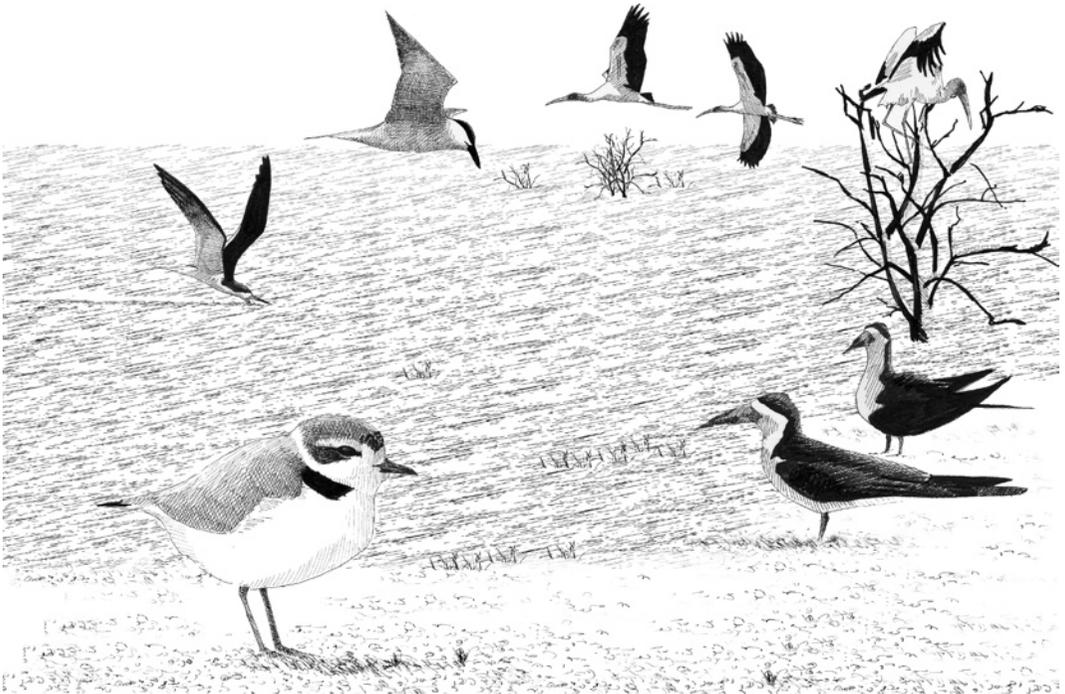


## II

---

# SPECIES ACCOUNTS

---



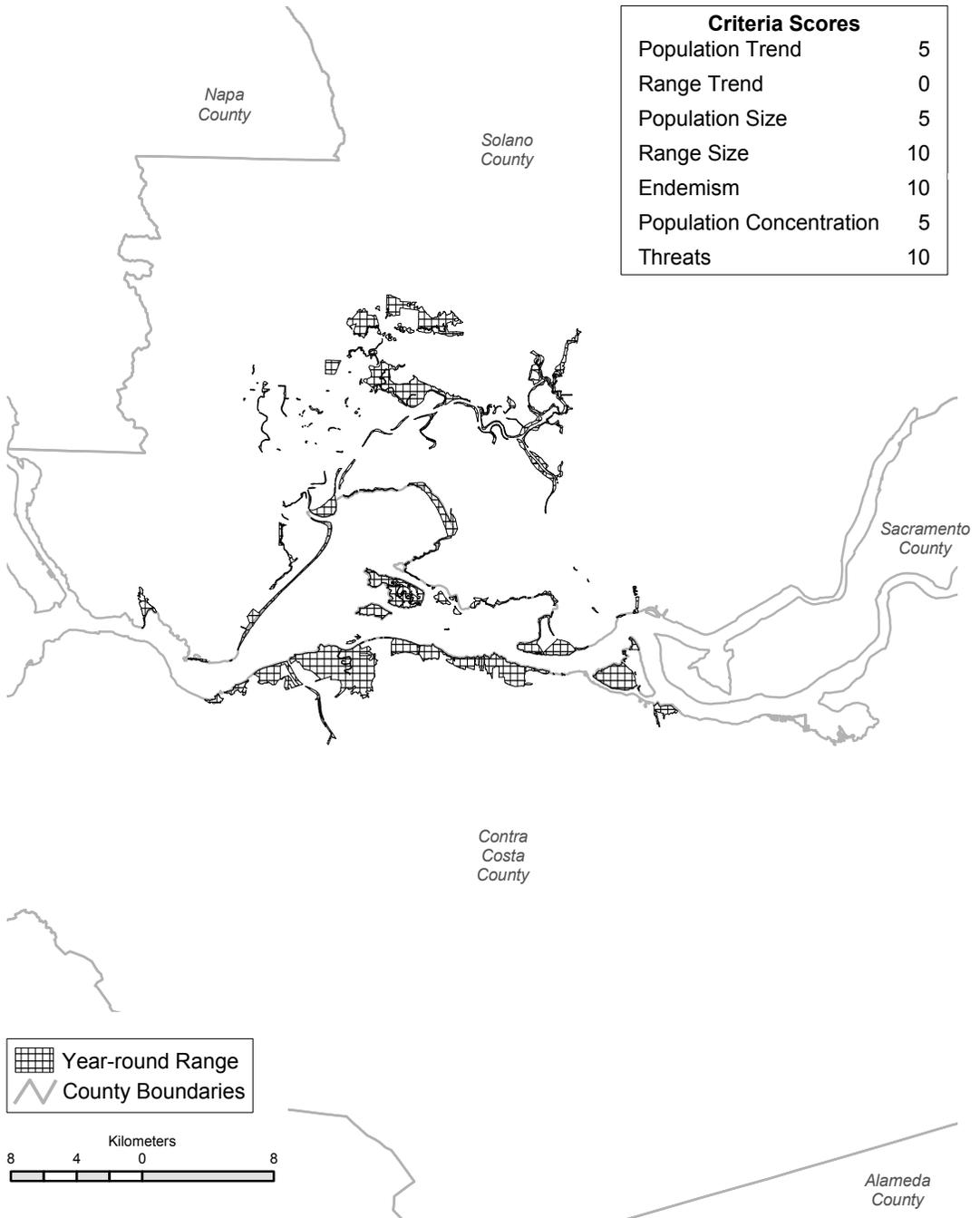
*Andy Birch*

PDF of Suisun Song Sparrow account from:

Shuford, W. D., and Gardali, T., editors. 2008. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.

# SUISUN SONG SPARROW (*Melospiza melodia maxillaris*)

HILDIE SPAUTZ AND NADAV NUR



Year-round range of the Suisun Song Sparrow, a California endemic, on the basis of recent fine-scale mapping of tidal marsh in areas of occupancy. Restricted to Suisun Marsh from the Carquinez Strait east to the confluence of the Sacramento and San Joaquin rivers near Antioch. Overall outline of range remains the same, though numbers appear to have declined at least slightly since 1944 (greatly since the 1850s).

### SPECIAL CONCERN PRIORITY

Currently considered a Bird Species of Special Concern (year round), priority 3. Not included in the original list (Remsen 1978), but included on CDFG's (1992) unprioritized list.

### BREEDING BIRD SURVEY STATISTICS FOR CALIFORNIA

Data inadequate for trend assessment (Sauer et al. 2005).

