Populations of Wilson's and red-necked phalaropes at Mono Lake: A comparison of contemporary and historical survey methods and results

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Executive Summary

Wilson's and red-necked phalaropes congregate in large numbers at Mono Lake and other saline lakes in western North America during their southward migration. Because of threats to their saline lake habitat, phalaropes have becoming species of increasing conservation concern. To better understand phalarope population trends, we surveyed phalarope populations at Mono Lake from 2019–2025. Here, we report results from these contemporary surveys and compare them with historical results. We also compare methodological differences between contemporary and historical studies measuring phalarope populations at Mono Lake and discuss how methodologies affect interpretation and comparability of results. Historical surveys (Jehl 1986, Jehl 1999, & Strauss et al. 2002) reported results as absolute lake-wide totals, whereas contemporary phalarope surveys used a standardized point-count method covering approximately 20% of the lake surface. The peak single-day counts of Wilson's and red-necked phalaropes recorded during 2019–2025 were 45,143 (in 2021) and 32,657 (in 2023), respectively (totals of birds identified to species, excluding unidentified phalaropes). During 2019–2025, peak annual counts occurred in late June to mid-July for Wilson's phalaropes, and from early August through mid-September for red-necked phalaropes. The average peak count of Wilson's/unidentified phalaropes from 2019–2025 (14,181 [SD 14,297]) was lower than during the 1980s–1990s (39,081 [SD 18,828]). However, for red-necked/unidentified phalaropes, the average peak count was greater from 2019–2025 (15,430 [SD 8,751]), than during 1981–1984 (11,500 [SD 2,517]) or 1989–1993 (12,364 [SD 6,187]). From 2022–2025, we also carried out surveys using an "absolute count" method once a year in late August for the Intermountain West Shorebird Survey (IMWSS). From 2022–2025, the IMWSS's average count of red-necked phalaropes was 19,783 (SD 7,223), with annual totals and trends tracking well with the peak annual counts of the point count surveys from the same years. Because historical "absolute count" surveys theoretically covered more of the lake than contemporary point count surveys, it appears that on average, red-necked phalarope numbers were truly greater in recent years than during the 1980s and early 1990s. Though there were far fewer Wilson's phalaropes recorded in 2019–2025 than in in the 1980s and 1990s, the magnitude of decline is uncertain because of the differences in historical and contemporary survey methodologies and coverage. Based on these results, we speculate that historical and contemporary survey methods may be more comparable for red-necked phalaropes than Wilson's, possibly due to the tendency of Wilson's to concentrate in large flocks close to shore. Red-necked phalaropes, on the other hand, tend to spread out more in smaller groups across the large middle of the lake, areas which may have been under-represented in historical surveys. Simultaneous surveys using both methods, and further analyses, are needed to fully understand how comparable historic and contemporary phalarope survey methods are at Mono Lake.

Introduction

Wilson's and red-necked phalaropes congregate in large numbers at Mono Lake and other saline lakes in western North America during their southward migration (Jehl 1986, 1999). Because of threats to their saline lake habitat, phalaropes have becoming species of increasing conservation concern in recent years (Castellino et al. 2024, Carle et al. 2026). There is a current need to better understand phalarope population trends, as well as to compare current and historic data that may have been collected using different methodologies. As part of coordinated phalarope monitoring across six major North American phalarope staging sites from 2019–2025, we surveyed phalaropes at Mono Lake. Surveys occurred during six coordinated week-long survey windows annually in which all sites were surveyed. Here, we report on results specifically from Mono Lake surveys. See Carle et al. 2024 for the most recent report on regional survey results.

Phalarope Survey Methods

We surveyed Mono Lake from 2019-2025 during standardized week-long survey windows, with six survey windows between late June and mid-September. Survey window dates for 2025 are shown in Table 1. At Mono Lake, 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. Boat counts consisted of two surveyors visiting permanent boat survey points (56 in 2019, 59 in 2020–2023; see Appendix, Fig A1) and simultaneously counting phalaropes in a 400 m radius from the boat, using binoculars. This survey uses point counts that cover approximately 20% of the lake surface, though total percent coverage of the lake surface varied somewhat because of fluctuating lake levels. The survey route circumnavigated the lake, including zig-zag transects through the middle of the eastern half of the lake, and covered all habitat types and water depths, with survey effort proportionally higher in areas expected to have aggregations of phalaropes (i.e., areas with shallowly submerged tufa; Appendix 1, Fig. A1). Additionally, shore surveys were conducted using spotting scopes and binoculars from standardized locations in defined areas (Fig. A1). Professional biologists carried out boat surveys, and trained observers carried out shore surveys. For grand totals of Mono Lake phalarope counts, the boat and shore survey counts were combined (see details in Carle & Rubega 2021 & Carle et al. 2024). The survey protocol was based on that of surveys conducted by Rubega & Keimel (2017) in 1990 and 1991, with modifications. See Carle & Rubega (2021) for detailed descriptions of survey methodology and changes from the 1990s protocol. When comparing our results to those of other studies in this report, we refer to this method in this report as the "point count protocol."

Table 1. Standardized survey window dates in 2025. Each survey window was one week long and each window was separated by eight days.

