Coordinated phalarope surveys at western North American staging sites, 2019-2020

By Ryan Carle[1*], Gabbie Burns[2], Sarah Hecocks[1], Deborah House[3], Ron Larson[4], Ashli Lewis[5], Ann E. McKellar[6], John Neill[7], Michael Prather[8], John Reuland[4], Margaret Rubega[9], and L. Max Tarjan[2]

[1] Oikonos Ecosystem Knowledge

[2] San Francisco Bay Bird Observatory

[3] Watershed Resources Specialist, Los Angeles Department of Water and Power

[4] East Cascades Audubon Society

[5] California State Parks

[6] Environment and Climate Change Canada

[7] Utah Division of Wildlife Resources

[8] Eastern Sierra Audubon Society

[9] University of Connecticut

*corresponding author contact: ryan@oikonos.org

Cover photo: David Carle

Executive Summary

Wilson's and red-necked phalaropes (*Phalaropus tricolor and P. lobatus*, respectively), have poorly understood conservation statuses. These species breed in northerly latitudes of North America to migrate to staging areas at saline lakes in western North America, before migrating to South American lands and waters. Given saline lake habitat is threatened worldwide by water diversion and climate change, there is an urgent need to better understand phalarope population and trends. We conducted coordinated monitoring of western North American staging areas of historical importance to phalaropes: Great Salt Lake (Utah), Mono Lake (California), Lake Abert (Oregon), Owens Lake (California), south San Francisco Bay (California), and Chaplin Lake (Saskatchewan). We conducted surveys at each site during week-long "survey windows," from mid-July to mid-September, 2019 and 2020, with the goal of at least one survey per site per window. Methods were standardized within sites but varied across sites, including plane-based, boat-based, and land-based surveys. We report results from Great Salt Lake, Mono Lake, and Lake Abert in 2019 and for all surveyed sites in 2020. The peak Wilson's phalarope count from all sites combined was 339,715 birds in 2019 (3 sites), and 126,288 birds in 2020 (6 sites). Inclusion of unidentified birds in Wilson's phalarope peak counts resulted in high counts of 370,811 birds in 2019 and 236,434 birds in 2020. The peak red-necked phalarope count from all sites combined was 154,581 birds during 2019 (3 sites), and 53,762 in 2020 (6 sites). Inclusion of unidentified birds in red-necked phalarope peak counts resulted in high counts of 291,643 birds in 2019 and 123,697 birds in 2020. The three additional sites monitored in 2020 added ≤1% of the combined totals for each species/unidentified peak count. Timing of both species was similar to historic patterns, with peak numbers in mid-July for Wilson's phalaropes and in mid- to late-August for red-necked phalaropes. Numbers of both species at Great Salt Lake outnumbered those at other sites by an order of magnitude in 2019 and 2020. There is a need for continuing standardization of survey methods across sites, research on phalarope movements among sites and residence times at sites, and attention toward the issue of interpretation of unidentified phalarope counts. Continued monitoring will help us understand phalarope population trends, migratory patterns and timing, and response to climate and environmental factors, and will provide a valuable indicator of the health of saline lake ecosystems.

Introduction

Wilson's and red-necked phalaropes (*Phalaropus tricolor and P. lobatus*, respectively) are banner species of saline lakes in the interior west of North America, where they stop in flocks of up to hundreds of thousands. The conservation status of these phalarope species, however, is poorly understood (Lesterhuis and Clay 2009, Rubega et al. 2020). This data gap is largely due to the difficulty of counting these unusual shorebirds that spend much of their time swimming far from shore on large lakes. Given their reliance on saline lakes, many of which are existentially threatened by water diversion and climate change (Moore et al. 2016, Wurtsbaugh et al. 2017), there is an urgent need to better understand phalarope population trends. Indeed, the National Audubon Society considers the Wilson's phalarope "climate endangered" (Langham et al. 2015) and the red-necked phalarope "highly vulnerable" (Wilsey et al. 2019) to climate change based on modeled loss of wetland habitats predicted with climate change.

Phalaropes breed in northerly latitudes of North America, and during southward migration significant numbers (i.e., tens of thousands to hundreds of thousands) of Wilson's and red-necked phalaropes stop at just a few hyper-saline lakes in western North America (Jehl 1986, 1988). Smaller numbers of phalaropes are also seen at wetlands across a broad geographic front in western North America, and whether and how either species' movements vary seasonally or annually is unknown. Both species spend boreal winters in the southern hemisphere–Wilson's phalaropes in interior saline wetlands in South America, and red-necked phalaropes at sea off the western coast of South America.

Among the most important North American phalarope staging sites historically are Great Salt Lake (Utah), Mono Lake (California), Lake Abert (Oregon), San Francisco Bay (California), and Chaplin Lake (Saskatchewan; Jehl 1988). With major phalarope population concentrations occurring during a relatively short time period at these staging sites, coordination of surveys across sites offers a good opportunity to understand population trends of the species overall (Jehl 1986, 1999). To understand the population trends of phalaropes, these major staging sites must be surveyed in a narrow time range, so that movement of the birds between sites does not confound results. Although ongoing shorebird or waterbird monitoring has been conducted at some staging sites, there have not been consistent phalarope censuses at most staging sites since the 1990s (Jehl 1999). With respect to phalarope populations there been no coordination of survey effort, and there is a need for a standardized, repeatable annual survey method to allow year to year comparisons of survey data within and across sites.

In 2019, we founded the International Phalarope Working Group with partners from around the western hemisphere, and identified the establishment of coordinated surveys in western North America as a top priority for phalarope conservation research (Carle and Rubega 2019). The objective of coordinated surveys is to create an annual index of phalarope numbers at major staging sites and evaluate population trends. In 2019 and 2020, we initiated a program of coordinated annual phalarope-specific surveys at Great Salt Lake, Mono Lake, south San Francisco Bay, Lake Abert, Owens Lake (California), and Chaplin Lake.

At Great Salt Lake, phalaropes often number in the hundreds of thousands annually (Jehl 1988, 1999, Utah Division of Wildlife unpublished data). Flocks of tens of thousands of Wilson's and red-necked phalaropes have been consistently recorded at Mono Lake, Lake Abert, and Chaplin

Lake (Jehl 1986, 1988, 1999, LADWP unpublished data). San Francisco Bay has at times hosted flocks of 40,000 birds (Jehl 1988). From the 1920s until relatively recently, the bed of Owens Lake was dry, but since 2001, the use of shallow flooding by the City of Los Angeles to control dust has resulted in increased water availability at Owens Lake. Historical acccounts indicate that Owens Lake was likely an important habitat for phalaropes prior to its desiccation (Herbst and Prather 2014), though no quantitiative data exist from that time. Given the presence of habitat at Owens Lake as a result of the dust control project, we included it in the surveys.

At many of these sites, annual waterbird or shorebird surveys were already in place, but we made efforts to coordinate the timing of these with phalarope-focused surveys at multiple sites. In 2019 we made progress in forming connections and organizing new survey efforts; however, we only achieved full coordination of counts at Great Salt Lake, Lake Abert, and Mono Lake in 2019. During 2020, we added coordinated counts at Owens Lake, south San Francisco Bay, and Lake Chaplin. In this report we present results from our 2019 and 2020 coordinated surveys and comparisons between years for sites with sufficient data.

Methods

Study sites

In 2019 and 2020, we coordinated surveys across six phalarope staging sites in western North America: Great Salt Lake (Utah, U.S.A.), Mono Lake (California, U.S.A.), Lake Abert (Oregon, U.S.A.), Owens Lake (California, U.S.A.), the south San Francisco Bay (California, U.S.A.), and Chaplin Lake (Saskatchewan, Canada; Fig. 1). These sites were chosen because historically, they have hosted consistent large aggregations of Wilson's and red-necked phalaropes (Jehl 1988).

The other factor for selection of sites for coordinated surveys was whether there was a local organization or agency that had the resources and willingness to conduct surveys. We did not survey several staging sites that have historically hosted large numbers of phalaropes, such as the Lahontan Valley/Stillwater National Wildlife Refuge complex (Nevada), and East Coteau and Reed lakes (Saskatchewan; Jehl 1988), because of a current lack of resources or connections with partners to survey these locations.

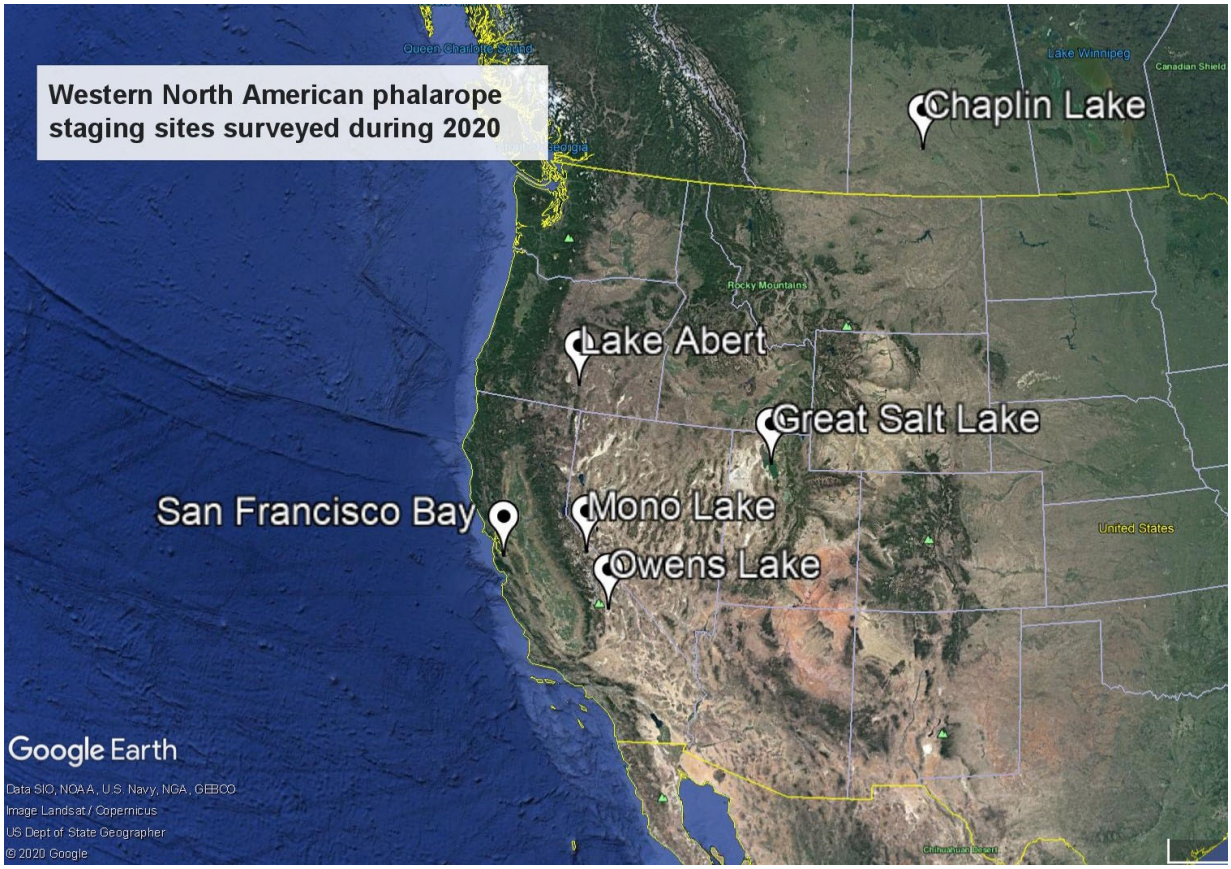

Figure 1. Western North American phalarope staging site surveys locations, 2020.

There are several other western North American staging sites with historic records of large but inconsistent aggregations of phalaropes, which we did not survey; for example, sites with one historic record of a large flock and no other indication of visitation by phalaropes (e.g., Bowdoin NWR, Montana, and Crescent Lake, Texas; Lesterhuis and Clay 2009). The addition of more sites in future years would improve our understanding of phalarope trends and distribution.

We conducted surveys at each site during week-long "survey windows," in which the goal was to conduct at least one survey per site (see suvey windows and survey dates at each site in Tables 1 and 2). By surveying all sites during these survey windows, we sought to reduce the chance of double-counting birds moving between sites. We chose a week-long window to allow for flexibility of survey dates for partners to work around local weather conditions and logistical constraints.

Survey methods were tailored to the specific terrain, resources, and staffing available at each site, and are detailed below. We attempted to keep methods and survey coverage standardized within sites, so that each survey window's data could be directly compared. We present results from 2019 for Great Salt Lake, Mono Lake, and Lake Abert, because those sites had consistent surveys with coordinated timing (Table 1). We report results from all monitored sites for 2020 (Table 2).

Table 1. Dates of 2019 phalarope surveys at western North American staging sites. Blank cells indicate no survey was conducted during that window. ESA is Eastern Sierra Audubon, LADWP is Los Angeles Department of Water and Power.