### GENERAL RANGE AND ABUNDANCE

Song Sparrows (*Melospiza melodia*) range from southern Alaska across central and southern Canada south through the United States into northern (locally to central) Mexico and Baja California; sparrows occupy a large part of northern range in summer only, much of mid-central and southern portion in winter only (AOU 1998, Arcese et al. 2002). In California, the species is resident in much of the state except for the higher mountains and most of the southeastern deserts away from the Salton Sink and Colorado River valley (Grinnell and Miller 1944, Small 1994). Of the 24 subspecies currently recognized, 9 occur in California (Patten 2001, Arcese et al. 2002).

The Suisun Song Sparrow (*M. m. maxillaris*) is a California endemic. Its year-round range is confined to tidal salt and brackish marshes fringing the Carquinez Strait and Suisun Bay east to Antioch, at the confluence of the San Joaquin and Sacramento rivers (Grinnell and Miller 1944). Abundance varies greatly by site, but highest numbers are currently found in Benicia State Park and Martinez shoreline (see below).

Recent studies by Patten (2001) confirm that *maxillaris* is phenotypically distinct from birds to the west in San Pablo Bay and those breeding to the east in the Sacramento Valley, but Chan and Arcese (2002) could not establish that *maxillaris* is genetically differentiated from these two adjacent subspecies.