Survey Window	Survey Window 2025 dates
late June-early July	June 26-July 2
mid-July	July 11-July 17
late July-early August	July 26-August 1
mid-August	August 10-August 16
late August-early September	August 25-August 31
mid-September	September 9-September 15

In results of the contemporary phalarope surveys, we identify annual "high count dates" as the day with the highest count of identified Wilson's or red-necked phalaropes, and report totals of unidentified phalaropes on the same days alongside those totals in the text. For historical comparisons, we report high count dates as the totals of each identified species combined with unidentified phalaropes from the same day. The issue of unidentified phalaropes affecting results tends to be small at Mono Lake, where birds are counted from the boat or shore in relatively close proximity to observers. At other sites where aerial surveys or shore surveys covering large distances are used, such as Great Salt Lake and Lake Abert, unidentified phalaropes can be a bigger issue for interpretation of results (see discussion in Carle et al. 2024). We are currently working on modeling analysis methods to better predict the species identities of unidentified phalaropes at all sites.

Ryan Carle and Nora Livingston surveying for phalaropes during the 2025 season. Photo by Halie Cook.

Methods of other studies of phalarope populations on Mono Lake

In the results and discussion, we refer to methods of and compare results with other studies of phalaropes at Mono Lake (Table 2). Several of these studies followed a protocol developed by Jehl (1986, 1988, 1999), which we hereafter refer to as the "Jehl protocol." This method consists of circumnavigating the lake on a single day from at a distance approximately 400 m offshore, and counting all phalaropes observed within an unconstrained count area. Results of surveys using this method were reported as absolute count estimates of all phalaropes at Mono Lake. Jehl's papers focused on Wilson's phalarope numbers at Mono Lake (1988, 1999) state that the entire lake was surveyed by boat. His paper focused on red-necked phalaropes at Mono Lake (1986), states that to account for the large middle of the lake that is >2km from shore, "routine transects" were carried out across the middle of the lake (Jehl 1986). It is unclear whether Jehl also used mid-lake transects to census Wilson's phalaropes, and if the transects across the middle of the lake used for red-necked phalaropes included extrapolation estimates for unsurveyed areas. Mono Lake is large enough that truly covering the entirety of the lake surface by boat is improbable, so it is possible that Jehl's survey methods omitted some portion of the total lake area. It is also notable that in the 1980s and 1990s, Mono Lake's surface area was smaller than during our 2019–2025 surveys, making it potentially easier to survey more of the total lake surface area.

The Jehl protocol was followed by Strauss et al. (2002), who surveyed one day annually in mid- to late-August from 1989–1993, as part of a survey covering all shorebirds at Mono Lake. Strauss et al. (2002) stated that they used the protocol from Jehl (1999) without further detail, so it is also unclear if they included mid-lake transects or only covered the near-shore areas. For phalarope estimates, only boat-based counts were used, though the shoreline was simultaneously surveyed from shore for other shorebird species (Strauss et al. 2002). Strauss et al. (2002)'s surveys were in mid- to late-August, and were well timed to capture peak annual red-necked phalarope numbers at Mono Lake (usually August–September; Jehl 1986). However, their surveys occurred after the normal peak timing of Wilson's phalaropes (usually mid- to late-July; Jehl 1988). Therefore, we do not include results for Wilson's Phalaropes from Strauss et al. (2002) in our figures or discussion.

We also carried out boat-based phalarope counts as part of the Intermountain West Shorebird Survey (IMWSS), on one day annually at Mono Lake in mid- to late-August from 2022–2025. The IMWSS was designed for comparison with the regional surveys of Shuford et al. (2002), of which those of Strauss et al. (2002) were a Mono Lake-specific sub-set. During the IMWSS, we attempted to replicate Strauss et al. (2002)'s methods using the Jehl protocol, to produce an absolute lake-wide population estimate for phalaropes that could be directly compared to historic surveys. On the IMWSS, we followed a consistent route circumnavigating the lake, mostly following the shoreline but including several large zig zags through the middle of the eastern part of the lake (Appendix 1, Fig. A2). The boat route roughly followed the same route as used in our phalarope surveys using the point count protocol (Appendix 1, Figs. A1, A2). Surveyors counted using a transect method, with each surveyor covering a 180° sweep on one side of the boat and continuously counting birds with no constraint on count distance. If large groups of phalaropes

occurred, the boat stopped for focused counts. In some areas with high densities of birds and few landmarks, observers counted in 400 m radii from the boat at stops, and GPS waypoints were used to measure distances between count stops, and to attempt to prevent double counting. We did not include any extrapolations. Simultaneously, teams of surveyors walked the entire shoreline and counted shorebirds. Shore observers were instructed to only count to 300m distance from shore, and the boat surveyors did not count birds within 300 m from shore. For a grand total, we summed the boat and shore counts.

We also reference Winkler (1977), who carried out a shoreline survey covered by foot or canoe, and also did a canoe-based boat survey around the islands, but did not attempt to cover the large interior of the lake.

Table 2. Studies quantifying phalarope numbers at Mono Lake and the methods they used.

