

Phalarope Surveys at Mono Lake 2019 Report



By Ryan Carle¹ & Margaret Rubega²

¹Oikonos - Ecosystem Knowledge, ryan@oikonos.org

²University of Connecticut, margaret.rubega@uconn.edu

Wilson's phalaropes (*Phalaropus tricolor*) and red-necked phalaropes (*P. lobatus*) are banner species of saline lakes in the interior west of North America, where they stop in flocks of hundreds of thousands. Little conservation attention has been paid to phalaropes, but the fact that neither species is listed as "threatened" or "endangered" may be due primarily to lack of information about their populations and trends. This 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, there is an urgent need to better understand the population trends of phalaropes. Indeed, the National Audubon Society considers Wilson's phalaropes "climate endangered" (Langham et al. 2015) and red-necked phalaropes "highly vulnerable" (Wilsey et al. 2019) to climate change based on modeled loss of wetland habitats predicted with climate change.

Phalaropes breed in the northern latitudes of North America. During southward migration, Wilson's and red-necked phalaropes stage at just a few hyper-saline lakes in North America (Jehl 1986, 1988). Both species spend boreal winter in the southern hemisphere—Wilson's phalaropes in hyper-saline interior wetlands in South America, and red-necked phalaropes on the ocean. Hyper-saline lakes in the Great Basin desert of the western U.S. are vitally important to the world populations of both species, serving as unique gas stations on their trans-hemispheric migrations (Jehl 1986, 1988). Historically, Great Salt Lake, Utah, Mono Lake,

California, and Lake Abert, Oregon, have hosted large concentrations of phalaropes (Jehl 1986, 1999). Because of the unique concentration of phalaropes at these sites during a short time frame in late summer/early fall, simultaneous censuses of these Great Basin lakes potentially gives a useful index for addressing world population trends, especially for Wilson's phalaropes (Jehl 1999). However, 1997 was the last year for which phalarope data exist from Great Salt Lake, Mono Lake, and Lake Abert together. At Mono Lake, Jehl (1999) conducted annual phalarope surveys from 1980-1997 and Rubega and Keimel conducted surveys in 1990, 1991, and a partial survey in 2017. Thus, with the exception of the 2017 survey, there is a thirty-year data gap in our understanding of phalarope numbers, timing, and habitat use of Mono Lake. The lack of information about the number of phalaropes currently using the lake is a major gap in our understanding of the lake's current health and the evaluation of the success of the mandated restoration of the Mono Lake ecosystem.

During 2019, we partnered with California State Parks to census phalaropes at Mono Lake. Phalaropes present a difficult monitoring problem because they are not tied to consistent locations where they can be counted, and are often located far out on the water and not viewable from shore. The phenology of each species' use differs, with Wilson's phalaropes historically peaking in numbers at Mono Lake in late July (Jehl 1988), and red-necked phalaropes peaking in late August through September (Jehl 1986). Evidence from molt and mass gain patterns (Jehl 1988) suggests that individual Wilson's phalaropes spend about a month at the lake before migrating en masse over a short time period. Thus, peak counts likely represent an index of Wilson's phalarope annual total numbers. In contrast, red-necked phalaropes do not exhibit mass gain that might indicate residence time at Great Basin lakes. Without individual turnover rates for red-necked phalaropes, it is impossible to know whether a peak count, or the sum of many serial counts, provides a meaningful estimate of the total number of red-necked phalaropes at Great Basin lakes.

We based our 2019 census protocol on a study design created by Margaret Rubega and Bridget Keimel during boat surveys in 1990 and 1991, which they partially repeated in 2017. We also coordinated with partners at Great Salt Lake and Lake Abert to census phalaropes at similar times in 2019. In this report we present results from the 2019 Mono Lake surveys.

Methods:

Mono Lake surveys: Our 2019 protocol followed the methods of Rubega and Keimel (2017), with adaptive modifications. The base protocol calls for surveying phalaropes by boat by traveling to defined count station points (Fig. 1), where two observers count phalaropes in a 360° span within a fixed-distance radius. Any single station set of counts that differs by more than 10% is repeated. Flocks of <100 birds are counted and reported by the individual. Flocks >100 birds are counted in 10s, 100s, or 1000s and reported in corresponding round numbers. Count times are held to under 5 minutes to minimize recounting birds. During 1990 and 1991 there were 45 count stations and observers counted in a 75 m radius from the boat (for a total count area at each point of 17,671 m²). The lake had risen by 2017, so eight additional stations (for a total of 53) were added that year in an area in the north/northeast of the lake that had previously been dry land (Fig. 1, red circles). Original 1990s points were located at least 1 km from each other; 2017 points were located 0.4-1.0 km from each other.