### SEASONAL STATUS IN CALIFORNIA

Year round, nonmigratory; breeds from early March to July (PRBO unpubl. data).

### HISTORIC RANGE AND ABUNDANCE IN CALIFORNIA

Grinnell and Miller (1944) described the Suisun Song Sparrow as an "abundant" resident in the brackish estuarine marshes, at or near sea level,

in Suisun Bay from the vicinity of the confluence of the Sacramento and San Joaquin rivers west to the Carquinez Straits. This included the once vast brackish tidal marshes in northern Suisun Bay, the marshes along the southern edge of the bay in northern Contra Costa County, an isolated area of marsh in Benicia, and numerous marsh islands probably as far east as Browns Island near Antioch. Specimens were collected prior to 1944 in Antioch, Martinez, and Port Costa, Contra Costa County, and at Grizzly Island, Cordelia Slough, and Benicia, Solano County (Grinnell and Miller 1944).

No prior quantitative estimates of historic abundance exist, but such estimates have recently been made on the basis of estimates of historic tidal marsh habitat and current sparrow densities. Prior to development, diking, and filling that began in the 1800s, there were about 26,000–26,500 ha of tidal marsh fringing Suisun Bay (Marshall and Dedrick 1994, SFEI 1998). By 1944, the area of remaining marsh habitat was likely close to what is available at present. On the basis of Grinnell and Miller's (1944) observations and recent studies indicating Song Sparrows are presently ubiquitous residents of even the smallest marsh fragments where sufficient high marsh vegetation exists (PRBO unpubl. data), Suisun Song Sparrows were likely present predevelopment throughout Suisun Bay marshes. The predevelopment breeding population was between 202,000 and 313,000 breeding birds, assuming that historic densities were similar to current estimates and the habitat extent was 26,250 ha (the mean of the range estimate). The higher figure is based on an observed mean density of 14.9 Song Sparrows per ha (PRBO unpubl. data) and an assumption that 20% of adults are "floaters" (i.e., nonbreeders; Nur et al. 2000), whereas the lower figure is based on an observed mean number of breeding birds documented at two typical sites in Suisun Bay, Benicia State Park and Rush Ranch (mean = 7.7 breeding birds per ha; see below). Marshall and Dedrick's (1994) published estimate of historic population size of at least 140,000 individuals is based on densities of the Samuels Song Sparrow (*M. m. samuelis*) in Richmond, Contra Costa County, which tend to be lower than densities of the Suisun Song Sparrow. Thus, this estimate is probably too low.

If the extent of remaining marsh habitat in 1944 was close to that at present, which is uncertain, the breeding population size in 1944 was likely close to the current population size: 43,000 to 66,000 (see below). It seems reasonable

to expect, though, that sparrow numbers were somewhat higher in 1944 than now because of the direct and indirect effects of a huge increase in human population around the bay in subsequent decades.

### RECENT RANGE AND ABUNDANCE IN CALIFORNIA

Despite local extirpations and declines from habitat loss and degradation, and increases from habitat enhancement and restoration, the overall range and extent of habitat for the Suisun Song Sparrow appears to be relatively unchanged since Grinnell and Miller's (1944) time (see map).

Currently, Suisun Bay holds an estimated 3735 ha of fully tidal marsh, 1842 ha of muted tidal marsh, and 20,069 ha of managed and diked marsh (SFEI 1998). Thus, the total area of potentially available prime habitat (fully and muted tidal marsh) is presently about 20% of predevelopment tidal marsh. The area's tidal marshes today are highly fragmented and separated by large areas of managed marsh, especially in northern Suisun Bay within Grizzly Island. There are no continuous tracts of fully tidal marsh greater than 1000 ha: 13 parcels are >100 ha, 103 are 2–100 ha, and 76 are <2 ha (SFEI 1998). Half of the existing tidal marsh habitat, and presumably at least half of the existing population of Suisun Song Sparrows, is found within the seven largest sites.

