

# Trends in Waterbird Counts in South San Francisco Bay

Prepared by Max Tarjan  
San Francisco Bay Bird Observatory

Prepared for Amy Larson (1), Laura Cholodenko (2) and Dave Halsing (3)

1. California Wildlife Foundation
2. California State Coastal Conservancy
3. South Bay Salt Pond Restoration Project

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## Executive Summary

The South Bay Salt Pond Restoration Project (SBSPRP) is restoring historic salt evaporation ponds to a mix of tidal marsh habitat and managed ponds to improve wildlife habitat, flood protection, and public access. Evaluating wildlife response to the actions of this multi-decade restoration project is essential for sustaining baseline populations. At the outset of the project, the SBSPRP and regulatory agencies defined targets (baseline waterbird counts), thresholds (percent declines below the baseline), and triggers (counts below baseline values over a given number of consecutive years) for waterbird populations in the project area and/or South San Francisco Bay (Appendix 1). With more than a decade of monitoring data available, it is possible to assess trends in waterbird counts in the context of targets for the SBSPRP. The purpose of this report is to develop reproducible analyses that can be incorporated into annual reports of waterbird surveys for the SBSPRP. We also evaluated the value of external data sources, namely nesting surveys from the San Francisco Bay Bird Observatory's Colonial Waterbird Program (which began in 1982), for showing trends of nesting waterbirds in the SBSPRP.

Waterbird counts in 2017 exceeded the baseline values for most guilds, with counts for 5 out of 9 guilds increasing more than 20% relative to SBSPRP targets. Eared Grebe have increased in salt production ponds, but not in SBSPRP sites. Bonaparte's Gulls and dabbling ducks have declined by 16% and 7%, respectively, but remain above their significance thresholds. Phalaropes have declined by 78%, which is below their significance threshold and a trigger—three consecutive years more than 25% below NEPA/CEQA baseline, or any single year more than 50% below NEPA/CEQA baseline—has been reached. Understanding the cause of phalarope declines and obtaining more accurate estimates of population trends will require targeted surveys during their peak season and/or evaluation of external datasets. Breeding bird surveys from the Colonial Waterbird Program can supply historic counts at 42 sites within the SBSPRP and salt production

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ponds. Due to inconsistent coverage, these counts are most useful at the site-level for 11 sites, and would be most informative in combination with additional data sources for a better understanding of historical nesting abundances throughout the SBSPRP area and South San Francisco Bay.

## **Introduction**

The South Bay Salt Pond Restoration Project (SBSPRP) is the largest tidal wetland restoration project on the West Coast of the Americas. In 2002, the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW, formerly California Department of Fish and Game) entered into an historic agreement with Cargill Salt to acquire 15,100 acres of salt evaporation ponds in the South San Francisco Bay. The SBSPRP has begun to restore the area to a mix of tidal and ponded habitats while continuing to provide flood protection and improved public access to many sites.

Salt production ponds have been present in the San Francisco Bay for over 150 years (Ver Planck 1958) and have significant wildlife value (Anderson 1970, Accurso 1992, Takekawa et al. 2001, Warnock et al. 2002). Due to the loss of wetlands elsewhere, the ponds now provide important foraging and roosting areas for many waterbirds. As a major migratory and wintering location along the Pacific Flyway, the San Francisco Bay supports more than a million birds throughout the year (Page et al. 1999, Warnock et al. 2002). One of the goals of the South Bay Salt Pond Restoration Project is to maintain migratory bird populations that currently use salt ponds while supporting increased populations of native species that use tidal marsh (Takekawa et al. 2005). The SBSPRP has committed to restoring some ponds to tidal marsh, while retaining some pond habitat (as managed ponds) within the project area for waterbirds. Information is needed to ensure that habitat requirements of large numbers of waterbirds can be met with reduced pond acreage, including both salt production ponds and wildlife managed ponds.

