Science Foundation Chapter 5 Appendix 5.1 – Case Study Tidal Marsh Song Sparrows

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DESCRIPTION OF THE SPECIES

This case study considers three endemic subspecies of Song Sparrow (*Melospiza melodia*): Alameda Song Sparrow (*M. m. pusillula*), San Pablo (also Samuel's) Song Sparrow (*M. m. samuelis*) and Suisun Song Sparrow (*M. m. maxillaris*). All three are California Species of Special Concern (Chan and Spautz 2008, Spautz and Nur 2008a, and Spautz and Nur 2008b) and all are dependent on tidal-marsh habitat, primarily found in fully-tidal marsh, but also in muted tidal marsh, where available. Each subspecies is associated with one or two of the key subregions of the estuary: in Suisun Bay, the Suisun Song Sparrow; in San Pablo Bay, the San Pablo Song Sparrow; in South San Francisco Bay, the Alameda Song Sparrow. Central San Francisco Bay has the San Pablo Song Sparrow in the west (Marin county), but Alameda Song Sparrow in the east (Contra Costa and Alameda counties).

Tidal marsh Song Sparrows are year-round resident, nesting in the marsh plain ("high marsh" and "mid-marsh" regions), with small territories that often line tidal channels (Takekawa et al. 2011). They mainly consume terrestrial invertebrates (Grenier 2004). The subspecies appear to demonstrate low levels of dispersal outside the breeding season, as well as limited movement during the breeding season (Johnston 1956, PRBO unpublished).

CRITERIA FOR SELECTION OF THE SPECIES

Tidal marsh Song Sparrows have been well studied since 1996 by PRBO (now "Point Blue Conservation Science"; Nur et al. 1997; Spautz et al. 2006; Greenberg et al. 2006, Stralberg et al. 2010) and others (Nordby et al. 2009). Two recent studies have focused on anticipated impacts of climate change on tidal marsh Song Sparrows: Veloz et al. 2012 and Nur et al. 2012, which findings we summarize here. The three subspecies are of high conservation concern and are considered highly vulnerable to climate change due to (i) anticipated impacts on their habitat (tidal marsh) and (ii) direct effects of flooding on nest success, as elaborated below. Finally, tidal marsh Song Sparrows are indicative of several tidal-marsh-inhabiting passerines in the San Francisco Estuary, in particular the Salt Marsh Common Yellowthroat (*Geothlypis trichas sinuosa*). The latter is also a California Species of Special Concern (Gardali and Evens 2008). Management recommendations that benefit tidal marsh Song Sparrows are likely to apply to the Salt Marsh Common Yellowthroat.

OTHER INFORMATION ABOUT THE SPECIES

Since 1996, the San Pablo and Suisun Song Sparrows have demonstrated population declines; abundance of the Alameda Song Sparrow increased prior to 2002, but has decreased more recently (Wood et al. 2009).

Nur et al. (2012) attribute recent declines to low reproductive success, as a result of nest predation and nest inundation (see also Nordby et al. 2009).

REVIEW OF CLIMATE CHANGE EFFECTS ON THE GUILD

Two key impacts that have been assessed are changes in habitat, and nest failure due to flooding.

The availability of tidal marsh habitat and specific characteristics of tidal marsh habitat, including salinity, are expected to change in the short term (2030), mid-term (2050) and long-term (2100). Considering the two "bookend" scenarios (BEHGU Scenarios 2 and 3), mid marsh can be expected to decrease by 4% by 2050 and by 94% by 2110 under the scenario of high sea-level rise and low sediment concentration (Scenario 2). Even full and complete restoration by 2110 will still result in 42% loss of mid-marsh. High marsh will be even more severely impacted, though the importance of high marsh for tidal marsh Song Sparrows is not as clear as it is for mid-marsh. Nevertheless, 94% or greater loss of high marsh surely will have a strong impact. Under the most benign scenario, Scenario 3 (low sea-level rise, high sediment concentration), mid-marsh is expected to increase by 101% by 2050 and by a cumulative 158% by 2110. Still, high marsh is expected to decrease by 54% by 2050 and by a cumulative 80% by 2110.

Veloz et al. (2012) estimate that as a result of changes in the amount and quality of tidal marsh habitat in the next century, the abundance of tidal marsh Song Sparrows can be expected to change substantially, with the direction and magnitude depending on the scenario. Averaged over the four scenarios they considered, which correspond to Scenarios 1 to 4, Song Sparrow abundance for the entire estuary was predicted to increase 13% from 2010 to 2110.

Whether current tidal marshes will be able to survive intact despite increasing global sea level will depend on whether accretion (organic and non-organic) can keep up with or outpace increasing water levels. A key consideration with regard to changes in habitat will be: as water levels increase, can tidal marshes migrate to areas that are currently supratidal? That will depend on the availability of such areas, as well as on the ability for tidal marsh plant species to migrate as well (i.e., establish themselves in new sites). Dispersal of tidal marsh Song Sparrows is not likely to be an important limiting factor, unless there are specific barriers to dispersal.