The abundance of Suisun Song Sparrows in tidal marsh varies considerably among sites. Absolute densities (calculated with DISTANCE software; Buckland et al. 1993) range from <5 birds per ha at Hill and Cordelia Sloughs to >21 birds per ha at Martinez Shoreline (PRBO unpubl. data). The mean density for 11 Suisun Bay sites surveyed in 2000 was 14.9 birds per ha (95% C.I.: 11.3–19.6 birds per ha; PRBO unpubl. data). Densities derived independently from intensive spot mapping in 2000 and 2001 ranged from 6.5–6.9 birds per ha at Rush Ranch to 8.4–9.0 birds per ha at Benicia State Park (PRBO unpubl. data). Marshall (1948) found 2.8 birds per ha at Benicia in the 1940s. In 1990, Marshall and Dedrick (1994) spot mapped the area later studied by PRBO at Rush Ranch and found 5.1 birds per ha.

The most recent estimate of the total number of Suisun Song Sparrows is 43,000 to 66,000 breeding birds on the basis of 5578 ha of tidal and muted tidal marsh in Suisun Bay (PRBO unpubl. data). The higher figure is based on an observed mean density of 14.9 birds per ha (PRBO unpubl. data) and an assumption that 20% of adults

are “floaters,” or nonbreeders (Nur et al. 2000), whereas the lower figure is based on an observed mean of 7.7 breeding birds per ha at two typical sites in Suisun Bay, Benicia State Park and Rush Ranch. Marshall and Dedrick (1994) estimated the population size to be about 19,000 individuals from a calculated area of 3480 ha of tidal marsh and Johnston's (1956b) density of 5.49 birds per ha for Samuels Song Sparrows studied in Richmond. The population using managed marsh in the Grizzly Island area has not been thoroughly studied; Marshall and Dedrick (1994) estimated at least 400 additional birds breeding in this habitat, but true numbers are likely to be much higher (H. Spautz pers. obs.).

### ECOLOGICAL REQUIREMENTS

Suisun Song Sparrows occur in virtually every tidal marsh in Suisun Bay, though densities vary considerably, presumably reflecting variation in habitat suitability (PRBO unpubl. data). As with all Song Sparrow subspecies, dense vegetation is required for nesting sites, song perches, and cover for refuge from predators (Marshall 1948). Where vegetation is too short and sparse, Suisun Song Sparrow nests are more likely to be exposed to predators or flooding during high tides (Marshall 1948, Johnston 1956a, PRBO unpubl. data). The dominant plants of tidal marshes in Suisun Bay vary greatly with salinity. In portions of Benicia State Park at Southampton Bay, there is California Cord Grass (*Spartina foliosa*) in low elevations, Pickleweed (*Salicornia virginica*) at higher elevations, and Gumplant (*Grindelia stricta*) on the highest ground along slough edges and levees. In more brackish areas, there is a higher diversity of plants and the above species are interspersed with numerous others, particularly *Scirpus* (*S. acutus*, *S. americanus*, and *S. californicus*), cattail (*Typha* spp.), *Juncus balticus*, and, increasingly, the non-native invasive Peppergrass (*Lepidium latifolium*). In managed marshes, Song Sparrows tend to be found in relatively low numbers in taller vegetation such as cattail and *Scirpus* found next to pooled water along levees; Song Sparrows tend to be absent where the marsh is permanently flooded or allowed to dry completely in the spring and summer (Walton 1975, Marshall and Dedrick 1994, PRBO unpubl. data).

Suisun Song Sparrows are associated primarily with tidal channels, especially in marshes where Pickleweed dominates and Gumplant lines the channels. Sparrow territories are lined single file every 10 to 50 m along sloughs, providing each

pair with access to the slough and its overhanging banks for food and cover. In San Pablo Bay, Song Sparrow territories along natural channels are smaller than those along man-made channels (mosquito ditches), suggesting the natural habitat is of higher quality (Collins and Resh 1985), but this has not been studied in Suisun Bay. In marshes where there are no sloughs, some tidal influence is still required; few Song Sparrows occur in diked areas with stagnant water (e.g., southern Goodyear Slough). In brackish or freshwater marshes with substantial cover of tall *Scirpus maritimus*, Tule (*S. acutus*), or cattail (e.g., Point Edith and Rush Ranch), the association of Song Sparrows with channels is weaker (H. Spautz pers. obs.).

Exposed ground for foraging is also a requirement. In salt marshes, dense Pickleweed is opened up by small mammals and tidal action. Marshall (1948) noted that the densest vegetation used by Song Sparrows is *Scirpus* with at least 2- to 5-cm spaces at their bases, providing openings for foraging on the ground. The year-round diet of the Song Sparrow in California is roughly 79% vegetable and 21% animal matter, the latter taken mostly in May (Beal 1910).

