	0	1	1	2	0	1	0	1

Table 2 Measurements and observations of captured R. raviventris in the Emeryville Crescent Marsh, 1982.

	S. Sculpture Marsh	Shellmound Marsh	
	2/22	2/23	2/27
body length	7.5 cm	6.4 cm	6.4 cm
tail length	7.8 cm	7.3 cm	7.4 cm
tail/body ratio	1.04	1.14	1.16
hind foot length	1.6 cm	1.4 cm	1.4 cm
ear length	0.9 cm	0.9 cm	0.7 cm
tip of tail	blunt	blunt	blunt
tail pattern	unicolor	unicolor	unicolor
tail hairs	no white hairs	no white hairs	no white hairs
behavior	placid	placid	placid
diameter of tail 2 mm from body	2.8 mm	2.7 mm	2.7 mm
sex	male	male	male
testes	desc.	desc.	desc.
venter coloration	grayish white cinnamon on edges	grayish white	grayish white
comments	- trap 20 meters from upland veg. - in tall *Salicornia* averaging 34 cm.	-trap 25 meters from upland vegetation -in tall *Salicornia* averaging 30 cm -dark upper body and ears	- trap 200 meters from upland vegetation - trap 4 meters from bays edge - in tall *Salicornia* averag. 42 cm - dark upper body and ears

Populations apparently congregate towards the higher areas of the marsh during the winter as a response to extreme high tides (Fisler, 1965). Dense vegetative cover along the upper edges of the marsh acts as an important refuge during the extreme high tides. Destruction of upland marsh vegetation is a significant factor in the displacement of SMHM populations. Fisler (1965) cites examples of this situation occurring in marshes south of San Rafael. His study is recommended as a thorough discussion of the ecology, taxonomy, and physiology of the Reithrodontomys of the Bay Area. Zetterquist (1977) reports the presence of R. raviventris in marginal habitats such as diked marshes and cattails. This study may have significant impact on current views of SMHM ecology and management, and expand the definition of predictable SMHM habitat. It merits further investigation.

Mortality factors include predation, drowning, winter chill, and water pollution. The decline in habitat may lead to the extinction of isolated populations whose numbers fall below the threshold level. Furthermore, small disjunct populations may tend toward inbreeding, limitations on the gene pool, and genetic random drift. These traits are deleterious to the population's adaptive potential and eventual survival (Zetterquist, 1977).

Local Distribution

The areas where R. raviventris was captured in the Emeryville Crescent, the Shellmound Marsh and the South Sculpture Marsh, contain favorable SMHM habitat. Each has large stands of Salicornia that are tall and dense in places. In addition, there is substantial vegetative cover along the upper edges of both areas. This is a critical feature to be looked for when evaluating the suitability of a habitat for SMHM. It is possible that R. raviventris inhabits the Duck Club Marsh, although it was not trapped. It would probably be restricted to the purer stands of Salicornia along the southeastern edge and surrounding utility pole islands in the middle of the marsh. These areas are bordered by thick upland vegetation. Much of this marsh appears to be too wet and lacking in upland cover to be good habitat for SMHM. It is unlikely that resident populations exist in the sparse patches of Salicornia found in the Neck. The sculpture areas of the Sculpture Marsh have sustained such extensive damage to the upper Salicornia zone and upland vegetation that resident SMHM populations are improbable. Trampling of vegetation destroys protective cover and critical upland refuges.

This distribution analysis is based on areas having optimal habitat features, but does not preclude the possibility that the SMHM may utilize less favorable

areas. The dispersal of mice throughout the marsh during the summer months, as reported by Fisler (1965), may occur within the study area. For example, wetter stands of Salicornia in the Duck Club Marsh and Salicornia areas behind the trampled sculpture sites may be frequented by nearby resident populations.

The other major marsh complex along the East Bay shoreline is the Hoffman Marsh (see map, p. vi; refer to the report by Mark Oddi, which investigates this area). No SMHM were found in two previous surveys of the Hoffman Marsh. A survey by the URS Research Company for Caltrans consisted of 150 trap-nights over 15 acres of shoreline vegetation (1972). Further procedural details are not given. There were no SMHM captured. The URS report did assume, however, that the SMHM inhabited the marsh because of suitable habitat and proximity to known SMHM localities to the north. The California Department of Fish and Game also surveyed the Hoffman Marsh and a narrow marsh channel to the northwest over three 46 trap-nights in June, 1978. None of the endangered species were found.