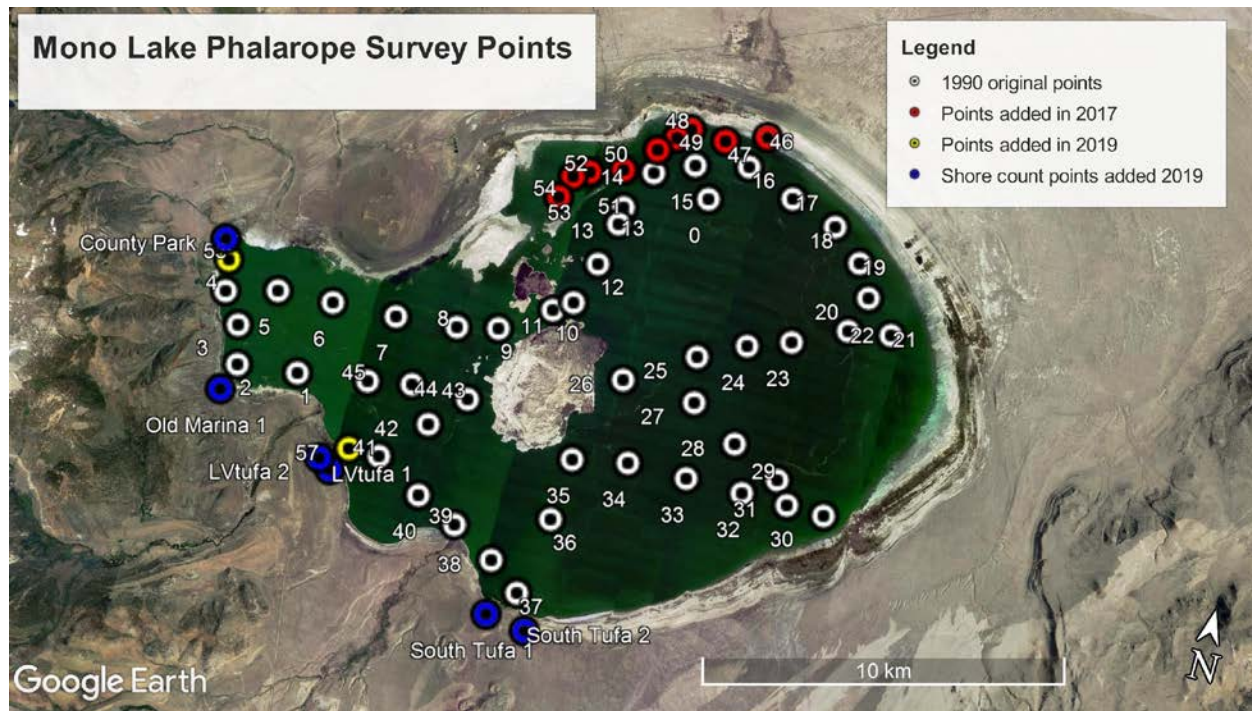


Figure 1. Standardized count stations for Mono Lake 2019 phalarope surveys. Numbered points are boat stations (original 1990s points with white circles, points added in 2017 with red circles, and points added in 2019 with yellow circles). Named points (blue circles) are shore count stations added in 2019.

During 2019, we conducted nine full-lake censuses from July 11 through September 17, conducting two surveys on back-to-back days roughly every two weeks (with the exception of the mid-September survey on a single day). We alternated survey directions, starting either at point 1 and ending at point 45, or vice versa. Throughout the summer, four observers participated in surveys: Ryan Carle, Ashli Lewis, Sarah Hecocks, and Kristie Nelson. We attempted to use the protocol from the 1990, 1991, and 2017 surveys, but quickly realized that modifications needed to be made to accurately record the numbers of phalaropes present at Mono Lake under contemporary conditions. For example, the lake level elevation was at 6,375 ft. in 1990 and 1991; in 2019 the lake level elevation was 6,381 ft. (Mono Lake Committee, unpublished data). This six vertical foot rise in lake level meant that points close to shore in 1990 were much farther offshore during 2019. To account for this, we added two new boat points at nearshore tufa groves at Lee Vining Tufa and County Park during 2019 (making the whole survey 55 points; Fig. 1, yellow circles). It was also apparent that with a 75 m count radius, we would register only a small fraction of birds present on the lake. We therefore experimented with count radii and on July 11, 12, and August 1 surveys, we recorded phalaropes in an unconstrained count radius, defined as being as far as we could enumerate. It became evident on August 1 that the unconstrained count radius would result in double-counting at points separated by only 400-600 m in the north/northeast of the lake, where most birds were concentrated (see ***Impact of different count radius on count totals*** section in results). We eventually picked a standardized radius of 400 m (for a total count area at each point of 503,000 m²) which we used for counts from August 2 onward. During all surveys, one observer conducted a 75 m radius count immediately after the 400 m radius count, to compare with the 1990s surveys. We worked to standardize distance

estimation among observers by using a range finder to target tufa outcrops from the boat at the start of surveys, and by regular communication between observers as conditions and locations changed. Range finders could not be used at most count stations, because appropriate objects big enough to target with the range finder were absent, but use of the range finder at the start of surveys helped observers visualize the apparent size of nearby birds at a known distance, as an aid to estimating distance consistently thereafter.