Analyses of the relationship between the abundance of tidal marsh Song Sparrows (all three subspecies) and a series of vegetation and habitat variables around point count stations indicate that abundance varies significantly with four variables (Spautz et al. 2006). Sparrow abundance responded positively to shrub cover (primarily Gumplant and Coyote Brush [*Baccharis pilularis*]) and negatively to *Juncus* cover, which tends to be too sparse or short for nesting, and to pond cover. At the landscape level, all three tidal marsh Song Sparrow subspecies (including the Samuels and Alameda [*M. m. pusillula*] Song Sparrows) were positively associated with marsh size and proportion of adjacent natural upland, and negatively with the proximity to nearest water edge and with proportion of adjacent marsh (tidal or nontidal) or agriculture (Spautz et al. 2006). Thus, Song Sparrows tend to be denser along upland edges of large marshes, especially where shrubs are present.

Nest height of Suisun Song Sparrows averaged 36 cm (SD = 16,  $n = 875$ ; PRBO unpubl. data) and nest success ranged from 2% to 27% at two sites in Suisun Bay, Benicia State Park and Rush Ranch, between 1996 and 2004 (Spautz et al. 2003, Herzog et al. 2004). Though adult and juvenile survival rates are unknown for this subspecies, if they are typical of other Song Sparrows, then nest success rates would need to be 25% or higher to achieve long-term population stability

(PRBO unpubl. data). Predation is the highest cause of nesting failure (74%) versus tidal flooding (1% of nests), abandonment (2% of nests), and failure to hatch (4% of eggs; Spautz et al. 2001, PRBO unpubl. data). Sites where nest success was lowest and predation highest were smaller, had higher perimeter-to-area ratios, and were more isolated (PRBO unpubl. data). Thus, even though Suisun Song Sparrows are present in marsh fragments of a large size range, low reproductive success at smaller, more isolated marshes may not be sufficient to replace birds lost to mortality at these sites.

Suisun Song Sparrow nests are found in a large variety of substrates, including but not limited to *Scirpus americanus*, *S. maritimus*, *S. acutus*, *Grindelia stricta*, *Lepidium latifolium*, *Salicornia virginica*, *Juncus balticus*, *Distichlis spicata*, and *Triglochin maritima* (PRBO unpubl. data). Nests built in the non-native invasive *L. latifolium* are apparently no less likely to be successful than nests built in native plants (Spautz and Nur 2004). Nesting requirements and overall success of nests in muted and nontidal, managed marshes in Suisun Bay have not been studied.

## THREATS

Further habitat loss, fragmentation, and degradation are the primary threats to the Suisun Song Sparrow (Takekawa et al. 2006). Alteration of marsh habitat by non-native invasive Cord Grass (*Spartina* spp.) may also have adverse effects (Gutenspergen and Nordby 2006), although the effects of the non-native plant, Peppergrass, are apparently neutral or positive (Spautz and Nur 2004). Increased diversion of fresh water from the San Joaquin and Sacramento rivers has caused increases in salinity in Suisun Bay (Peterson et al. 1995), which may eventually favor vegetation adapted to saline rather than brackish conditions, particularly in the bay's southern portion. The extreme northern portion of tidal marsh (around Hill Slough and Rush Ranch) is less likely to be affected (Scollon 1993, Cogswell 2000). Although Alameda Song Sparrows are adapted to drinking salt water at seawater concentrations, the comparable tolerance of Suisun Song Sparrows is unknown (Basham and Mewaldt 1987).

There also are concerns that habitat fragmentation and lack of sufficient dispersal corridors will impede dispersal following catastrophic disturbance or habitat changes, such as those resulting from rapid salinity changes (Scollon 1993, Cogswell 2000). Because Suisun Song Sparrows

and other tidal marsh subspecies are highly sedentary, it has been assumed that birds are unlikely to disperse across inhospitable habitat. Larsen (1989 cited in Cogswell 2000) assumed a maximum dispersal distance of 50 m across inhospitable habitat, which is unrealistically small. However, maximum dispersal distance is not known. A study of color-banded Suisun and Samuels Song Sparrows found that juvenile birds commonly disperse up to 1 km within tidal marsh habitat, but successful dispersal of birds across large stretches of unsuitable habitat has not yet been confirmed (PRBO unpubl. data). Chan and Arcese (2002) found no genetic differentiation between Samuels and Suisun Song Sparrows and their neighbors to the east, suggesting dispersal occurs among the populations or there has been insufficient time since genetic isolation for differences in microsatellite differentiation to develop.