Jehl protocol	**Point Count protocol**	**Winkler protocol**
Jehl 1986, 1988, 1999	Contemporary phalarope surveys	Winkler 1977
Strauss et al. 2002	Rubega & Keimel 2017	
Contemporary IMWSS		

Results

In 2025, the high count of Wilson's phalaropes on Mono Lake surveys was 8,722 on June 29th (Fig. 1, darkest blue line; zero unidentified phalaropes on the same day). Wilson's phalarope numbers were fairly consistent from late June to mid-August, with survey window high counts of at least 6,000 Wilson's phalaropes. The second highest count of the year was on August 1st, of 8,332 Wilson's phalaropes (2,676 unidentified phalaropes on the same day; Fig. 1). The 2025 peak for Wilson's Phalaropes was higher than during 2024 (peak of 6,817, zero phalaropes on same day; Fig. 1), though the peak timing was similar. The 2021 peak count (45,143) was higher than that of any other year by >30,000 birds (Fig. 1). All annual peak counts occurred in either the late June-early July window or the mid-July window, and in all years numbers began to decline in the mid-August survey window and dropped to zero or nearly zero by mid-September (Fig. 1)

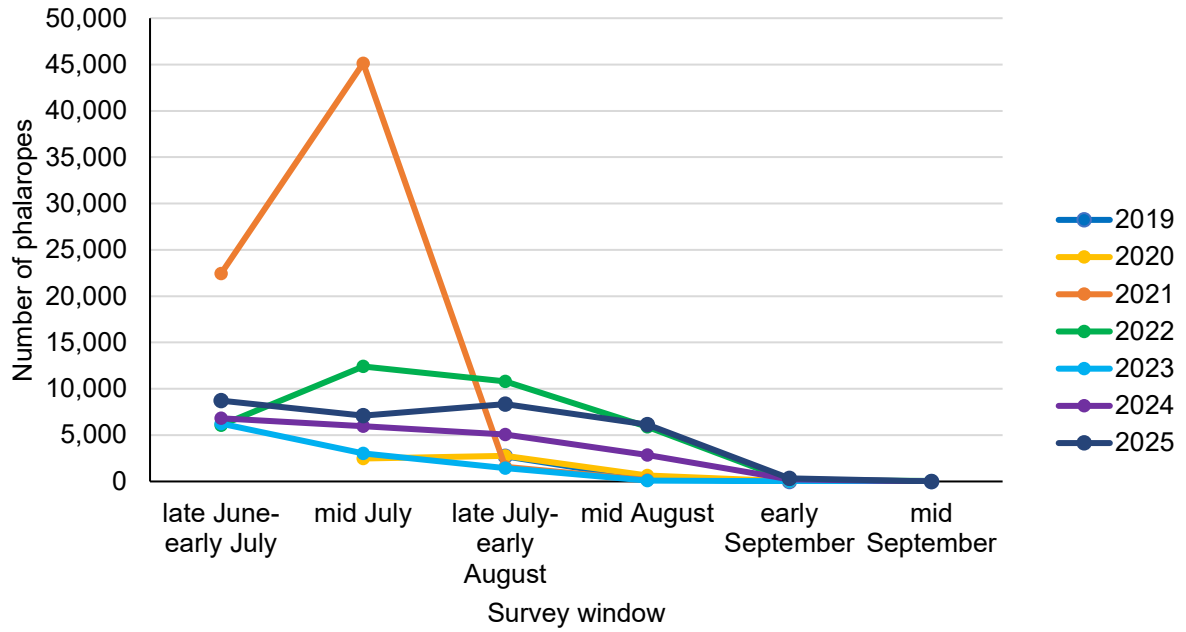


Fig. 1. Wilson's phalarope high counts at Mono Lake during each survey window, 2019–2025. Only birds identified as Wilson's phalaropes are shown.

The average peak count of Wilson's/unidentified phalaropes on our surveys from 2019–2025 (14,181 [SD 14,297]) was lower than during the 1980s–1990s (39,081 [SD 18,828], 18 years, Jehl 1999; Fig. 2). However, our survey methods differed substantially from those of Jehl (1999) (see methods section of this report), so these results cannot be considered a direct comparison. Nevertheless, our survey follows a similar route to that used by Jehl (1999), and though we only counted phalaropes at point count stations, we did get a general sense of the total magnitude of phalarope flocks on the lake. Qualitatively, we do not believe that the point count method regularly missed tens of thousands of birds, and we do believe it is likely that Wilson's phalarope numbers have declined substantially at Mono Lake since the 1980s. We are working to develop quantitative methods to extrapolate absolute estimates from our surveys for better direct comparison with Jehl's results in the future.

Rubega & Keimel's (2017) surveys from 1991 and 2017 provide a more direct comparison to the contemporary point count surveys, though methods still differed somewhat from ours. Rubega & Keimel (2017) used the same point count boat survey transect as us, but had fewer points because the lake was smaller during their surveys (see Appendix, Fig. A1). They also constrained their count area, but were unable to accurately calibrate measurements of the exact radius of their counts around the boat, whereas we use a 400 m radius. They registered peak counts of 35,225 Wilson's/unidentified phalaropes in 1991 and 15,264 in 2017 (Rubega & Keimel 2017; Fig. 2). Compared with the 1991 survey, our contemporary point count survey results have only been of comparable magnitude in 2023, when we registered 45,143 Wilson's/unidentified phalaropes (Fig. 2). Otherwise, our highest contemporary annual peak count of Wilson's/unidentified phalaropes was 15,529 in 2019 (Fig. 2). Notably, Rubega and

Keimel's 1991 survey totals, using the point count method, exceeded Jehl's totals, using the absolute count method, that year (Fig. 2).