We also added a shore count from select locations, which we conducted weekly, as well as on the same days as boat counts. The shore count was added because boat counts were not picking up the true magnitude of major nearshore flocks of phalaropes, especially at tufa groves. In these areas, the boat counts did not reliably register all the phalaropes present because boat counts were taken from a fixed radius and were relatively far offshore, phalaropes were blocked from view by tufa groves, and the boat could not enter into extremely nearshore areas where birds were sometimes located, due to submerged rocks and osprey nest disturbance. Shore counts were conducted at South Tufa, Lee Vining Tufa, Old Marina, and County Park because these areas have tufa groves blocking boat views, and easy vehicular access and clear views from shore. We created a standardized shore count protocol that was used in all surveys starting on July 26. On dates prior to July 26, South Tufa and Lee Vining Tufa were counted without explicitly defined count boundaries, but from the same locations that were formalized in the protocol and used in later counts. Old Marina and County Park counts began on July 26, with the exception of one County Park count on July 11. The shore count protocol consisted of one observer counting with a spotting scope at standardized GPS points at shore locations. At each shore count point, count area and distance were standardized using fixed landmarks and maps (Appendix 2, Figs A2.1, 2.2). We estimated the total lake area surveyed at each shore point by measuring the areas of polygons of count coverage created Google Earth Pro based on photographs from the sites with count boundaries marked on them (Table 1, see detailed methods in Appendix 2). Lake area covered by each shore count varied by site (Table 1) and was based on the specific topographies and views afforded by each site. The estimated count area for each shore count location was less than the 0.5 km² area of each boat point. Shore count and boat count areas overlapped at each area to various degrees, with the most overlap at Old Marina and County Park and the least at South Tufa (Appendix 2). Shore counts were conducted by either Ryan Carle, volunteers David Carle and Janet Carle, or Krista Fanucci of the Mono Lake Committee.

To quantify the total number of phalaropes observed per species on each survey, we totaled each observer's counts from all boat points and combined them with shore counts. For areas where shore count and boat count points overlapped we used both counts in our overall daily lake sum, but adjusted relevant boat count totals by subtracting the percentage of overlap area between the boat count point and the shore count (see Appendix 2 for detailed methods). This method was used for four boat points that overlapped with shore counts, at South Tufa (boat point 37), Lee Vining Tufa (boat point 57), Old Marina (boat point 2), and County Park (boat point 55; Fig. 1). Finally, we averaged the whole-lake totals of each of observer to obtain a single total lake count for each date. We used this method only on counts in which the 400 m radius boat count was used (August 2 onward), as it was impossible to quantify the count area and overlap with shore counts of boat surveys in which we used an unconstrained count radius. On September 17, no shore count was conducted so we report only boat count totals.

Table 1. Total estimated lake surface areas (km²) of count phalarope count stations at Mono Lake during 2019. See Appendix 2 for maps of shore count areas.

Phalarope Count Station	Total Count Area (km ²)
Boat point – 400 m radius	0.50
County Park shore count	0.20
Lee Vining Tufa shore count point 1	0.13
Lee Vining Tufa shore count point 2	0.16
Old Marina shore count	0.47
South Tufa shore count point 1	0.22
South Tufa shore count point 2	0.25

For surveys with an unconstrained boat count radius (July 11, 12, and August 1), we produced whole-lake totals by simply adding the totals of the boat and shore counts together for each observer and averaged the two observer's results. This method likely resulted in an unknown degree of double counted birds at overlapping shore and boat count locations on those dates, but it was impossible to estimate the degree of count overlap without a fixed boat count radius. We present these data in Figure 2 with the caveat that the July 11, 12, and August 1 surveys used different methods and are likely an overestimate.

The survey method we used results in an index of how many birds were present at the points counted, in the count radius, rather than a full estimate of the entire lake. Nevertheless, much of the lake was traversed on survey days, giving observers a sense of the total magnitude of birds at the lake and what proportion of birds were recorded on survey points. The repeated surveys also yielded directly comparable within-year counts (once the count radius was standardized) useful for assessing relative numbers of birds using the lake on different dates, and spatial habitat use on the lake.

Results:

Maximum numbers of phalaropes: For counts using the 400 m radius and a combined sum of boat and shore count numbers, the season maximum Wilson's phalarope count on Mono Lake during 2019 was $2,712 \pm 75$ SD birds on August 2, the maximum red-necked phalarope count was $5,573 \pm 177$ SD birds on September 2, and the maximum unidentified phalarope count was $12,817 \pm 3,197$ on August 2 (Fig. 2). The maximum single-day total number of all phalaropes observed on a boat/shore survey using the 400 m count radius was $17,526 \pm 1,113$ SD on August 2.

