

Coordinated phalarope surveys at western North American staging sites, 2019-2022

Version 2, updated August 2024, see Appendix 2 for summary of changes from version 1



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Cover photo: Wilson's Phalaropes at Mono Lake, by Ryan Carle

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Summary

Wilson's and red-necked phalaropes (*Phalaropus tricolor* and *P. lobatus*, respectively) breed in mid- to northerly latitudes of North America and migrate to saline lakes in western North America. At saline lakes staging sites, Wilson's phalaropes double their fat reserves and molt before migrating to South America, and red-necked phalaropes stop for an unknown amount of time to feed and continue on their southward migration. Saline lake habitat is threatened worldwide by water diversion and climate change, so there is an urgent need to better understand the populations trends and habitat use of phalaropes, as well as flexibility of staging site selection. We conducted coordinated monitoring of western North American staging areas of 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, 2019-2022, with at least one survey per site per window. Methods were standardized within sites but varied across sites, and included 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 six surveyed sites in 2020-2022. We report totals of unidentified phalaropes along with the species-specific totals counted for the same window, to account for the impact of unidentified birds on interpretation of results.

The maximum annual counts in a single survey window for Wilson's/unidentified phalaropes was 364,345 in 2019 (Great Salt Lake, Mono Lake, Lake Abert only), 236,452 in 2020, and 295,624 in 2021, and 197,112 in 2022. The overall decrease in Wilson's phalaropes numbers in 2022 were driven primarily by lower numbers at Great Salt Lake. The maximum annual counts in a single survey window for red-necked/unidentified phalaropes was 291,524 in 2019 (Great Salt Lake, Mono Lake, Lake Abert only), 123,694 in 2020, 147,952 in 2021, and 124,184 in 2022. Similar to Wilson's phalaropes, red-necked phalarope numbers were lower in 2020 and 2022 than in the other two years, driven primarily by numbers at Great Salt Lake. There is a need for continued monitoring of phalarope populations and habitat use as phalaropes respond to rapid habitat loss at Lake Abert and Great Salt Lake.

Introduction

Wilson's and red-necked phalaropes (*Phalaropus tricolor* and *P. lobatus*, respectively) are iconic species of saline lakes in the interior west of North America, where hundreds of thousands of individual phalaropes stop each year. The population trends of these phalaropes, however, are 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. Many saline lakes are existentially threatened by water diversion and climate change (Larson et al. 2016, Wurtsbaugh et al. 2017, Hall et al. 2023), so there is an urgent need to better understand the population trends of the phalaropes that critically rely on them.

Phalaropes breed in mid- to northerly latitudes of North America, and during southward migration hundreds of thousands of Wilson's and red-necked phalaropes stop at 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. The majority of the world population of Wilson's phalaropes uses North American saline lakes as migratory staging sites (Jehl 1988, 1999). The North American red-necked phalarope population uses a greater diversity of habitat, including the Atlantic and Pacific coasts, and it is unknown what proportion of their overall population stages at saline lakes (Rubega et al. 2020). Wilson's phalaropes spend the boreal winter at interior saline wetlands in South America (Hurlbert et al. 1984, Castellino & Lesterhuis 2020), and red-necked phalaropes at sea off the western coast of South America (Rubega et al. 2020).

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 1986, 1988). With major phalarope population concentrations occurring during a relatively short time period at these sites, coordination of surveys across sites offers an opportunity to survey a large proportion of the population at once (Jehl 1986, 1999). To achieve this, these major staging sites must be surveyed in a narrow time range, so that movement of the birds between sites does not confound results.

In 2019, we founded the International Phalarope Working Group with partners from around the western hemisphere, and identified coordination of surveys in western North America as a top priority for phalarope conservation research (Carle and Rubega 2019). Objectives of the coordinated surveys are to create an annual index of phalarope numbers at major staging sites to evaluate population trends and habitat use of each site, and to understand how phalaropes respond to habitat change at saline lakes. In 2019, 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 in order to address these questions.

Methods

Study sites

In 2019–2022, we coordinated surveys across six phalarope staging sites in the western U.S. and Canada: Great Salt Lake (Utah), Mono Lake (California), Lake Abert (Oregon), Owens Lake (California) the south San Francisco Bay (California), and Chaplin Lake (Saskatchewan; Fig. 1). These sites were chosen because they historically hosted consistent large aggregations of Wilson’s and red-necked phalaropes (Jehl 1986, Jehl 1988, Rubega et al. 2020). Owens Lake currently usually hosts >1,000 phalaropes annually (Carle et al. 2022), but was essentially dry during historic surveys in the 1980s and 1990s, supporting few phalaropes at that time



Figure 1. Western North American phalarope staging site surveys locations, 2019–2022.

We conducted surveys at each site during week-long survey windows, with the goal of conducting at least one survey per site per window (Table 1; see Carle et al. 2022 for details on previous survey year dates and effort). By surveying all sites during each survey window, we reduced the chance of double-counting birds moving between sites. At Mono Lake, two sites were conducted per survey window (see Mono Lake methods). Survey windows were in late June–early July (2021–2022 only), mid-July, late July–early August, mid-August, late August–early September, and mid-September (2019–2022; see dates in Table 1). Despite efforts to do all surveys within the exact dates of the windows, for various reasons this was sometimes not possible, and some surveys occurred outside windows. We included surveys in analysis that fell within 2 days on either side of the survey window, effectively lengthening the each survey window to 11 days. In a limited number of cases in which a site had both a survey that fell in the

exact survey window, and one that fell 1-2 days outside it, we preferentially used the survey that fell within exact survey window dates. 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 that year. We report results from all six monitored sites for 2020-2022.

Table 1. Dates of 2022 phalarope surveys at western North American staging sites. Blank cells indicate no survey was conducted during that window. Asterisks indicate dates that were 1-2 days outside the week-long survey windows but were included in those survey windows for summary. Results from surveys >2 days outside of survey windows are listed in Appendix 1, Table A5.

Site	Jun 29- Jul 5	Jul 14-20	Jul 29- Aug 3	Aug 13-19	Aug 28- Sep 3	Sep 12-18
Great Salt Lake	No survey	7/14	8/1	8/15	8/29	9/12
Mono Lake	6/30, 7/1	7/14, 7/15	7/29, 8/2	8/15, 8/16	8/29, 8/31	9/12, 9/13
Lake Abert	7/7*	7/23*	8/3	8/19	8/31	9/14
Owens Lake	6/29	7/15	7/26*, 8/4*	8/16, 8/17	9/2	9/17
Chaplin Lake	No survey	7/15	7/29	8/19	No survey	No Survey
SF Bay	7/5	7/19	8/2*	8/16	8/30	9/13

Great Salt Lake

At Great Salt Lake (hereafter GSL), 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 (Appendix 1, Fig. A1). 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. Flocks of >75,000 birds 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 ~3 hours traveling over the water ~800 m from the shoreline of GSL 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 there, 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 it 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, Harold Crane Waterfowl Management Area 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, transects parallel to the shore and spaced approximately 1.9 kilometers apart were flown over the extent of those concentrations.

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 2020-2022; Appendix 1, Fig. A2) and simultaneously counting phalaropes in a 400 m radius from the boat, using binoculars. 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 2020-2022; Appendix 1, Fig. A2). Shore surveyors used spotting scopes and binoculars. Each shore survey count area was standardized but total area covered varied by shore survey point (see Appendix 1, Table A3 for count areas). Shore surveys were conducted by trained volunteers. 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 that samples approximately 20% of the surface of Mono Lake (percent sampled varies year to year depending on the lake level). Count stations were spread across the full extent of the lake (Appendix 1, Fig. A2). Mono Lake had two surveys during each survey window; we report here the highest single-survey counts in each window.

Lake Abert

At Lake Abert, Oregon, (42.703° N, -120.221° W) shore-based surveys were conducted by volunteers from East Cascades Audubon Society. Observers arrived early in the morning to avoid heatwaves reducing visibility, and drove along highway 395 on the east side of the lake, stopping at approximately 15 pullouts to make counts, with ~0.25 miles between pullouts. Observers used binoculars to identify and count nearby birds and used scopes for distant birds. Where birds were in flocks, numbers of birds in each field of view were estimated in multiples of 25, 50, 100, 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 occupied. Because Lake Abert is 3-5 miles across on average, about half or less of the lake could be adequately counted. Phalaropes usually appeared to be 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 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–June to control dust. Some water is also released outside this period to maintain wildlife habitat. The Dust Control Program Area is divided into numerous discrete dust control management units referred to as Dust Control Areas (DCAs; Appendix 1, Fig. A3). DCAs differ in size, depth, salinity and water persistence.