In order to gauge the impact of tidal marsh restoration project on bird populations of the region, the SBSPRP compiled targets (baseline waterbird counts), thresholds (percent declines below the baseline), and triggers (counts below baseline values over a given number of consecutive years) for species and/or guilds within South San Francisco Bay (Appendix 1). A selection of guilds/species are of particular concern because as tidal restoration continues, their preferred habitat type (managed ponds) will decrease. Species and guilds of particular concern include Ruddy Ducks, diving ducks, small shorebirds, phalaropes, and Eared Grebes. Targets (i.e. baseline counts) for these guilds were defined as part of the Adaptive Management Plan (South Bay Salt Pond Restoration Project 2007) along with NEPA/CEQA significance thresholds, which specify a given percent decrease below baseline values. The Plan also identifies triggers, observable downward trends in waterbird counts that warrant a pause and conversation with project stakeholders, which take the form of a decrease in counts over a given number of consecutive years (e.g., two or three). While not all guilds were prescribed NEPA/CEQA

thresholds (e.g., dabbling ducks, medium shorebirds, fish eaters), some guilds have goals defined by the USFWS Don Edwards San Francisco Bay National Wildlife Refuge. In the absence of NEPA/CEQA significance thresholds for the SBSPRP, the Refuge goals offer an alternative metric for assessing waterbird population trends in the SBSPRP area.

The objectives of ongoing waterbird monitoring are to document avian use of current and former salt evaporation ponds in the South San Francisco Bay and to use data collected on waterbird abundance, distribution, and habitat associations to inform regional conservation, management, and habitat restoration efforts. To meet these objectives, SFBBO and the U.S. Geological Survey have conducted regular waterbird surveys since 2003. Annual reports that summarize the data are prepared each year by SFBBO and shared with land managers and the SBSPRP. These reports inform restoration actions and pond management. As the SBSPRP proceeds, understanding how waterbirds use managed ponds, restoration sites and salt production ponds, identifying key habitat associations, and incorporating features needed by marsh or pond-dependent species into restoration design plans will be increasingly important in maintaining numbers of waterbirds in the South Bay.

## **Report Objectives**

SFBBO and the U.S. Geological Survey (USGS) have been monitoring waterbirds in SBSPRP sites (managed ponds) and surrounding Cargill salt production ponds since 2003, and the data are reported to the SBSPRP Management Team. Our task is to create an updated assessment of the status of waterbirds in the context of the SBSPRP's targets and NEPA/CEQA significance thresholds for waterbird populations. We intend to incorporate similar analyses into future annual reports of waterbird surveys for the SBSPRP, so we required that the update be reproducible. Our second task is to evaluate the value of external data sources, namely nesting surveys from SFBBO's Colonial Waterbird Program, for showing trends of colonially nesting waterbirds in the SBSPRP.

## **Methods**

### **Data Collection**

#### *Pond Surveys*

We conducted waterbird surveys at each of the 82 ponds in the Alviso, Coyote Hills, Dumbarton, Eden Landing, Mowry, and Ravenswood complexes. Survey frequency changed over the course of the study with the availability of resources. USGS conducted monthly waterbird surveys within the SBSPRP (Eden Landing, Alviso, and Ravenswood complexes) from October 2002 to April 2013, while SFBBO conducted monthly surveys in Cargill-managed ponds (Mowry, Coyote Hills, and Dumbarton) from October 2005 to April 2015 (De La Cruz et al. 2018).

During this time, data from 2005–2007 were used to establish baseline conditions before most restoration activities, but after the SBSPRP had started the Initial Stewardship Plan (2003) and salt was no longer being produced. SFBBO then conducted surveys at all 82 ponds during seven 6-week survey periods each year from January 2014 to January 2018. Surveys of all 82 ponds are conducted twice during the spring, fall, and winter seasons and once during the summer season. These surveys provide an index of bird abundance rather than absolute abundance, as birds may move between sites during each 6-week survey period.

We performed surveys exclusively at high tide, defined as a tide of 4.0 feet or greater at the Alameda Creek Tide Sub-Station (37° 35.70' N, 122° 08.70' W). During each survey, we observed birds from the nearest drivable road or levee using spotting scopes and binoculars. We counted the total number of individuals of all waterbird species present on each pond and recorded the location of each using aerial site photos superimposed with 250 m<sup>2</sup> individually labeled grids. For each grid-scale sighting of an individual bird or bird group of the same species, we recorded behavioral data (whether the bird or bird group was foraging or roosting). For roosting birds only, we recorded whether we observed the bird or bird group on a levee, an island, or a manmade/artificial structure (e.g., blind, fence post).