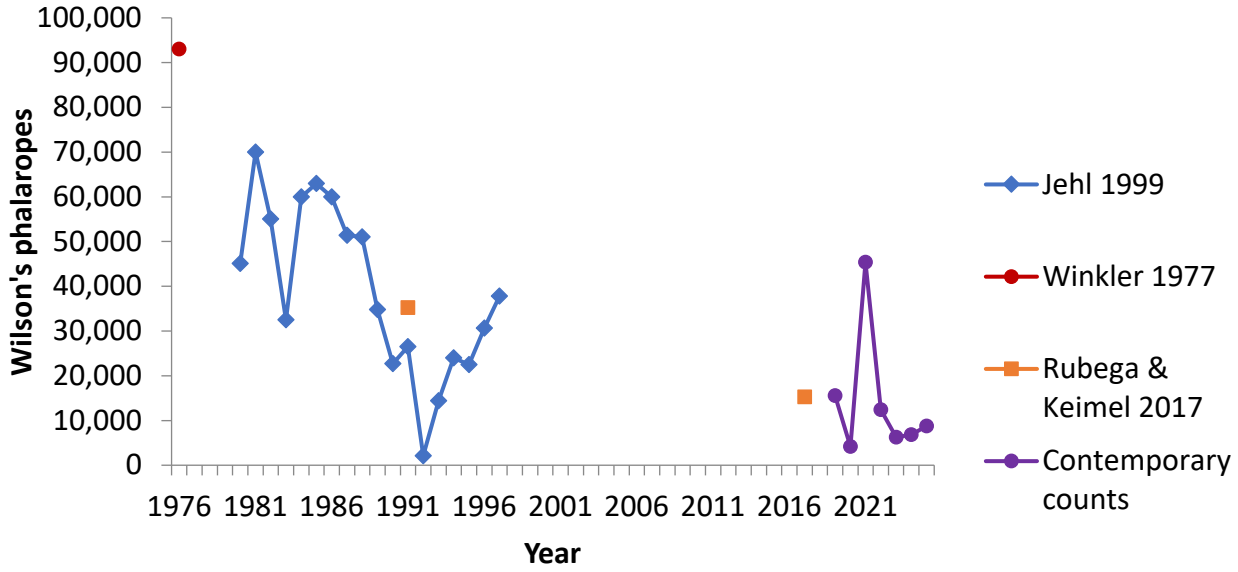


Fig. 2. Peak single-day annual counts of Wilson's/unidentified phalaropes at Mono Lake from different studies 1976-2025. Note that each study had differing methods and coverage, with Jehl's surveys attempting to estimate an absolute count on Mono Lake, and contemporary surveys using point counts covering approximately 20% of the lake surface, with proportionally more coverage of areas expected to have phalaropes.

The 2025 high count of red-necked phalaropes at Mono Lake was 18,891 on August 1st (same day unidentified count was 2,676; Fig. 3). This was the second-highest annual peak count at Mono Lake for red-necked phalaropes during our seven-year time-series (Fig. 3). The red-necked phalarope peak count in 2025 exceeded the average maximum count from 2019–2025 of 15,430 (SD 8,751). Unidentified phalaropes usually do not greatly affect the interpretation of red-necked phalarope high counts at Mono Lake, with unidentified phalarope counts of <500 birds on all annual peak count days except in 2025. Red-necked phalarope counts peaked at Mono Lake in August or September in all years (Fig. 3). The high count in 2025 occurred in the late July-early August window (August 1), and was the earliest annual peak count we recorded at Mono Lake from 2019–2025 (Fig. 3). It was also unusual that after the peak, numbers consistently declined throughout the rest of the season rather than the more typical pattern of plateauing through mid-September (Fig. 3).