As part of this study, the Hoffman Marsh was surveyed for suitable SMHM habitat. The Salicornia covering the Hoffman Marsh is generally short-to-medium height and rarely dense. Dense upland vegetation is found only along the north and west sides and atop a raised levee running across the southern section of the Hoffman Marsh. Two marshes are located to the northwest on both sides of a railroad track levee. The marsh fringing the bay side is relatively wet but could develop into suitable SMHM habitat. The marsh on the other side of the tracks, referred to as the University Marsh in Mark Oddi's report, contains some dense pickleweed and thick upland vegetation on the eastern edge. This Salicornia stand and western portions of the Hoffman Marsh appear to have the most suitable SMHM habitat in the area. Additional surveys are needed to establish the status of the species in these areas.

Habitat Destruction

The sensitivity of the salt marsh environment has helped hasten its rapid decline in the San Francisco Bay region. Several processes altering SMHM habitat are presently occurring, or have the potential to occur, within the Emeryville Crescent Marsh. A visibly severe problem in the Crescent is the trampling of marsh vegetation by sculpture builders, sightseers, and birdwatchers. Pickleweed is extremely sensitive to trampling and regenerates very slowly (Bodega Bay Institute, 1978). Sculpture buildres can completely destroy the Salicornia surrounding their work in a matter of hours (Stephen Bailey, pers. corr., 1982). Moreover, marsh soils are readily compacted. Severe trampling can create a 'hardpan' surface

which resists recolonization by marsh vegetation, increases soil salinity, and decreases soil moisture (Bodega Bay Institute, 1978; see also paper by James Doyle). Trampled openings in the marsh vegetation eliminate protective cover and inhibit movement of the SMHM between the marsh and upland refuges. Sculpture builders presently cause the most trampling damage. Presumably, birdwatchers and hikers would tend to remain on the few rough trails that border the marsh. A California Highway Patrol officer related that he had observed up to twenty 'sightseers' in the marsh at one time, many of whom were illegally, and dangerously, parked along Highway 80.

Factors of vegetational change can alter SMHM habitat. Successional domination by Spartina can result from marsh subsidence; conversely, the Salicornia zone can be taken over by upland vegetation and grasses as sediment deposition occurs (Dr. Howard Shellhammer, pers. corr., 1982). The nature of vegetational change that might be caused by increasing freshwater discharge from Temescal Creek and the Oakland Storm Drain, and chemical pollution from these outfalls and the bay is not precisely known.

No studies concerning the displacement of R. raviventris by introduced species were located. The only small mammal that was found in substantial numbers in the Salicornia zone was the common house mouse. Schaub (1972) found large numbers of Mus present at established SMHM localities. Therefore, it is unlikely that Mus populations will significantly threaten the SMHM in the Emeryville Crescent.

Effects of Development

The viability of the Emeryville Crescent as a salt marsh harvest mouse habitat could be significantly altered by proposed commercial and recreational developments. The Golden Gate Audubon Society's publication, The Crescent (Bodega Bay Institute, 1978), is recommended for a thorough environmental assessment of some major proposals.

Santa Fe Land, Inc. presently owns the marsh and the feasibility of any project is dependent upon mitigation by them. The North Harbor site of the Port of Oakland is considered as a potential port terminal site in the Port of Oakland Shoreline Plan (1968) and by the Metropolitan Transportation Commission (Bodega Bay Institute, 1978). The facility would extend roughly 2/3 of a mile westwards from the western edge of the Duck Club Marsh. The large fill required for this project would decrease tidal flushing to the marsh. Additional marsh impacts from this facility would probably include increased human disturbance, turbidity of surrounding water, debris and chemical pollution, and acceleration of marsh sedimentation (Bodega Bay Institute, 1978). Essentially, any commercial or recreational

developments in the Crescent or adjacent areas would have deleterious effects on SMHM populations through such actions as filling, grading, pollution, and vegetation change induced by sedimentation.