### *Breeding Colony Surveys*

The Colonial Waterbird Program is a citizen science-led approach to conservation of the Bay Area's colonial waterbird population. Following a standardized training, volunteers monitor 13 species of gulls, terns, shorebirds, herons, egrets, and cormorants throughout the breeding season (February-August) for 6-8 survey dates per colony. Volunteers have tracked colonies throughout the Bay Area since 1982, primarily focusing on colonies of the following species: Great Blue Heron, Snowy Egret, Great Egret, Double-crested Cormorant, California Gull, Forster's Tern, and Caspian Tern. Citizen scientists use binoculars and spotting scopes to estimate the number of breeding adults, active nests, and chicks. Each nest is identified by its breeding stage (e.g. nest building, incubation, downy chicks, feathered chicks), and the volunteers note evidence of human disturbance or predation.

### **Analyses**

We visualized waterbird trends by selecting the counts within the peak season for each species/guild (i.e. the season when the species/guild was most abundant) and compared the fits of linear and nonlinear models in R version 3.5.1 (R Development Core Team 2018). Upon inspection of the data and model fits, linear models proved insufficient to capture long-term nonlinear trends for these species. We next compared two methods of characterizing nonlinear trends: non-parametric locally weighted smoothing (LOESS) in the ggplot2 package (Wickham 2016) and Generalized Additive Models (GAM) using the gam package. GAMs were more sensitive to count variability in the data, and the ability to include additive effects was

unnecessary in the absence of covariates. We therefore used LOESS regression for the purpose of illustrating overall trends in counts (De La Cruz 2018).

We assessed directional changes in counts over time by comparing the most recent three-year average of complete counts to baseline counts. We defined baseline counts as the targets for each guild/species in the Adaptive Management Plan (Appendix 1). For guilds/species that were not included in the Adaptive Management Plan, we defined baseline values as the mean count per survey from 2005–2007, which is the earliest period for which counts are available in both the SBSPRP area and salt production ponds. We summarized nest counts collected by Colonial Waterbird Program volunteers at sites within the SBSPRP and salt production ponds using R version 3.5.1 (R Development Core Team 2018) and plotted counts and LOESS curves for 11 relevant sites using R package ggplot2 (Wickham 2016).

## **Reproducible Reporting**

Analyses were performed following guidelines of reproducible research so future annual reports will recreate and build on these assessments. We analyzed data using R and prepared reports using RMarkdown. These products are available in a public archive for future use:

<https://github.com/mtarjan/sf-waterbirds>.

## **Results & Discussion**

### **Pond Surveys**

The most recent waterbird counts (averaged across 2015-2017) exceeded the SBSPRP targets (i.e. baseline values) for most guilds (Table 1, Figures 1-3). Ruddy ducks more than tripled, while diving ducks (also includes Ruddy Ducks) nearly doubled. Small shorebirds in fall and spring and Least Terns have increased by more than 20%. For these species/guilds, the increases are largely due to higher counts within the SBSPRP area. Eared Grebe were the exception; Eared Grebe counts have increased overall, but this is attributed to their use of salt production ponds rather than their use of SBSPRP sites. Counts of dabbling ducks and medium shorebirds changed by less than 10% compared to 2005-2007 counts, with a 7% decrease and 5% increase, respectively. Bonaparte's Gulls decreased by 16%, but did not reach their threshold of a 50% decline. Phalarope numbers declined by 78%. Phalarope counts reached a trigger and crossed a NEPA/CEQA significance threshold in 2017. This decline warrants investigation, although power analyses (Tarjan & Heyse 2018) suggest that it is difficult to accurately detect changes in the abundance of phalarope using current monitoring methods. Accurate characterization of SBSPRP site use by phalaropes may require more frequent or more targeted surveys during their peak season. NEPA/CEQA significance thresholds also require that a decline is due to restoration activities. The cause of the declines in phalaropes cannot be attributed to restoration

activities without further investigation of phalarope population trends outside of the SBSPRP area and/or South San Francisco Bay.