	Survey window						
Site	**Outside survey window-early**	**July 11-17**	**July 28-August 3**	**August 16-22**	**August 31-September 6**	**September 11-17**	**Outside survey windows-late or between windows**
Great Salt Lake		7/16	7/30	8/20		9/11	
Mono Lake		7/11, 7/12	8/1, 8/2	8/19, 8/20	9/2, 9/3	9/17	
Lake Abert	6/17	7/15	8/3	8/16	8/31, 9/6		7/27, 8/10, 8/24, 9/9
Owens Lake (ESA)					9/6		8/8
Owens Lake (LADWP)	4/23-4/24			8/19			9/23-9/24

Great Salt Lake

At Great Salt Lake, Utah (41.115 N°, -112.477 W°) aerial surveys were conducted by Utah Division of Wildlife Resources personnel from a small plane (Cessna 185 Skywagon) between 25-60 m above the surface of the water travelling at 130-160 km per hour. Phalarope counts by species, number, and general location were recorded by two separate observers, one looking out each side of the aircraft, using hand-held audio tape recorders during the flight and transcribed afterward. Large flocks (>75,000) were counted several times by both surveyors, usually by groups of 5,000, and totals decided by consensus.

Each survey started around 7 a.m. and lasted about 3 hours traveling over the water about 800 m from the shoreline of Great Salt Lake in a counter-clockwise direction (see Appendix 1, Fig. A1, for route map). Counting started on the shoreline along the north side of Ogden Bay north of Fremont Island and west to Promontory Point then north to Little Valley Harbor in Gunnison Bay. From the harbor, the survey continued across the lake west-northwest to Gunnison Island and south along the western and southern shores to the southern tip of Antelope Island where the survey turned east over adjacent wetlands and then entered Farmington Bay. The northern shoreline of Antelope Island to White Rock Bay was then surveyed followed by the rest of Ogden Bay, the western shore of Bear River Bay, Bear River Migratory Bird Refuge and adjacent private wetlands, Willard Spur, and finished along the eastern shore of Bear River Bay if extensive water was present. If phalarope flocks were observed in the open water away from

the shoreline, east-west transects spaced 1.9 kilometers apart were flown over the extent of these concentrations.

Table 2. Dates of 2020 phalarope surveys at western North American staging sites. Blank cells indicate no survey was conducted during that window. ESA is Eastern Sierra Audubon, LADWP is Los Angeles Department of Water and Power.

	Survey window						
Site	**Outside survey window-early**	**July 15-21**	**July 29-August 4**	**August 13-19**	**August 31-September 6**	**September 15-21**	**Outside survey windows-late or between windows**
Great Salt Lake		7/15	7/28*	8/13	9/2	9/14*	
Mono Lake		7/16, 7/18	7/31, 8/2	8/13, 8/15	9/4, 9/5		
Lake Abert	5/27, 6/1, 7/1	7/15	7/29		8/31	9/22*	
Owens Lake (ESA)		7/18	8/4	8/19	9/3	9/21	
Owens Lake (LADWP)				8/18-8/19		9/21-9/23*	
San Francisco Bay	7/7	7/21	8/4	8/18	9/1	9/15	9/29
Chaplin Lake		7/17	8/1	8/14, 8/17			7/24, 8/7

*Asterisks indicate dates that were 1 day outside the week-long survey windows but were included in those survey windows for summary. The last two days of the 9/21-9/23 Owens Lake survey were outside the survey window but were a continuation of the the 9/21 survey, which was in the survey window. The combined count of those dates at Owens Lake was considered to fall in the survey window; all areas where phalaropes were recorded during that survey were surveyed on 9/21-9/22.

Mono Lake

At Mono Lake, California (38.028° N, -119.011° W) surveys were conducted by Oikonos Ecosystem Knowledge and the University of Connecticut, with staff and equipment support from California State Parks and the Mono Lake Committee. Two surveys were conducted during each survey window, either on consecutive days, or with one day between surveys. Surveys consisted of a combination of boat- and shore-based counts. The survey protocol was based on that of historical surveys conducted by Rubega and Keimel (2017) in 1990 and 1991, with modifications. Boat counts consisted of two surveyors visiting permanent boat survey points (56 in 2019, 59 in 2020; Appendix 1, Fig. A2) and simultaneously counting phalaropes in a fixed-distance radius from the boat, using binoculars. The first three 2019 surveys (July 11, July 12,

and August 1) used an unlimited boat survey radius; all subsequent 2019 and 2020 surveys used a standard 400 m radius. We used a rangefinder to determine that 400m was a count radius likely to result in phalarope detections without being so large that accurate identifications became difficult. We calibrated observers' estimates of the 400 m count radius during each survey by practicing with a range finder on static objects, and by referencing print outs of aerial images showing the 400 m radius for count points with landmarks. Shore surveyors counted from locations in discrete areas with limited overlap with the boat survey (there were 4 shore count locations in 2019, 5 in 2020; Appendix 1, Fig. A2). Shore surveyors used a combination of spotting scopes and binoculars. Shore survey count areas were standardized but varied by shore survey point (see Appendix 1, Table A3 for count areas). Shore surveys were conducted by trained volunteers. On both boat and shore surveys, phalaropes were counted in 1s, 10s, 100s, or 1,000s, depending on flock size, with results reported in corresponding round numbers. In areas where boat and shore survey points overlapped, the proportion of overlap was multiplied by the number of birds counted in the boat count, and the result was subtracted from that boat point's count (these instances made up a small proportion of overall points and birds). For detailed methods see Carle and Rubega (2019, 2020).

The Mono Lake count is an index-count, to be compared to itself year to year, rather than an attempt to count of every bird on the lake. Count stations were spread across the full extent of the lake, though counts were limited to the 400 m radius at boat count stations. See Appendix 1, Fig. A2 for a map of the survey points.

Lake Abert

At Lake Abert, Oregon, (42.703° N, -120.221° W) shore-based surveys were conducted by volunteers for Eastern Cascades Audubon. Observers arrived at the lake early in the morning to avoid heatwaves reducing visibility, and drove along highway 395 on the east side of the lake, stopping at 15 pullouts to make counts, with gaps of approximately 0.25 miles between pullouts. Observers used binoculars to identify and count nearby birds and use scopes for more distant birds. Where birds were in flocks, numbers of birds in each field of view were estimated, (usually in multiples of 25, 50, 100 and etc.) and then the size of entire flock was estimated by multiplying the numbers of birds in each field times the numbers of scope fields the flock occupies.

Because Lake Abert is 3-5 miles across on average, about half or less of the lake could be adequately counted. It usually appeared that most phalaropes were in relatively visible areas either at the narrow south end of the lake or near the eastside springs at the north end. Occasionally large flocks of shorebirds could be seen on the far shore, but could not be counted. Phalaropes were identified to species if they were close enough to the observers to make accurate identifications.

Owens Lake

At Owens Lake, California (36.445 N°, -117.945 W°) surveys of the Owens Lake Dust Control Program Area were conducted by both Eastern Sierra Audubon (ESA) and the Los Angeles

Department of Water and Power (LADWP). The Owens Lake Dust Control Program Area totals 48 square miles, of which 30 square miles is currently water-based. LADWP applies water to portions of Owens Lake from October through June for the purpose of dust control. Some water is also released outside this period to maintain wildlife habitat. The Dust Control Program Area is further divided into numerous discrete dust control management units referred to as "DCA's" (Dust Control Areas) or "cells" (Appendix 1, Fig. A3). Cells differ in size, depth, salinity and water persistence.

LADWP biologists conducted four surveys a year of the entire Owens Lake Dust Control Program Area: April, August, September and October. These "lakewide surveys" required 1-3 days to complete. One to two of these "lakewide surveys" have overlapped the phalarope survey windows in 2019 and 2020 (August and September). ESA conducted smaller-scale surveys during other survey windows to fill in these gaps. ESA surveys covered 5-6 cells in 2019 and 9-16 cells in 2020, all in the northern half of Owens Lake (see Appendix 1, Fig. A3, for map of surveyed cells). Starting time was near dawn each day. All surveys at Owens Lake were conducted by driving along roads and berms surrounding cells, stopping periodically to survey using binoculars and spotting scopes. For survey windows with both LADWP and ESA surveys, we report the results of the LADWP surveys, because they covered the whole lake.

South San Francisco Bay

At San Francisco Bay, California (37.444° N, -122.069° W) the San Francisco Bay Bird Observatory (SFBBO), with financial and logistical support from multiple agencies and landowners (see acknowledgements), planned to survey phalaropes at former salt evaporation ponds, managed ponds, and several other sites in southern San Francisco Bay (hereafter referred to as "San Francisco Bay"). Thirty-one sites were selected, composed of a subset of ponds in the Alviso, Mowry, Newark, and Ravenswood complexes of the Don Edwards San Francisco Bay National Wildlife Refuge, a subset of ponds in Eden Landing Ecological Reserve, Alviso Marina County Park, Spreckles Marsh, New Chicago Marsh, Crittenden Marsh, Coyote Hills Regional Park, and the Sunnyvale Water Pollution Control Plant (see site maps in Appendix 1, Fig. A4). Together these sites comprise 6,687 out of 20,357 acres of former commercial salt pond habitat (encompassing areas where 99% of historical SFBBO phalarope observations occurred), in addition to 378 acres of other diked wetlands and treatment ponds in south San Francisco Bay (where multiple observations of phalaropes have occurred on eBird; Tarjan 2020). Note that the scope of the 2020 surveys was south of the San Mateo Bridge and that additional managed ponds, diked or muted tidal marshes, and storage or treatment ponds exist in north San Francisco Bay. Coverage throughout the entire 54,732 acres of potential phalarope habitat in north and south San Francisco Bay is a goal of future surveys.

Due to COVID-19 restrictions, in 2020 SFBBO was able to survey only 17 of the 31 target sites, equivalent to 3,229 acres and 46% of the target area (Appendix 1, Fig. A4). Access was not approved for sites on the Don Edwards San Francisco Bay National Wildlife Refuge, including Alviso, Mowry, and Newark ponds, New Chicago Marsh, and Ravenswood pond RSF2 (14 sites). Surveys were not completely synchronized or completed at all sites in some cases due to interfered access and poor air quality considerations (during 2020, wildfires caused exceptionally poor and dangerous air quality in California in August and September). Surveys were conducted

from shore using binoculars and 40x spotting scopes. Surveys were conducted between 8 a.m. and 12 p.m by SFBBO staff and trained volunteers. Count boundaries were delineated by maps and instructions.

Chaplin Lake

At Chaplin Lake, Saskatchewan (50.411° N, -106.603° W), an established protocol developed by the Canadian Wildlife Service and University of Saskatchewan involved weekly fall shorebird surveys at 18 point count stations throughout the roads and dikes that surround and bisect the lake (Appendix 1, Fig. A5). Point count stations had a radius of either 200m or 500m depending on topography and proximity of neighboring stations, and therefore these surveys did not cover the entire available habitat on the lake (Appendix 1, Fig. A5). However, in 2020, efforts were made to count all phalarope species seen while traveling in a vehicle between survey points, essentially covering the entire road/dike system that is accessible by vehicle, and associated distance that is visible into the lake from shore.

Observers counted all shorebirds seen within the point count station radius during an unlimited time period, using binoculars and spotting scopes. Shorebirds were identified to species whenever possible, and surveys were conducted at any time of day provided weather conditions are appropriate (i.e., no heavy precipitation or strong winds). In 2020, surveys were conducted weekly from July 17 to August 28. Thus, surveys conducted on July 17, August 1, and August 14/17 fell within the windows defined in this report. Of those dates, the full road/dike network was surveyed during the August 1 and August 14/17 surveys.

Caveats for comparisons between sites

As described above, the methods and coverage of surveys each site were variable. Reasons for differing survey methodologies were related to factors including the site topography and conditions, the level and training of staffing available, and the choices of those designing the surveys at each site. In comparing the results from each site, it is important to keep in mind that the following factors varied across sites 1) survey effort (i.e., number of observer hours at each site); 2) observer training (i.e., some sites used trained professional biologists, others used trained volunteers); 3) survey area (i.e., some sites used point counts with fixed radii, others counted an entire area regardless of distance); 4) estimation methods (i.e., at different sites, different estimation methods were used for flock size); 5) vantage/proximity to birds (i.e, at some sites surveys were conducted from planes, at others from boats, and others from shore, and survey distances from water or birds varied); 6) methods to control double-counting (i.e., some sites had duration limits for counts, other did not); 7) time of day/time distribution of effort; and completeness of the survey (i.e., did the survey entirely or partially sample the site).

Importantly, care was taken to keep methods consistent *within* sites, meaning that surveys carried out on different dates or years at a single site should be fully comparable. There is a need to continue developing more standardized methods across sites to improve our phalarope population estimates.

Results and discussion

The maximum combined 2019 count of Wilson's phalaropes from Great Salt Lake, Mono Lake, and Lake Abert was 339,715 birds during the July 11-17 window (Table 3, Fig. 2). The combined maximum count of Wilson's and unidentified phalaropes during the July 11-17, 2019 window was 370,811 birds (Table 3). The maximum 2020 Wilson's phalarope count from all monitored sites combined was 126,288 birds during the July 15-21 window (Table 3, Fig. 3). Adding the total number of unidentified phalaropes from all sites to the total Wilson's count during the July 15-21, 2020 window resulted in a count of 236,434 birds (Table 3). Historically, red-necked phalaropes make up a small proportion of overall phalaropes at staging sites in mid-July (i.e., <10%; Jehl 1986, Jehl 1988, Rubega and Keimel 2017). Thus, it is probable that many of the unidentified birds during the July 11-17, 2019 and July 15-21, 2020 windows were Wilson's phalaropes. Overall, the peak 2020 Wilson's and unidentified total was 134,377 birds fewer in 2020 than in 2019, even with the addition of Owens Lake, San Francisco Bay, and Chaplin Lake in 2020 (these additional sites combined added only 1,056 birds to the 2020 total; Table 3).