LADWP biologists conduct four surveys a year of the entire Owens Lake Dust Control Program Area: April, August, September and October. These “lakewide surveys” required 6–7 people 1–3 days to complete. ESA conducted smaller-scale surveys during other survey windows to fill in these gaps. LADWP worked with ESA to determine the best subsample of DCAs to consistently survey during the other phalarope survey windows, as surveying all DCAs is not needed due to a lack of habitat and available personnel. Based on an analysis of phalarope abundance on lakewide surveys for the time period 2015-2020, 16 DCAs were subsampled, which accounted for 91% of all phalaropes based on past data (D. House, LADWP, unpublished data; Appendix 1, Figure A3).

The August 16-17, 2022 lake-wide survey conducted by LADWP covered all DCAs; for that day, we report data only from the 16 areas covered by the other 2022 surveys. Starting time was near dawn each day. All surveys were conducted by driving along roads and berms surrounding DCAs, stopping periodically to survey using binoculars and spotting scopes.

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), surveyed at former salt evaporation ponds, managed ponds, and several other sites in southern San Francisco Bay (hereafter referred to as SFB). 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 (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 SFB (where multiple observations of phalaropes have occurred

on eBird; Tarjan 2019). Note that the scope of the 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.

Surveys at the majority of SFB sites were synchronized with the coordinated survey windows of other North American staging sites. A few SFB sites were surveyed on alternative dates surrounding the primary survey dates due to staff availability and access limitations. 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, from 2020–2022, all phalaropes seen while traveling in a vehicle between survey points were counted, 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 2022, surveys were conducted weekly from July 15 to August 26. Thus, surveys conducted on July 15, July 29, and August 19 fell within the windows defined in this report.

Caveats for comparisons between sites

The methods and coverage of surveys varied at each site. 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, it is important to keep in mind that the following factors varied across sites 1) observer training; 2) survey area; 3) estimation methods; 4) vantage/proximity to birds; 5) methods to control double-counting and error; 6) time of day/time distribution of effort; and 7) completeness of site coverage. Care was taken to keep methods consistent *within* sites, meaning that surveys carried out on different dates or years at a single site are comparable.

Data summary & analysis

For each site, we summed the grand total of Wilson's, red-necked, and unidentified phalaropes observed in each survey window. For each survey window, we summed the totals across all sites to produce a region-wide total for each species. We defined the peak annual region-wide totals

for each species as the highest count of that species occurring within a single survey window, combined with the unidentified phalarope count from the same window.

Whether phalaropes can be identified to species depends on a variety of factors, including survey method, site characteristics, weather conditions, flock size, and observer. Unidentified phalaropes present a challenge for data summary and interpretation. Wilson's phalaropes generally occur in large numbers at staging sites earlier than red-necked phalaropes (Jehl 1986, 1988, 1999). At our survey sites, Wilson's phalaropes are typically the predominant species present from June to mid-July, both species can be present in large numbers in late July-mid August, and from late August on most birds are red-necked phalaropes. No quantitative analysis has been completed to determine a correction factor ratio to categorize unidentified phalaropes to species. Jehl (1999) estimated that 75% of unidentified phalaropes at staging sites in late July were Wilson's. Given differences in timing, phalarope use, and latitudes of the sites we surveyed, we were not confident that a single correction ratio would be appropriate, so we did not use Jehl's ratio.

We report raw counts of Wilson's, red-necked, and unidentified phalaropes in the Appendix, Tables A1, A2, and A3 and combined species/unidentified counts in the Appendix, Table A4. For interpretation, discussion, and visualization of 2022 high counts at individual sites, we report totals of Wilson's and red-necked phalaropes identified to species separate from unidentified phalarope totals.

To identify inter-annual peak counts for each site, and to identify region-wide annual peak counts, we identified the highest single-survey window count of each identified species, and combined that total with the unidentified birds from that survey window. In the case of Mono Lake, with multiple surveys per window, we used the unidentified phalarope count from the survey day that corresponded to the identified species' high count at Mono Lake during the survey window. In identifying annual peak counts, all unidentified birds were considered to be the species for which it was a high count, and to *not* be the other species. Using this method, the counts of identified species drove assignment of annual peak counts, rather than assignment being driven by high counts of unidentified birds, which could sometimes be greater than those of identified birds. In the vast majority of year/site peaks, counts of identified Wilson's and red-necked phalaropes occurred on different days, so double-counting of unidentified birds did not occur. However, in two cases (GSL in 2021 and Chaplin Lake in 2021), peaks of identified birds of both species were on the same survey day, with accompanying counts of unidentified birds. Because of the limited number of these situations, we allowed for unidentified birds to be counted in both Wilson's/unidentified and red-necked/unidentified phalarope totals in those cases. This issue affected only site-specific peak counts, and not region-wide peak counts, which never had overlapping dates for both species. There were no region-wide annual peak-count survey windows that were the same for both Wilson's and red-necked phalaropes during our time-series.

These methods are imperfect and involve assumptions about the species-identity of unidentified phalaropes. A caveat of these methods for assigning unidentified phalaropes is that, especially in late July-mid August, unidentified birds were likely a mixture of both species, but we treat them

as all one or the other. For counts falling in late July-mid August, it should be kept in mind that though we grouped unidentified birds with whichever species had a high count for a given window or survey, that species proportions are uncertain.

Results and discussion

Peak counts: Wilson's phalaropes

The maximum 2022 count during a single survey window of Wilson's phalaropes and unidentified phalaropes combined was 197,112 birds during the July 29-August 3 window (Fig. 2, Table A4). Of that count, 62,619 birds were identified as Wilson's phalaropes and the remainder were unidentified phalaropes (Fig. 2, Tables A1, A3). 2022 was the first year of our time-series in which the Wilson's/unidentified phalarope total did not exceed 200,000 birds (Fig. 2, Table A4). Previous totals were 364,345 in 2019, 236,452 in 2020, and 295,624 in 2021 (Fig. 2, Table A4). Peak counts occurred during the mid-July window in 2019 and 2020, and during the late July-early August window in 2021 and 2022.

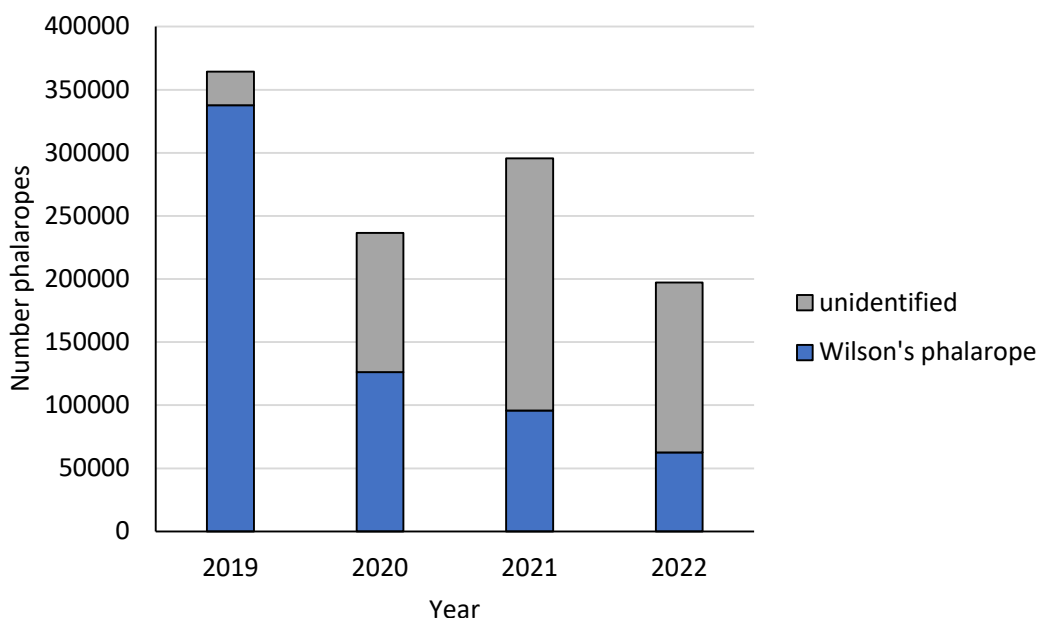


Figure 2. Peak single-window counts across six sites of Wilson's/unidentified phalaropes and red-necked/unidentified phalaropes, 2019-2022. Peak counts were identified based on the single survey window with the highest count of identified Wilson's phalaropes across all six sites; the unidentified counts from the same window were added to the Wilson's phalarope count. At Mono Lake, where there were two surveys per window, the unidentified count corresponding with the day of the peak count of identified Wilson's phalaropes was used. Peak counts occurred during the mid-July window in 2019 and 2020. Peak counts occurred during the late July-early August window in 2021 and 2022. During late July and August windows, many red-necked phalaropes can be present, though we

assume here that all unidentified birds were Wilson's. In 2019, the only data available during the peak count window were from Great Salt Lake and Lake Abert.