Reproductive failure caused by high levels of nest predation may also have a significant impact. Predators include non-native species, such as the house cat (*Felix catus*), Norway Rat (*Rattus norvegicus*), and Red Fox (*Vulpes fulva*), and some native predators, such as the American Crow (*Corvus brachyrhynchos*) and Common Raven (*Corvus corax*), that respond positively to human disturbance. Nest success was significantly lower in the Suisun sites than at three San Pablo Bay sites and lowest of all California tidal marsh sparrow subspecies (Greenberg et al. 2006).

Disturbances such as oil exploration, grazing, and recreational use may contribute to habitat degradation, destruction of nests and/or nesting habitat, or disruption of breeding behavior (Takekawa et al. 2006).

Although threats from global climate change are beyond the scope of management at just the state level within the next 20 years, the loss of tidal marsh habitat in San Francisco Bay from projected sea level rise (Galbraith et al. 2002, Orr et al. 2003) deserves discussion. In urbanized portions of Suisun Bay lacking adjacent natural habitat into which tidal marsh can move, a projected 0.4-m rise in sea level (IPCC 2001, Orr et al. 2003) could drown large areas of tidal marsh, making them unsuitable for Suisun Song Sparrows.

## MANAGEMENT AND RESEARCH RECOMMENDATIONS

- Protect existing habitat and restore additional (particularly large contiguous) areas throughout Suisun Bay to tidal action. The Goals Project (1999) recommends that tidal

marsh be increased by 250% in Suisun, via conversion from managed and muted tidal marsh and diked bay lands.

- Restore dispersal corridors with dense, moderately tall vegetation, particularly in the highly fragmented areas in northern Suisun Bay. Cogswell (2000) and Scollon (1993) provided detailed recommendations for improving connectivity among tidal marsh fragments in Suisun Bay to benefit Song Sparrow dispersal.
- Determine which water management and vegetation control practices used to enhance waterfowl habitat also enhance breeding and dispersal habitat for Song Sparrows. Promote these practices in northern Suisun Bay, particularly where habitat fragmentation is the most severe.
- Study the effect of invasive exotic plant species, particularly *Spartina alterniflora* (yet to invade Suisun Bay) and Peppergrass, on the population density and reproductive success of Song Sparrows.
- Identify habitat requirements and ecological conditions that support self-sustaining sparrow populations, paying particular attention to ideal restoration of tidal marsh habitat.
- Identify dispersal needs and constraints and synthesize this information with that on reproductive success and survival to determine long-term population viability.
- Identify important nest predators and evaluate predator control measures, if necessary.
- Study the effects of contaminants (including pesticides and agricultural runoff) on reproductive success.

## MONITORING NEEDS

The Breeding Bird Survey and Christmas Bird Count are inadequate for monitoring population trends of this subspecies. Its prime habitat of tidal marshes is difficult to survey, and access requires permits out of concern for protecting the endangered California Clapper Rail (*Rallus longirostris obsoletus*) and Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*). PRBO has been conducting standardized point counts based on variable circular plots in Suisun Bay tidal marshes since 1996, which allows the estimation of absolute density (Nur et al. 1997). Such monitoring should continue and be expanded to allow for tracking of population trends in tidal and managed marshes and restoration sites. Monitoring of reproductive success should also continue to track

ambient conditions, assess the impacts of non-native plants, assess management and restoration practices, and identify causes of nest failure and important nest predators.

## ACKNOWLEDGMENTS

This account benefited from discussions with Y. Chan, J. Collins, J. L. Grenier, and D. Stralberg, review by J. C. Nordby, D. Stralberg, and C. McCreedy, and development of range maps by L. Pomara.

