San Francisco Common Yellowthroat (*Geothlypis trichas sinuosa*)

Climate Change Vulnerability Assessment for the Golden Gate Biosphere Region

This document represents an evaluation of climate change vulnerability for San Francisco common yellowthroat in the Golden Gate Biosphere (GGB) region of California. The following information is based on stakeholder input provided during and following a winter 2022 vulnerability workshop as well as sources from the scientific literature.

Species Description

The common yellowthroat (*Geothlypis trichas*) is a small, brightly colored songbird found throughout North and Central America (Guzy & Ritchison 2020). The species exhibits plumage variation throughout its extensive range, but generally, male common yellowthroats are identified by a distinctive black mask and a yellow throat, while the female lacks the black mask and the yellow throat contrasts with dull olive upperparts (Guzy & Ritchison 2020). Common yellowthroats breed and forage in swamps, marshes, and the wet edges of streams and riparian areas with dense vegetation (Kaufman 1996; Gardali & Evens 2008), where they nest near the ground in grasses and herbaceous vegetation (Gardali & Evens 2008). Common yellowthroats are primarily insectivores, but will also eat spiders and occasionally seeds (Kaufman 1996; Terrill 2000).

The San Francisco subspecies of the common yellowthroat (*Geothlypis trichas sinuosa*), also known as the salt marsh yellowthroat (Schussler 1918), is found in coastal riparian, freshwater and brackish wetland areas of Marin County, San Pablo Bay and San Francisco Bay tidal marshes, and freshwater wetlands in San Mateo County (Figure 1; Terrill 2000; Stralberg & Gardali 2007; Gardali & Evens 2008). The subspecies is also abundant in tidal marshes of Suisun Bay (Nur et al. 1997), which is outside of the Golden Gate Biosphere (GGB) region. Even across the subspecies range, there is geographic variation in its preferred habitat, with only 5% occurring in tidal marsh, about 60% in brackish marsh, and 20% in riparian habitats (Gardali & Evens 2008). However, Shuford (1993) reported 80% of common yellowthroats in Marin County were found in freshwater marsh, riparian thickets, and coastal swales. It is generally a year-round resident in the region, though some individuals may migrate as far south as San Diego County in winter (Gardali & Evens 2008). Other common yellowthroat subspecies are migratory through the area and may be encountered during migration season and in winter (Terrill 2000). The San Francisco common yellowthroat is listed as a California Species of Special Concern within the state, a designation driven by historic and ongoing losses of its wetland and riparian habitats in the San Francisco Bay region (Gardali & Evens 2008; CDFW 2023).