Peak counts Red-necked Phalaropes

The maximum 2022 count during a single survey window of red-necked phalaropes and unidentified phalaropes was 124,184 birds during the August 13-19 window (Fig. 3, Table A4). Of that count, 72,496 birds were red-necked phalaropes and the remainder were unidentified phalaropes (Fig. 3, Tables A2, A4). Historically, most Wilson's phalaropes depart staging sites by mid-August (Jehl 1988, Rubega and Keimel 2017). Thus, it is probable that many of the unidentified birds during the red-necked phalarope peak count were red-necked phalaropes. The maximum annual counts in a single survey window for red-necked/unidentified phalaropes in previous survey years were 291,524 in 2019 (Great Salt Lake, Mono Lake, Lake Abert only), 123,694 in 2020, 147,952 in 2021 (Fig. 3).

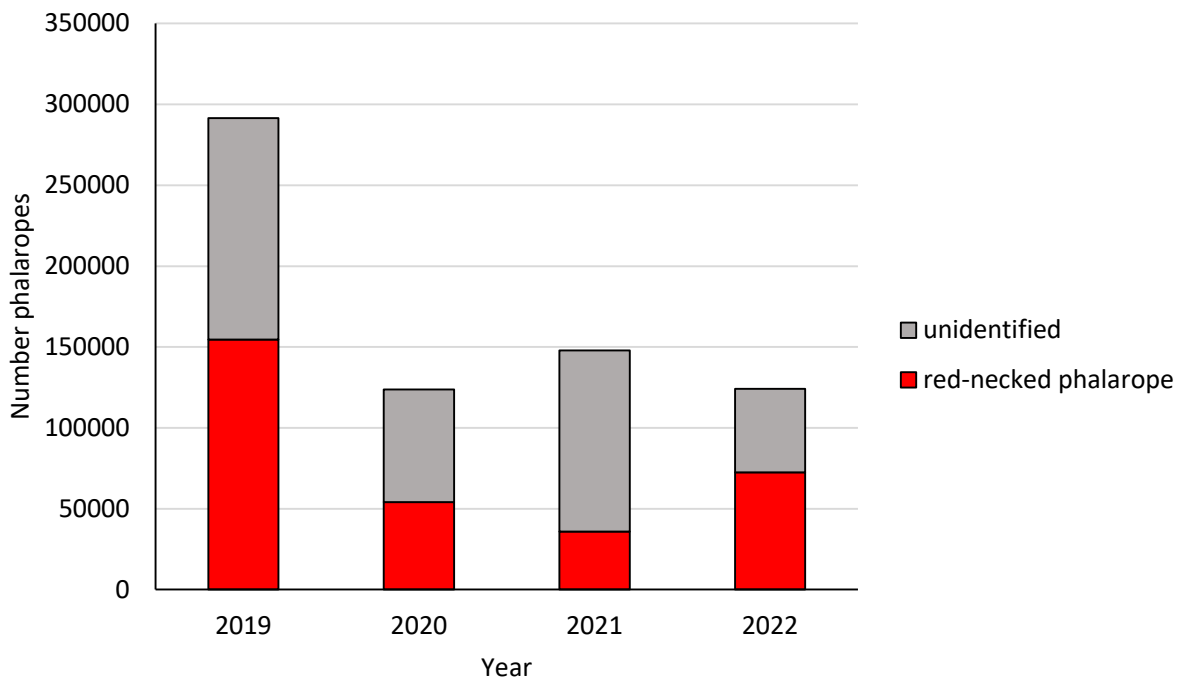


Figure 3. Peak single-window counts across six sites of red-necked/unidentified phalaropes 2019-2023. Peak counts were identified based on the single survey window with the highest count of identified red-necked phalaropes across all six sites; the unidentified counts from the same window were added to the red-necked phalarope count. At Mono Lake, where there were two surveys per window, the unidentified count corresponding with the day of the peak count of identified red-necked phalaropes was used. Peak red-necked/unidentified phalarope counts occurred during the mid-August window in 2019, 2021, and 2022 and during the late August-early September window in 2020. During the mid-August window, many Wilson's phalaropes can be present, though we assume here that all unidentified birds were red-necked. In 2019, the only data available during the peak count window were from Great Salt Lake, Lake Abert, and Mono Lake.

Comparisons across sites

Wilson's phalaropes

Similar to previous years, in 2022 GSL had the largest aggregations of Wilson's phalaropes of any site, with a peak Wilson's count of 36,970 (Wilson's/unidentified count that day was 165,705; Fig. 4, Tables A1, A3). Mono Lake's 2022 peak Wilson's count was 12,409 (zero same-day unidentified phalaropes), down from 45,143 in 2021 (Fig. 4). The 2022 high count of Wilson's/unidentified phalaropes at Lake Abert was 6,500 on July 7 (Fig. 4; zero same-day unidentified phalaropes). There was a notable 2022 high count of 14,545 Wilson's phalaropes at Chaplin Lake on July 29 (Fig. 4). This was the largest count of Wilson's phalaropes recorded at Chaplin Lake during this study. Other sites' peak Wilson's phalarope counts were 1,169 at Owens Lake on August 16, and 735 at SFB on July 19 (Fig 4).

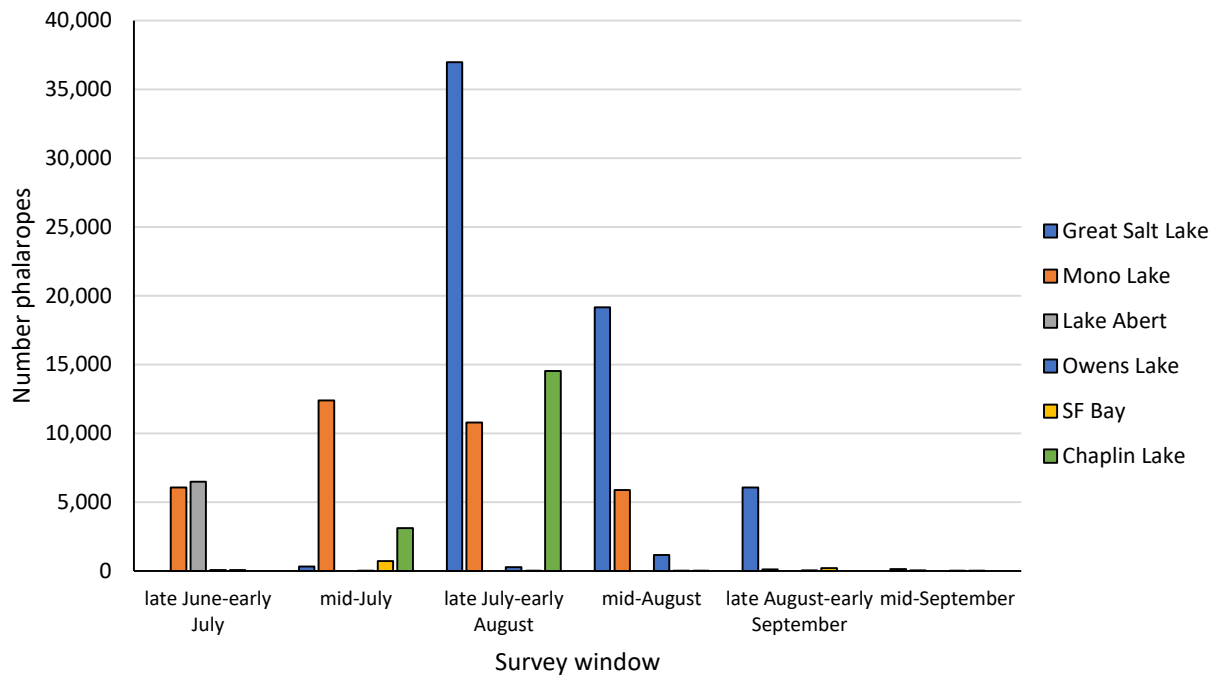


Figure 4. Peak Wilson's phalarope counts during survey windows at western North American staging sites, 2022. Only phalaropes identified as Wilson's phalaropes are shown. See Appendix, Table A1 for exact numbers from each site for 2023. SF Bay is the south San Francisco Bay salt ponds.