Table 3. Maximum phalarope counts in survey windows at western North American staging sites, 2019 and 2020. 2019 counts are from only Great Salt Lake (GSL), Mono Lake, and Lake Abert. 2020 totals from those three sites are shown, as well as the totals from all six monitored sites in 2020 (GSL, Mono Lake, Lake Abert, Owens Lake, south San Francisco Bay, and Chaplin Lake).

Year	Wilson's phalarope	Wilson's/Unidentified phalaropes combined	Red-necked phalarope	Red-necked/Unidentifed phalaropes combined
2019 (GSL, Mono, Abert)	339,715 (Jul 11-17)	370,811 (Jul 11-17)	154,581 (Aug16-22)	291,643 (Aug 16-22)
2020 (GSL, Mono, Abert)	125,405 (Jul 15-21)	235,396 (Jul 15-21)	52,243 (Aug 31-Sep 6)	121,863 (Aug 31-Sep 6)
2020 (all 6 sites)	126,288 (Jul 15-21)	236,434 (Jul 15-21)	53,762 (Aug 31-Sep 6)	123,697 (Aug 31-Sep 6)

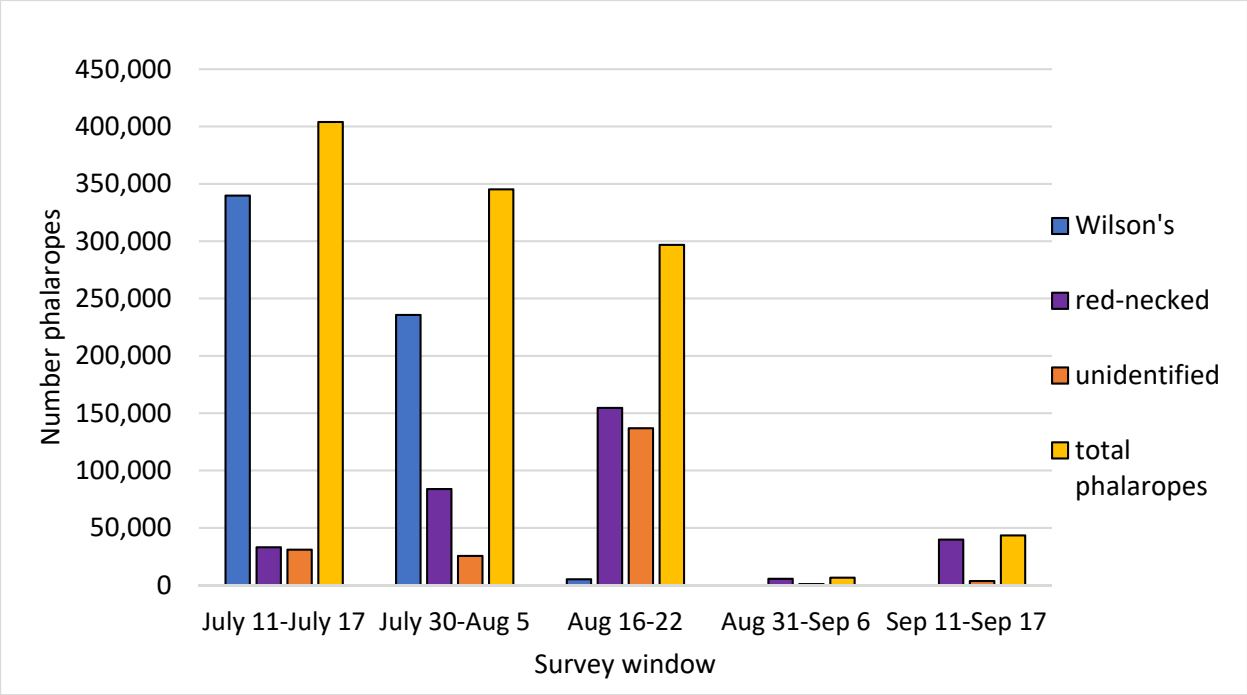

Figure 2. Total numbers of Wilson's, red-necked, and unidentified phalaropes counted per survey window at Great Salt Lake, Mono Lake, and Lake Abert during 2019. All sites were surveyed in each survey window, with the exceptions of Great Salt Lake in the Aug 31-Sep 6 window and Lake Abert in the Sep 11-17 window. At Mono Lake, which had two surveys during each survey window, the survey with the highest count was used in the totals shown.

The maximum 2019 count of red-necked phalaropes from Great Salt Lake, Mono Lake, and Lake Abert was 154,581 during the August 16-22 window (Table 3, Fig. 2). The combined maximum count of red-necked and unidentified phalaropes during the August 16-22, 2019 window was 291,643 birds (Table 3). During 2020, the maximum red-necked phalarope count from all monitoring sites combined was 53,762 during the August 31-September 6, 2020 window (excluding Chaplin Lake, for which there were no data; Table 3, Fig. 3). The combined count of red-necked and unidentified phalaropes during that window was 123,697 birds (Table 3). Historically, most Wilson's phalaropes present at staging sites have departed by mid-August, and very few remain into late August (Jehl 1988, Rubega and Keimel 2017). Thus, it is probable that at least some of the unidentified birds during the August 16-22, 2019 window were red-necked phalaropes, and that many were red-necked during the August 31-September 6, 2020 window. Overall, the peak 2020 red-necked and unidentified total was 167,946 birds fewer in 2020 than in 2019, even with the addition of Owens Lake, San Francisco Bay, and Lake Chaplin in 2020 (these additional sites only added 1,828 birds to the 2020 total; Table 3). Proportionally, the decrease in the peak red-necked/unidentified phalarope count in 2020 vs. 2019 (65% decrease) was greater than the decrease in the peak Wilson's/unidentified count (42% decrease).

Though the magnitude of numbers of both Wilson's and red-necked phalaropes was markedly lower in 2020 than in 2019 (Table 3), the timing of both species was similar across years. Peak

Wilson's phalarope counts occurred during mid-July, followed by a clear decline in numbers, and red-necked phalarope numbers peaked in mid- to late-August, followed by a decline in September (Figs. 1, 2; note, red-necked numbers shown in Figure 2 are low during the August 31-Sep. 6, 2019 window possibly because there was no Great Salt Lake survey during that window).

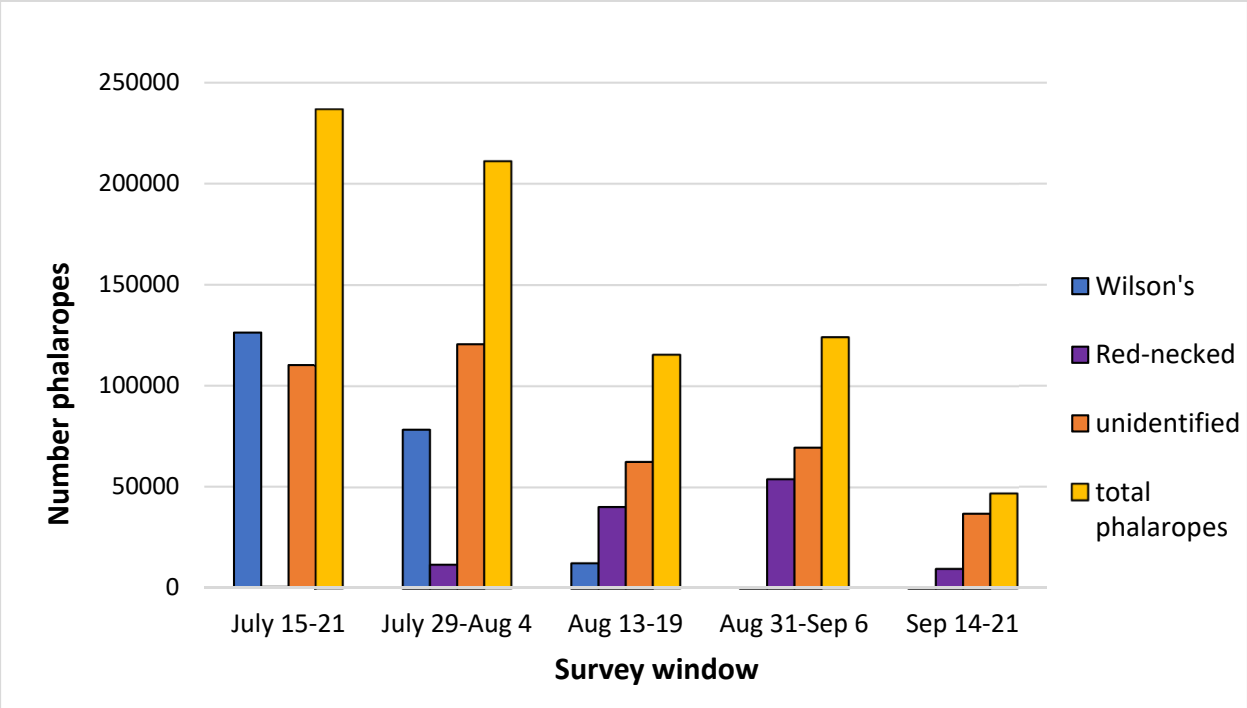

Figure 3. Total numbers of Wilson's, red-necked, and unidentified phalaropes counted per survey window Great Salt Lake, Mono Lake, Lake Abert, Owens Lake, south San Francisco Bay, and Chaplin Lake during 2020. All sites were surveyed in each survey window, with the exceptions of Mono Lake in the Sep 14-22 window, Lake Abert in the Aug 13-19 window, and Chaplin Lake in the Sep 13-22 window. At Mono Lake, which had two surveys during each survey window, the survey with the highest count was used in the totals shown here.

Wilson's phalaropes

Comparisons across sites

Of all western North American staging sites, and as the site with the greatest total area, Great Salt Lake historically has hosted the greatest aggregations of Wilson's phalaropes (Jehl 1988, Jehl 1999). 2019 and 2020 were no exception— Great Salt Lake had an order of magnitude more Wilson's phalaropes than any other site during both years. In 2019, Great Salt Lake had >99% of all Wilson's phalaropes identified during the peak window (337,698 birds; July 11-17). The maximum counts of Wilson's phalaropes at Mono Lake and Lake Abert in 2019 were 2,712 and 1,084, respectively (both during the July 30-Aug 5 window). However, during 2019 Lake Abert

had 24,261 unidentified birds on July 15 and 89,000 unidentified birds on August 10. Mono Lake had a peak combined total of Wilson's and unidentified phalaropes of 15,529 on August 2, 2019.

During 2020, Great Salt Lake had a peak of 122,850 Wilson's phalaropes on July 15, which accounted for 97% of the Wilson's phalaropes recorded during the peak count survey window (July 15-21; Fig. 3). Examining 2020 numbers from sites other than Great Salt Lake, Lake Abert and Mono Lake had the next largest aggregations of Wilson's phalaropes (Figs. 4, 5). A count of 21,830 unidentified phalaropes at Lake Abert on July 1, 2020 was likely composed mainly of Wilson's phalaropes, given the very early timing. The peak 2020 count of Wilson's phalaropes at Mono Lake was 2,765 on July 31 (Fig. 5). An additional 1,385 unidentified phalaropes were also recorded at Mono Lake on July 31, 2020. Peak 2020 Wilson's phalarope counts at other sites were 1,144 at Owens Lake on August 18-19, 767 at San Francisco Bay on July 21, and 370 at Chaplin Lake on August 7 (Fig. 5). See Appendix 1, Tables 1 and 2 for maximum numbers during each survey window at each site.