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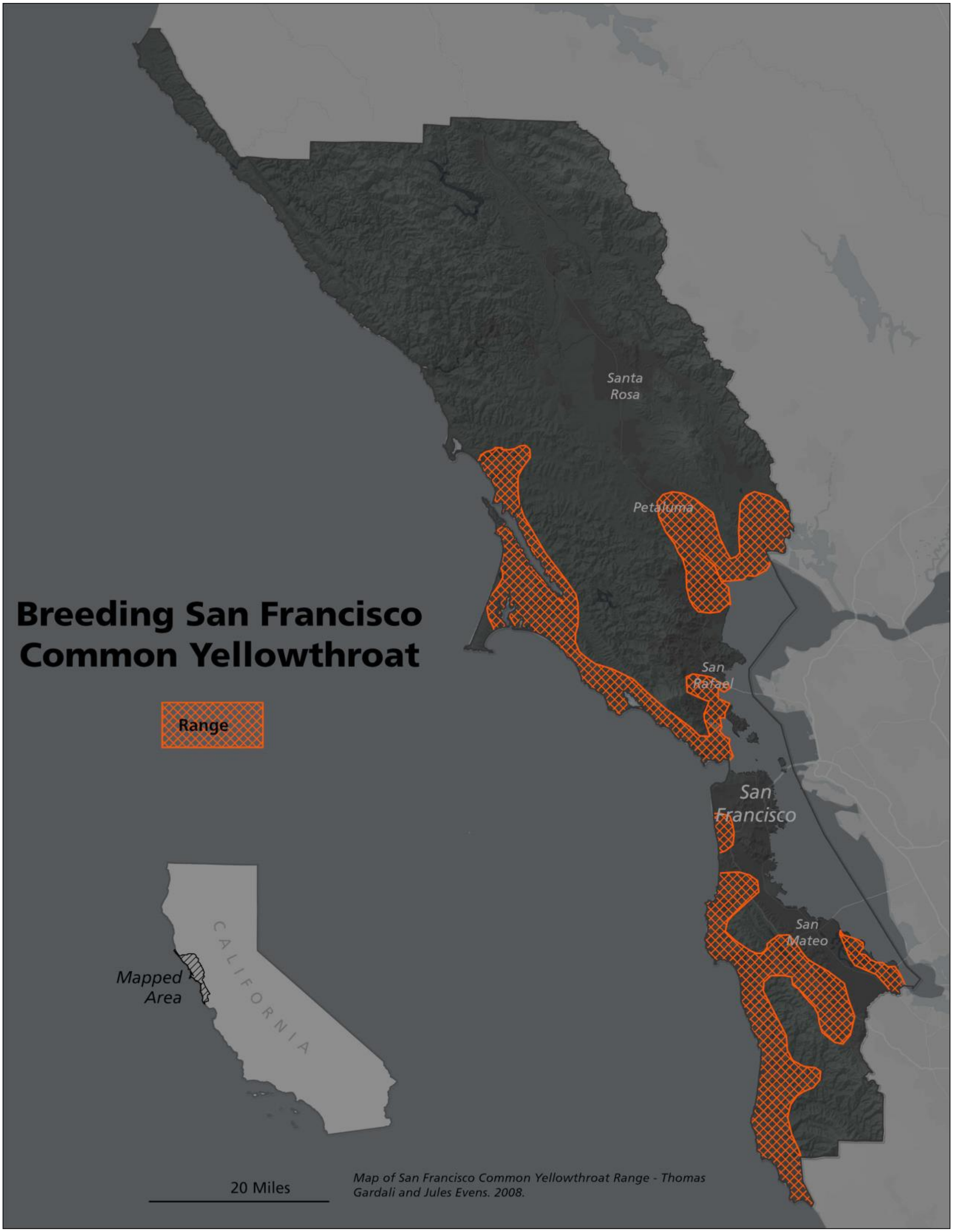

Figure 1. Breeding San Francisco common yellowthroat range within the GGB region (map provided by the National Park Service).

Species Vulnerability → Moderate *(moderate confidence)*

Vulnerability is evaluated by considering the species' sensitivity and exposure to various climate and non-climate stressors as well as the species' adaptive capacity (i.e., ability to cope with these stressors), and is given a ranking of low, moderate, or high. The confidence ranking represents confidence in the accuracy of the ranking based on available scientific knowledge, and is similarly ranked on a scale from low to high.

Summary of species vulnerability

San Francisco common yellowthroats are sensitive to climate stressors that impact foraging and nesting habitat quality and availability, including changes in precipitation patterns and sea level rise. Changes in disturbance regimes, particularly storm surges and flooding, can inundate common yellowthroat habitat, wash away nests and eggs, or drown nestlings. Non-climate stressors, including development, agricultural activities, and dams and water diversions can threaten the habitat on which common yellowthroats depend, though in some situations agricultural areas can provide suitable aquatic edge habitat. Invasive and problematic species can also impact the common yellowthroats through direct predation and by outcompeting the native vegetation on which the species relies. However, there are some invasive plants, such as pepperweed (*Lepidium latifolium*), that common yellowthroat uses as habitat.