## LITERATURE CITED

- American Ornithologists' Union (AOU). 1998. Checklist of North American Birds, 7th ed. Am. Ornithol. Union, Washington, DC.
- Arcese, P., Sogge, M. K., Marr, A. B., and Patten, M. A. 2002. Song Sparrow (*Melospiza melodia*), in The Birds of North America (A. Poole and F. Gill, eds.), no. 704. Birds N. Am., Philadelphia.
- Basham, M. P., and Mewaldt, L. R. 1987. Salt water tolerance and the distribution of south San Francisco Bay Song Sparrows. *Condor* 89:697–709.
- Beal, F. E. L. 1910. Birds of California in relation to the fruit industry, part 2. U.S. Dept. Agri. Biol. Surv. Bull. 34.
- Buckland, S. T., Anderson, D. R., Burnham, K. P., and Laake, J. L. 1993. Distance sampling: Estimating abundance of biological populations. Chapman & Hall, London.
- California Department of Fish and Game (CDFG). 1992. Bird species of special concern. Unpublished list, July 1992, Calif. Dept. Fish & Game, 1416 Ninth St., Sacramento, CA 95814.
- Chan, Y., and Arcese, P. 2002. Subspecific differentiation and conservation of Song Sparrows (*Melospiza melodia*) in the San Francisco Bay region inferred by microsatellite loci analysis. *Auk* 119:641–657.
- Cogswell, H. 2000. Song Sparrow, in Baylands ecosystem species and community profiles: Life histories and environmental requirements of key plants, fish, and wildlife (Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project, P. R. Olofson, ed.), pp. 374–385. San Francisco Bay Regional Water Quality Control Board, Oakland, CA.
- Collins, J. N., and Resh, V. H. 1985. Utilization of natural and man-made habitat by the salt marsh Song Sparrow *Melospiza melodia samuelis* (Baird). *Calif. Fish Game* 71:40–52.
- Galbraith, H., Jones, R., Park, R., Clough, J., Herrod-Julius, S., Harrington, B., and Page, G. 2002. Global climate change and sea level rise: Potential losses of intertidal habitat for shorebirds. *Waterbirds* 25:173–183.
- Goals Project. 1999. Baylands ecosystem habitat goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco/San Francisco Bay Regional Water Quality Control Board, Oakland.
- Greenberg, R., Elphick, C., Nordby, J. C., Gjerdrum, C., Spautz, H., Shriver, G., Schmeling, B., Olson, B., Marra, P., Nur, N., and Winter, M. 2006. Flooding and predation: Trade-offs in the nesting ecology of tidal-marsh sparrows. *Studies Avian Biol.* 32:96–109.
- Grinnell, J., and Miller, A. H. 1944. The distribution of the birds of California. *Pac. Coast Avifauna* 27.
- Gutenspergen, G. R., and Nordby, J. C. 2006. The impact of invasive plants on tidal-marsh vertebrate species: Common Reed (*Phragmites australis*) and Smooth Cordgrass (*Spartina alterniflora*) as case studies. *Studies Avian Biol.* 32:229–239.
- Herzog, M., Liu, L., Nur, N., Spautz, H., and Warnock, N. 2004. San Francisco Bay Tidal Marsh Project annual report 2004: Distribution, abundance, and reproductive success of tidal marsh birds. Available from PRBO Conserv. Science, 3820 Cypress Dr., #11, Petaluma, CA 94954.
- Intergovernmental Panel on Climate Change (IPCC). 2001. Climate change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson, eds.). Cambridge Univ. Press, Cambridge.
- Johnston, R. F. 1956a. Population structure in salt marsh Song Sparrows. Part I. Environment and annual cycle. *Condor* 58:24–44.
- Johnston, R. F. 1956b. Population structure in salt marsh Song Sparrows. Part II. Density, age structure, and maintenance. *Condor* 58:254–272.
- Larsen, C. J. 1989. A status review of the Suisun Song Sparrow (*Melospiza melodia maxillaris*) in California. Dept. Candidate Species Status Rep. 89-6 to the Fish and Game Commission from Wildl. Mgmt. Div. Nongame Bird and Mammal Section, Calif. Dept. Fish & Game, Sacramento.
- Marshall, J. T., Jr. 1948. Ecologic races of Song Sparrows in the San Francisco Bay region. Part I. Habitat and abundance. *Condor* 50:193–215.
- Marshall, J. T., Jr., and Dedrick, K. G. 1994. Endemic Song Sparrows and yellowthroats of San Francisco Bay. *Studies Avian Biol.* 15:316–327.
- Nur, N., Geupel, G. R., and Ballard, G. 2000. The use of constant-effort mist-netting to monitor demographic processes in passerines: Annual variation in survival, productivity, and floaters, in Strategies for bird conservation: The Partners in Flight planning process (R. Bonney, D. N. Pashley, R. J. Cooper, and L. Niles, eds.), pp. 185–194. Proceedings RMRS-P-16, U.S. Forest Serv., Rocky Mtn. Res. Station, Ogden, UT.
- Nur, N., Zack, S., Evens, J., and Gardali, T. 1997. Tidal marsh birds of the San Francisco Bay region: Status, distribution, and conservation of five category 2