It is noteworthy that on August 2, the shore count total of unidentified birds was 8,500, all at South Tufa. There is substantial evidence that these 8,500 birds were primarily Wilson's phalaropes, particularly because two days earlier, on July 31, 9,120 birds were counted at South Tufa and identified by Ryan Carle as Wilson's phalaropes (Fig. 3). Likewise, the flock of birds present at South Tufa throughout late July and early August was identified as primarily Wilson's phalaropes by Ryan on shore counts on July 13 (3,300 birds) and July 26 (9,400 birds; Fig. 3), and boat counts consistently identified the flock at South Tufa to be composed only of Wilson's phalaropes. The timing of the peak (late July/early August) and rapid departure during August of the flocks of unidentified phalaropes seen from shore counts was also suggestive of Wilson's Phalaropes. The overall highest count of Wilson's phalaropes recorded during our 2019 surveys was 9,467 from shore counts only on July 26 (no boat survey was conducted that day). For

combined boat and shore counts, we officially report the Wilson's phalarope high here as $2,712 \pm 75$ SD birds on August 2, but the Wilson's phalarope total was likely around 11,200 birds on August 2 if the shore count birds at South Tufa were to be considered Wilson's. However, for the purposes of transparency we did not assume that birds identified in the shore count as unidentified were necessarily Wilson's. Shore count locations, especially at South Tufa, were distant, making positive identification to species challenging.

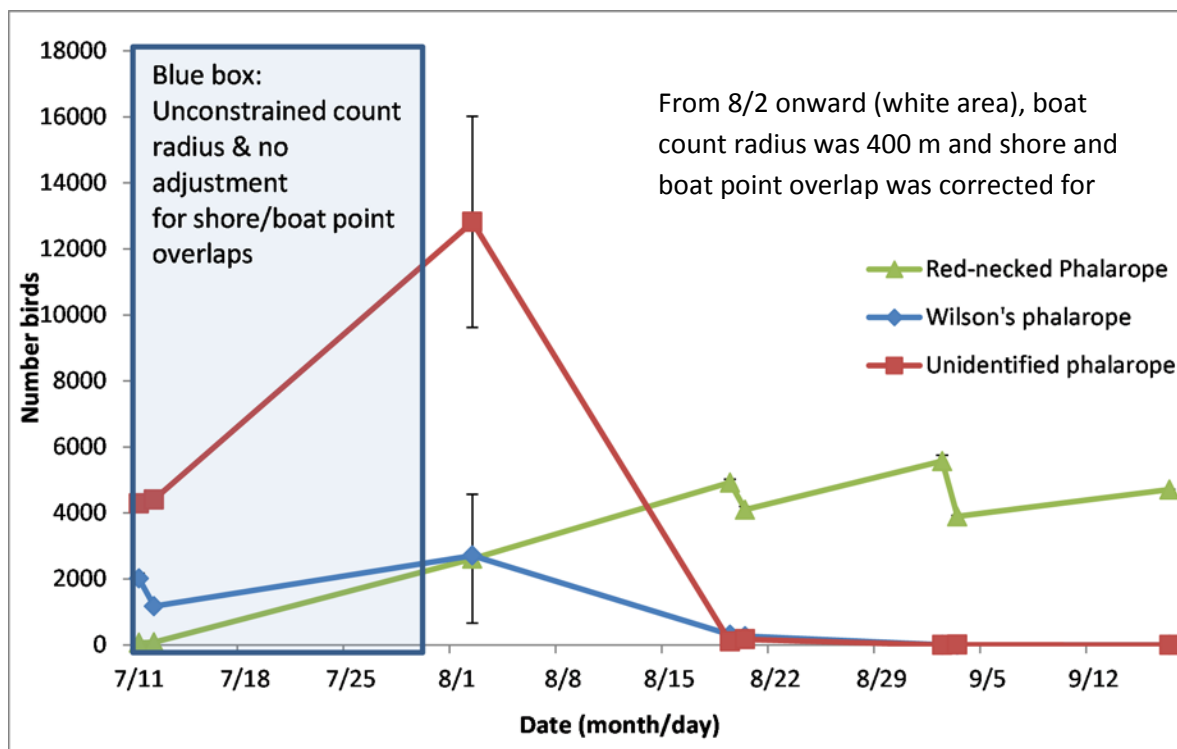


Figure 2: Total number of Wilson's, red-necked, and unidentified phalaropes recorded on Mono Lake from combined boat and shore surveys during 2019. Totals shown for each date are the average $\pm$ SD of the two boat surveyors' totals combined with shore counts. For points with overlapping shore and boat counts for counts from 8/2 onward, an adjustment was made to the boat totals to account for the percent of overlap between count areas (see text, Appendix 2). 9/12 is boat data only because no shore count was conducted that day. SD is shown for all dates but with the exception of August 2 it was too small to appear within the scale of the graph. Points close together are from surveys on consecutive dates. An August 1 survey is omitted from the graph because we believe the results were biased from double-counting at closely-placed boat points with an unconstrained count radius; July 11 and 12 surveys (shown in the blue box) also used an unconstrained count radius, which could not be adjusted to account for overlap with shore points; however we include them to show that, even if results are inflated, fewer birds were present on the lake during July. Raw data from all dates and surveyors, as well as overall whole-lake totals are in Appendix 1.