Recent projections modeling the availability of San Francisco common yellowthroat habitat under climate change suggests a substantial portion of their habitat in the GGB region is at risk of degradation and loss. This is a particular concern in areas where marsh accretion is not keeping pace with sea level rise, where marsh salinity is increasing, and where development constrains the ability of marsh edges to move landward in response to sea level rise. The San Francisco common yellowthroat is a state-listed species of concern and there is significant public and regulatory support for protecting the coastal marsh and riparian habitats on which they depend. Ongoing wetland restoration and protection activities are likely to increase the resilience of this subspecies to climate change, including regulatory mechanisms to protect marsh and freshwater wetland habitats from further degradation and loss, land management activities to reduce habitat fragmentation and restore vegetative communities on which this subspecies depends, and activities that restore natural flows and sedimentation processes that support low-salinity marsh edge habitats.

Sensitivity and Exposure → Moderate *(moderate confidence)*

Sensitivity *is a measure of whether and how a species is likely to be affected by a given change in climate factors, climate-driven changes in disturbance regimes, and non-climate stressors. By contrast,* ***exposure*** *is a measure of how much change in these factors a species is likely to experience. Sensitivity and exposure are combined here* *into one score representing both components of vulnerability, with high scores corresponding to increased vulnerability and low scores suggesting a species is less vulnerable.*

Sensitivity and future exposure to climate factors → High *(moderate confidence)*

- **Changes in precipitation amount and timing** are likely to impact San Francisco common yellowthroats by altering the extent and periodicity of inundation in their foraging and breeding habitat. Their close association with wet margins of marsh habitats means that sudden shifts in marsh extent associated with extreme flooding or drying may alter habitat availability for this species (Terrill 2000). Additionally, nests are located in grasses and herbaceous vegetation near the ground, making them susceptible to acute flooding (Gardali & Evens 2008). Changes in precipitation also have the potential to impact delivery of sediment supplies needed to maintain and rebuild marsh surfaces impacted by subsidence and sea level rise (Stralberg et al. 2011; Vuln. Assessment Worksheets, pers. comm., 2022).
- **Sea level rise** is likely to impact San Francisco common yellowthroat by inundating the marsh edge habitat that is important to this subspecies (Gardali et al. 2012). San Francisco common yellowthroats are more likely to occur in areas with lower salinity (e.g., Suisun; Schussler 1918; Stralberg et al. 2011), so as salinity increases and moves further up the estuary, some areas may become less suitable habitat (Stralberg et al. 2011). Additionally, the ability of marshes to shift landward with rising sea levels may be constrained in urban areas and on sites with steeper topography, which is likely to translate to substantial habitat loss for the San Francisco common yellowthroat, particularly as sea level rise accelerates in the second half of this century (Veloz et al. 2013; Hayden et al. 2019). Migration space for marshes also includes the tidal marsh-upland transitional habitats (Thomson et al. 2013; Collins & Ball 2015) where common yellowthroats occur in low densities, especially along the San Francisco Bay edge.

Sensitivity and future exposure to climate-driven changes in disturbances → Moderate *(low confidence)*

- **Storm surge** is likely to impact San Francisco common yellowthroat because low-growing marsh vegetation is vulnerable to inundation during and after storms (Terrill 2000; Hayden et al. 2019). Their nests are placed low to the ground along marsh edges, where they are highly vulnerable to storm surge (Gardali & Evens 2008; Nur et al. 2012). Additionally, their nesting season extends from early March through late July (Terrill 2000), resulting in the potential for exposure to heavy precipitation (concentrated from January to March in California) at the beginning of their breeding season (Luković et al. 2021). Despite uncertainty in the current models (Thorne et al. 2013), it is reasonable to assume that the species could be sensitive to shifts in the timing of these events as a single storm can cause breeding failure with negative long-term population impacts (Nur et al. 2012).