### **Breeding Colony Surveys**

SFBBO's Colonial Waterbird Monitoring Program tracked waterbird breeding colonies at 42 sites within the SBSPRP from 1982 to 2018, namely: Alviso A7, Alviso A6, Alviso A8, Alviso A9/10, Alviso A12, Alviso A16, Alviso A4, Alviso A5, Alviso A18, Alviso A17, Alviso A5/A6/A7/A8, Alviso A9/A10/A11/A14, Moffett A2W, Moffett AB1, Moffett AB2, Moffett A3W, Moffett A3N, Moffett A2E, Eden Landing E6B, Eden Landing E8A, Eden Landing E4/7, Eden Landing, Eden Landing E10, Eden Landing E11, Eden Landing E9, Eden Landing E12, Eden Landing E14, Dumbarton N1, Dumbarton N2, Dumbarton N3, Dumbarton, Coyote Hills 2A/3A/4A levees, Coyote Hills N2A, Coyote Hills N5/N7 levee, Coyote Hills, Coyote Hills N4, Mowry M4/M5 levee, Mowry M1/M2 levee, Mowry, Ravenswood R1, Ravenswood, Mountain View A1.

Consistency in site visitation over time varied. Notably, some important breeding sites for terns were not visited by SFBBO in recent years (e.g. RSF2), but were undergoing intensive study by the U.S. Geological Survey (J. Ackerman, personal communication). SFBBO's coverage of breeding sites for American Avocets and Black-necked Stilts was opportunistic, and usually only occurred when these species shared a nesting site with terns (C. Strong, personal communication). Combining information from other efforts will be essential for determining larger-scale trends in waterbird nesting. Due to inconsistency in coverage, we reviewed counts at the colony level rather than summing across sites.

The Colonial Waterbird Program provides counts for multiple species of interest, comprising American Avocets, Black-necked Stilts, Caspian Terns, and Forster's Terns, for 11 colonies in the SBSPRP and salt production ponds (Figure 4). Counts span the years of the SBSPRP, as well as in the decades preceding the project. This suggests that the data could improve estimates of baseline counts and provide an understanding of historical variability in site use. In ten out of the eleven colonies considered, breeding Forster's Terns have declined either before or following Phase I of the restoration project. Nest counts have increased outside of the project footprint, suggesting that Forster's Terns may be moving elsewhere in the San Francisco Bay Area to breed, however this increase is confounded by survey effort and may be a result of increased coverage by the Colonial Waterbird Program in later years. A thorough investigation of the significance of the decline of nesting Forster's Terns at SBSPRP sites merits a synthesis of multiple datasets.

### **Acknowledgements**

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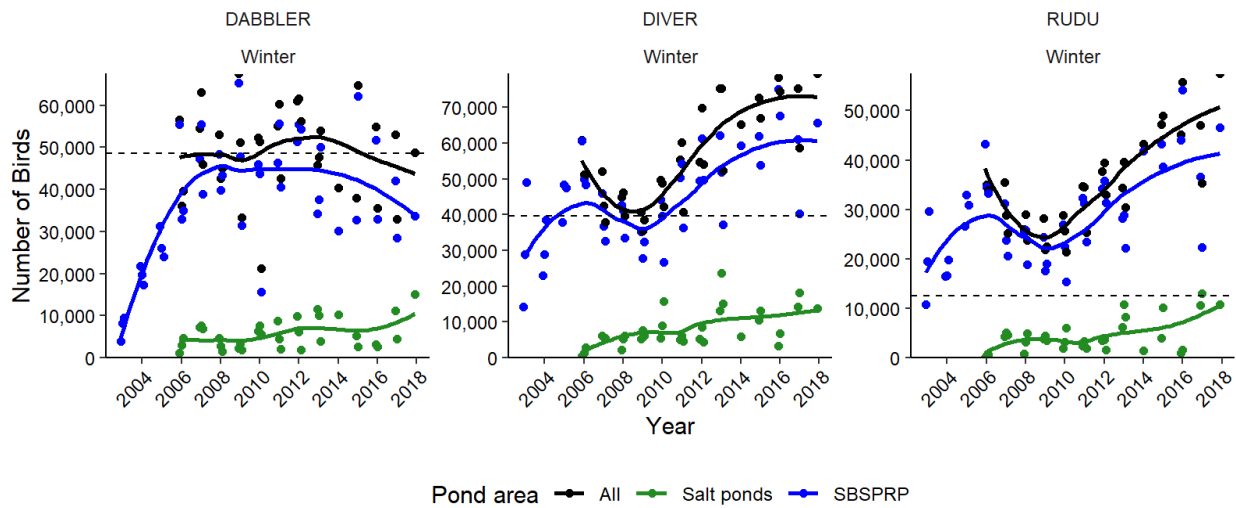