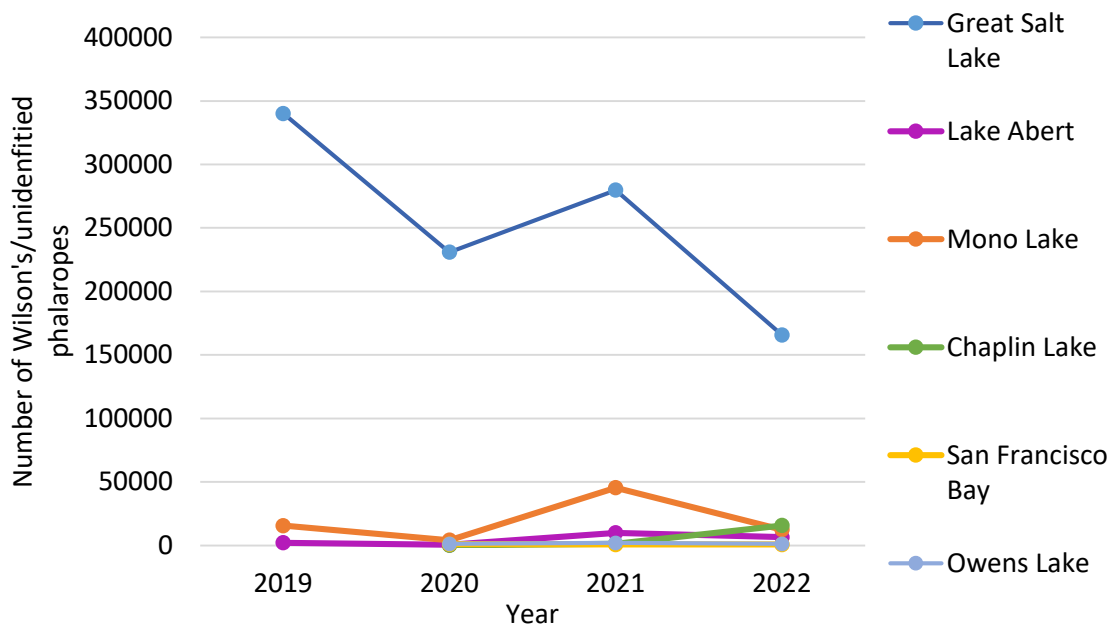


Fig. 5. Peak counts of Wilson's/unidentified phalaropes from each site, 2019-2022.

Peak counts were identified based on the survey window with the highest count across sites of identified Wilson's phalaropes; the unidentified counts from the same window were added to the Wilson's phalarope count. At Mono Lake, where there were two surveys per window, the unidentified count corresponding with the day of the peak count of identified Wilson's phalaropes was used. Number of Wilson's phalaropes at Lake Abert is likely under-represented here because large (>20,000 birds) flocks of unidentified phalaropes occurred in 2019 and 2022 at Lake Abert on days with no identified birds; those counts are not shown here. There were insufficient data from Chaplin Lake, San Francisco Bay and Owens Lake in 2019.

Red-necked phalaropes

Among sites, GSL also had the highest counts of red-necked phalaropes in all study years (Fig. 6). In 2022, the high count of red-necked/unidentified phalaropes at GSL was 59,075 during the mid-August window (same day red-necked/unidentified phalarope count was 109,680; Fig. 6, Tables A2, A3). Mono Lake's peak 2022 red-necked phalarope count was 10,587 on August 16 (there were three same-day unidentified phalaropes; Fig. 6). Other red-necked phalarope 2022 peak counts were 4,357 at SFB on August 30, and 1,404 at Owens Lake on September 2 (Fig. 6). Counts of 2,870 unidentified phalaropes on August 31 at Lake Abert and 1,200 unidentified at Chaplin Lake on July 29 may have included large proportions of red-necked phalaropes, given the timing.

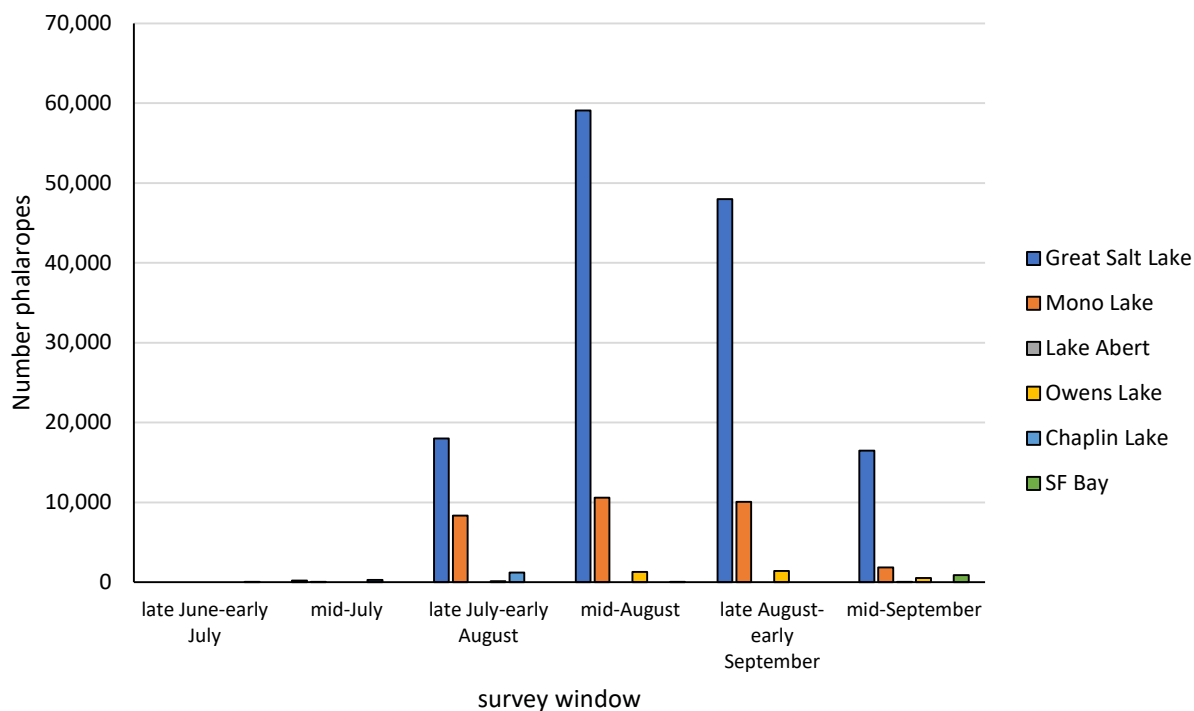


Figure 6: Peak counts of red-necked phalaropes during each survey window at western North American staging sites, 2022. Only phalaropes identified as red-necked phalaropes are shown here. See Appendix, Table A2 for exact numbers from each site. SF Bay is the south San Francisco Bay salt ponds.

Discussion

After four years of coordinated monitoring across six sites, several trends have become clear. The most obvious is that GSL, now as in the past, hosts the vast majority of phalaropes compared to other staging sites. During 2019-2022, GSL's numbers clearly drove the overall phalarope trends we report. GSL is in crisis as its volume has shrunk >50% compared to the volume at an average lake elevation (Fig. 7; Hall et al. 2023). Approximately 40% of the microbialite habitat needed for pupal attachment of alkali flies had also been compromised by declining lake levels as of 2022 (Utah Division of Wildlife unpublished data), which is a concern for phalaropes, which frequently prey on alkali flies (Jehl 1988, Rubega & Inouye 1994, Frank & Conover 2019). Our results demonstrate that the vast majority of both Wilson's and red-necked phalaropes using the Interior West rely on GSL, and that the fate of their habitat is critical to the health of the species.



Fig. 7. Great Salt Lake in 1984, 2001, and 2022, near the all-time high, average, and all-time low, respectively. Record keeping began in 1847. Lake elevation levels are 4,209, 4,200, and 4,189 feet above mean sea level, respectively. Images from NASA.