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Dependency on habitat and/or other species → Moderate *(moderate confidence)*

San Francisco common yellowthroats are dependent on coastal riparian and wetland transitional habitat (Kaufman 1996; Gardali & Evens 2008), which has faced historic and ongoing declines in extent and integrity and is vulnerable to a number of climate and non-climate stressors including sea level rise, storm surge and inundation, land-use conversion, and fragmentation (Nur et al. 1997; Takekawa et al. 2006; Parker et al. 2011; Parker & Boyer 2019). Within their preferred habitat, abundance of this subspecies is positively correlated with the abundance of channels, whether natural or artificial (Nur et al. 1997). They nest in dense, low-growing vegetation (Terrill 2000) such as hardstem bulrush (*Schoenoplectus acutus*) and alkali bulrush (*Bolboschoenus maritimus*; Stralberg et al. 2010). The placement of their nests near the ground may make them particularly vulnerable to climate-driven increases in storm events and flooding, especially when inundation is exacerbated by the effects of sea level rise (Stralberg et al. 2011; Hayden et al. 2019). San Francisco common yellowthroats are primarily insectivores and glean insects on or near the ground to feed both themselves and their young (Terrill 2000).

Sensitivity and current exposure to non-climate stressors → High *(high confidence)*

Non-climate stressors can exacerbate ecosystem sensitivity to changes in climate factors and disturbance regimes, and/or can be exacerbated by these changes.

- **Residential and commercial development** and the associated development of **roads, highways and trails** has and continues to drive fragmentation and loss of riparian and wetland edge habitat on which San Francisco common yellowthroat depend (Duffy et al. 2016). Urbanization in the San Francisco Bay Area and consequent habitat loss is believed to be a primary driver of the decline of the San Francisco common yellowthroat population over the past century (Terrill 2000). Development also constrains the ability for marshes to migrate landward in response to sea level rise, limiting the possibility of habitat shifts (Hayden et al. 2019).
- **Agriculture and rangelands** have driven widespread loss and degradation of wetland and riparian habitat important to San Francisco common yellowthroats in the region (Ackerly et al. 2018; Baumgarten et al. 2018, 2021). Agricultural diversion of water has also contributed to increases in salinity in the San Francisco Bay ecosystem (Takekawa et al. 2006), and San Francisco common yellowthroat, which is associated with lower salinity habitats (Stralberg et al. 2010), may be negatively impacted by these shifts. However, modeling of common yellowthroat occurrence in association with site-specific and landscape-level variables indicated a positive relationship between yellowthroat occurrence and agricultural lands, possibly due to the greater presence of suitable habitat available relative to urbanized areas (Spautz et al. 2006).Agriculture adjacent to tidal wetlands often creates transitional areas that common yellowthroats will use if vegetation structure is suitable, even where they are steeply sloped (Nur et al. 2018). However, in inland riparian freshwater systems, cattle grazing of riparian

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corridors significantly diminishes vegetation structure and common yellowthroat numbers are reduced or absent (Shuford 1993).

- **Dams and diversions** are abundant throughout the GGB region (Nicely et al. 2007; Baumgarten et al. 2018, 2021). Dams can alter flow volume, timing, and sediment transport, all of which impact the quality and availability of marsh and riparian edge habitat that support San Francisco common yellowthroat. As sea level rise threatens coastal tidal marsh habitat, sediment transport, which can be limited by damming and water diversions, is of increasing importance to accretion to keep pace with marsh loss (Hayden et al. 2019). **Flood control measures** (e.g., levees) designed to protect developed areas are also widespread throughout the GGB region (Baumgarten et al. 2018, 2021), and are associated with simplification and reduction of riparian habitat that impacts both the insect populations and availability of nesting habitat for songbirds, including San Francisco common yellowthroat (Gardali & Evens 2008; Gardali et al. 2012). Predictive modeling of yellowthroat occurrence in the San Francisco Bay region suggests the species is more likely to be detected in areas farther from levees, perhaps because levees are associated with a lack of low-marsh tidal vegetation used by this species in parts of its range (Stralberg et al. 2010).
- **Invasive and problematic species** may increase risks to the San Francisco common yellowthroat as a result of both predation and habitat impacts. Common yellowthroats nesting closer to developed areas may be more vulnerable to predation due to increased numbers of predatory species associated with human development, including feral cats (*Felis catus*), rats (*Rattus* spp.), raccoons (*Procyon lotor*), and corvids (Gardali & Evens 2008; Vuln. Assessment Worksheets, pers. comm., 2022). Few data are available on causes of nest failure, though studies have found evidence of brood parasitism by brown-headed cowbirds (*Molothrus ater*) in another yellowthroat subspecies in Minnesota and Michigan (Hofslund 1957; Guzy & Ritchison 2020).