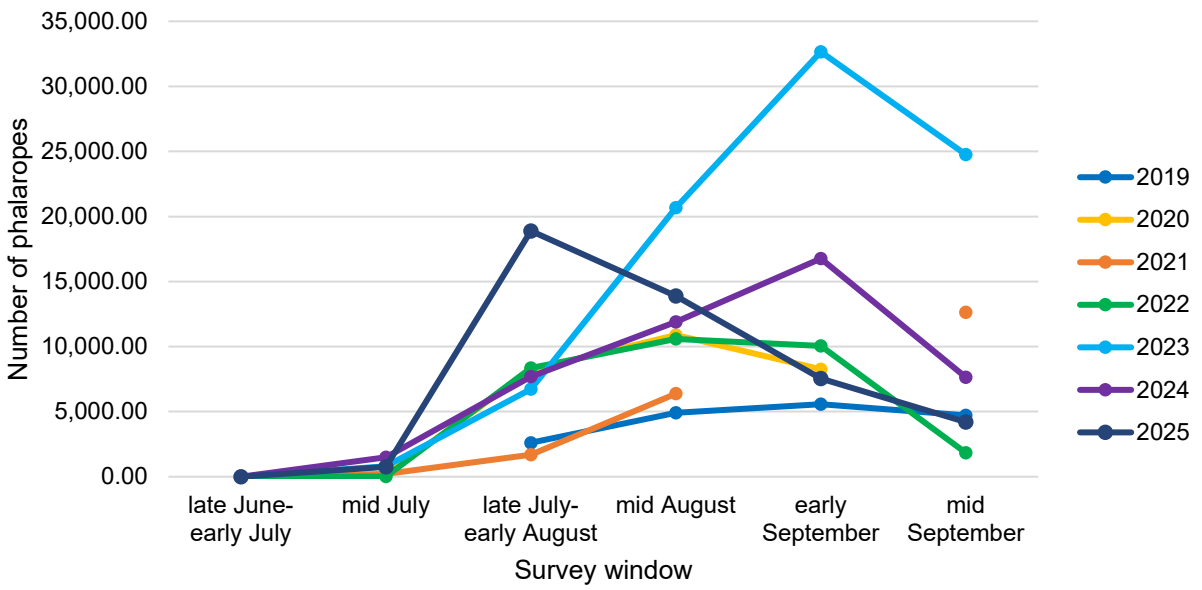


Fig. 3. Red-necked phalarope high counts at Mono Lake during each survey window, 2019-2025. Only birds identified as red-necked phalaropes are shown.

Compared with historical data, our average annual peak count of red-necked phalaropes from 2019–2025 (15,430 [SD 8,751], 6 years) was higher than that the average peak count from surveys using the Jehl method in 1981–1984 (11,500 [SD 2,517], 4 years; Jehl 1986; Fig. 4). The 2019–2025 average was also higher than the 1989–1993 average of Strauss et al. (2002; 12,364 [SD 6,187]; Fig. 4). Interestingly, red-necked phalarope high count averages from 2019–2022 (9,925 [SD 3,039]) were similar to Jehl's averages from 1981–1984 and Strauss' from 1989–1993, but the 2023–2025 average was much higher (range 16,766–32,657, average 22,771 [SD 8,626]; Fig. 4). This result indicating higher red-necked phalarope numbers from 2023–2025 was further corroborated by our data from the 1-day a year IMWSS survey following the Jehl protocol. From 2022–2025, the IMWSS's average count of red-necked phalaropes was 19,783 (SD 7,223), with annual totals and trends tracking well with the peak annual counts of the point count surveys (Fig. 4). Indeed, for paired years with both the point count phalarope surveys and the IMWSS (2022-2025), the peak count results of the phalarope surveys were tightly correlated with the IMWSS results (Fig. 5), with an 11% (SD 5%) average difference in absolute values. It is noteworthy, however, that the peak point-count totals did not always occur in the same week as the IMWSS.

Based on the consistency of results between the phalarope surveys and the IMWSS surveys, red-necked phalarope numbers were higher at Mono Lake from 2023–2025 compared to 1981–1984, 1989–1993, and 2019–2022 (Fig. 4). This was especially driven by 2023, which had the highest single-day record for red-necked phalaropes at Mono Lake with 32,657 (point count surveys, Fig. 4). Regionally, there was not a corresponding increase in red-necked phalarope numbers across the six surveyed western North American staging sites in 2023–2025, though there was a slight increase in across all surveyed sites combined in 2024 compared to all recently surveyed years except 2019 (Carle et al. 2024 & partners' unpublished data). Owens Lake also saw a

significant increase in red-necked phalaropes in 2023, though not in 2024 and 2025 (Carle et al. 2024 & partners' unpublished data).

