Suisun shrew, *Sorex ornatus sinuosus*
Paul W. Collins

Description: This is a small (91-108 mm TL), dark, nearly black shrew with a long (35-48 mm), nearly unicolored tail; steely black dorsum; dark clove-brown ventrum; and slightly larger, higher skull with a somewhat broader rostrum (Grinnell 1913, Jackson 1928, Rudd 1955a, Museum Specimen Inventory). *S. o. sinuosus* is the darkest subspecies of ornate shrew (Owen and Hoffmann 1983). According to Grinnell (1913), *sinuosus* is easily distinguished from adjacent upland *californicus* by its slightly larger size, darker coloration, and deep clove-brown colored ventrum (which is silvery-gray in *californicus*). The summer pelage of *sinuosus* is paler and more brownish (less blackish) than the winter pelage (Grinnell 1913). Weight is from 3.4-6.8g for males and 3.3-6.7g for females (Rudd 1955b), generally heavier than sympatric *californicus* (Rudd 1955b).

Taxonomic Remarks: Grinnell (1913) described the Suisun shrew as a species, *S. sinuosus*. Brown (1970, 1974) found the karyotypes of *S. ornatus* and *S. sinuosus* to be similar, and both distinct from *S. vagrans* populations in the San Francisco Bay area. He also found that the karyotypes found in Bay area populations that were previously thought to be *S. v. vagrans*, or hybrids of *vagrans*, *ornatus*, and *sinuosus*, were more similar to *ornatus* and *sinuosus*. Based on additional genetic studies, Brown and Rudd (1981) included the Suisun shrew as a subspecies of *S. ornatus*. Hall (1981) recognized the species status of *sinuosus* whereas others (Williams 1979, Junge and Hoffmann 1981, Wilson and Reeder 1993) recognized it as a subspecies of *S. ornatus*.

The systematics of shrews in the San Francisco Bay region remains complex and unresolved. *S. o. californicus* are considered to occupy upland habitats in the region whereas two different, darker subspecies occupy the salt marshes: *S. v. halicoetes* in the South Bay, and *S. o. sinuosus* in the North Bay (San Pablo and Suisun bays) (Junge and Hoffmann 1981). Rudd (1955b) evaluated morphological variation in salt marsh-inhabiting populations of shrews along the north shore of San Pablo (Tolay Creek) and Suisun bays. Based on the intermediate nature of morphological characters found in the shrew populations at Tolay Creek, he concluded that hybridization could be occurring between *S. vagrans vagrans* and *S. sinuosus*. However, Brown (1970, 1974) determined that the purported hybrid populations in the San Pablo Bay area possessed karyotypes typical of *S. ornatus*, and found no evidence of interbreeding between *vagrans* or *ornatus* despite the occurrence of populations of both species near Petaluma and north of San Rafael. Brown and Rudd (1981) concluded that "populations from Tolay, Novato, and San Antonio Creeks and from the Petaluma River that were once considered *S. vagrans* or hybrids are now considered slightly differentiated populations of *S. o. californicus*," while populations on Tubbs Island and in marshes east of Sonoma Creek are *S. o. sinuosus*. The identity of shrews from Solano County in the vicinity of Lake Chabot (Williams 1986), and from salt marshes along the lower part of the Napa River, approximately 5 mi (8 km) northwest of Vallejo (Longhurst 1940) remain uncertain.

Distribution: *S. o. sinuosus* has a restricted geographic distribution. It occurs in tidal and brackish marsh communities along the north shore of San Pablo and Suisun bays, from Sonoma Creek and Tubbs Island, Sonoma County on the west (Brown and Rudd 1981), eastward to Grizzly Island, Solano County (Williams 1986). Although Rudd (1955a) identified the range of *sinuosus* as extending west to the mouth of Petaluma Creek, recent studies suggest that shrews inhabiting tidal and brackish marshes west of Sonoma Creek (Brown and Rudd 1981) and east of Grizzly Island (Williams 1983) are *S. o. californicus*.