  San Francisco common yellowthroat abundance and distribution has also been shown to be negatively correlated with increasing density of invasive broom species (Stralberg & Gardali 2007) and pickleweed (*Salicornia pacifica*) (Nur et al. 1997). However, non-native pepperweed (*Lepidium latifolium*) has been positively correlated with the presence of common yellowthroat (Nur et al. 1997; Spautz et al. 2006; Stralberg et al. 2010), suggesting that impacts of invasive plants on this species are variable and species-specific.

Adaptive Capacity → Moderate *(moderate confidence)*

Adaptive capacity *is the ability of a species to respond to or cope with climate change impacts with minimal disruption. High adaptive capacity corresponds to lower overall climate change vulnerability, while low adaptive*

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capacity means that the species will be less likely to cope with the adverse effects of climate change, thus increasing the vulnerability of the species.

Species extent, status, connectivity, and dispersal ability → Moderate (high confidence)

The San Francisco common yellowthroat has experienced an 80-95% decline of its total population over the last century (Guzy & Ritchison 2020). A major factor in this decline is the loss of over 80% of tidal marsh habitat within the subspecies' range (Marshall & Dedrick 1994). Studies have found that species associated with tidal marshes are disproportionately likely to be listed as endangered, threatened, or of conservation concern (Greenberg et al. 2006), and this pattern holds true in the San Francisco Bay where 50% of marsh-associated species have a special conservation status (Takekawa et al. 2011). Substantial recent investments in salt marsh and wetland restoration in the San Francisco Bay area may help in creating new habitat for San Francisco common yellowthroat (Callaway et al. 2011, Point Blue unpublished data). However, climate-driven shifts in precipitation, storm events, and sea level rise are likely to drive further degradation and conversion of yellowthroat habitat, particularly in urbanized areas where floodplains and marshes are constrained from moving landward in response to sea level rise (Veloz et al. 2013; Hayden et al. 2019).

The San Francisco common yellowthroat is a relatively mobile species, so marsh isolation is not a significant hindrance and the population may be able to remain connected despite habitat fragmentation (Nur et al. 1997; Vuln. Assessment Worksheets, pers. comm., 2022). However, long-term habitat degradation and declines have likely constrained population size and limited connectivity (Gardali & Evens 2008; Vuln. Assessment Worksheets, pers. comm., 2022).

Intraspecific/life history diversity → Moderate (low confidence)

The common yellowthroat as a species has a substantial diversity of habitat affiliations across its extensive range in North America, with different subspecies often having distinct habitat preferences (Guzy & Ritchison 2020). Even within the GGB region, the San Francisco common yellowthroat subspecies has been documented using a range of aquatic habitats including swamps, riparian zones, and brackish and freshwater marsh edges in association with a variety of native and non-native vegetation in which it forages and breeds (Spautz et al. 2006; Stralberg et al. 2010; Veloz et al. 2013).