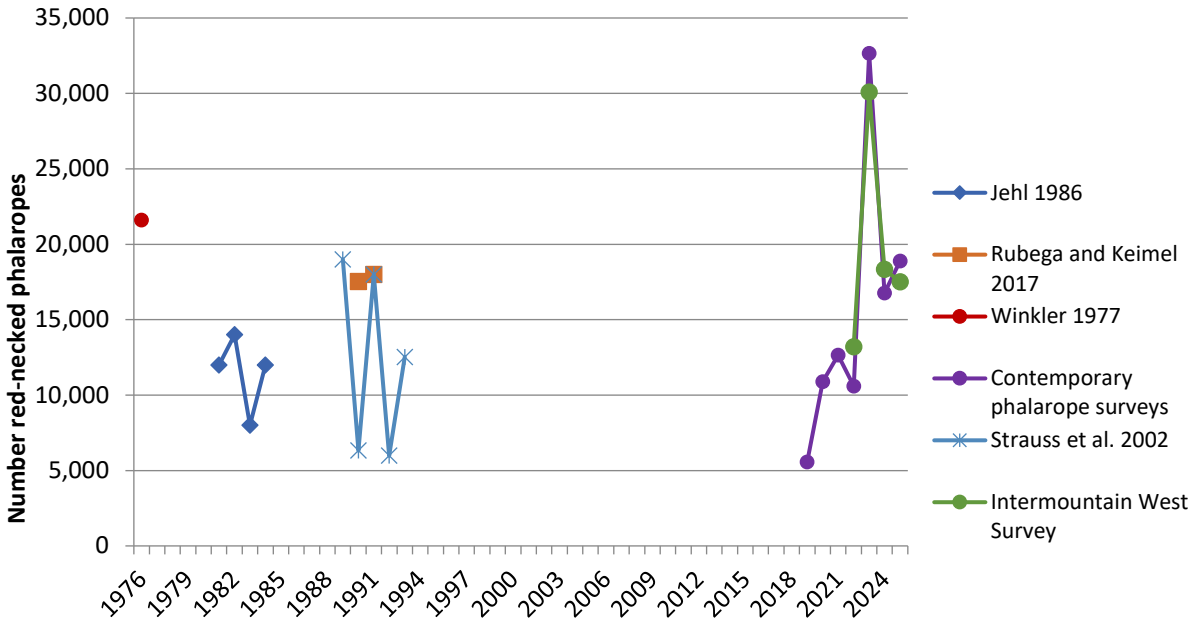


Fig. 4. Peak single-day annual counts of red-necked/unidentified phalaropes at Mono Lake from different studies 1976-2025. Note that each study had differing methods and coverage, with Jehl's surveys attempting to estimate an absolute count on Mono Lake. Contemporary phalarope surveys using point counts covering approximately 20% of the lake surface, with emphasis of coverage on areas expected to have phalaropes. Intermountain West Survey used similar methods to Jehl 1986 and Strauss et al. 2002, attempting to quantify an absolute number of birds on the lake.

The factors regulating red-necked phalarope annual population fluctuations at saline lake staging sites are not understood, and could be influenced by carry-over effects from previous years' conditions at saline lake staging sites (Murray et al. 2002, Mu et al. 2002), annual breeding success in the arctic (Walpole et al. 2008), individual choice of migration pathways (e.g., saline lake vs. ocean routes; Taylor et al. 2007), and/or oceanographic conditions on the non-breeding grounds in the Pacific Ocean in the southern hemisphere (Warnock et al. 2002, Nisbet & Viet 2015, Hunnewell et al. 2016). A good example of the conundrum of understanding red-necked phalarope population trends occurred at what was historically their most important staging site in eastern North America, at the Bay of Fundy, Canada. At that site, there was a >99% decline in red-necked phalarope abundance during fall migration from 1982–1989 (Brown et al. 2010, Nisbet & Viet 2015, Hunnewell et al. 2016). The cause of this episode is still debated, but leading hypotheses are that El Niño impacts to the marine environment in the species' non-breeding range in the southern hemisphere resulted in the population decline, and/or that local conditions around the Bay of Fundy caused birds to redistribute during staging (Brown et al. 2010, Nisbet & Viet 2015, Hunnewell et al. 2016). Saline lake staging sites offer perhaps the best opportunity to track population changes in this species in western North America, because it is

when the birds are most concentrated and accessible; however, there is still much to learn in terms of understanding the "why" behind the numbers we observe year to year at Mono Lake and other staging sites.

Comparisons of results of point count and Jehl protocol methods

It is notable that contemporary annual peak numbers of red-necked phalaropes using the point count method averaged higher than Jehl (1986)'s and Strauss et al. (2002)'s, and in some cases far exceeded their totals (Jehl's maximum was 14,000 in 1982, ours was 32,657 in 2023). Barring an extreme increase in numbers, the point count surveys should theoretically be lower than those of Jehl (1986, 1999) and Strauss et al. (2002), who attempted to estimate absolute lake-wide abundances. The convergence of results between contemporary point count surveys' peak red-necked phalarope numbers and IMWSS numbers suggests that at least for red-necked phalaropes, the point count and Jehl protocol methods produced comparable results for evaluating season-high peak counts. This further supports the hypothesis that comparisons between contemporary point-count and historic absolute count totals for red-necked phalaropes at Mono Lake may result in valid assessment of trends.

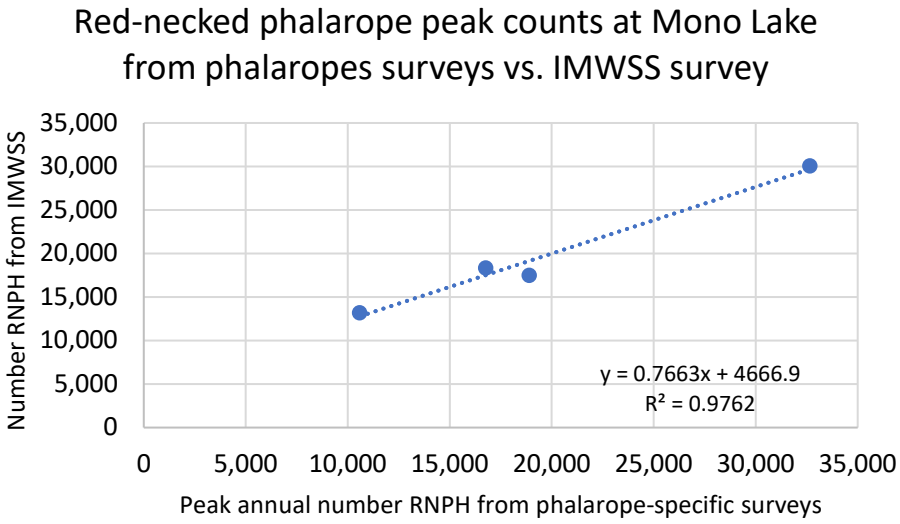


Fig. 5. Scatterplot of Red-necked phalarope peak counts at Mono Lake from phalarope point-count surveys (x-axis) vs. IMWSS survey (y-axis). Trend line and equation shown is from a linear regression analysis performed using Excel.