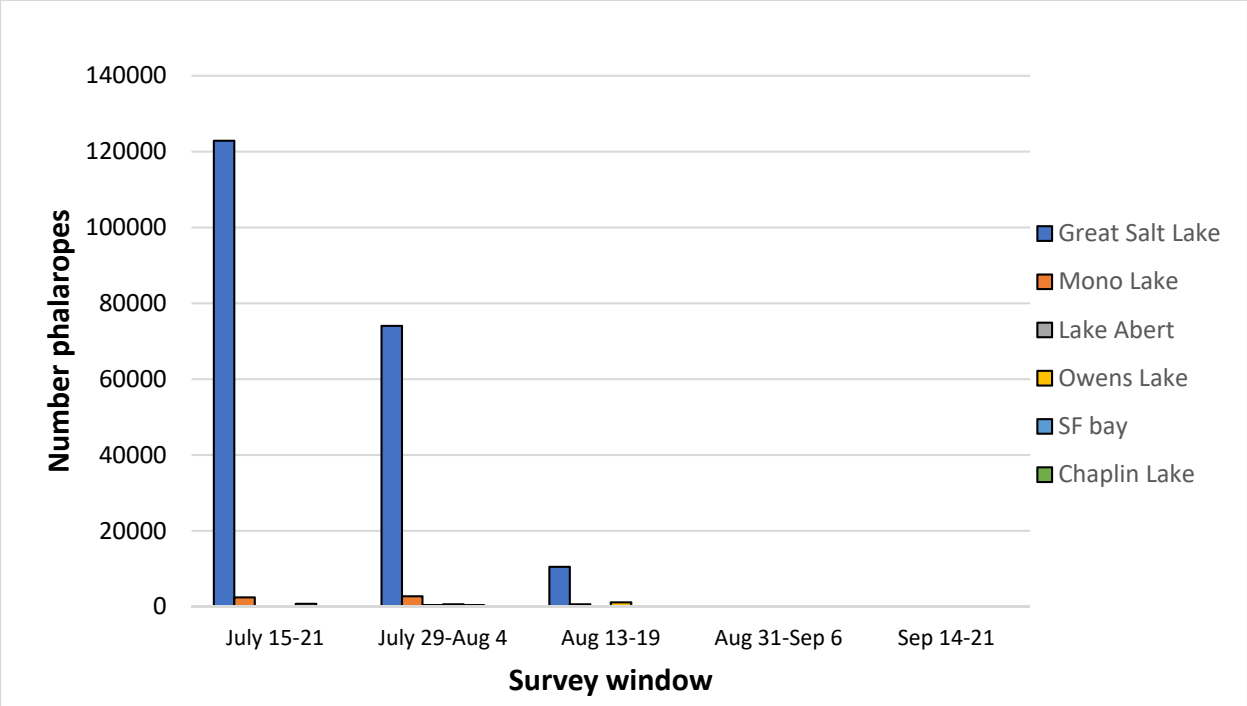

Figure 4. Peak Wilson's phalarope counts during survey windows at western North American staging sites, 2020. At Mono Lake, two surveys were conducted in each survey window, and the single survey with the highest count is shown for each survey window. See Appendix 1, Table A1 and A2 for exact numbers from each site for 2019 and 2020.

The 2020 timing of Wilson's phalaropes was similar across some, but not all sites. Peak numbers occurred in mid- to late-July at Great Salt Lake, Mono Lake, and San Francisco Bay, but the peak at Owens Lake was August 18-19 (Fig. 4). An interesting peak count of 20,183 unidentified phalaropes was recorded at Lake Abert outside of the survey windows on July 1, 2020. This July 1 high count at Lake Abert was suggestive of the possibility that Wilson's phalaropes had an

earlier migration than expected in 2020. It is possible that by not starting our standardized surveys until mid-July we could have missed large aggregations, or even peak numbers, in early July.

To explore this possibility, we examined eBird data (Sullivan et al. 2009) from late June and early July 2020 at our sites to see if large aggregations were reported then. eBird is unreliable for phalarope censuses because large flocks of phalaropes are difficult to count, phalaropes frequent areas inaccessible to casual birders (e.g., the middle of Mono or Great Salt Lakes), and eBird observations are not well-standardized for coverage or observer error. However, if large groups of phalaropes were reported in late June and early July on eBird, it could provide clues as to the timing of Wilson's phalarope staging during 2020. There were eBird reports of up to 20,000 Wilson's phalaropes in late June and 50,000 in early July at Lake Abert, corroborated by our formal count of 20,183 on July 1. At Great Salt Lake, there were eBird reports of up to 200,000 Wilson's phalaropes (with a note "guesstimate, abundant") in late June, and up to 1,000-100,000 Wilson's phalaropes in early July at one site at Great Salt Lake (Antelope Island State Park causeway). Aggregations of ≥100 and ≤600 Wilson's phalaropes were reported on eBird at Mono Lake, San Francisco Bay, and Owens Lake in the last days of June and the first week of July. There were few Wilson's phalaropes reported at Chaplin Lake in June or early July (≤18 birds).

eBird data showed Wilson's phalaropes were present at most sites by late June, and that numbers of Wilson's phalaropes reported in the last days of June at Lake Abert and Great Salt Lake were similar in magnitude to the peak numbers in mid-July of our formal surveys. Historically, Wilson's phalarope females arrive at staging sites in mid-June, with total numbers gradually building to a peak in mid- to late-July when both females and males are present (Jehl 1988). It seems possible based on the eBird data and our data that Wilson's phalaropes arrived at staging sites in 2020 earlier than historical records would suggest, and that numbers may have already been falling by our first survey window from July 15-21. This suggests that for Wilson's phalaropes, additional standardized surveys at the beginning of July could help ensure that peak counts are captured. It should be kept in mind that phalaropes may be moving among sites, and that birds observed in late June and early July at Lake Abert, for example, may have been counted at other sites in mid-July. This underscores the importance of our standardized count windows, which help control for the possibility of movement among sites. It is easy to imagine that the August 18-19 peak at Owens Lake could have been related to birds departing Mono Lake or other sites and moving southward or eastward. More data on movement is needed to clarify residence times and movement among sites to better interpret population trends.

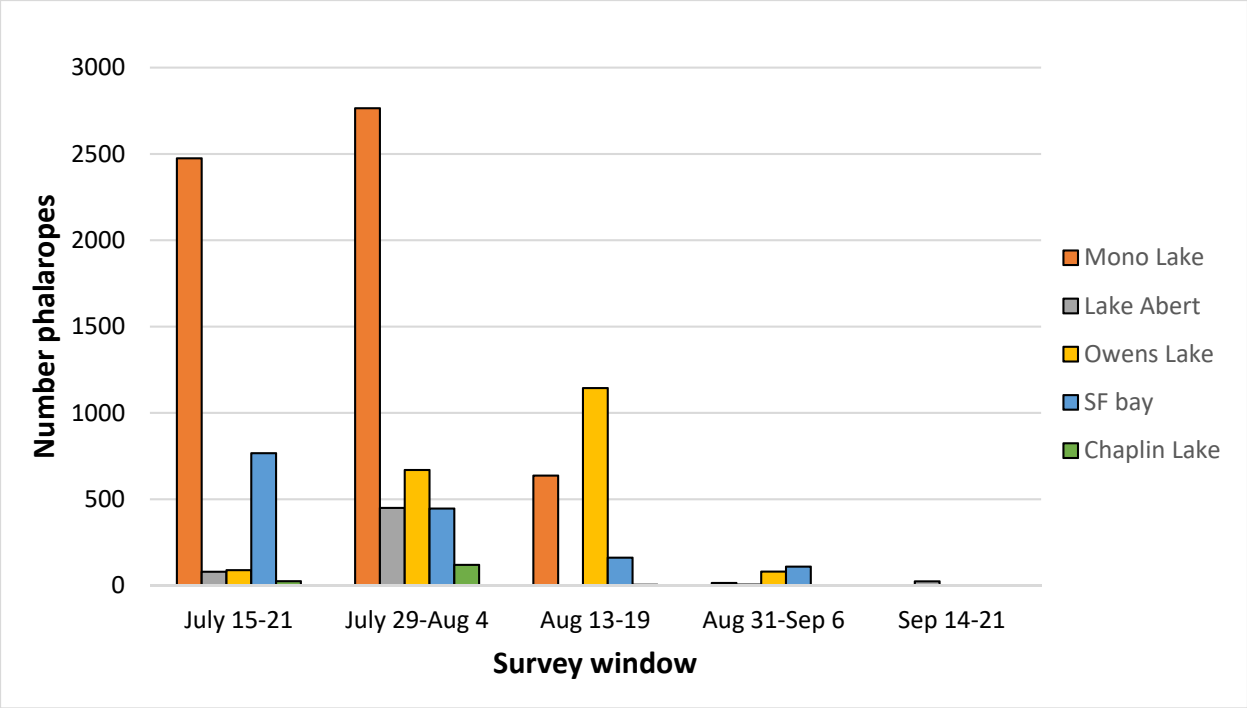

Figure 5. Peak Wilson's phalarope counts during survey windows at western North American staging sites, 2020, excluding Great Salt Lake. At Mono Lake, two surveys were conducted in each survey window, and the single survey with the highest count is shown for each survey window. See Appendix 1, Table A1 and A2 for exact numbers from each site for 2019 and 2020.

Wilson's phalarope comparisons across years at specific sites

At sites with standardized surveys in both years, peak Wilson's phalarope numbers were much lower in 2020 than in 2019. Peak daily numbers of combined Wilson's and unidentified phalaropes were 33% lower at Great Salt Lake (Fig. 6) and 73% lower at Mono Lake (Fig. 7) in 2020 than in 2019. The peak 2020 count of unidentified phalaropes at Lake Abert (on July 1st, outside the coordinated survey windows) was 75% lower than in 2019 (Fig. 8). These results may represent a real, potentially quite concerning, decrease in Wilson's phalarope numbers across staging sites in 2020. Phalaropes may have been at other staging sites we did not monitor, but our coordinated surveys covered the most historically important and consistent ones (Jehl 1988, 1999). However, it is possible that Wilson's phalaropes arrived and departed so early in the year that peak numbers could have been missed. Also, surveyors at Great Salt Lake noted that in 2020 birds were more spread out and in smaller flocks on the open water of the lake, making them easier to miss in a survey flight mostly restricted to lake's perimeter.

We are still evaluating historical data from all sites to determine which years can be compared based on standardized methods and coverage, so we do not generally compare 2019 and 2020 to historical trends here. However, a survey at Mono Lake in 1991 recorded 35,225 Wilson's phalaropes, using comparable methods to our contemporary Mono Lake surveys (Rubega & Keimel 2017). Our 2019 Mono Lake high count was 66% lower than the 1991 total, and our

2020 count was 88% lower (Fig. 7). Decreases in phalarope numbers at Mono Lake may have resulted from birds using different sites in different years, rather than true population decreases. Even if that is the case, the magnitude of these differences suggests that we need much better understanding of phalarope movements in order to understand population trends.

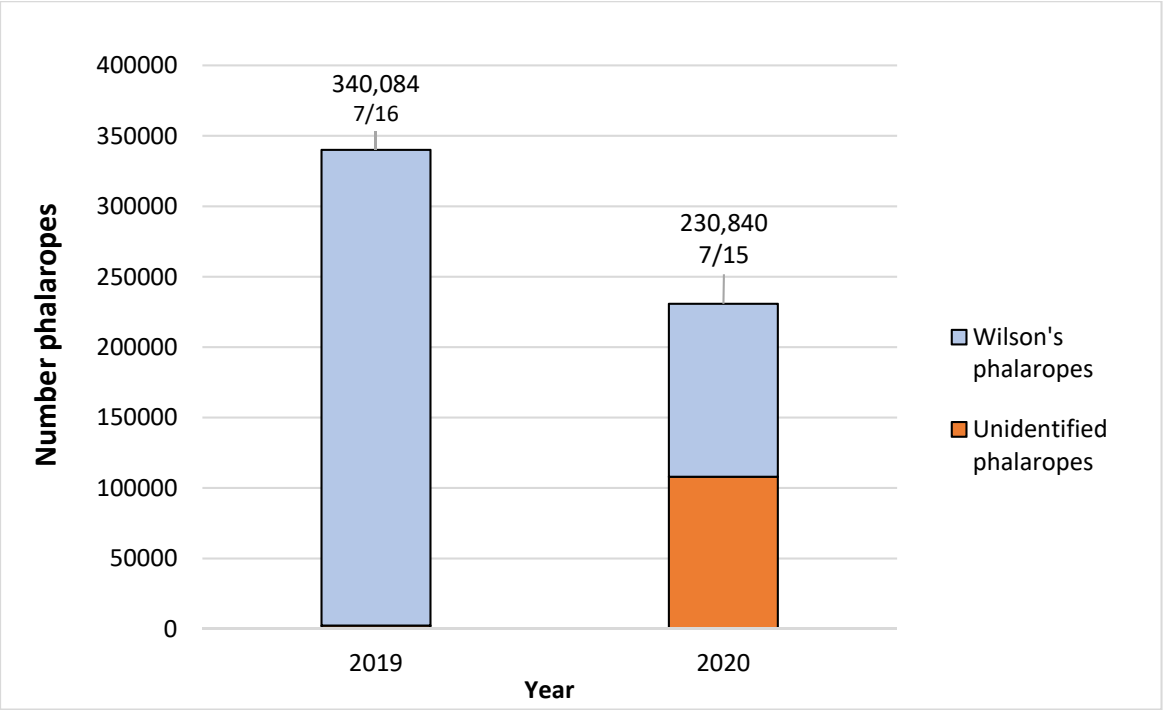

Figure 6. Maximum Wilson's and unidentified phalarope counts at Great Salt Lake during 2019 and 2020. The combined total of Wilson's and unidentified phalaropes and date of the count are shown above the bars.