Little is known about the population genetics of the San Francisco subspecies of the common yellowthroat relative to other populations of this species, and the need for genetic work is highlighted by Gardali & Evens (2008). It is described as an endemic subspecies based on natural history accounts and specimens (Grinnell 1901; Terrill 2000; Gardali & Evens 2008), and the reported range of the subspecies is based on plumage and molt timing, not DNA. Overlapping ranges of resident and migratory populations has caused debate over subspecies delineations (Marshall & Dedrick 1994; Guzy & Ritchison 2020). A study of another local endemic subspecies, the Brownsville common yellowthroat (*Geothlylpis trichas insperata*), showed that it was able to maintain genetic diversity in a highly fragmented landscape (Roy et al. 2013).

Resistance and recovery → Moderate (moderate confidence)

The San Francisco common yellowthroat's mobility and use of a wide variety of marsh and riparian edge vegetation allows them to adapt to a variety of foraging and nesting habitats (Spautz et al. 2006; Gardali et al. 2012). They are also able to re-nest if their first brood is lost (Kaufman 1996), which supports recovery from climate-driven events such as storms and flooding (Vuln. Assessment Worksheets, pers. comm., 2022). However, modeling has demonstrated that other species that re-nest remain vulnerable to inundation, depending on the timing and frequency of flooding (Nur et al. 2012).

Management potential → Moderate (high confidence)

While the common yellowthroat is an abundant and widely-distributed species, the San Francisco common yellowthroat is state-listed as a subspecies of concern, which could bring additional resources to bear on conservation and management of functioning healthy ecotones, particularly in more brackish or freshwater systems (CDFW 2023). Currently, prioritized management action in the region is largely driven by species considered at higher risk of extirpation such as the federally-endangered Ridgway's rail (*Rallus obsoletus*; USFWS 2013). However, San Francisco common yellowthroat are in potential conflict with the habitat requirements of Ridgeway's rail (e.g., low vs. high salinity marshes, *Salicornia*-dominated marshes; Nur et al. 2012; USFWS 2013), reducing the likelihood that they will benefit from management actions geared towards conservation of this species. Because they are dependent on aquatic edge habitat for foraging and nesting, San Francisco common yellowthroat may benefit from federal and state regulations encouraging the protection and recovery of wetland habitat (Kondolf et al. 2007; Callaway et al. 2011). These have resulted in significant recent investments in these ecosystems in the GGB region, though common yellowthroat habitats continue to face steep challenges from climate change and multiple anthropogenic stressors (Gardali & Evens 2008; Gardali et al. 2012; Hayden et al. 2019).

Conserving intact habitat for the San Francisco common yellowthroat is extremely important for the persistence of this declining subspecies (Stralberg & Gardali 2007; Gardali & Evens 2008), particularly in the context of increasing stressors associated with climate change. There are several management options that support the health and persistence of the riparian and coastal wetland fringe habitats used by the San Francisco common yellowthroat (e.g., low-salinity edge habitat with dense, low-growing vegetation that hosts a high abundance of insects and other macroinvertebrates). These include increasing floodplain connectivity, preventing and removing shoreline hardening, supporting and restoring riparian and wetland vegetation along transitional ecotones, and supporting natural flow regimes (Terrill 2000; Gardali & Evens 2008; Veloz et al. 2013). Habitat restoration efforts that enhance high tide refugia and promote dense vegetation can provide a buffer and potentially increase overwinter survival during storm events (Nur et al. 2018). Supporting and enhancing sediment transport to allow marsh accretion to keep up with sea level rise and subsidence processes will also be critical to maintaining these wetland fringe habitats (Stralberg et al. 2011; Hayden et al. 2019). Biosolids additions to floodplain and marsh surfaces are gaining traction as a potential way to both find

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an application for this material and enhance marsh elevations to support persistence in the face of climate-driven threats to marsh habitats (Bay Area Biosolids Coalition et al. 2022; Vuln. Assessment Worksheets, pers. comm., 2022).

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Further information on the Golden Gate Biosphere Region Climate Adaptation Project is available on the project page (www.ecoadapt.org/goto/GGBRClimateProject).

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