Wilson's phalaropes present a different scenario, with contemporary point-count survey data showing much lower numbers than historic surveys using the Jehl protocol (Fig. 2). Unfortunately, the IMWSS is timed after the departure of most Wilson's phalaropes from Mono Lake, so we could not compare the peak totals from contemporary point count and IMWSS surveys for Wilson's phalaropes. We speculate that the Jehl protocol might work better for capturing the lake-wide abundances of Wilson's phalaropes than red-necked phalaropes, because Wilson's phalaropes often concentrate in dense flocks in just a few nearshore locations on the

lake (Jehl 1988). The unconstrained count area of the Jehl method might be more flexible for locating and counting these large aggregations of Wilson's phalaropes than the point count method, which could miss large groups of phalaropes if they do not fall in the standardized point count areas. On the other hand, red-necked phalaropes tend to spread out in more diffuse flocks across greater areas of the lake surface, and to congregate less in near-shore areas, making it harder to count absolute lake-wide numbers. Thus, perhaps Jehl's method of circumnavigating the lake just offshore with limited transects in offshore areas could result in relatively lower detection rates of red-necked phalaropes than Wilson's. For these reasons, the point count and absolute count methods may be more comparable for red-necked phalaropes than for Wilson's phalaropes at Mono Lake. The point count method theoretically covers a smaller part of the lake than the Jehl protocol, but might cover offshore areas better. This idea is also supported by the fact that Rubega and Keimel (2017) used the point count method in 1990 and 1991 and registered higher or similar totals of red-necked phalaropes to Strauss et al. 2002, who used the Jehl protocol.

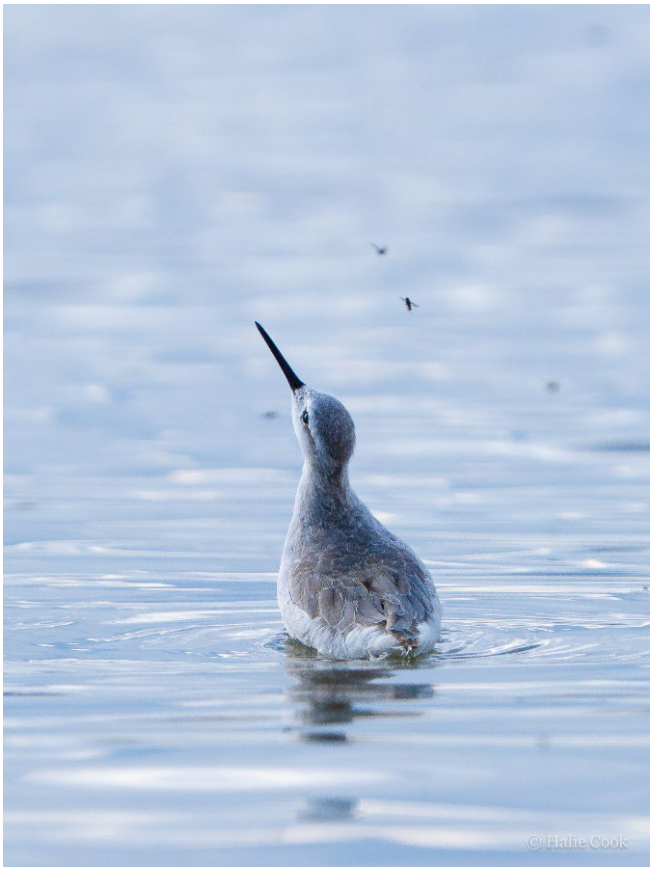
Red-necked phalaropes at Mono Lake. Photo by Ryan Carle.

These differences between survey protocols are important to explore and understand for interpretation of phalarope survey results and population trends at Mono Lake. Much uncertainty remains in terms of comparing survey methods, and carrying out simultaneous surveys using both methods would be the best way to better understand the differences. It is noteworthy that even if the Jehl protocol might be better at capturing the maximum number of birds at Mono Lake than the point count method, that it does not mean it is "better" for phalarope surveys. The point count and Jehl protocols have differing goals, with the former attempting to quantify an estimate of density within a standardized and repeatable survey area, and the former attempting to produce absolute estimates of the number of birds on the lake. Both methods have obvious benefits and drawbacks, but for contemporary surveys replicability and repeatability of surveys was a key priority. Repeatable density estimates are as valuable as absolute estimates, can be easily repeated in the future, and likely more precisely measure what they set out to measure.