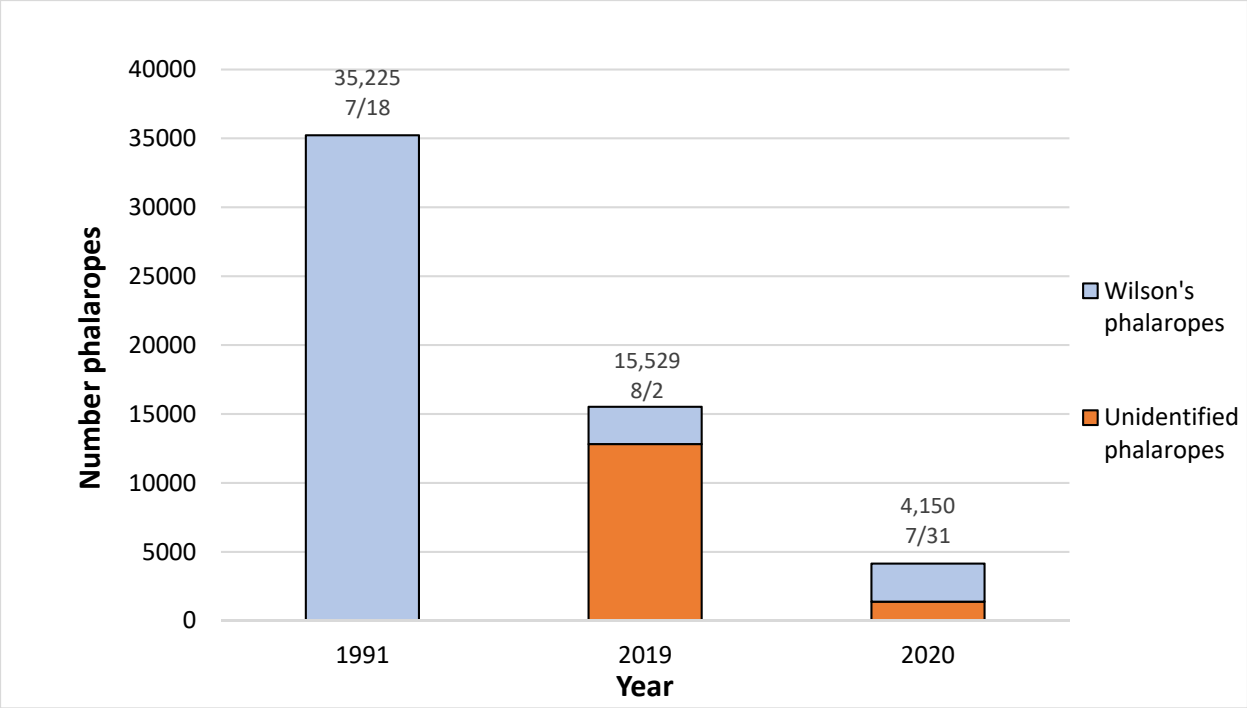

Figure 7. Maximum Wilson's and unidentified phalarope counts at Mono Lake during 2019 and 2020. The combined total of Wilson's and unidentified phalaropes and date of the count are shown above the bars. 1991 counts used the same base protocol as 2019 and 2020 counts, though the protocol was modified during 2019 and 2020 to include the additional boat survey points, shore survey points, and a greater count radius for boat counts. In short, 2019 and 2020 counts covered a greater area than 1991 counts, but Mono Lake also had a much greater surface area in 2019-2020 than in 1991.

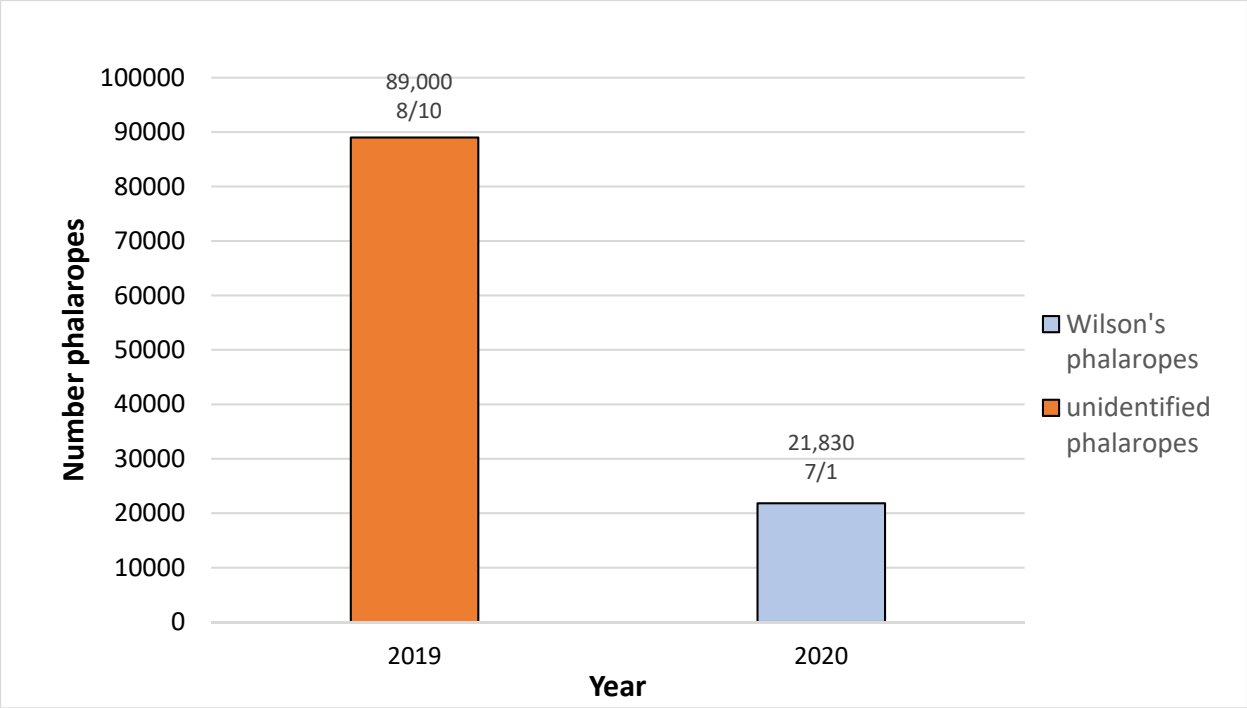

Figure 8. Maximum Wilson's and unidentified phalarope counts at Lake Abert during 2019 and 2020. Note that no Wilson's phalaropes were identified on the peak 2019 count, and no unidentified phalaropes were recorded on the peak 2020 count.

Red-necked phalaropes

Comparisons across sites during 2020

Similar to Wilson's phalaropes, Great Salt Lake historically has had the greatest aggregations of red-necked phalaropes of western North American staging sites, and this held true in 2019 and 2020 (Fig. 9). In 2019, the peak survey window total of red-necked phalaropes at Great Salt Lake, Mono Lake and Lake Abert was 154,851, with 97% of those at Great Salt Lake. Combining same day red-necked and unidentified phalaropes counts during that window resulted in a total count of 291,524 birds, 264,430 of which were at Great Salt Lake (91% of the total count). In 2020, the peak survey window total of red-necked phalaropes across sites was 53,762 birds during the August 31-September 6 window, eighty-one percent of which were at Great Salt Lake (43,725 birds; Fig. 9). Combining same day red-necked and unidentified phalaropes counts during that window resulted in a total count of 123,697 birds, 113,345 of which were at Great Salt Lake (92% of the total count).

In both 2019 and 2020, Mono Lake had the next highest totals of red-necked phalaropes, with a 2019 high count of 5,573, and a 2020 high count of 10,891 (Fig. 9). Lake Abert had a 2019 high count of 22,000 unidentified phalaropes on August 16 (with the timing suggesting that many of these birds were probably red-necked), and a 2020 high count of 675 red-necked phalaropes on September 22. The peak 2020 red-necked counts at other sites were 1,700 on September 1 at San Francisco Bay, 1,116 on September 21 at Owens Lake, and 50 on July 17 at Chaplin Lake.

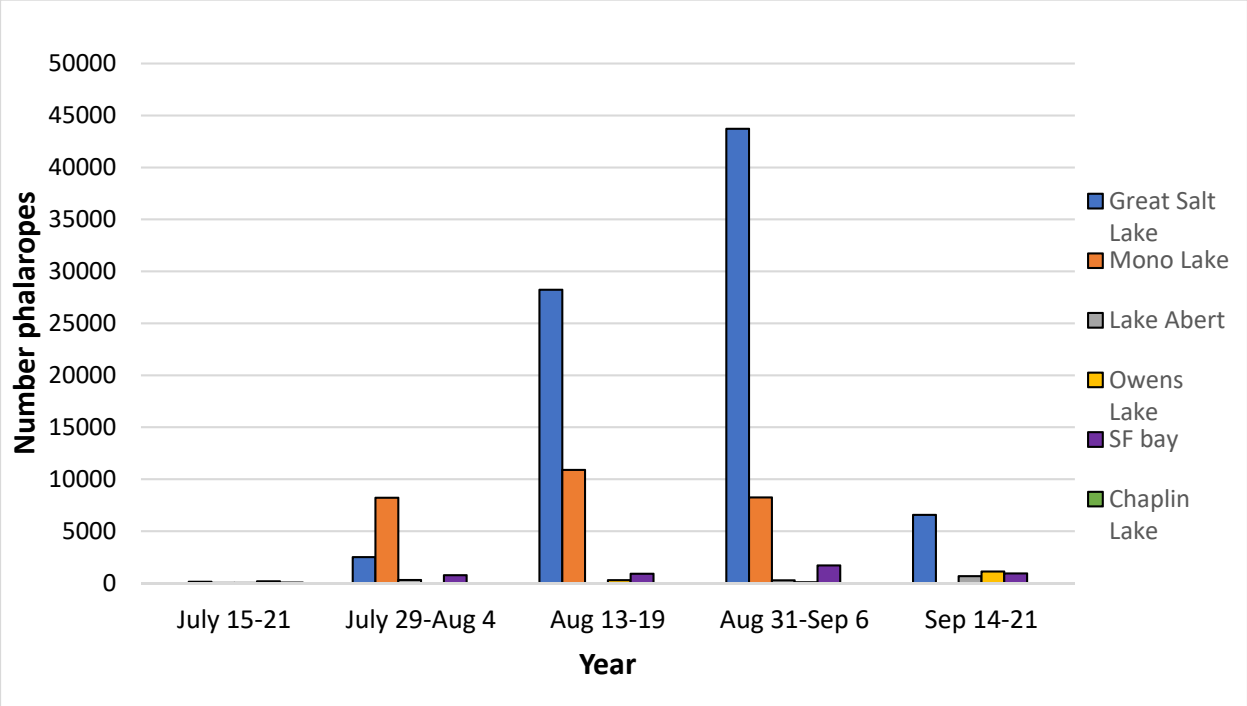

Figure 9: Peak counts of red-necked phalaropes at each site during each survey window at western North American staging sites, 2020. All sites were surveyed in each survey window, with the exceptions of Mono Lake in the Sep 14-22 window, Lake Abert in the Aug 13-19 window, and Chaplin Lake in Sep 13-22 window. See Appendix 1, Table A1 and A2 for exact numbers from each site for 2019 and 2020.

Red-necked phalarope timing was fairly similar across sites during 2020, with highest counts during both the August 13-19 and August 31-September 6 windows at most sites (Fig. 9). The peak count at Owens Lake on September 21 was the only exception (Fig. 9). It can easily be imagined that birds departing other sites might stop at Owens Lake on their way south or east, resulting in later peaks there. Our surveys appeared to capture the timing of red-necked phalarope peak numbers well in 2020 (Fig. 9), so we did not make any comparisons to timing indicated by eBird data. Surveys were missed during the September 14-21 window at Mono Lake and the August 13-19 window at Lake Abert, but all sites were surveyed during the peak window of August 31-September 6.

Red-necked phalarope comparisons across years

At Great Salt Lake, peak red-necked phalarope counts were 71% lower in 2020 (43,725 birds) than in 2019 (149,660 birds; Fig. 10). If unidentified phalaropes seen on the peak red-necked phalarope count days are added, there were 57% fewer birds at Great Salt Lake in 2020 than in 2019 (Fig. 10).

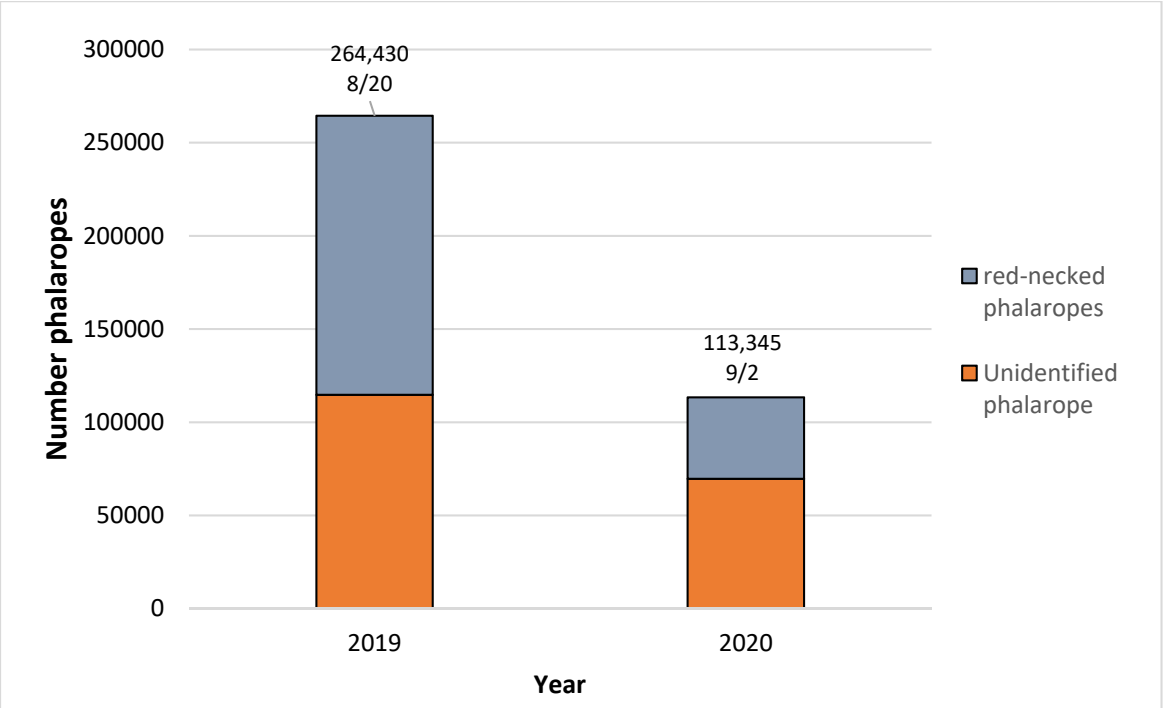

Figure 10. Maximum red-necked and unidentified phalarope counts at Great Salt Lake during 2019 and 2020. The combined total of red-necked and unidentified phalaropes and date of the count are shown above the bars.