Phalaropes rely on large, perennial saline lakes with abundant alkali flies to fuel their molt and migration (Jehl 1988, 1999), and no other site can replace the size and extent of GSL's habitat. The other largest sites are Lake Abert, which was virtually dry during the 2021 and 2022 surveys, and Mono Lake, where habitat is much more stable than at other sites because of regulation of water diversions, but nevertheless remains far below target management levels (Hall et al. 2023). Mono Lake has <10% of the surface area of GSL, even at GSL's current low level (Hall et al. 2023). Should GSL dry further or become unsuitable habitat to support large numbers of phalaropes, it is unknown if phalaropes could respond by moving to other sites like Mono Lake, or shortening their staging periods. Either response could negatively impact survival and population trajectories of the species, as has been demonstrated in other shorebirds experiencing major loss of staging habitats (Piersma et al. 2016, Studds et al. 2017). Concentration at just a few remaining staging sites can result in competition for limited prey resources, birds being unable to refuel sufficiently to meet energy needs, ultimately leading to mortalities (Sutherland and Dolman 1994, Studds et al. 2017). This has been theorized to be the mechanism behind sudden and major population declines of shorebirds that stage in the mudflats of the Yellow Sea in Asia, which have experienced major habitat losses (Piersma et al. 2016, Studds et al. 2017, Murray et al. 2017). Inadequate prey at key staging sites has also been linked to survival and serious population declines in the case of Red Knots (*Calidris canutus rufa*) on the Atlantic Coast of the U.S. (Morrison et al. 2007, McGowan et al. 2011).

We have observed patterns that suggest responses to habitat loss by phalaropes, such as the large increase in Wilson's phalarope numbers at Mono Lake in 2021 when Lake Abert was drying up. In 2022, numbers were lower at GSL than in previous years, but we did not see a corresponding increase at other sites. It is noteworthy that GSL was not surveyed in the late-June to early July window in 2022, so it is possible that the Wilson's phalarope peak could have been missed. However, peak numbers of Wilson's phalarope at GSL and other staging sites usually occur in mid- or late-July (Jehl 1999, Carle et al. 2021), periods when GSL was surveyed in 2022. It is still unclear if the low numbers of phalaropes at GSL in 2022 were related to habitat loss or

reduced prey base there, but this will likely become more clear with continued monitoring in the near future if the lake continues to decline. Plans to track Wilson's phalaropes during 2023 may also help illuminate how the birds respond to habitat loss and how and if they can respond by moving between staging lakes.

During 2019-2022, there was also a declining trend in overall phalarope numbers, with both species having the highest totals across all sites in 2019, and markedly lower totals in 2020 and 2022. In 2022, Wilson's phalarope total numbers did not exceed 200,000 for the first time in the study period. Historically, numbers of Wilson's phalaropes at GSL ranged from 387,000-603,000 in the period from 1982-1991 (four years of complete surveys; Jehl 1999).

Contemporary peak count numbers of Wilson's/unidentified phalaropes at GSL (average 254,090 [SD 73,948]) were more similar to numbers from GSL from 1992-1997, which ranged from 118,000 to 267,000 (average 211,220 [SD 63,380], $n = 5$ years). Only one previous year, 1994, had a lower overall Wilson's phalarope estimate from GSL (118,000; Jehl 1999) than 2022 (165,705). Phalarope numbers can be highly variable across years (Jehl 1999), so continued monitoring is important for understanding if this is a long- or short-term pattern.

As saline lakes continue to be threatened by water diversion and climate change across the interior west of North America, it is increasingly important to monitor phalarope populations to understand their response to rapidly changing habitat. Phalaropes are a bell-weather indicator for the network of saline lakes, and the near-future is a crucial time in the effort to protect saline lakes.

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Appendix 1.

Table A1. Maximum Wilson's phalarope counts in survey windows at all sites surveyed. Counts were included in this table, and in summary and analysis for this report, if they fell within the specific survey window dates or were ≤ 2 days outside of it. Only Mono Lake consistently had >1 count per survey window. At SF Bay (San Francisco Bay), Owens Lake, and Chaplin Lake the entire site was sometimes surveyed over multiple days (maximum 3 days). Counts that were outside exact survey dates (≤ 2 days) are italicized. SF Bay is south San Francisco Bay.

Wilson's phalarope									
Year	survey window	window dates	GSL	Mono	Abert	Owens	SF Bay	Chaplin Lake	Total
2022	late June-early July	June 29-July 5	No data	6078	<i>6500</i>	74	85	No data	12,737
2022	mid-July	July 14-July 20	325	12409	No data	43	735	3129	16,641
2022	late July-early August	July 29-August 3rd	36,970	10805	0	<i>299</i>	10	14535	62,619
2022	mid-August	August 13-August 19	19,170	5887	0	1169	19	19	26,264
2022	late August-early September	August 29-September 3	6,080	129	0	50	220	No data	6,479
2022	mid-September	September 12-September 18	150	60	0	10	15	No data	235
2021	late June-early July	June 29-July 5	35750	22,440	<i>9855</i>	19	738	No data	68,802
2021	mid-July	July 14-July 20	23825	45,143	No data	1,987	12	780	71,747
2021	late July-early August	July 29-August 3	93310	1,579	0	11	240	580	95,720

2021	mid-August	August 13-August 19	14,490	158	0	425	24	0	15,097
2021	late August-early September	August 28-September 3	975	No data	No data	0	33	No data	1,008
2021	mid-September	September 12-September 18	1,185	0	No data	0	0	No data	1,185
2020	mid-July	July 15-July 21	122,850	2,475	80	90	767	26	126,288
2020	late July-early August	July 29-August 4	74,045	2,765	450	670	446	120	78,496
2020	mid-August	August 13-August 19	10,530	637	No data	1,144	162	5	12,478
2020	late August-early September	August 31-September 6	145	15	6	81	110	No data	357
2020	mid-September	September 15-September 21	100	No data	25	0	0	No data	125
2019	mid-July	July 11-July 17	337,698	No data	0	No data	No data	No data	337,698
2019	late July-early August	July 30-August 5	231,920	2,712	2,050	No data	No data	No data	236,682
2019	mid-August	August 16-August 22	4895	312	0	No data	No data	No data	5,207
2019	late August-early September	August 31-September 6	No data	4	0	No data	No data	No data	4
2019	mid-September	September 11-September 17	2	0	No data	No data	No data	No data	2

Table A2. Maximum red-necked phalarope counts in survey windows at all sites surveyed. Counts were included in this table, and in summary and analysis for this report, if they fell within the specific survey window dates or were ≤ 2 days outside of it. Only Mono Lake consistently had >1 count per survey window. At SF Bay (San Francisco Bay), Owens Lake, and Chaplin Lake the entire site was sometimes surveyed over multiple days (maximum 3 days). Counts that were outside exact survey dates (≤ 2 days) are italicized. SF Bay is south San Francisco Bay. The late June-early July survey window was surveyed only in 2021-2023.

Red-necked phalarope									
Year	survey window	window dates	GSL	Mono	Abert	Owens	SF Bay	Chaplin	Total
2022	late June-early July	June 29-July 5	No data	0	0	0	0	No data	0
2022	mid-July	July 14-July 20	200	9	No data	0	186	88	483
2022	late July-early August	July 29-August 3rd	17,985	8,345	0	117	87	72	26,606
2022	mid-August	August 13-August 19	59,075	10,587	0	1,277	1,557	0	72,496
2022	late August-early September	August 29-September 3	48,000	10,064	0	1,404	4,357	No data	63,825
2022	mid-September	September 12-September 18	16,470	1,831	10	533	2,882	No data	21,726
2021	late June-early July	June 29-July 5	6,710	5	0	0	35	No data	6,750
2021	mid-July	July 14-July 20	3,570	218	No data	0	313	407	4,508
2021	late July-early August	July 29-August 3	29,255	1,694	300	3	370	0	31,622

2021	mid-August	August 13- August 19	28,170	6,378	0	110	1,196	0	35,854
2021	late August- early September	August 28- September 3	10,115	No data	No data	2,719	2,992	No data	15,826
2021	mid- September	September 12- September 18	9,065	12,647	No data	2,489	6,767	No data	30,968
2020	mid-July	July 15-July 21	0	129	8	5	182	50	374
2020	late July- early August	July 29- August 4	2,505	8,220	300	0	758	0	11,783
2020	mid-August	August 13- August 19	28,235	10,891	No data	280	904	0	40,310
2020	late August- early September	August 31- September 6	43,725	8,252	267	86	1,700	No data	54,030
2020	mid- September	September 15- September 21	6,570	No data	675	1,550	935	No data	9,730
2019	mid-July	July 11-July 17	33,030	No data	0	No data	No data	No data	33,030
2019	late July- early August	July 30- August 5	81,330	2,612	5	No data	No data	No data	83,947
2019	mid-August	August 16- August 22	149,660	4,921	0	No data	No data	No data	154,581
2019	late August- early September	August 31- September 6	No data	5,573	0	No data	No data	No data	5,573
2019	mid- September	September 11- September 17	35,100	4,707	No data	No data	No data	No data	39,807

Table A3. Maximum unidentified phalarope counts in survey windows at all sites surveyed. Counts were included in this table, and in summary and analysis for this report, if they fell within the specific survey window dates or were ≤ 2 days outside of it. Only Mono Lake consistently had >1 count per survey window. "Mono WIPH high-date" and "Mono RNPH high-date" columns show unidentified counts correspond ding to the high-count date within the window for each species at Mono lake, due to multiple counts per window there. At SF Bay (San Francisco Bay), Owens Lake, and Chaplin Lake the entire site was sometimes surveyed over multiple days (maximum 3 days). Counts that were outside exact survey dates (≤ 2 days) are italicized. SF Bay is south San Francisco Bay. The late June-early July survey window was surveyed only in 2021-2023.