## Tables

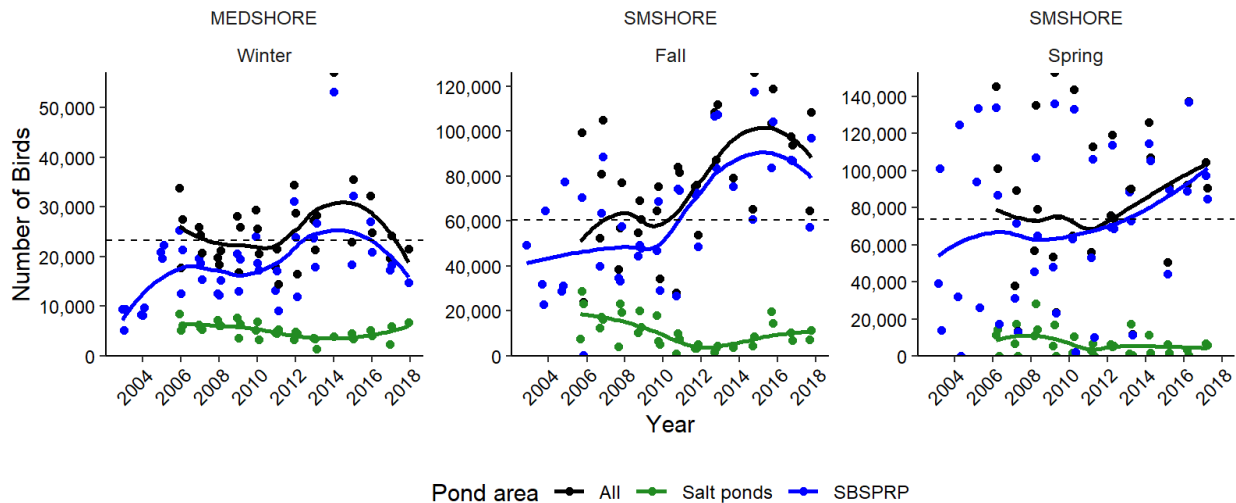
**Table 1.** Summary of recent three-year average (2015-2017) waterbird trends compared with SBSPRP targets and baseline values (2005-2007). Season = the season in which the species/guild counts are highest; SBSPRP target = baseline count defined by the SBSPRP Science Advisory Team. Targets for dabbling ducks and medium shorebirds were not defined in the Adaptive Management Plan, so we assumed that baseline values were the mean count per survey in 2005-2007 (denoted by \*); Threshold = NEPA/CEQA significance threshold; Percent change = percent difference between recent counts (three-year average for 2015-2017) and SBSPRP targets; Trigger = true if a trigger was detected, where two out of the last three consecutive years had counts below baseline values for most species/guilds. The trigger for PHAL, BOGU, and EAGR was three consecutive years more than 25% below NEPA/CEQA baseline, or any single year more than 50% below NEPA/CEQA baseline.

<b>Species/Guild</b>	<b>Season</b>	<b>SBSPRP Target</b>	<b>Threshold</b>	<b>Percent change</b>	<b>Trigger</b>
RUDU	Winter	12602	-15%	282%	FALSE
DIVER	Winter	39645	-20%	85%	FALSE
SMSHORE	Fall	60623	-20%	61%	FALSE
SMSHORE	Spring	73728	-20%	28%	FALSE
EAGR	Winter	5640	-50%	56%	FALSE
PHAL	Summer	3225	-50%	-78%	TRUE
BOGU	Winter	1270	-50%	-16%	FALSE
DABBLER	Winter	48524*	NA	-7%	FALSE
MEDSHORE	Winter	23312*	NA	5%	FALSE
LETE	Summer	63	NA	21%	FALSE