Life History: There is somewhat more information available on the biology of *S. o. sinuosus* compared to other subspecies of *Sorex ornatus*. Life history data of *S. v. halicoetes* and *S. o. relictus*

probably also apply to this taxon (see *S. v. halicoetes* and *S. o. relictus* accounts). As with other *S. ornatus* subspecies, reproduction in *sinuosus* from late February, peaks in April and May, with a second smaller breeding peak in late summer and early fall as young of the previous spring begin to breed (Rudd 1955b, Owen and Hoffmann 1983). Suisun shrews are active both day and night but during the breeding season are more active nocturnally (Newman and Rudd 1978a, Rust 1978).

Suisun shrews have high minimum (4.5 Kcal/day) and maximum (6.0 Kcal/day) metabolic rates which require that individuals consume a large volume of food daily to survive (Newman and Rudd 1978a). Torpor has been observed in *S. o. sinuosus* (Newman and Rudd 1978b), which enhances survival by reducing energy intake demands. Although Suisun shrews were found to be one of the largest small mammal consumers of energy in the salt marsh community, their numbers are apparently not limited by food availability (Newman 1970). Densities have been recorded up to 111/ha (Newman 1970), with substantial seasonal and annual fluctuations. No data are available on home range size. Diet is probably composed largely of amphipods, isopods, insects and other invertebrates.

Habitat: *S. o. sinuosus* inhabits salt and brackish marshes around the northern margins of San Pablo and Suisun bays (Owen and Hoffmann 1983). According to Williams (1986), Suisun shrews inhabit "tidal marshes characterized in order of decreasing tolerance to inundation, by *Spartina foliosa*, *Salicornia ambigua*, and *Grindelia cuneifolia*, and brackish marshes dominated by *Scirpus californicus* and *Typha latifolia*." In general, salt marsh shrews prefer areas of low, dense vegetation, which provide adequate cover and nesting places along with a plentiful supply of invertebrates (Johnston and Rudd 1957, Rudd 1955b). According to Rudd (1955b), structure rather than species composition of a plant community determined whether an area was suitable for Suisun shrews. Hadaway and Newman (1971) captured Suisun shrews most often at the junction between *Salicornia* marshes and upland levees vegetated with coyote brush (*Baccharis* sp.) and grasses. Rudd (1955b) suggested that driftwood and other surface litter above the mean high-tide line is an important habitat feature for nesting and foraging. Like *S. vagrans halicoetes*, Suisun shrews probably inhabit marshlands 1.8 to 2.4 m above sea level which are not regularly flooded by tidewater (Johnston and Rudd 1957).

Contiguous upland habitats may provide important refuge during flooding of salt marshes (Williams 1983). However, Hadaway and Newman (1971) recorded no difference in the catch effort of *S. o. sinuosus* between dry periods and periods of inundation which they felt indicated that this species may react to flooding by staying within its home range rather than seeking higher ground.

Status: Class II. Recent trapping efforts suggest that the Suisun shrew is rare, but data are insufficient to consider listing appropriate. Also, this taxon's habitat is protected by virtue of its occurrence with the salt marsh harvest mouse (*Reithrodontomys megalotis*) and California clapper rail (*Rallus longirostris obsoletus*), both of which are protected under State and Federal endangered species acts. All of the marshes from which Suisun shrew populations are known are proposed as critical habitat for the salt marsh harvest mouse (Shellhammer et al. 1984).

This taxon has been adversely affected by the degradation and loss of salt and brackish marsh habitats in the San Pablo and Suisun bays. When Europeans arrived in the San Francisco Bay Area more than 200 years ago, the salt and brackish marshes around San Pablo and Suisun bays covered 547 square kilometers (Shellhammer et al. 1984). Since then, more than 77% (421 of 547 sq km) of these marshes have been filled, flooded, or converted to other types of vegetation (Jones and Stokes et al. 1979). Today there are only 70 sq km of marsh present around San Pablo Bay and 55.7 sq km around Suisun Bay (Shellhammer et al. 1984). Loss of this amount of marsh habitat has undoubtedly

had a profound effect on the overall size and distribution of Suisun shrew populations and is the principal reason for concern about the present status of this taxon.