Unidentified phalarope											
Year	survey window	window dates	GSL	Mono WIPH high-date	Mono RNPH high-date	Abert	Owens	SF Bay	Chaplin	UNID total on same day as WIPH	UNID total on same day as RNPH
2022	late June-early July	June 29-July 5	No data	11	11	0	0	2	No data	13	13
2022	mid-July	July 14-July 20	63,770	0	70	No data	0	0	300	64,070	64,140
2022	late July-early August	July 29-August 3rd	128,735	2,058	658	2,500	0	0	1200	134,493	133,093
2022	mid-August	August 13-August 19	50,605	3	3	1,050	0	30	0	51,688	51,688
2022	late August-early Sep	August 29-Sep 3	67,225	510	510	2,870	0	0	No data	70,605	70,605
2022	mid-Sep	Sep 12-Sep 18	49,145	211	211	0	125	875	No data	50,356	50,356
2021	late June-early July	June 29-July 5	81,977	0	60	0	0	16	No data	81,993	82,053
2021	mid-July	July 14-July 20	202,125	245	245	No data	0	414	500	203,284	203,284
2021	late July-early August	July 29-August 3	186,420	10,253	10,253	3,070	76	84	1	199,904	199,904
2021	mid-August	August 13-August 19	102,675	5,105	5,105	4,315	0	3	0	112,098	112,098

2021	late August-early Sep	August 28-Sep 3	36,700	No data	No data	No data	522	792	No data	38,014	38,014
2021	mid-Sep	Sep 12-Sep 18	53,545	0	0	No data	515	0	No data	54,060	54,060
2020	mid-July	July 15-July 21	107,990	1	1	2,000	33	140	0	110,164	110,164
2020	late July-early August	July 29-August 4	119,335	1385	743	0	0	5	0	120,725	120,083
2020	mid-August	August 13-August 19	62,270	241	37	No data	76	0	30	62,617	62,413
2020	late August-early Sep	August 31-Sep 6	69,620	0	0	0	44	0	No data	69,664	69,664
2020	mid-Sep	Sep 15-Sep 21	36,975	No data	No data	0	0	32	No data	37,007	37,007
2019	mid-July	July 11-July 17	2,386	No data	No data	24,261	No data	No data	No data	26,647	26,647
2019	late July-early August	July 30-August 5	12,735	12,817	12,817	0	No data	No data	No data	25,552	25,552
2019	mid-August	August 16-August 22	114,770	107	173	22,000	No data	No data	No data	136,877	136,943
2019	late August-early Sep	August 31-Sep 6	No data	0	0	1,050	No data	No data	No data	1,050	1,050
2019	mid-Sep	Sep 11-Sep 17	3640	0	0	No data	No data	No data	No data	3,640	3,640

Table A4. Sums of counts from all surveyed sites for each species and combined species/unidentified counts for each survey window. The highest annual count per year for each species is in bold. Only Great Salt Lake, Mono Lake, and Lake Abert are included in 2019 totals because of limited data from other sites. Data from all 6 sites are included in 2020-2022 totals. The late June-early July survey window was surveyed only in 2021-2022.

Year	Survey window	Window dates	WIPH sum	WIPH/unidentified sum	RNPH sum	RNPH/unidentified sum
2022	late June-early July	June 29-July 5	12,737	12,750	0	13
2022	mid-July	July 14-July 20	16,641	80,711	483	64,623
2022	late July-early August	July 29-August 3rd	62,619	197,112	26,606	159,699
2022	mid-August	August 13-August 19	26,264	77,952	72,496	124,184
2022	late August-early September	August 29-September 3	6,479	77,084	63,825	134,430
2022	mid-September	September 12-September 18	235	50,591	21,726	72,082
2021	late June-early July	June 29-July 5	68,802	150,795	6,750	88,803
2021	mid-July	July 14-July 20	71,747	275,031	4,508	207,792
2021	late July-early August	July 29-August 3	95,720	295,624	31,622	231,526
2021	mid-August	August 13-August 19	15,097	127,195	35,854	147,952
2021	late August-early September	August 28-September 3	1,008	39,022	15,826	53,840
2021	mid-September	September 12-September 18	1,185	55,245	30,968	85,028
2020	mid-July	July 15-July 21	126,288	236,452	374	110,538
2020	late July-early August	July 29-August 4	78,496	199,221	11,783	131,866

2020	mid-August	August 13- August 19	12,478	75,095	40,310	102,723
2020	late August- early September	August 31- September 6	357	70,021	54,030	123,694
2020	mid- September	September 15- September 21	125	37,132	9,730	46,737
2019	mid-July	July 11-July 17	337,698	364,345	33,030	59,677
2019	late July- early August	July 30- August 5	236,682	262,234	83,947	109,499
2019	mid-August	August 16- August 22	5,207	142,084	154,581	291,524
2019	late August- early September	August 31- September 6	4	1,054	5,573	6,623
2019	mid- September	September 11- September 17	2	3,642	39,807	43,447

Table A5. Phalarope counts occurring >2 days outside of standardized count windows at all sites, 2019-2022. These counts were not included in summary results, but followed the same protocols as other counts. When relevant, noteworthy from outside the windows are sometimes referenced in the text. "NA" indicates that a count was >2 weeks outside a window. The late June-early July window was first introduced and standardized in 2021. The 7/1/2020 count at Lake Abert would have fallen in that window had it been surveyed that year.

Year	Site	Days outside window	Survey Date	Wilson's	Red- necked	Unidentified
2022	Lake Abert	3	7/23/2022	0	0	5,400
2022	Owens Lake	3	7/26/2022	539	38	0
2022	SF Bay	8	6/21/2022	18	0	0
2022	SF Bay	9	9/27/2022	0	1,963	0
2021	Lake Abert	2	7/27/2021	0	0	3,930
2021	SF Bay	10	9/28/2021	0	811	0
2020	Chaplin Lake	3	7/24/2020	178	0	0
2020	Chaplin Lake	3	8/7/2020	370	0	0
2020	Lake Abert	14	7/1/2020	21,800	30	0
2020	SF Bay	8	7/7/2020	548	1	0

2020	SF Bay	8	9/29/2020	1	40	0
2019	Lake Abert	24	6/17/2019	0	0	736
2019	Lake Abert	1	7/27/2019	1084	5	0
2019	Lake Abert	6	8/10/2019	0	0	89,000
2019	Lake Abert	2	8/24/2019	160	170	0