Conversely, peak red-necked phalarope counts at Mono Lake were 95% greater in 2020 (10,891 birds on August 15) than in 2019 (5,573 birds on September 2; Fig. 11). Adding unidentified birds to peak 2020 totals at Mono Lake made a negligible difference (e.g., 37 unidentified birds on the 2020 peak red-necked phalarope count; Fig. 11). One comparable historical count exists at Mono Lake, with 17,535 red-necked phalaropes observed on September 16, 1990 (Rubega & Keimel 2017). Mid-September aerial counts of phalaropes at Mono Lake from 2003-2018 have ranged from a low of 881 in 2016 to a high count of 32,623 in 2008 (LADWP, unpublished data). Due to the mid-September timing of the aerial surveys, these were most likely primarily red-necked phalaropes. Both our 2019 and 2020 peak counts were far lower than that 1990 result (Fig. 10). As with Wilson's phalaropes, more years of standardized, coordinated surveys across major staging sites are needed to clarify trends.

It is important to note that red-necked phalarope peak counts are more difficult to interpret than Wilson's phalarope peak counts, because the two species' biology at stop-over sites differs. Wilson's phalaropes undergo a predictable pattern of molt and mass gain at stop-over sites, with

numbers building to a peak until a mass departure (Jehl 1988), but red-necked phalarope numbers do not display this pattern. The "residence time" (how long an individual bird stays) at migratory staging sites is unknown for red-necked phalaropes, and numbers show protracted highs over weeks or months, rather than a discrete peak (Jehl 1986, this study). If red-necked phalarope residence time is relatively short (e.g., days to weeks), it could mean that the various survey windows are counting different individuals cycling through. This would have profound implications for interpretation of population trends. Tracking studies will help solve this riddle, as well as clarify how and if birds are moving among staging sites or only visiting one site each year. Despite this question of residence time, the decrease in red-necked phalarope numbers in 2020 vs. 2019 is concerning, as are the lower totals recorded in 2019-2020 compared with historic counts.

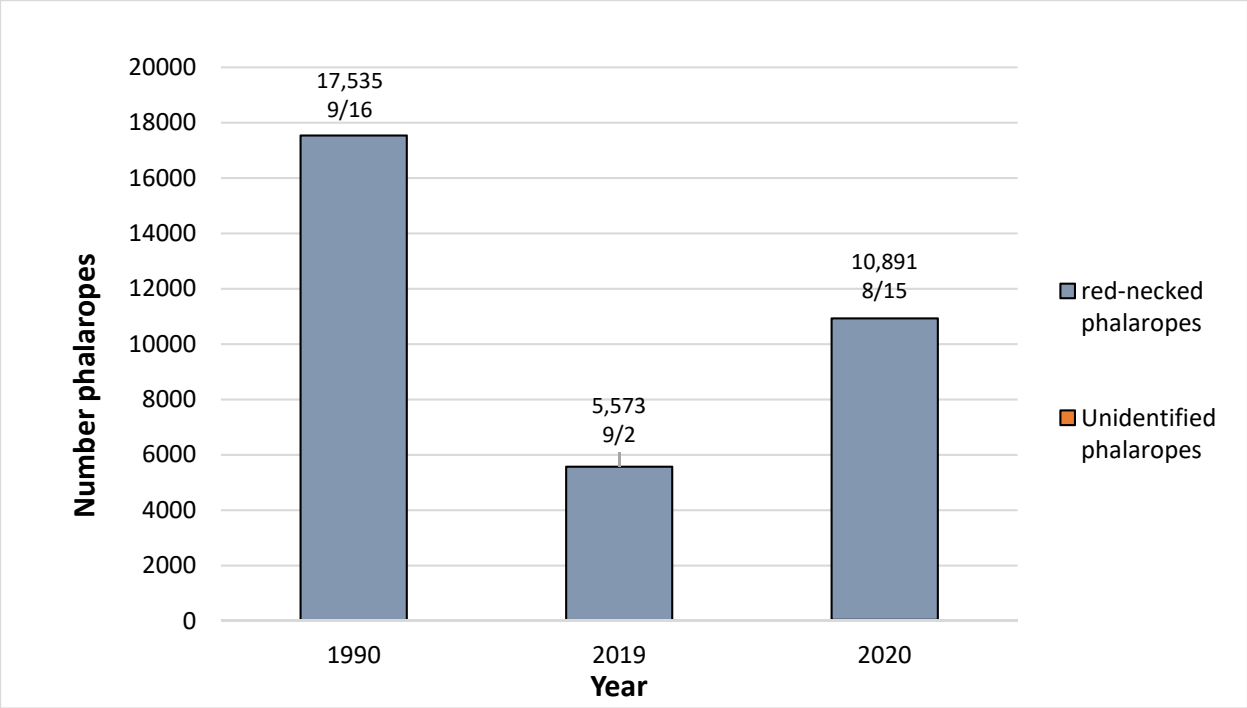

Figure 11. Maximum red-necked and unidentified phalarope counts at Mono Lake 1990, 2019 & 2020. The combined total of red-necked and unidentified phalaropes and date of the count are shown above the bars.

Conclusions

Our results confirmed the usefulness of coordinated surveys across major phalarope staging sites for interpreting population trends, migratory timing, and habitat use. The value of these coordinated surveys will compound as they continue over more years. Even with just two years of coordination, we were able to better understand large-scale patterns in timing and annual numbers, and to interpret the results at each site within a regional context. For example, we can have more confidence that there was either a decrease or change in timing of both Wilson's and

red-necked phalaropes in 2020 based on the low numbers of Wilson's phalaropes across all sites; if we only had data from one site, it would be impossible to know if the birds had just been elsewhere. Likewise, interpreting long-term population trends will rely on having data from multiple sites to account for the mobility of phalaropes.

The process of interpreting the results from all the sites in this report together highlighted some important issues, including that greater standardization of methods would be beneficial. The differences between methods and coverage at each site make interpretation of results more challenging—one example of this is the relatively small proportion of both Wilson's and red-necked phalaropes observed in 2020 at south San Francisco Bay, Owens Lake, and Chaplin Lake, which together made up ≤1% of the combined high count totals from Great Salt Lake, Lake Abert, and Mono Lake (using species/unidentified totals). Was this difference because San Francisco Bay, Owens Lake, and Chaplin Lake had lesser survey coverage than the other sites, or were there really fewer birds there? Greater methodological standardization and coordination of timing of surveys would help with these sorts of interpretations.

Another important consideration is the matter of how to treat unidentified phalarope counts. Depending on the year and site, unidentified phalaropes sometimes made up a substantial portion of the total count. In 2020, for example, unidentified phalaropes outnumbered the peak totals of either species in all but one survey window (Fig. 3). Thus, unidentified phalarope counts cannot simply be ignored in the interpretation of the trends of each species. Here, we chose to report unidentified phalarope counts along with the totals of each species on that species' peak count day. Because peak counts of Wilson's phalaropes have generally occurred in the early summer, and of red-necked phalaropes in the late summer, it is probable that unidentified bird counts from each species' peak are composed mainly of that species. However, this should not be assumed. Climate change could influence the timing of phalaropes at staging sites, resulting in unexpected changes in relative species composition at different times of year; our goal is to capture these sorts of changes in the data and not assume we know which species unidentified birds are. The proportions of unidentified birds identified is influenced by multiple factors, including observer skill and training, distance of surveyors from birds, and weather conditions. These factors become difficult to parse out from multiple different sites using different methods. Greater attention is needed to this issue in the future, including greater standardization of factors that influence identification to species.

Despite these methodological questions, coordinated surveys provide insight into which habitats phalaropes are using and when, providing an invaluable contemporary baseline from which to evaluate the response of phalaropes to site-specific environmental changes and climate change. Great Salt Lake, by far the largest of the survey sites, continues to host the vast majority of migratory Wilson's and red-necked phalaropes in western North America. Great Salt Lake is under threat of ecosystem collapse due to increased salinities and desiccation, which are currently driven by water diversions and are expected to be worsened by climate change (Conover & Bell 2020). Furthermore, the habitats most used by phalaropes at Great Salt Lake are shallow areas with relatively fresher water, habitats which are likely to decline in availability as the lake level drops (Frank and Conover 2019). Globally and regionally in western North

America, the saline wetland habitat that phalaropes rely on is threatened by desiccation from water diversion and climate change. One stark example is that in 2014, water diversions coupled with drought caused Lake Abert to shrink to 5% of its maximum size, and the salinity more than tripled (Moore 2016, Larson et al. 2016). This caused a loss of the phalarope prey base, and a subsequent decline in shorebird use (Larson et al. 2016, Moore 2016, Senner et al. 2018).

At other staging sites, the story is more hopeful. Mono Lake was once severely threatened with desiccation and ecosystem collapse from water diversions, but was "saved" in the 1990s via advocacy and court decisions that restored freshwater inflow (Hart 1996). Now, Mono Lake is among the least threatened of phalarope staging areas, because it is subject to court-mandated water management (Hart 1996). Water levels have rebounded at Mono Lake to healthier levels, though they are still far short of the intended management level set by the courts. Nevertheless, Mono Lake remains threatened by climate change, which is driving lower annual snow packs and greater frequency of drought years (Ficklin et al. 2013, Costa-Cabral et al. 2013). Owens Lake, once nearly completely dry, now hosts substantial habitat for phalaropes and other birds (Herbst & Prather 2014); that Owens Lake registered more than 1,000 each of both Wilson's and red-necked phalaropes in 2020 is noteworthy and shows the value of restored habitat. At south San Francisco Bay, hyper-saline former salt production ponds used by phalaropes have been flooded to create salt marsh habitat for other species, modifying habitat used by phalaropes (Tarjan 2020). Opportunistic counts of phalaropes declined following these habitat modifications, but future surveys during peak migration times are needed for a better understanding of trends in phalarope use of south San Francisco Bay (Tarjan 2020). At Chaplin Lake, water levels are regulated by a sodium sulphate mining operation, which maintains shallow, rather constant water levels, and is generally thought to be good for shorebirds by maintaining high salinity and an abundance of invertebrate prey (Beyersbergen & Duncan 2007), although detailed habitat studies are lacking.

Given the mosaic of threats and variable levels of protection of North American phalarope staging sites, and that climate change impacts have moved from a future threat to a current one, it is imperative for phalarope conservation to continue coordinated monitoring across the region rather than disjointed surveys at single sites, or no surveys at all. We have yet to understand whether phalaropes are adaptable enough to simply change staging sites if one dries up. Many other questions still abound, including understanding species population trends, stop-over length of individual red-necked phalaropes at staging sites, and whether and how phalaropes move between staging sites. Continued monitoring combined with focus studies will help us understand phalarope migratory patterns and trends, response to climate and environmental factors, and the importance of saline lake systems to these and other wildlife species.

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Artwork by Sarah Hecocks

Literature cited

Beyersbergen, G.W. and Duncan, D.C. 2007. Shorebird Abundance and Migration Chronology at Chaplin Lake, Old Wives Lake and Reed Lake, Saskatchewan: 1993 and 1994. Canadian Wildlife Service Technical Report Series No. 484. Prairie and Northern Region. Edmonton, Alberta. 57 pp.

Carle R. & M. Rubega. International Phalaropes Meeting Summary. Unpublished report of International Phalarope Working Group. Available at: https://oikonos.org/wp-content/uploads/2020/03/Phalarope-meeting-report_final.pdf

Carle, R. & M. Rubega. Phalarope surveys at Mono Lake 2019 report. Unpublished report to California State Parks. Available at: https://oikonos.org/wp-content/uploads/2020/03/Phalarope-Surveys-at-Mono-Lake-2019-Report.final_.pdf

Carle, R. & M. Rubega. Mono Lake phalarope surveys 2020 report. Unpublished report to California State Parks. Available at: https://oikonos.org/wp-content/uploads/2021/02/Mono-Lake-phalarope-report-2020.pdf

Conover, M.R. and Bell, M.E. 2020. Importance of Great Salt Lake to pelagic birds: eared grebes, phalaropes, gulls, ducks, and white pelicans. In *Great Salt Lake biology* (pp. 239-262). Springer, Cham.