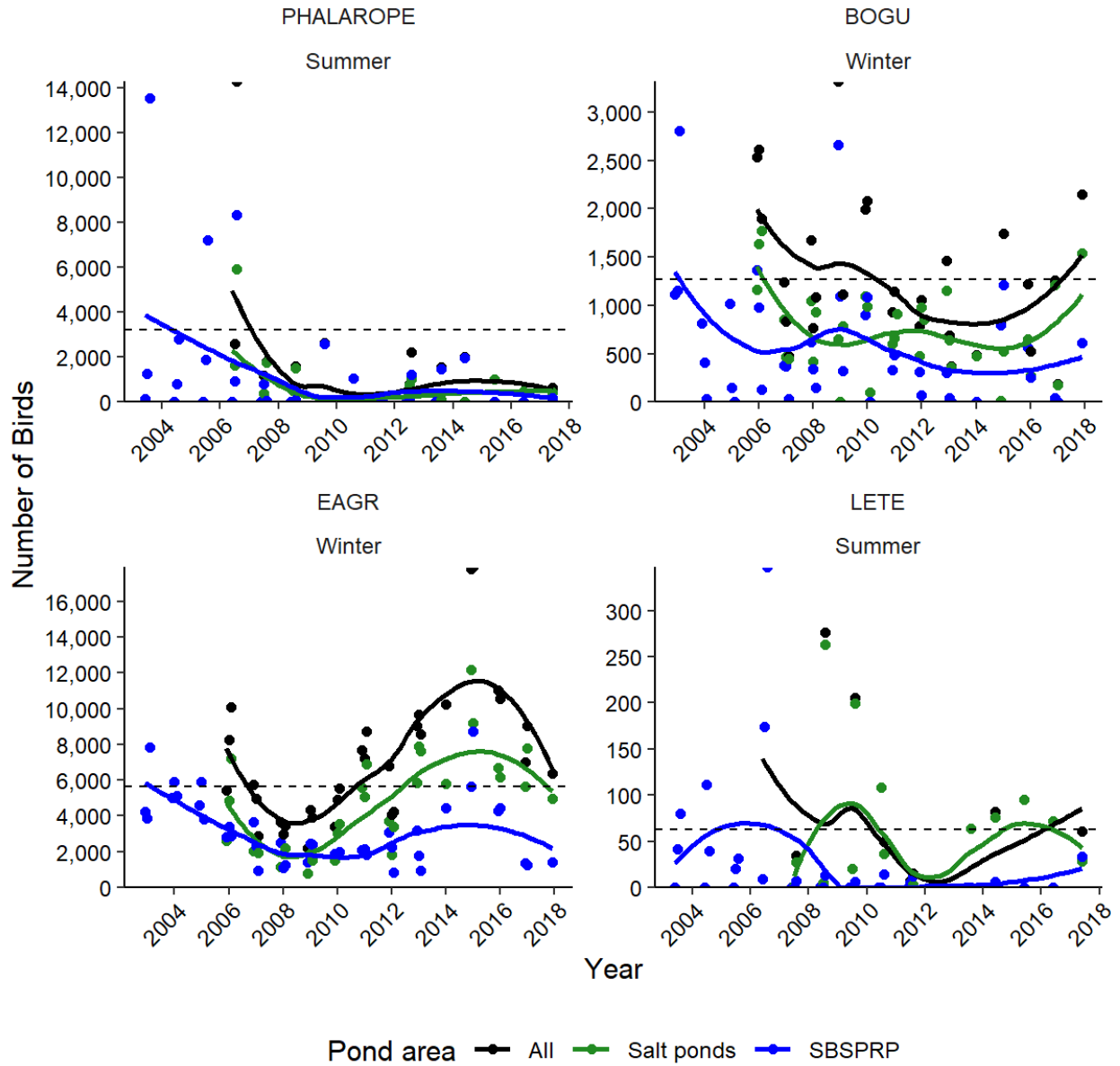
## Figures



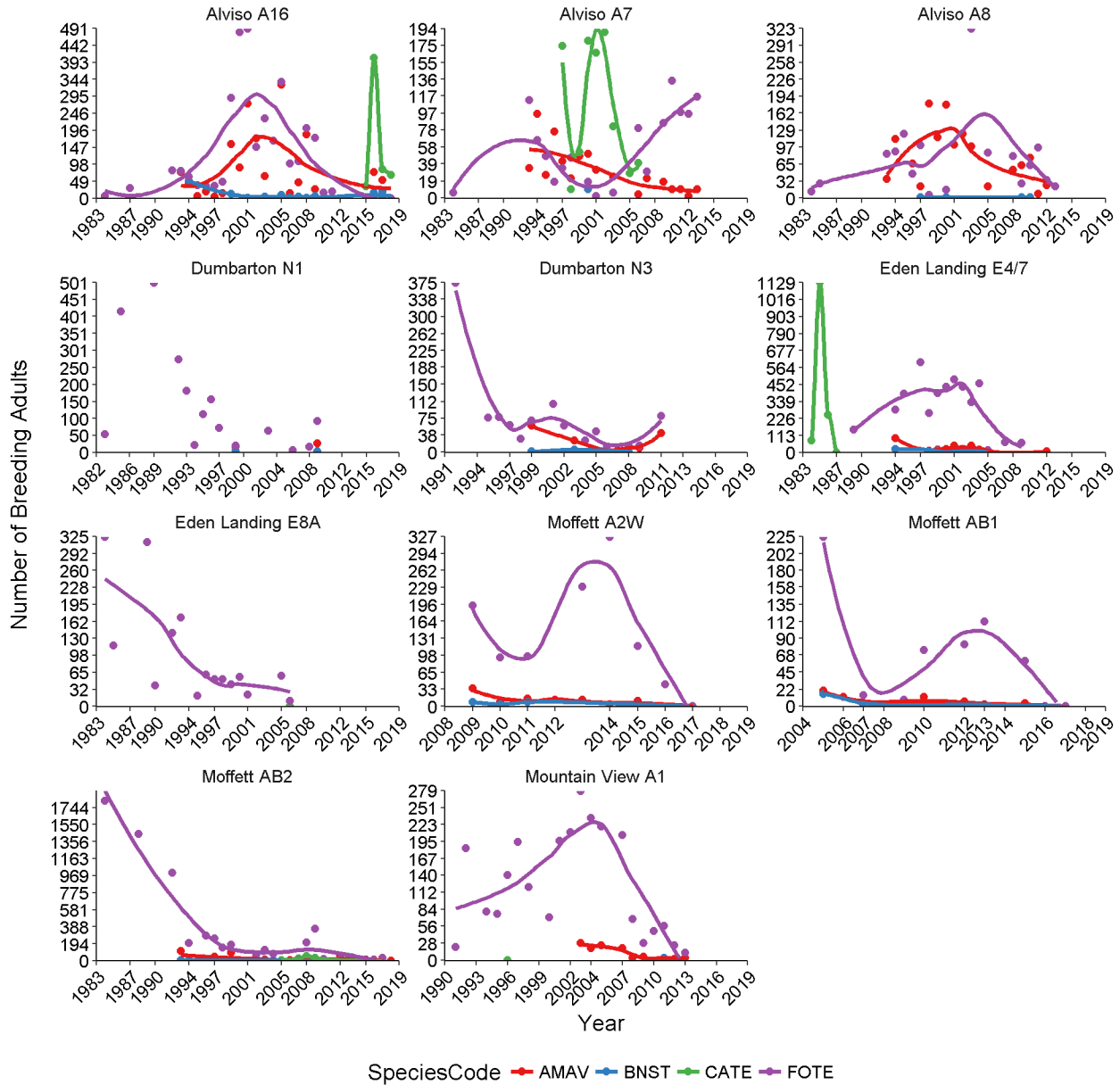
**Figure 1.** Counts of dabbling ducks, diving ducks, and Ruddy Ducks (RUDU) during peak seasons within the SBSPRP and salt production ponds. Lines represent LOESS curves and the dashed lines denote SBSPRP Targets or baseline values (average counts from 2005-2007).



**Figure 2.** Counts of medium and small shorebirds during peak seasons within the SBSPRP and salt production ponds. Lines represent LOESS curves and the dashed lines denote SBSPRP targets or baseline values (average counts from 2005-2007).



**Figure 3.** Counts of phalaropes (PHAL), Bonaparte’s Gulls (BOGU), Eared Grebe (EAGR), and Least Terns (LETE) during peak seasons within the SBSPRP and salt production ponds. Lines represent LOESS curves and the dashed lines denote SBSPRP targets or baseline values (average counts from 2005-2007).



**Figure 4.** Number of breeding adults at SBSPRP sites and salt production ponds. Numbers were estimated from nest counts by citizen scientists in the Colonial Waterbird Program. Lines represent LOESS curves. AMAV = American Avocet; BNST = Black-necked Stilt; CATE = Caspian Tern; FOTE = Forster’s Tern.