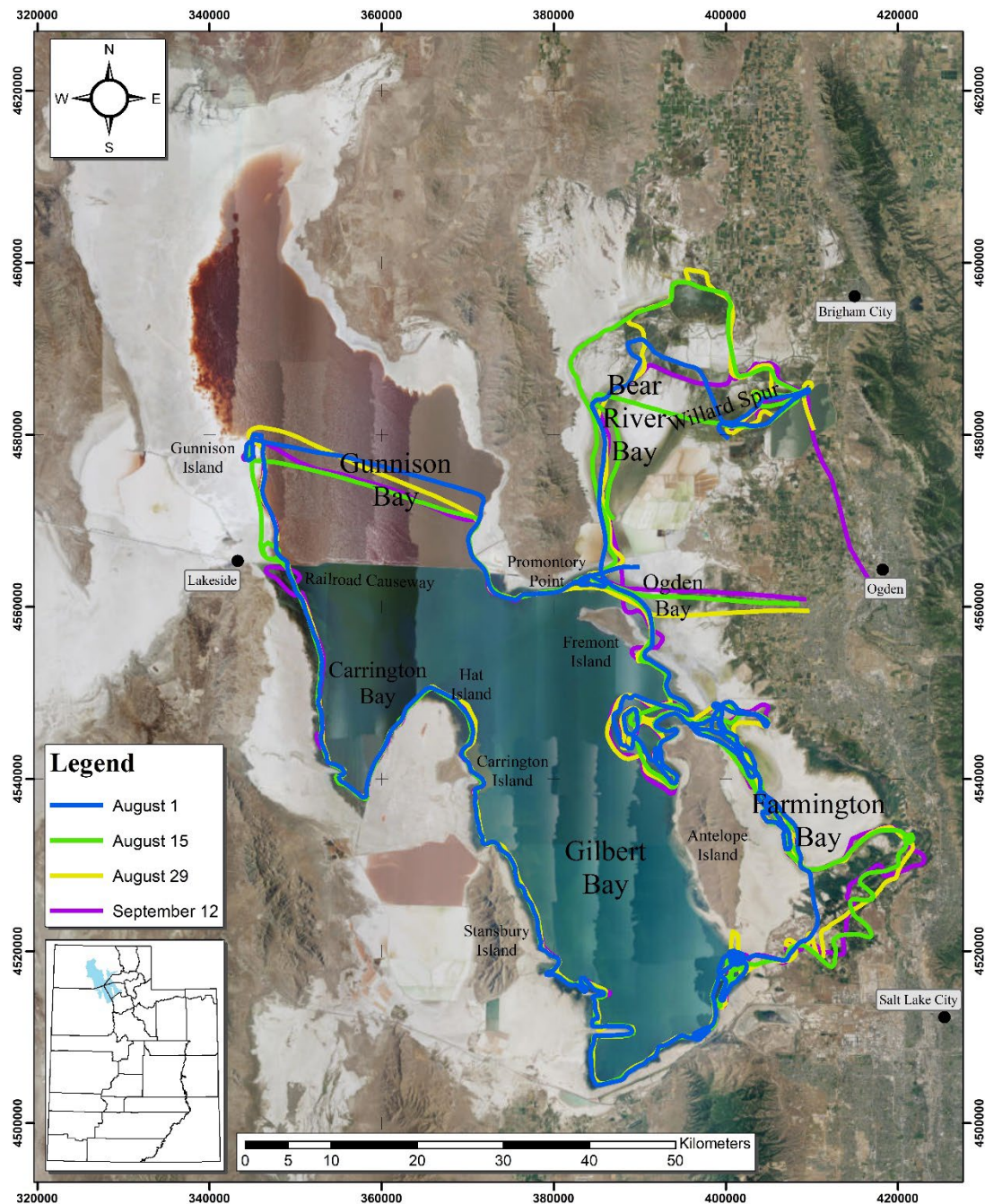


Figure A1. Phalarope survey flight paths in 2022 at Great Salt Lake, Utah. All flights originated and ended at the Ogden Airport and generally traveled in a counterclockwise direction.

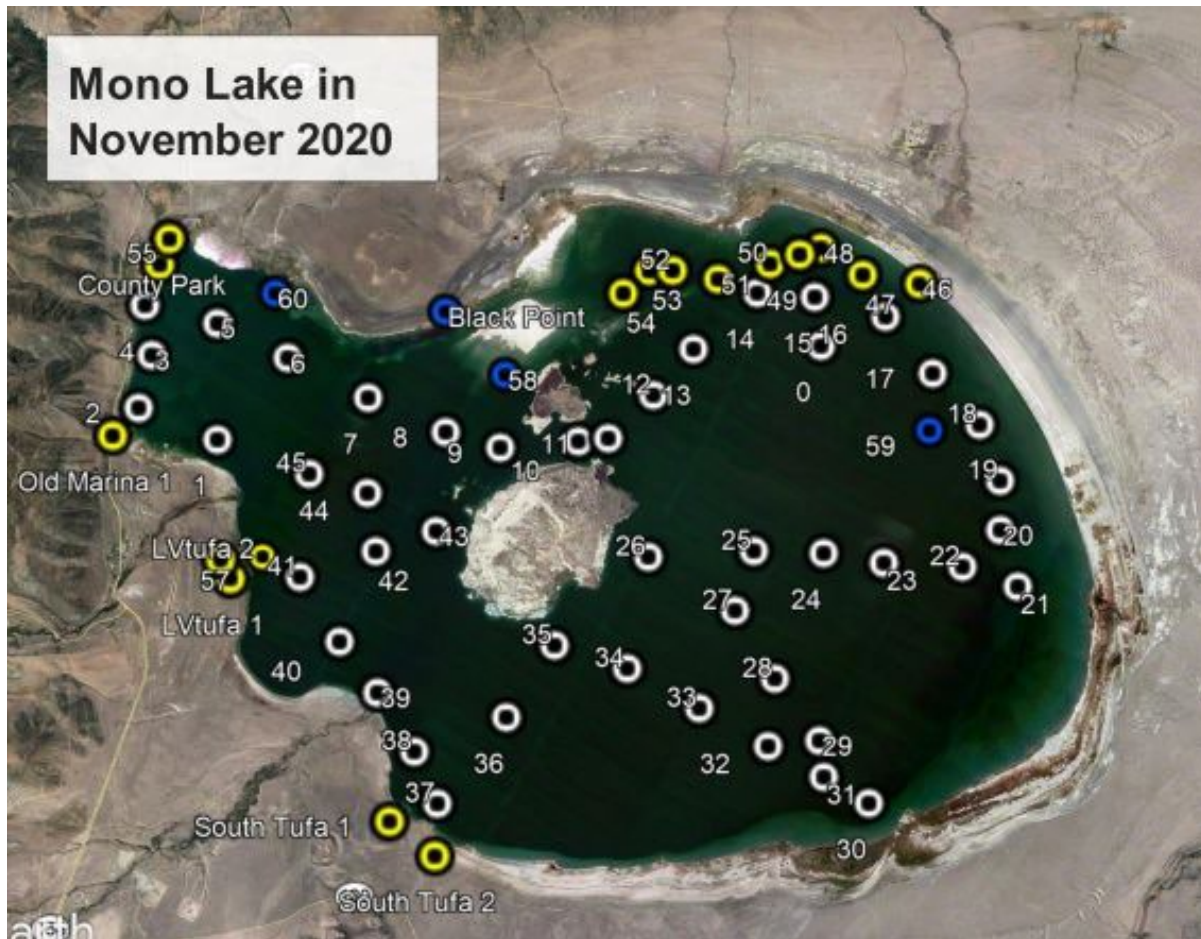
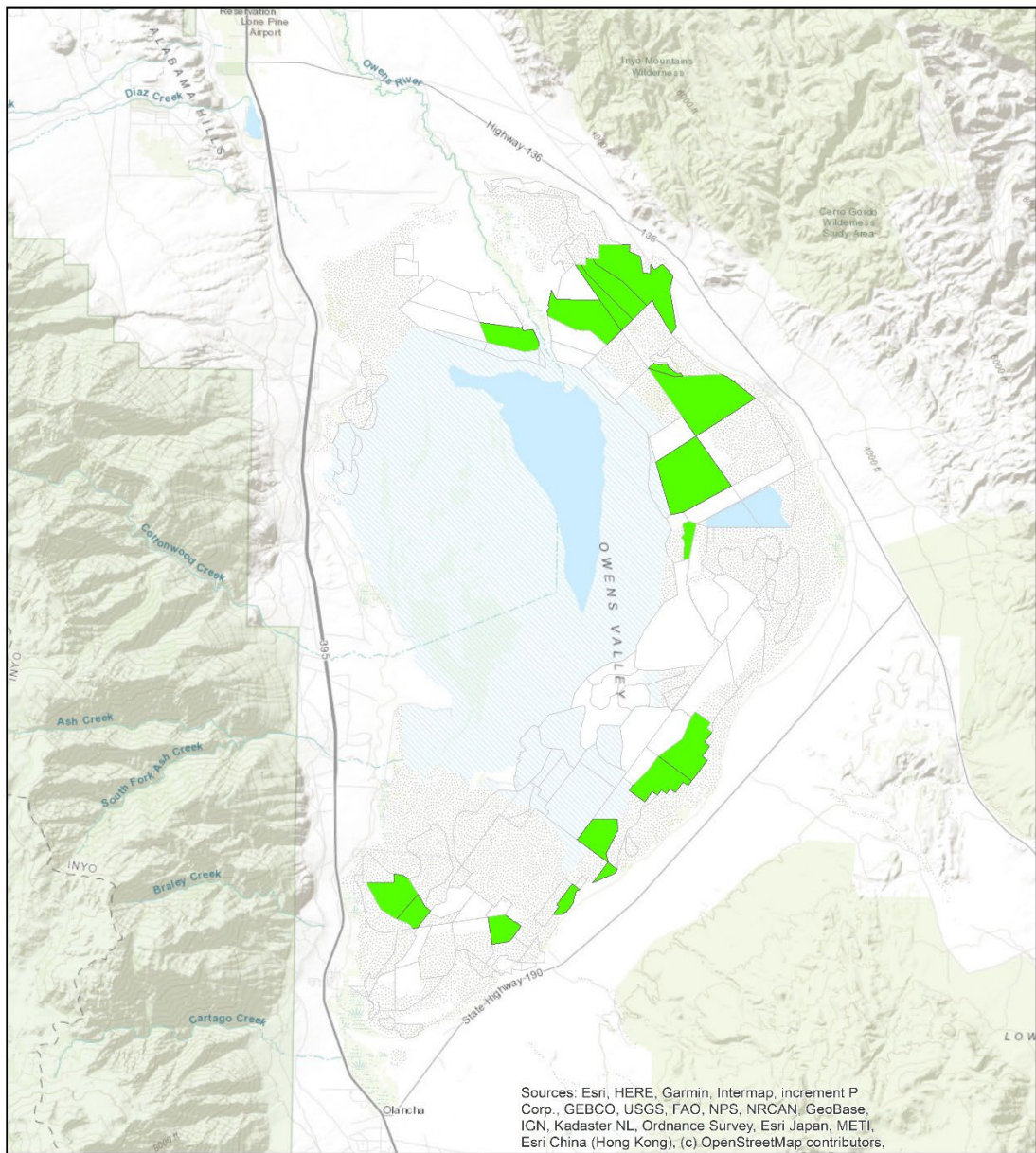