- taxa. Final draft report to National Biological Survey (now U.S. Geological Survey). Available from PRBO Conserv. Science, 3820 Cypress Dr., #11, Petaluma, CA 94954.
- Orr, M., Crooks, S., and Williams, P. B. 2003. Will restored tidal marshes be sustainable?, in Issues in San Francisco estuary tidal wetlands restoration (L. Brown, ed.). San Francisco Estuary and Watershed Sci. 1(1): article 5. Available at <http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art5>.
- Patten, M. A. 2001. The roles of habitat and signaling in speciation: Evidence from a contact zone of two Song Sparrow (*Melospiza melodia*) subspecies. Ph.D. dissertation, Univ. Calif., Riverside.
- Peterson, D., Cayan, D., DiLeo, J., Noble M., Dettinger, M. 1995. The role of climate in estuarine variability. *Am. Scientist* 83:58–67.
- Remsen, J. V., Jr. 1978. Bird species of special concern in California: An annotated list of declining or vulnerable bird species. Nongame Wildl. Invest., Wildl. Mgmt. Branch Admin. Rep. 78-1, Calif. Dept. Fish & Game, 1416 Ninth St., Sacramento, CA 94814.
- San Francisco Estuary Institute (SFEI). 1998. Bay Area EcoAtlas 1.50 beta 4. Available at [www.sfei.org/ecoa-tlas/index.html](http://www.sfei.org/ecoa-tlas/index.html). [Cited numbers of ha of marsh were calculated by PRBO from digital GIS shapefiles of the EcoAtlas.]
- Sauer, J. R., Hines, J. E., and Fallon, J. 2005. The North American Breeding Bird Survey, results and analysis 1966–2004, version 2005.2. USGS Patuxent Wildl. Res. Ctr., Laurel, MD. Available at [www.mbr-pwrc.usgs.gov/bbs/bbs.html](http://www.mbr-pwrc.usgs.gov/bbs/bbs.html).
- Scollon, D. B. 1993. Spatial analysis of the tidal marsh habitat of the Suisun Song Sparrow. M.A. thesis, San Francisco State Univ., San Francisco.
- Small, A. 1994. California Birds: Their Status and Distribution. Ibis Publ., Vista, CA.
- Spautz, H., and Nur, N. 2004. Impacts of non-native Perennial Pepperweed (*Lepidium latifolium*) on abundance distribution and reproductive success of San Francisco Bay tidal marsh birds. A report to the Coastal Program, U.S. Fish & Wild. Serv. Available from PRBO Conserv. Science, 3820 Cypress Dr., #11, Petaluma, CA 94954 or at [www.prbo.org/cms/docs/wetlands/lepidium04.pdf](http://www.prbo.org/cms/docs/wetlands/lepidium04.pdf).
- Spautz, H., Nur, N., Stralberg, D., and Chan, Y. 2006. Multiple-scale habitat relationships of tidal-marsh breeding birds in the San Francisco Bay estuary. *Studies Avian Biol.* 32:247–269.
- Spautz, H., Nur, N., and Wood, J. 2001. CISNET San Pablo Bay avian monitoring annual report. Unpublished report to U.S. Environmental Protection Agency. Available from PRBO Conserv. Science, 3820 Cypress Dr., #11, Petaluma, CA 94954.
- Takekawa, J., Woo, I., Spautz, H., Nur, N., Grenier, J. L., Malamud-Roam, K., Nordby, J. C., Cohen, A. N., Malamud-Roam, F., and Wainwright-De La Cruz, S. E. 2006. Environmental threats to tidal-marsh vertebrates of the San Francisco Bay estuary. *Studies Avian Biol.* 32:176–197.
- Walton, B. J. 1975. San Francisco Bay region salt marsh Song Sparrow survey, 1974. Report to Calif. Dept. Fish & Game, Sacramento.