Timing and spatial use of phalaropes: Wilson's phalaropes were present during our first surveys in mid-July ($2,017 \pm 156$ birds on July 11, plus 4,250 unidentified birds in shore counts that were probably Wilson's; $1,176 \pm 64$ birds on July 12, plus 4,390 unidentified birds in shore counts that were probably Wilson's; Figs. 2–4). The majority of Wilson's phalaropes were associated with South Tufa and Lee Vining Tufa, and were located there consistently from late

July through the end of August (Fig. 4). By July 26, 9,467 Wilson's phalaropes were identified at South Tufa and Lee Vining Tufa from shore counts only (Fig. 3). During the first days of August, Wilson's phalarope total boat and shore survey numbers peaked at $2,712 \pm 75$ SD birds (plus an additional 8,500 unidentified birds from shore counts, which would total 11,212 birds if considered Wilson's; Figs. 2–4). Smaller numbers (tens to hundreds) of Wilson's phalaropes were located along the northeastern shore, where they were present on all count days in July and August, except July 12 (Fig. 4). By mid-August, total lake-wide numbers of Wilson's phalaropes decreased to the hundreds (Figs. 2, 3), and a greater proportion of the birds were located along the western shore of Mono Lake (Fig. 4). Timing of Wilson's phalaropes at Mono Lake during 2019 was similar to results from the 1980s (Jehl 1988), with peak numbers in late July and early August followed by a rapid decrease by mid-August. Weekly shore counts during August also registered the relative decrease in number of total phalaropes seen from shore (which were either identified as Wilson's or were unidentified but likely Wilson's), from 9,467 birds on July 26, to 2,083 unidentified on August 8, to 1,222 on August 14, to 154 on August 20 (Fig. 3).

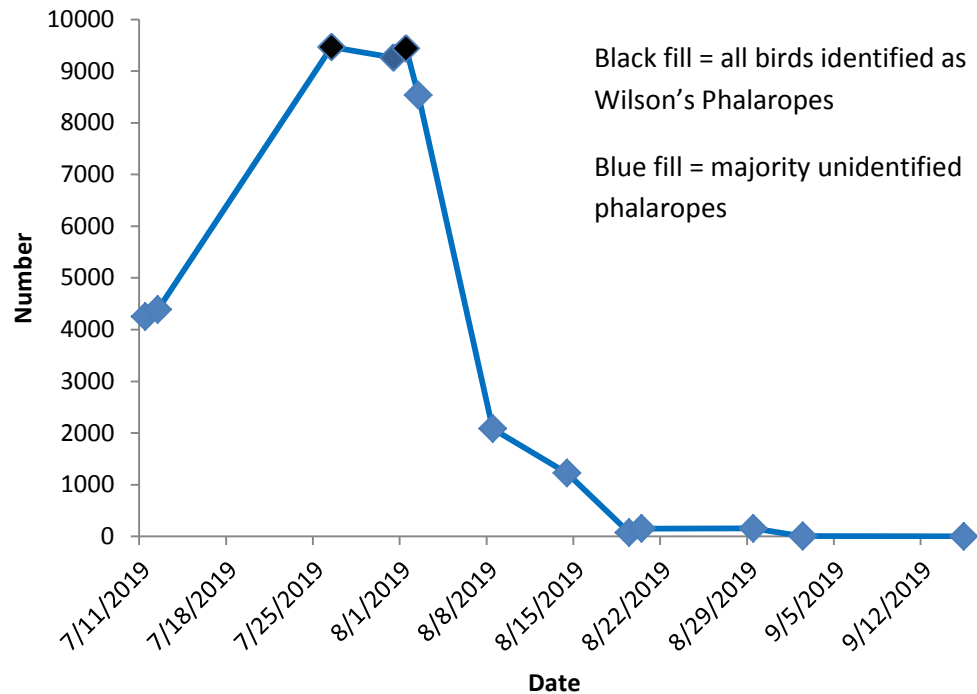


Figure 3. Total number of all phalaropes from shore counts alone, July 11–September 15, 2019. Shore counts were conducted only at South Tufa, Lee Vining Tufa, Old Marina, and County Park. For shore count methods, maps, and count areas see Appendix 2.