Figure A2. Mono Lake phalarope survey points. White dots are original 1990-1991 phalarope boat survey points, yellow dots are points added in 2017 and 2019, and blue dots are points added in 2020. Numbered dots are boat survey points, named dots are shore survey points. Note that areas in the north and east of the lake that were dry in 1990-1991 were flooded in 2019-2022.

Table A3. Total estimated lake surface areas (km²) 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



**Owens Lake Dust Control Program DCAs
Surveyed for Phalaropes**

☐ No
☒ Yes



0 2.5 5
Miles

Map Prepared by Los Angeles Department of Water and Power

Figure A3. Owens Lake dust control area "cells." Sixteen Dust Control Areas (DCAs) were surveyed by Los Angeles Department of Water and Power and Eastern Sierra Audubon in 2022.

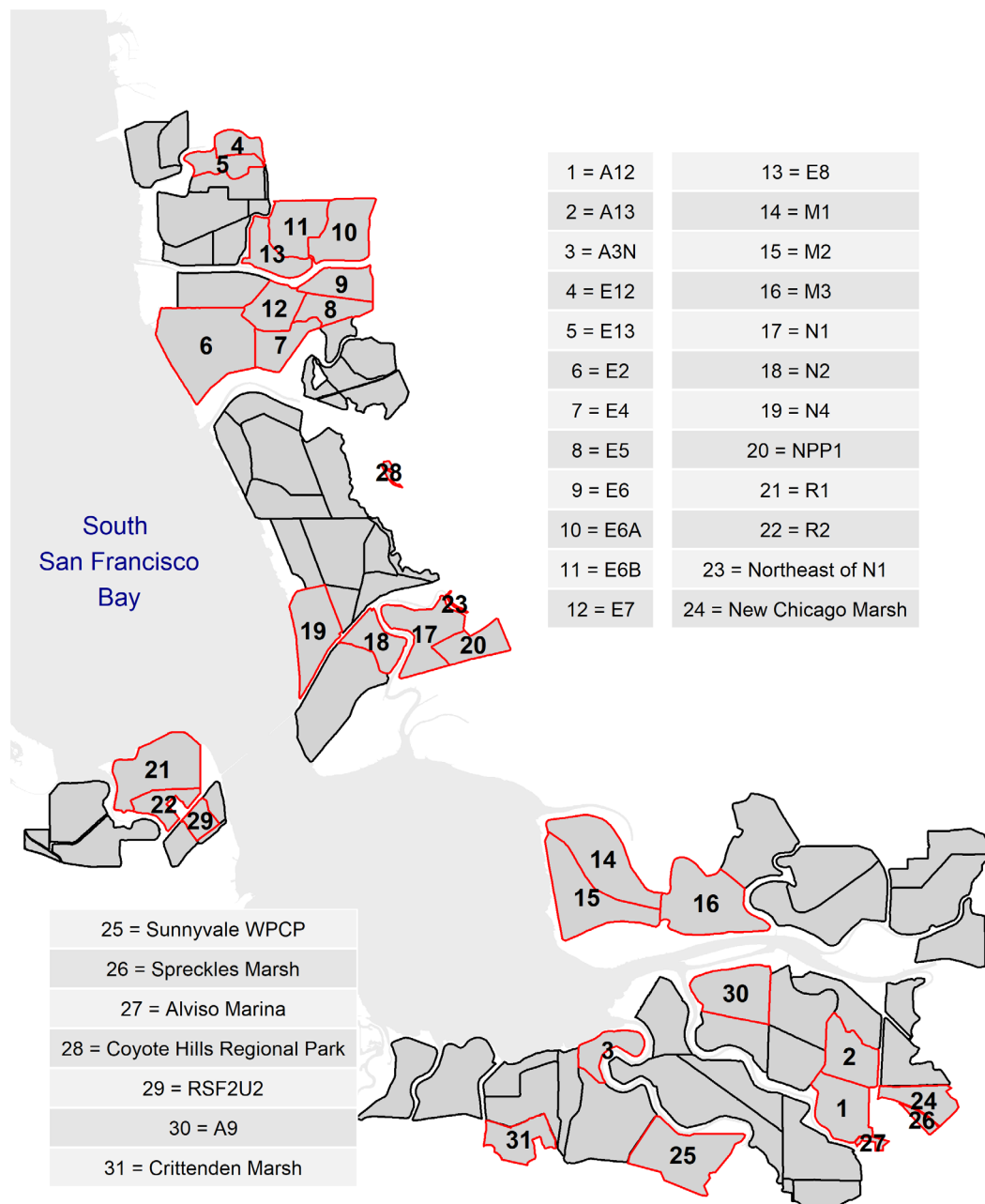


Figure A4. Map of 2022 phalarope survey sites in south San Francisco Bay. San Francisco Bay Bird Observatory used an area search approach to survey for phalaropes at sites outlined in red. Sites 1-22 and 29-30 are former salt production ponds. Other former and current salt production ponds are outlined in black. Sites 23-27 and 31 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.

Appendix 2

Summary of changes made to version 2 of this report:

We updated this report in August 2024 in order to fix errors that had been identified in the original version (version 1). These were:

- Correcting survey window dates in the appendices to reflect the correct 2023 dates (dates in Table 1 were correct in version 1 of the report)
- Totals shown in appendices in version 1 did not all sum correctly from numbers listed for each site, we corrected sums in the tables and references to incorrect sums in the text.
- Corrected data entry errors for several site totals for 2022 in appendices
- Standardized inclusion/exclusion of surveys that fell outside standardized survey windows (surveys that fell outside the survey windows by up to 2

days were included, those that fell outside windows by >2 days were excluded).

- Standardized extent of survey coverage at Chaplin and Owens Lakes so that all years reflect the same coverage
- Changed figures
- Added detailed data summary methods section
- Added Figure 3 showing red-necked/unidentified regional trends
- Revised Fig. 4 and 6 and their captions, to only show only identified species counts, consistent with treatment in the 2019-2023 report.
- Revised paragraphs about high counts at individual sites of each species to focus on birds identified to species, consistent with 2019-2023 report methods
- Addition of detailed appendices showing all results from 2019-2022
- Addition of an appendix showing counts occurring outside of standardized survey windows

With these changes, this report follows consistent data summary/analysis methods to our 2023 report (Carle et al. 2024).