## Appendix 1

Table of targets, thresholds, and triggers for each waterbird species and guild of interest for monitoring in the South Bay Salt Pond Restoration Project area and South San Francisco Bay. Adapted from the SBSRP Adaptive Management Plan: Adaptive Management Summary Table (Appendix 3) and restoration targets set by USFWS as part of the Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (2013). Originally compiled in Tarjan & Heyse (2018).

Species/ Guild	NEPA/CEQA Baseline (Target)	SBSRP Adaptive Management Trigger	NEPA/CEQA Significance Threshold	DESFBNWR Targets
Ruddy Duck (RUDU)	12602 (2005-2007 mid-winter survey mean); range: 10722 (2007)- 15575 (2005)	two years of decline in numbers below baseline conditions in South Bay as a whole out of any consecutive three years	decline in South Bay numbers of 15 percent as a result of the SBSP Restoration Project	
Diving Ducks (excludes RUDU)	27043 (mid-winter survey average 2005-2007); range: 19521 (2007)- 40326 (2005)	two years of decline in numbers below baseline conditions in South Bay as a whole out of any consecutive three years	decline in South Bay numbers of 20 percent as a result of the SBSP Restoration Project	
Small Shorebirds - Winter/Fall	60623 (fall; 2005- 2007 USGS/SFBBO mean); range 130662 (2005) to 241546 (2006)	two out of three consecutive years when the South Bay shorebird abundances fall below the baseline in any given season	decline in South Bay numbers of 20 percent as a result of the SBSP Restoration Project	

Small Shorebirds - Spring	73728 (2005-2007 USGS/SFBBO mean); range 140618 (2007) to 269331 (2006)	two out of three consecutive years when the South Bay shorebird abundances fall below the baseline in any given season	decline in South Bay numbers of 20 percent as a result of the SBSP Restoration Project	
Eared Grebe (EAGR)	5640 (winter; 2005-2007 USGS/SFBBO mean); range: 3826 (2007) to 8036 (2006)	AMP = three consecutive years more than 25% below NEPA/CEQA baseline, or any single year more than 50% below NEPA/CEQA baseline	decline in South Bay numbers of 50 percent as a result of the SBSP Restoration Project	
Phalaropes	3225 (summer; 2005-2007 USGS/SFBBO mean); range: 1013 (2007) to 5623 (2006)	AMP = three consecutive years more than 25% below NEPA/CEQA baseline, or any single year more than 50% below NEPA/CEQA baseline	decline in South Bay numbers of 50 percent as a result of the SBSP Restoration Project	
Bonaparte's Gull (BOGU)	1270 (winter; 2005-2007 USGS/SFBBO mean); range: 896 (2005) to 1917 (2006)	AMP = two out of three consecutive years more than 25% below NEPA/CEQA baseline, or any single year more than 50% below NEPA/CEQA baseline	decline in South Bay numbers of 50 percent as a result of the SBSP Restoration Project	
Dabbling Ducks	n/a	n/a	n/a	Over the next 5 years (FY 2018-2022), wintering waterfowl species richness and

				abundance on the Don Edwards is maintained relative to the 2012 (Richmond et. al 2014) baseline (grebes=5,343, waterfowl=80,793,14 species waterfowl).
Medium Shorebirds	n/a	n/a	n/a	Over the next 5 years (FY 2018-2022), wintering shorebird species richness and abundance is increased at Don Edwards SF Bay NWR from fair to good relative to the 2015 baseline (56,147, 22 spp).
Least Tern (LETE) post-breeding dispersants in South Bay	63 (2005-2007 mean); range: 36 (2007)-112 (2006)	decline in total number of birds using South Bay as post-breeding foraging area in any two out of three consecutive years	decrease in foraging habitat or prey availability for post-breeding dispersants in the South Bay, leading to a decline in the Bay Area breeding population	

## **Appendix 2**

### **Correction Notice**

This report was revised on April 28, 2021 to correct an error in waterbird counts. The original report contained duplicated waterbird counts from June 2015 to December 2017. This duplication resulted in summed counts that were artificially high during that time period. This error affected Figures 1, 2, and 3 and trend estimates in waterbird counts, which appear in Table 1. Corrected trend estimates are lower for all species/guilds. Corrected trend estimates resulted in qualitative (i.e. directional) changes for two species/guilds. In the original report, Bonaparte's Gulls and dabbling ducks were found to have increased, but the correct trend estimates are -16% and -7%, respectively.