Wilson's Phalarope

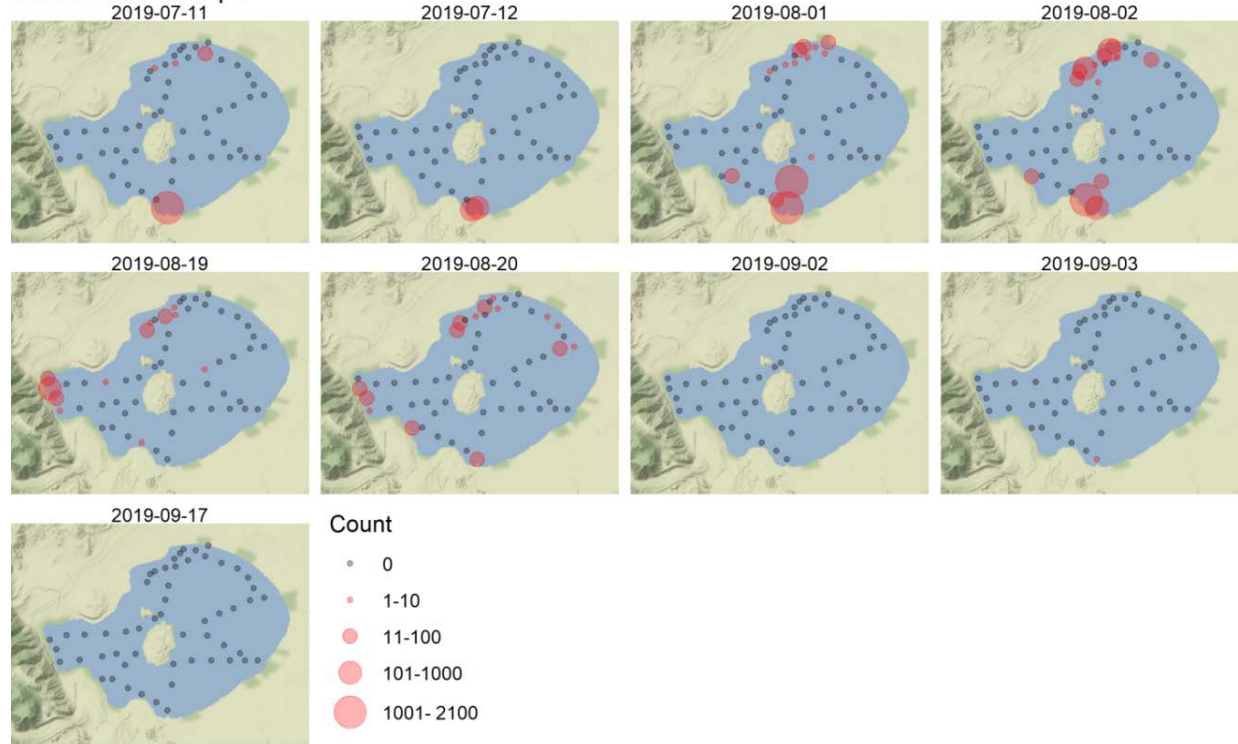


Figure 4. Distribution and magnitude of Wilson's phalaropes on Mono Lake across the 2019 season, from boat survey points alone. Size of circles indicates the magnitude of counts at a given location on each date. The peak count dates for this species were August 1 (unconstrained count radius with likely double counting of some birds) and August 2 (400 m count radius). On August 1 and 2 most of the birds were located at Lee Vining and South Tufa; the remainder were on the northeastern shore of the lake, where they were found on every count date Wilson's phalaropes were present but one. Note that July 11, 12, and August 1 had unconstrained count radii, whereas August 2 onward the count radius was 400 m.

Red-necked phalaropes were present in totals of <100 individuals during mid-July (Figs. 2, 5). From August 1–September 16, we registered >2,000 red-necked phalaropes, with a peak of $5,573 \pm 177$ on September 3 (Fig. 2). The protracted peak during August and September was consistent with historical timing of red-necked phalaropes at Mono Lake (Jehl 1986). During 2019, red-necked phalaropes were consistently located in the remote north/northeast sector of Mono Lake (Fig. 5). During September 2 and 3 surveys, more red-necked phalaropes were located in the middle of the eastern part of the lake (Fig. 5). Red-necked phalaropes used this north/northeastern part of the lake during surveys in 1981 and 1982 (Jehl 1986), and phalaropes (mostly unidentified) were concentrated exclusively there during late July surveys in 2017 (Rubega & Keimel 2017). It was notable that in 2019 there were very few red-necked phalaropes along the west and south shores of Mono Lake (Fig. 5), in areas where hundreds to thousands of birds were reported from 1980s surveys (Jehl 1986).