In addition, tidal marsh Song Sparrows are subject to direct effects of high water levels. Changes in water level reflect the combined effect of global warming, El Nino events, and storms, as well as other changes in peak flow. Both the changes in mean high water levels and extreme events are a concern. Especially high water levels, whether due to extreme tides or storms, are strongly correlated with nest failure (Nur et al. 2012). Extreme water levels affect a nesting attempt that is underway. However, timing of extreme water levels is also important: the complete nesting cycle requires about 25 days. Whereas, an extreme tide can cause failure of a nesting attempt that is underway, Song Sparrows will renest soon after the failure. However, if another extreme water event occurs within 25 days, then the renesting will also fail, which may lead to reproductive failure for an entire breeding season.

High water events during the winter, which may leave individuals vulnerable to predators, may also be of concern. In any case, inundation of marsh habitat because of major storms and extreme tides will reduce foraging opportunities for tidal marsh Song Sparrows, which may cause energetic stress. The winter storm event scenario (Scenario 5), is therefore of great concern since it projects extreme water levels to be maintained for over two weeks during the latter part of winter.

Winter Storm Extreme Event Scenario

While winter time climate-change impacts on Song Sparrows have not specifically been studied, studies by Thorne et al. (2014), which focused on Black Rails, provide reason for concern. This case study has specifically considered the BEHGU winter storm extreme event scenario.

i. Tidal marsh song sparrows will be affected throughout their range in the SF estuary. The winter storm event will inhibit their ability to forage and lead to increased mortality. Increased mortality will result from increased predation, as a consequence of reduction of refugia from high water levels, as well as loss of foraging habitat, which can also lead to increased mortality, directly or indirectly.

ii. The consequences of a winter storm event could be severe. High mortality during the winter period could result as a direct consequence of the storm. If so, recovery could be difficult, though not impossible. There may be more subtle effects, leading to poorer condition of over-wintering individuals, leading to reduce probability of breeding or reduced reproductive success.

iii. The timing, duration and sequence will influence the impacts of such an event. Duration may be the most important consideration. If inundation of the habitat were protracted, this would cause a large spike in mortality, both of juveniles and adults. The sequence of events is also important, especially if a second stressor affects these organisms at the same time or close in time (before or after the storm). Astronomical tides are most extreme in January, so a storm that coincides with an astronomical extreme tide will be of greatest concern.

OTHER STRESSORS

Nur et al. (2012) identified low reproductive success as a key bottleneck facing tidal marsh song sparrows. Nest success was only about 22%, below the level estimated needed for population sustainability, and below that observed for other species in the tidal marsh. High nest failure was due primarily to nest predation. Field evidence indicates predation from raccoons, other mammals, corvids, and snakes. The effects of climate change on nest predators are not known. In any case, the increasing risk of nest failure associated with high water levels (as a result of climate change) will be exacerbated by the current high levels of nest failure due to predation.

At the same time, Global Climate models predict warmer, drier conditions during the breeding season: such conditions are expected to increase nest survival based on statistical analysis of an 11-year data set. Warmer, drier conditions are expected to shorten the breeding season, and thus reduce the number of breeding attempts per Song Sparrow breeding pair per season, but current models predict that increases in nest survival due to warmer, drier conditions will compensate for the reduction in number of breeding attempts associated with warmer, drier conditions.

LIFE CYCLE CONSIDERATIONS

Nur et al. (2012) present results of population dynamic models, including population viability analysis. If current conditions continue, populations are expected to decline by more than 50% by 2050. The expected population trajectory with anticipated climate change depends on the assumptions of sea-level rise: under high sea-level rise, the probability of 80% population decline from 2010 to 2060 is 60%. However, under assumptions of low to moderate sea-level rise, the probability of such a severe decline is much less (1% and 10%, respectively). [To be revised with respect to the final assumptions of SLR, to be used throughout the

Update Project.] Because downscaled climate models for San Francisco Estuary tidal marshes predict warmer, drier conditions, which enhance nest success, population dynamic models predict population increases or relative stability with low to moderate sea-level rise. However, an increase in the magnitude of extreme tides (even if relatively rare) will have strong impacts on populations leading to stronger declines or causing expected population increases to turn into population declines.

The conclusion drawn from the population dynamic model and viability analysis is that population trajectory is sensitive to changes in nest success, which will reflect future climate conditions. However, the sensitivity of other demographic processes to climate conditions (e.g., juvenile and adult survival) needs to be explored.