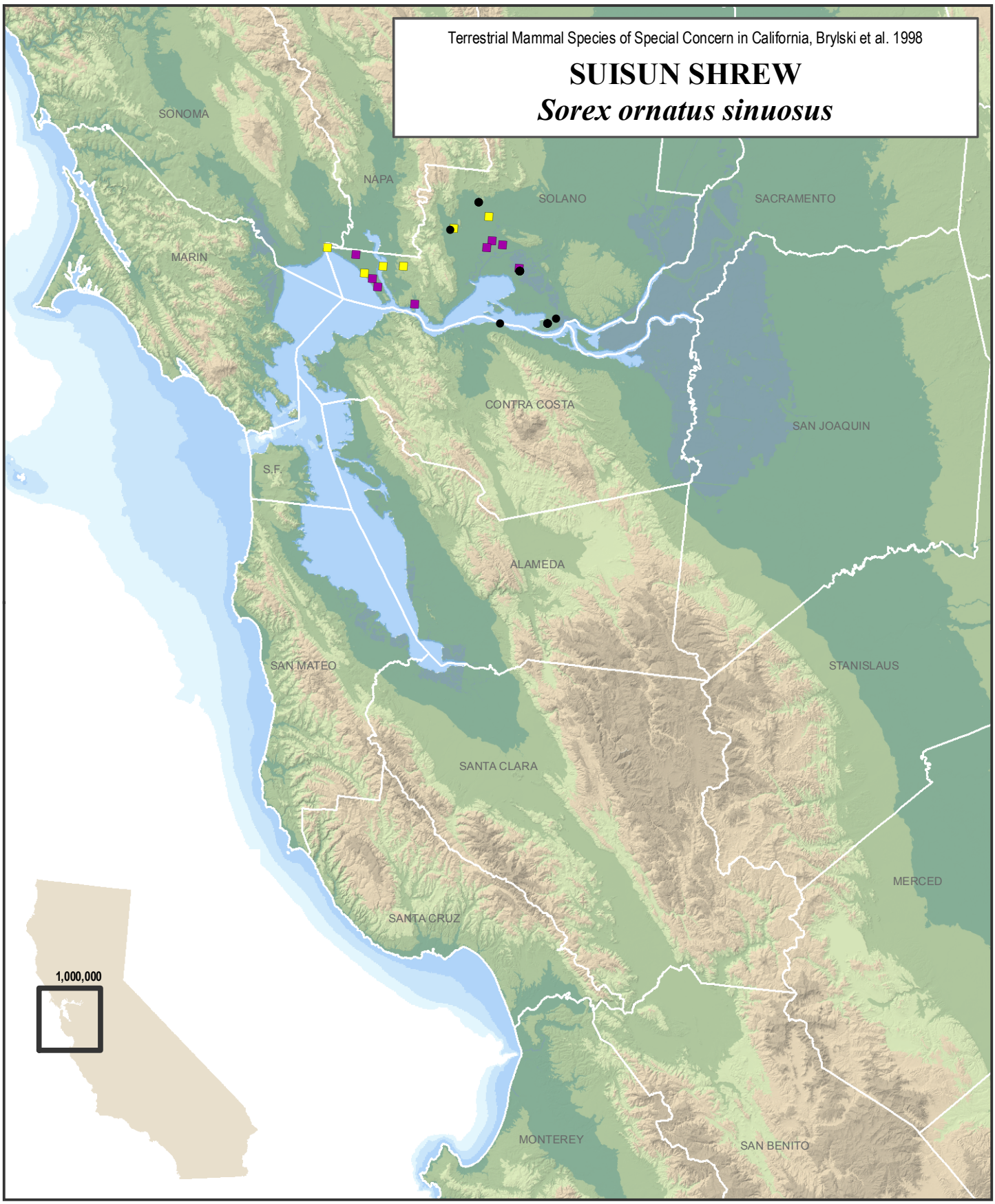
There are few recent records of the Suisun shrew. Except for Williams' (1983) study, there have been no other range-wide attempts made to locate and determine the status of extant populations of *S. o. sinuosus*. Williams (1983) reported a dead specimen on Grizzly Island in 1983 but survey efforts the same spring and summer in marshes throughout San Pablo and Suisun bays resulted in no captures. One individual was captured along the northern perimeter of Suisun Bay in 1985 (Williams 1986). Surveys at the Mare Island Naval Shipyard in Solano County captured two individuals in September 1987 and 16 between May and October 1990 (California Natural Diversity Data Base records). Maldonado (pers. comm.) captured a total of 16 individuals in late July and early August 1990 at the Grizzly Island Wildlife Area and at Rush Ranch. Although these records indicate that populations of this taxon occur in and around San Pablo and Suisun bays, the remaining potential habitat has been estimated at several thousand acres distributed among two dozen patches of marshland (Williams 1983).