Red-necked Phalarope

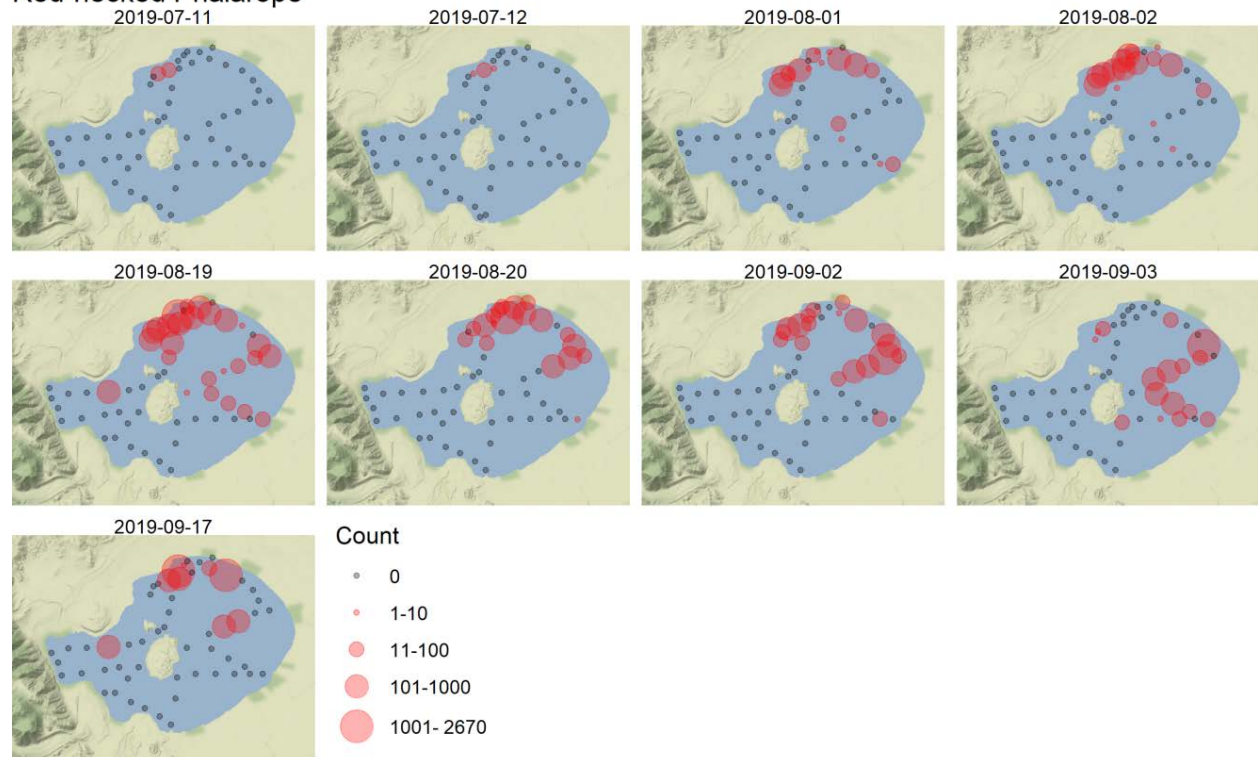


Figure 5: Distribution and magnitude of red-necked phalaropes at Mono Lake across the 2019 season, from boat survey points. Size of spots indicates the magnitude of counts at a given location on each date. Peak total count for this species was on September 2, when many birds were in open water in the eastern half of the lake, but note that the species was present over the shallowly submerged tufa groves in the north/northeast sector of the lake on every survey date.

We recorded the greatest number of unidentified phalaropes on August 1 ($28,826 \pm 1,158$) and August 2 ($12,817 \pm 3,197$ SD; combined boat and shore count totals). The unconstrained count radius used on August 1 was a major factor in the high count of unidentified phalaropes that day; as the distance from the counter grows, features distinguishing the two species become harder to make out, and more of these distant birds were counted. We also believe that because of the unconstrained count radius, many birds were double counted at boat counts located <500 m from each other in the north/northeast of the lake. On August 2, we constrained our count radius to 400 m. The relatively high unidentified count that day was due to the increased number of birds present on the lake challenging our developing identification skills. Our identification skills grew over the season, and by August 20, when we were using only 400 m count radii, our surveyors were more confident in their identifications, and we had few unidentified birds and greater numbers of identified red-necked phalaropes.

Comparison of counts on consecutive days: One area of uncertainty in counts at Mono Lake, where birds may move across wide areas from on time scales of hours to days, is the importance of day-to-day variation in count totals as they relate to the “true” total number of birds present. On three occasions, we counted birds on back-to-back dates, providing an (admittedly limited) opportunity to examine such variation. To compare counts on back to back days, we calculated

the difference between the average total sum of the two boat observers combined with shore counts on each day, and divided the difference by the total from the date (of the two back-to-back days) with the highest count (Table 2). No total count from any set of consecutive days differed by an order of magnitude (i.e., singles, tens, hundreds, or thousands of birds), thus consecutive days generally gave similar impressions of the magnitude of bird numbers on the lake. Percent differences are more important when the total count is larger; i.e., we deem an 800% count difference of unidentified phalaropes on Sep 2 and 3 (Table 2) as relatively biologically unimportant because it represents the difference between zero birds on one day and eight birds on the next. On counts with >1,000 birds, count differences on back-to-back days ranged from 13–42% (Table 2, bolded and italicized numbers). The greatest absolute count difference between two back-to-back counts was a 1,679 difference in red-necked phalaropes between September 2 (5,573 total) and September 3 (3,894 total; Table 2).