Proposals for recreational development in the Crescent may conflict with preservational goals for the marsh and its associated wildlife. The East Bay Regional Park District (EBRPD) Master Plan - 1980 proposes a bicycle-pedestrian pathway to be constructed along the Emeryville Crescent as part of a regional shoreline trail (EBRPD, 1980, p. 21). Approximately 1.5 miles of Crescent marshlands and upland habitat are in the projected pathway. The trail, since it passes through a Caltrans right-of-way, has been classified as a Class I Bikeway and must meet certain specifications. A minimum 8-foot paved section within a 14-foot graded area is required and a 30-foot fenced buffer zone is recommended between the trail and the highway (Bodega Bay Institute, 1978). Construction of this trail is likely to result in increased trampling from heavy equipment and workmen, mechanical destruction of marsh and upland vegetation, increased sedimentation and erosion from grading and fill, and the creation of a barrier between the Salicornia zone and the upland refuges used by the SMHM. Greater human activity in the marsh, as a result of the trail, would likely increase trampling damage. Proposed moats and fences designed to prohibit this intrusion would also destroy marsh vegetation, alter natural sedimentation and drainage, and create barriers between the upland and marsh zones (Bodega Bay Institute, 1978). These factors suggest that the construction of the proposed bikepath would have significant adverse effects on R. raviventris habitat.

The Crescent is recognized as containing sensitive natural habitat with important wildlife value. Several proposals would maintain the salt marsh and increase public access in a manner less damaging than the bike trail. Some representatives of local and state agencies concerned with the Crescent's future contend that any projected land use plan should increase access and benefit the general public in order to gain public and financial support. Peter Koos of EBRPD feels that increasing the public's awareness of the Crescent's value through controlled access will eventually help eliminate activities in conflict with preserving the area. Public access should be restricted to the upland-marsh interface and be properly controlled to minimize the damage that it may cause.

The establishment of an interpretive boardwalk through the marsh may produce several detrimental effects on SMHM habitat. Construction of the boardwalk could

alter the marsh in a manner similar to the proposed bikepath construction. Wildlife in the marsh can be disturbed by dogs and humans on the boardwalk. Dogs and people leaving the walkway could destroy marsh vegetation and prey upon wildlife. If this project is implemented, several measures should be taken to minimize damage to the marsh. These include delicate and conscientious construction of the boardwalk on raised piles, railing to contain visitors, prohibiting dogs, interpretive and regulatory signs, and a full-time 'ranger' with adequate policing authority.

A more favorable option for preserving the SMHS habitat would be the location of interpretive centers and observation platforms at the Duck Club Marsh and Northern Sculpture Marsh. These platforms would be located in upland areas and not in the marsh directly. These would increase public awareness of this natural resource and help validate the need for a full-time 'ranger' to monitor activities. Adequate fencing along the highway and at either end of the crescent is suggested to help preserve the salt marsh.

It is further suggested that human activity in the sculpture area be curtailed, especially in the Southern Sculpture Marsh. If a sculpture area must be maintained, it should be limited to the Northern Sculpture Marsh, as this would not likely affect the survival of the SMHM in the Crescent.

If present forms of use of the marsh continue they will have adverse results. Informal and unrestricted uses of the marsh, such as sculpture building, will continue to increase and eventually cause extensive damage. Furthermore, implementation of official conservation goals in the Crescent would preclude any adverse development options. It must be emphasized that the balancing of political, economic, social, and scientific interests in this issue is a delicate process with many complex variables. Many public and private groups have a stake in this process and the eventual outcome may not necessarily reflect conservation goals.

Summary

R. raviventris is present in the Emeryville Crescent Marsh. Further research is necessary to gain details on its distribution and population ecology at this locality.

A number of proposed developments for the marsh could be detrimental for the survival of the species there. A suggested project to protect the SMHM in this area would start with the exclusion of human traffic by constructing fences along the highway and at either end of the marsh. Mimimal limits of this fence would be at Temescal Creek and the beginning of the Neck section. Interpretive information

and observation platforms made available at each end of the Crescent are recommended to increase public support and awareness of this natural resource. A full-time 'ranger' to monitor activities is suggested. The need to limit public access is important because of the sensitive character and small size of this marsh.

The loss of the Crescent as a habitat for R. raviventris would continue the trend toward range fragmentation of the species and bring it a step closer to extinction. It is hoped that the decisions concerning the Crescent's future will be favorable for the preservation of this endangered species.

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