Costa-Cabral, M., Roy, S.B., Maurer, E.P., Mills, W.B. and Chen, L., 2013. Snowpack and runoff response to climate change in Owens Valley and Mono Lake watersheds. Climatic change 116: 97-109.

Ficklin, D.L., Stewart, I.T. and Maurer, E.P. 2013. Effects of projected climate change on the hydrology in the Mono Lake Basin, California. Climatic Change 116: 111-131.

Frank, M.G. and Conover, M.R. 2019. Threatened habitat at Great Salt Lake: Importance of shallow-water and brackish habitats to Wilson's and Red-necked phalaropes. The Condor 121: duz005. https://doi.org/10.1093/condor/duz005

Hart, J. Storm over Mono: the Mono Lake battle and the California water future. University of California Press; 1996.

Herbst, D.B. and Prather, M. 2014. Owens Lake: from dustbowl to mosaic of salt water habitats. Lakeline 34: 34-38.

Jehl, J.R. 1986. Biology of Red-necked Phalaropes (*Phalaropus lobatus*) at the western edge of the Great Basin in fall migration. Great Basin Naturalist 46: 185-197.

Jehl, J. R. 1988. Biology of the Eared Grebe and Wilson's Phalarope in the nonbreeding season: a study of adaptations to saline lakes. Studies in Avian Biology 12.

Jehl, J. R. 1999. Population studies of Wilson's Phalaropes at fall staging areas, 1980-1997: A challenge for monitoring. Waterbirds 22: 37-46.

Langham, G. M., Schuetz, J. G., Distler, T., Soykan, C. U., & C. Wilsey. 2015. Conservation status of North American birds in the face of future climate change. PloS one, 10(9).

Larson, R., Eilers, J., Kreuz, K., Pecher, W.T., DasSarma, S. and Dougill, S. 2016. Recent desiccation-related ecosystem changes at Lake Abert, Oregon: a terminal alkaline salt lake. Western North American Naturalist 76: 389-404.

Lesterhuis, A. J., & R.P. Clay. 2009. Conservation plan for Wilson's phalarope (*Phalaropus tricolor*). Manomet Center for Conservation Sciences, Manomet.

Moore, J.N. 2016. Recent desiccation of western Great Basin saline lakes: lessons from Lake Abert, Oregon, USA. Science of the Total Environment 554: 142-154.

Rubega, M. and B. Keimel. 2017. Final report on a 2017 census of phalaropes at Mono Lake, California. Unpublished report to California State Parks.

Rubega, M. A., D. Schamel, and D. M. Tracy. 2020. Red-necked Phalarope (*Phalaropus lobatus*), version 1.0. In Birds of the World (S. M. Billerman, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.renpha.01

Senner, N.R., Moore, J.N., Seager, S.T., Dougill, S., Kreuz, K. and Senner, S.E., 2018. A salt lake under stress: Relationships among birds, water levels, and invertebrates at a Great Basin saline lake. Biological Conservation 220: 320-329.

Sullivan, B.L., C.L. Wood, M.J. Iliff, R.E. Bonney, D. Fink, and S. Kelling. 2009. eBird: a citizen-based bird observation network in the biological sciences. Biological Conservation 142: 2282-2292.

Tarjan, LM. 2020. Migration timing and spatial distribution of phalaropes in San Francisco Bay. Reported prepared for California Wildlife Foundation, California State Coastal Conservancy, and South Bay Salt Pond Restoration Project.

Wilsey, C, B Bateman, L Taylor, JX Wu, G LeBaron, R Shepherd, C Koseff, S Friedman, & R. Stone. 2019. Survival by Degrees: 389 Bird Species on the Brink. Report by the National Audubon Society: New York.

Wurtsbaugh, W.A., Miller, C., Null, S.E., DeRose, R.J., Wilcock, P., Hahnenberger, M., Howe, F. and Moore, J. 2017. Decline of the world's saline lakes. Nature Geoscience 11: 816-821.

Appendix 1

Table A1. Maximum 2019 phalarope counts in survey windows at Great Salt Lake, Mono Lake, and Lake Abert.

Wilson's phalarope

Survey window	Great Salt Lake	Mono Lake	Lake Abert	Total
July 11-July 17	337,698	2,017	0	339,715
July 30-Aug 5	231,920	2,712	1,084	235,716
Aug 16-22	4,895	312	0	5,207
Aug 31-Sep 6	No data	4	0	4
Sep 11-Sep 17	2	0	No data	2

Red-necked phalarope

Survey window	Great Salt Lake	Mono Lake	Lake Abert	Total
July 11-July 17	33,030	83	0	33,113
July 30-Aug 5	81,330	2,612	5	83,947
Aug 16-22	149,660	4,921	0	154,581
Aug 31-Sep 6	No data	5,573	0	5,573
Sep 11-Sep 17	35,100	4,707	No data	39,807

Unidentified phalarope

Survey window	Great Salt Lake	Mono Lake	Lake Abert	Total
July 11-July 17	2,386	4,408	24,261	31,055
July 30-Aug 5	12,735	12,817	0	25,552
Aug 16-22	114,770	173	22,000	136,943
Aug 31-Sep 6	No data	8	1,050	1,058
Sep 11-Sep 17	3,640	0	No data	3,640

Table A2. Maximum 2020 phalarope counts in survey windows at all sites surveyed. SF Bay is south San Francisco Bay.

Wilson's phalarope

Survey window	Great Salt Lake	Mono Lake	Lake Abert	Owens Lake	SF Bay	Chaplin Lake	Total
July 15-21	122850	2475	80	90	767	26	126288
July 29-Aug 4	74,045	2765	450	670	446	120	78,496
Aug 13-19	10,530	637	.	1,144	162	5	12478
Aug 31-Sep 6	145	15	6	81	110	.	357
Sep 14-21	100	.	25	0	0	.	125

Red-necked phalarope

Survey window	Great Salt Lake	Mono Lake	Lake Abert	Owens Lake	SF Bay	Chaplin Lake	Total
July 15-21	0	129	8	5	182	50	374
July 29-Aug 4	2,505	8220	300	0	758	0	11783
Aug 13-19	28,235	10891	.	280	904	0	40310
Aug 31-Sep 6	43,725	8251	267	86	1,700	.	54029
Sep 14-21	6,570	.	675	1,550	935	.	9730

Unidentified phalarope

Survey window	Great Salt Lake	Mono Lake	Lake Abert	Owens Lake	SF Bay	Chaplin Lake	Total
July 15-21	107990	1	2000	33	140	0	110164
July 29-Aug 4	119,335	1385	0	0	5	0	120,725
Aug 13-19	62,270	241	.	76	0	30	62617
Aug 31-Sep 6	69,620	0	0	42	0	.	69662
Sep 14-21	36,975		0		32	.	37007

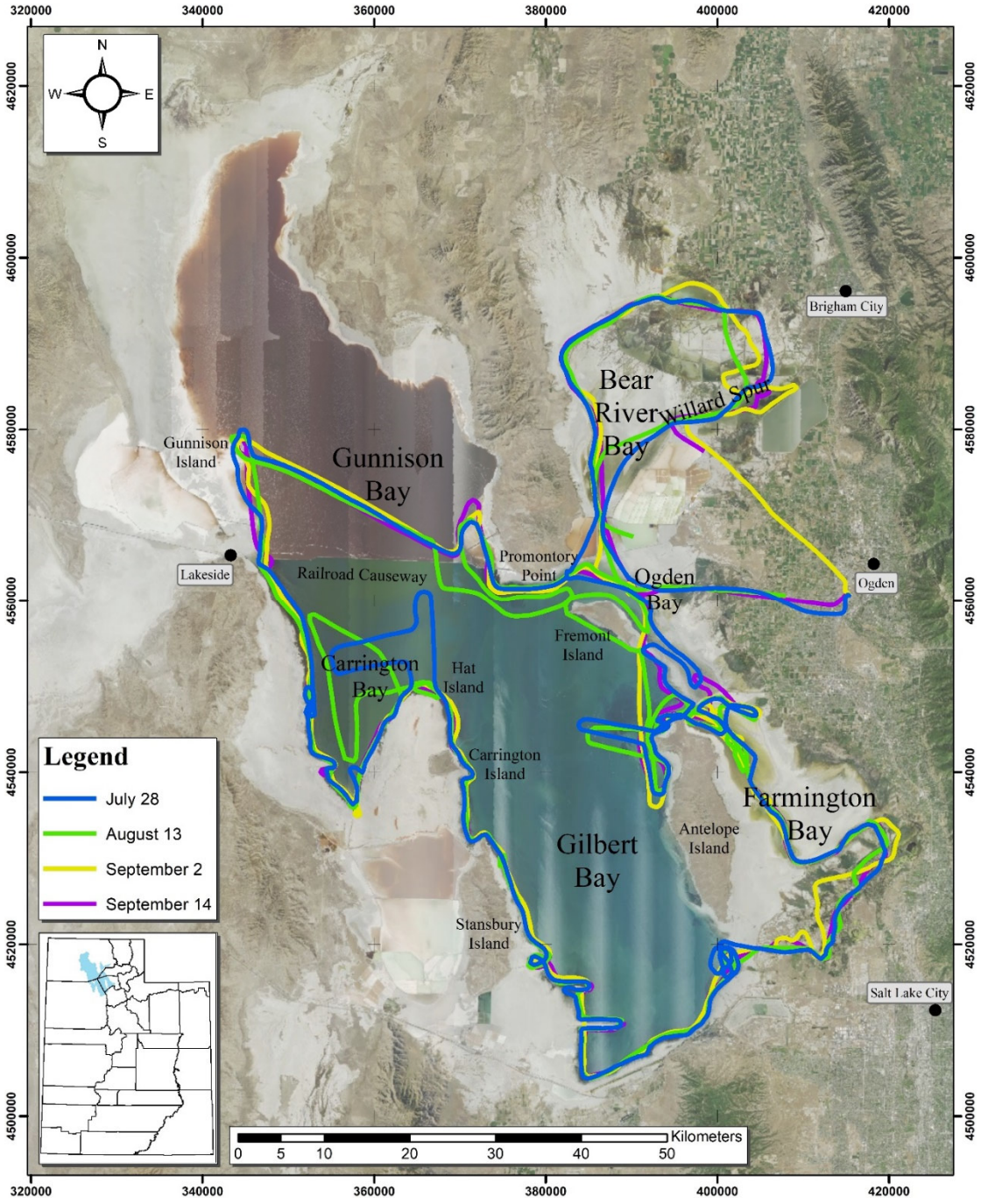

Figure A1. Phalarope survey flight paths in 2020 at Great Salt Lake, Utah. The path for the July 15th flight was not recorded but followed the same general route. All flights originated at Ogden Airport and traveled in a counterclockwise direction.

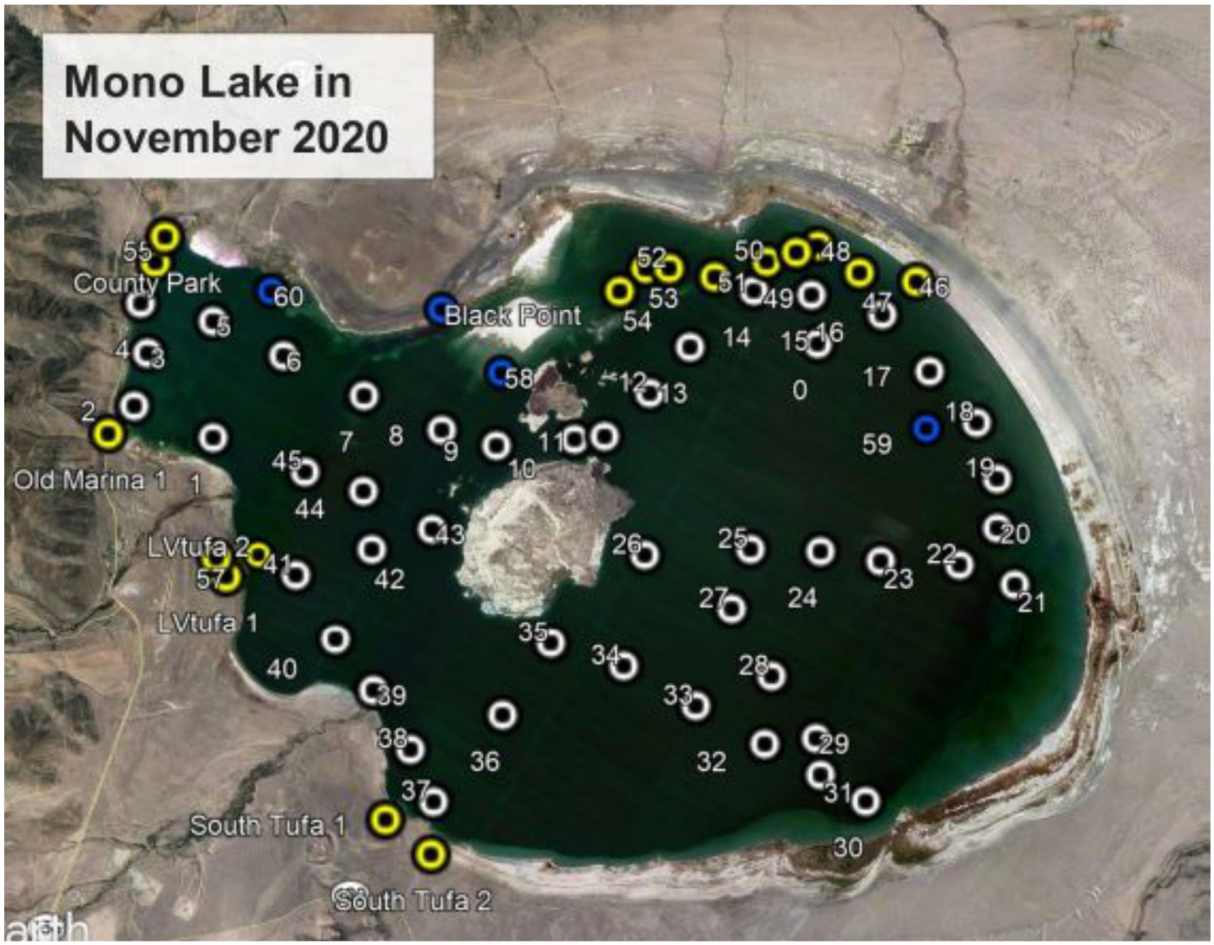

Figure A2. Mono Lake phalarope survey points. White dots are original 1990-1991 phalarope boat survey points, yellow dots are points added in 2017 and 2019, and blue dots are points added in 2020. Numbered dots are boat survey points, named dots are shore survey points. Note that areas in the north and east of the lake that were dry in 1990-1991 were flooded in 2019-2020.