Regional results across six surveyed North American staging sites

Phalaropes are highly mobile species, and population trends at Mono Lake are best interpreted in the context of regional trends. Because of this, we coordinate our surveys' timing with five other major phalarope staging sites in western North America: Great Salt Lake (Utah), Lake Abert (Oregon), Owens Lake (California), San Francisco Bay salt ponds (California), and Chaplin Lake (Saskatchewan, Canada). Detailed regional results from 2019–2023 are reported in Carle et

al. 2024. Briefly, numbers of both Wilson's and red-necked phalaropes at Mono Lake tend to be far lower than those at Great Salt Lake, which typically has peak counts of hundreds of thousands of each species (Carle et al. 2024). Of the six sites surveyed, Lake Abert and Mono Lake usually have the second highest annual numbers after Great Salt Lake, often in the tens of thousands and sometimes nearing or exceeding 100,000 at Lake Abert (Carle et al. 2024). Owens Lake, San Francisco Bay, and Chaplin Lake typically have numbers in the thousands but only rarely exceed annual totals of 10,000 birds of either species (Carle et al. 2024). There is a high level of annual variability in regional phalarope numbers, such that accurate trend analysis requires many years of data. However, we have not seen clear trends in either direction for regional phalarope numbers of either species from 2019–2025 (Carle et al. 2024). We are working on quantitative analysis of regional and site-specific trends that we plan to publish in 2026.



Wilson's Phalarope chasing flies at Mono Lake during 2025. Photo by Halie Cook.

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Appendix 1

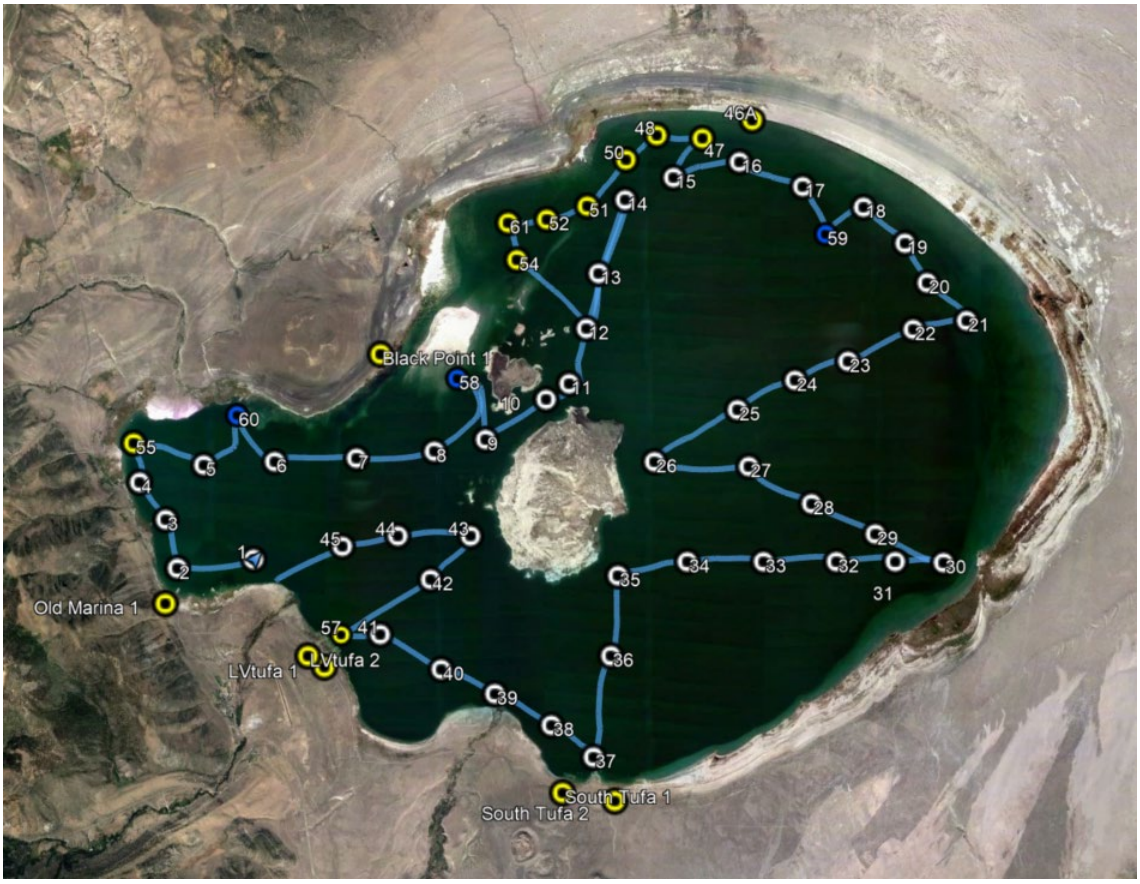

Figure A1. Mono Lake phalarope survey points. White dots are original 1990-1991 phalarope boat survey points used by Rubega & Keimel (2017), yellow dots are points added since surveys were re-initiated in 2017. Blue lines connecting dots show the typical route of the boat survey between points—counts are only made at points. Numbered dots are boat survey points, named dots are shore survey points. New points added since 2017 were in areas likely to be used by phalaropes that were dry when the survey was originally designed in the 1990s.

Figure A2. Mono Lake Intermountain West Shorebird Survey route. This route was based on the methods from Strauss et al. (2002). White dotes indicate the transect line of the boat survey, with yellow markers indicating places where the boat stopped for point-based counts and used distances measured with GPS to avoid double-counting birds. The entire shoreline was also surveyed by shore-based teams that counted out to 300m. The boat survey did not count within 300 m of shore, except in sections not covered by shore-based observers. Shore and boat counts were combined for the final totals.