The decline of the Suisun shrew is attributable to: *a*) loss and fragmentation of salt and brackish marsh in the San Pablo and Suisun bays due to diking, flooding, and filling of marshes for urban, industrial, and agricultural developments; *b*) the loss of adjoining upland habitats; *c*) habitat degradation due to sediment deposition from hydraulic mining in the Sierra Nevada Mountains during the 1980s; and d) creation of diked wetlands, bordered by steep earthen levees, which are managed solely for waterfowl (Williams 1983, 1986; Shellhammer et al. 1984).

The grassland and unsubmerged halophytic borders above the remaining marsh habitats, which serve as refuge for shrews during the highest tides and extended periods of flooding, have also been reduced (Shellhammer et al. 1984). And while the reduced refuged space along dikes may be sufficient for shrews to escape normal high tides, it may be insufficient for populations to survive during longer periods of prolonged flooding (Williams 1983). The influence of flooding may account for the low trap success which Williams reported for Suisun shrews in 1983 following the widespread and record high and sustained flooding that occurred during the winter of 1982-1983 in San Pablo and Suisun bays.

There is concern over whether the remaining marshes in San Pablo and Suisun bays can sustain populations of Suisun shrews because of their small size, their fragmentation, and the absence of upland refugium habitat. The marshes in Suisun Bay at Grizzly Island, Hill Slough and Peytonia Slough, and in San Pablo Bay at Fagan Marsh are thought to provide suitable marsh and upland habitats (Williams 1983).

Management Recommendations: Natural history studies on habitat relations, dispersal, factors affecting mortality, and population size, and genetic viability are needed. Genetic studies now underway are expected to resolve the systematic status of this taxon. (J. Maldonado pers. comm.). Management plans and practices for occupied tidal and non-tidal marshes administered by public and/or private agencies should be reviewed for their impacts on Suisun shrew populations. Habitat management for the Endangered salt marsh harvest mouse and California clapper rail may benefit the Suisun shrew (Shellhammer et al. 1984), but confirmation of this requires additional research. Wherever possible, tidal and brackish water marshes within the historic range of this taxon should contain a buffer zone of upland vegetation contiguous with the marsh, which is kept free of disruptive manipulations such as freshwater flushing, plowing, mowing, and/or burning.


Terrestrial Mammal Species of Special Concern in California, Brylski et al. 1998
SUISUN SHREW
Sorex ornatus sinuosus
SONOMA
NAPA
SOLANO
SACRAMENTO
MARIN
CONTRA COSTA
SAN JOAQUIN
S.F.
ALAMEDA
SAN MATEO
STANISLAUS
SANTA CLARA
MERCED
SANTA CRUZ
MONTEREY
SAN BENITO
1,000,000
RESOURCES AGENCY
CALIFORNIA
DEPARTMENT FISH & GAME
Locations verified by authors
(captures, observations, museum records)
CNDDB 1979 - 1998
CNDDB 1978 and before
Wildlife Branch:KFien12109