Table A3. Total estimated lake surface areas (km^2) of phalarope survey points at Mono Lake (using 2019 satellite imagery of lake level). See Carle and Rubega 2020 for full methodological details of Mono Lake surveys.

Phalarope Survey Point	**Total Count Area (km^2) Nov 2019 photo**
Boat point – 400 m radius	0.50
County Park shore survey	0.20
Lee Vining Tufa shore survey point 1	0.13
Lee Vining Tufa shore survey point 2	0.16
Old Marina shore survey	0.47
South Tufa shore survey point 1	0.22
South Tufa shore survey point 2	0.25
Black Point shore survey	0.66

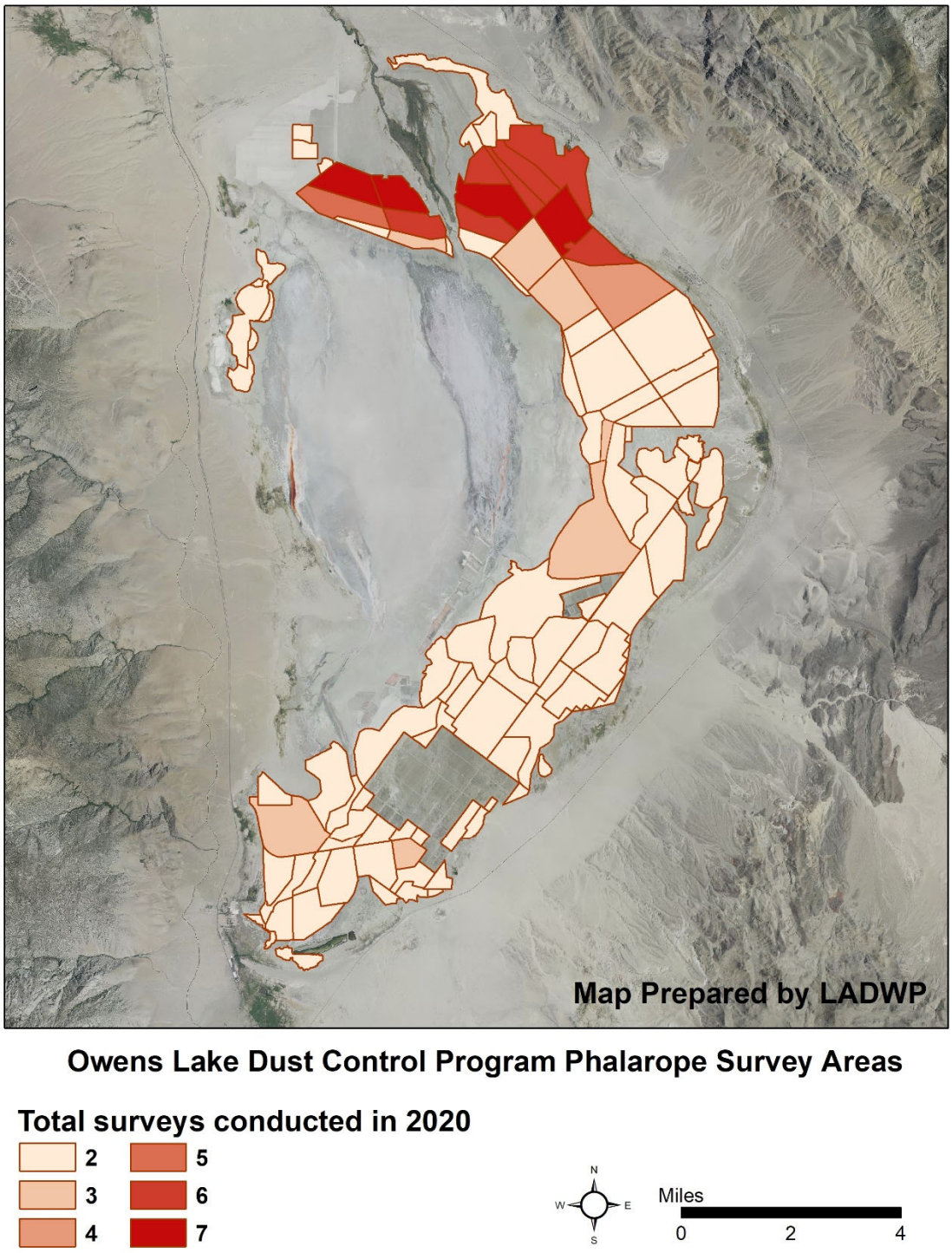

Figure A3. Owens Lake dust control area "cells." The entire dust control area was surveyed in LADWP surveys and Eastern Sierra Audubon surveys covered 5-6 cells in 2019 and 9-16 cells in 2020 in the northern half of the lakebed.

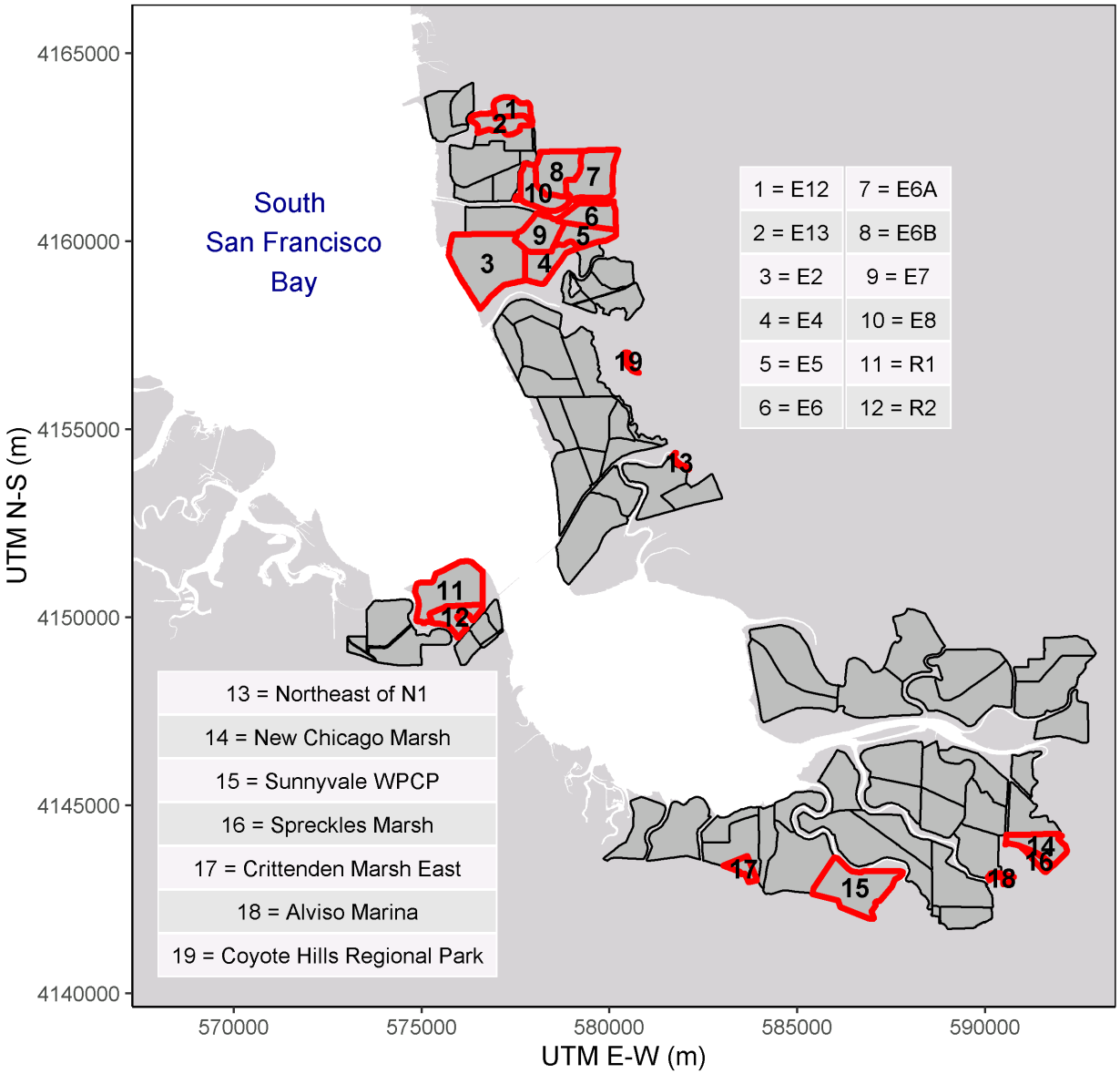

Figure A4. Map of 2020 phalarope survey sites in south San Francisco Bay. SFBBO used an area search approach to survey for phalaropes at sites outlined in red in 2020. Sites 1-12 are former salt production ponds. Other former and current salt production ponds are outlined in black. Sites 13-19 include water treatment ponds and diked wetlands.

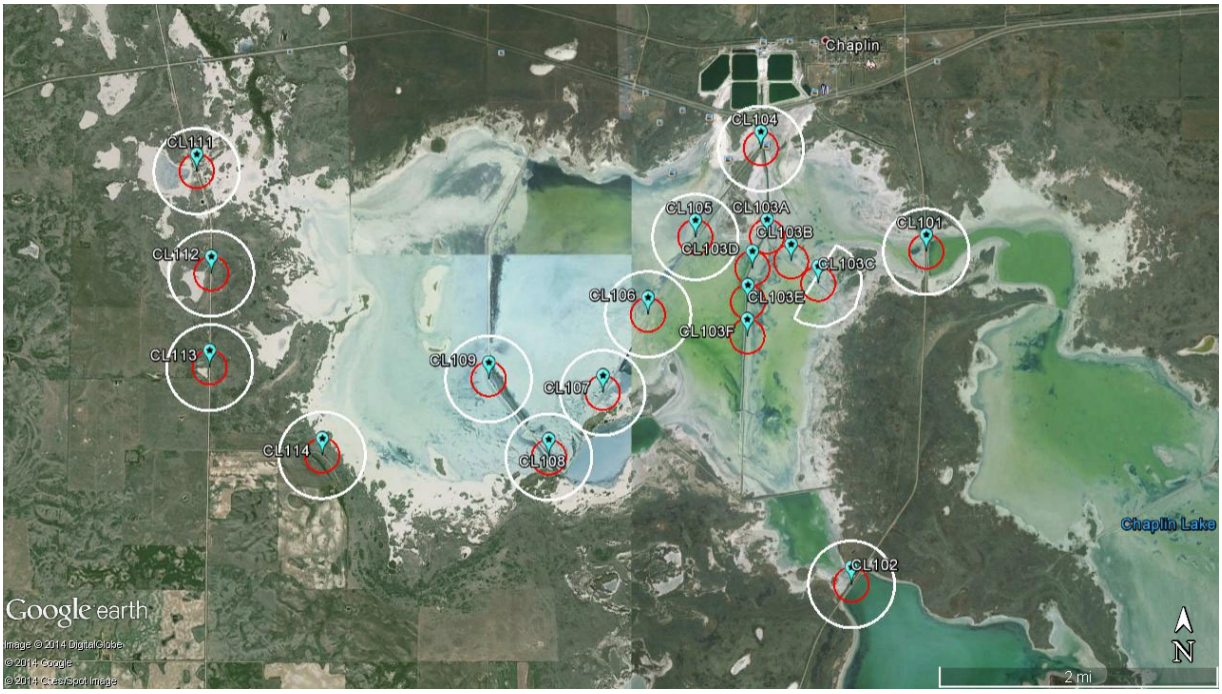

Figure A5. Point count stations at Chaplin Lake, Saskatchewan. Red circles indicate the 0-200 m buffers and the white circles indicate the 200-500 m buffers.