FACTORS THAT MAY AFFECT SPECIES RESILIENCE

Population resilience will be enhanced if reproductive success, especially nest survival is increased (see below for specific suggestions). Maintaining high over-winter survival of juveniles and adults is likely to contribute as well. Reducing mortality due to predation, especially during extreme tides/water levels will enhance resilience.

Maintaining connectivity of habitat will help maintain resilience. Particularly effective may be the establishment of restored tidal marshes near extant tidal marsh, especially marshes that are likely to be "sources" rather than "sinks."

LIKELY CLIMATE CHANGE IMPACTS AND RISKS

Current tidal marshes will surely change between now and 2100, but the magnitude of change expected depends on the climate change scenario. The total amount of tidal marsh habitat may shrink, but, even if it does not, we may expect movement of current tidal marshes into areas that are currently upland (above Extreme High Water levels). Therefore, it is important to maximize production of young and their successful recruitment into the breeding population as adults. Thus, maintaining effective habitat connectivity for tidal marsh Song Sparrows is essential.

Evidence to date points to the importance of nest survival (also referred to as "nest success") as a current population bottleneck. Current levels of nest success need to be increased despite future pressures from climate change (mediated through flooding of habitat) and predators (specifically, nest-predators and those preying on juveniles and adults).

MANAGEMENT ACTIONS TO BE CONSIDERED

Management should focus on two key demographic rates: reproductive success and over-winter survival. One priority is to increase reproductive success (or at least not allow it to decrease). Therefore reducing nest predation rates is recommended. This could be accomplished by reducing predator populations or by reducing access or exposure of nests to nest predators. This will be a challenge because numerous species are thought to prey upon song sparrow nests, including a variety of mammals, birds, and snakes. **Reducing nest predation due to predators entering from adjacent upland habitat** (natural and developed upland habitat) should be a focus, including predation due to feral cats. **Reducing nest predation will serve to offset nest failure due to flooding**, which may increase (and apparently has already increased) due to climate change. A change in nest predation can have a longer term effect on tidal

marsh song sparrows: with reduction in nest predation, Song Sparrows may in the future start nesting higher in the vegetation, which will allow them to escape nest flooding (Greenberg et al. 2006).

A second recommendation is to provide or enhance mounds or humps within the marsh, i.e., increase topographic relief. Such mounds may reduce the effects of extreme water levels on nest flooding. In addition, such mounds may provide refugia for first-year and adult Song Sparrows from extreme water levels during the winter, which occur when all or most of the marsh plain is inundated (due to effects of extreme tides and storm events; Thorne et al. 2012, Thorne et al. 2013). In other words, **marsh mounds may enhance over-winter survival of tidal marsh Song Sparrows**, as has been suggested for rail species residing in tidal marshes.

During the winter time, reducing predator populations or their access to or preference for tidal marsh habitat should also be explored. Reducing predation by feral cats should be a priority.

Recommendations regarding winter-storm event scenario:

That such an event will occur at some point in the future seems very likely. For example, Thorne et al. (2013) document two recent such storm events, one in January and one in March (in a different year). They documented extended habitat inundation, though not in a position to determine direct impacts on survival or subsequent reproductive success. Management should focus on anticipation of such events: in particular, by providing refugia from these extreme tides. If extreme water levels can be reduced, or at least the duration of habitat-inundation as a result of such storms, this would help alleviate the stress. Since mortality during or subsequent to the storm event is the primary concern, management that is directed to improving survival rates will help address this stressor.

UNCERTAINTY AND KNOWLEDGE GAPS

The future of tidal marsh habitat is uncertain with regard to its location, extent, and specific characteristics. Also the nature, or even the presence, of adjacent (non-tidal) habitat in the future is not known. This uncertainty is due to uncertainty regarding climate change projections and decisions regarding land-use (maintenance of levees, conversion of current diked baylands to tidal marsh, maintenance of managed ponds, etc.) There is also substantial uncertainty regarding response of tidal marsh plant species to climate change and due to impacts of invasive species; the distribution and abundance of tidal marsh plants will substantially affect tidal marsh birds. The magnitude, frequency, and timing of extreme water levels is difficult to predict but will have severe consequences for tidal marsh birds. Finally, the demographic response of tidal marsh Song Sparrows to climate change is not well known, especially with regard to survival rates.

Important Data Gaps

Impacts of climate change on survival of first-year birds and adults is not known. Small changes in survival rates can have substantial consequences for population growth (or decline) and population resilience. Therefore an important gap to address is information on environmental influences on survival of first-year and adult tidal marsh Song Sparrows. The more sensitive survival rates are to environmental conditions, the more concern there is that climate change may have deleterious consequences for populations. At the same time, sensitivity of survival rates to the environment suggests that management actions can be effective if they target this parameter.

Tidal marsh habitat is by nature patchy. The ability of tidal marsh birds to colonize newly restored habitat, or re-occupy habitat, needs to be better characterized, and barriers to dispersal need to be identified.

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