Table 2. Differences between total counts of Wilson’s, Red-necked, and unidentified phalaropes on consecutive count days during 2019. Bolded and italicized numbers are counts for which the total count for that category on both days was >1,000 birds. Absolute differences were calculated by subtracting the lower count from the two consecutive days from the higher. Percent differences were calculated by dividing the difference between the consecutive daily counts by the higher count of the two count totals. Totals for each day were calculated by averaging the counts of the two boat observers, combined with shore counts.

Dates	Count radius	WIPH % difference	WIPH absolute difference	RNPH % difference	RNPH absolute difference	Unidentified % difference	Unidentified absolute difference
7/11/2019-7/12/2019	Un-constrained	42%	842	20%	17	3%	119
8/19/2019-8/20/2019	400 m	15%	48	17%	822	38%	66
9/2/2019-9/3/2019	400 m	50%	2	30%	1679	800%	8

Spatially, locations of phalaropes were fairly similar on consecutive days (Figs. 4, 5), though there were enough differences to illustrate the importance of whole lake surveys, instead of relying on indices from a few stations. For example, more red-necked phalaropes were located far from shore in the southwest part of the lake on August 19 than August 20 (Fig. 5). Likewise, on September 3, red-necked phalaropes were nearly absent at points 46-55 in shallow waters in the north of the lake (31 birds) where there had been 643 red-necked phalaropes on Sep 2 (Fig. 5). On September 3 more red-necked phalaropes were registered in the middle of the eastern part of the lake; however we also registered fewer overall phalaropes on the lake on September 3. Thus it is unclear whether the birds departed the lake, moved around, or both, between those dates; this uncertainty is exacerbated by our lack of information about characteristic turnover rates for red-necked phalaropes. Similarly, Wilson’s phalaropes generally were in similar locations day to day, but there were day-to-day differences in relatively small numbers of birds

(Fig. 4). Part of this variability may have been due to the time of day we surveyed each point. On back-to-back days we purposely traveled through the survey stations in opposite directions and therefore visited the points at different times between 6 A.M. and 2:30 P.M. Phalaropes are mobile species that certainly move around throughout the day, and the variance in our back-to-back count data suggests that more quantitative examination of within-day and day-to-day movements would provide valuable insights into how phalaropes use lake habitats, and which areas are critical for successful migratory staging.

Comparison of counts between different boat observers: A key factor in estimating phalarope numbers, as for any other species of bird, is the error associated with the differences among individual surveyors. Table 3 shows absolute and percent differences between observers 1 and 2 on boat surveys. During most dates, differences between results from each observer were 10% or less (as dictated by the survey protocol), with a few notable exceptions (Table 3). On August 1 and 2, there were differences in red-necked phalarope totals of 49% and 69%, respectively, between observers. This was primarily driven by difference in ID confidence between observers, with one observer identifying birds as red-necked phalaropes that the other observer recorded as unidentified. This was also the case with the 42% difference in Wilson's phalarope numbers on August 1 (Table 3). From August 19 on, all differences between surveyors were less than 10%, as ID skills improved. While we did attempt to hold counts to the 10% difference between observers on all dates, this was at times complicated by identification differences (i.e. one observer calling birds unidentified and the other identifying them); in these cases we held the overall count to within 10% but because one observer influencing the other's identifications was undesirable, we let the totals of each species/category differ significantly. On August 1 three observers counted phalaropes; for simplicity the third observer is not shown in Table 3 but overall results of each observer are shown in Appendix 1, Table A1.1. Overall, these results underscore the importance of consistent and well-trained observers, as there is a steep learning curve for accurate phalarope ID. Likewise, we found that numbers got more consistent between observers the more experience we had working together; probably the most important factor to consistent results between observers was making sure our count radius estimates were calibrated.

Table 3. Absolute and percent differences between boat observers total survey counts. Percent difference was calculated by dividing the absolute difference by the highest count on each date. Bolded and italicized numbers are shown where total counts were >1,000 birds.

Date	Absolute difference WIPH	% difference WIPH	Absolute difference RNPH	% difference RNPH	Absolute difference unidentified	% difference unidentified
7/11/2019	220	10%	19	25%	0	0%
7/12/2019	90	8%	0	0%	5	25%
8/1/2019	1253	42%	1035	49%	1637	8%
8/2/2019	102	4%	2759	69%	4521	69%
8/19/2019	17	5%	139	3%	3	9%
8/20/2019	23	8%	136	3%	0	0%
9/2/2019	0	0%	251	4%	0	0%
9/3/2019	0	0%	51	1%	0	0%
9/17/2019	0	0%	12	0%	0	0%

Impact of different count radii: In terrestrial habitats, count distances are often constrained by detectability. On open water, as at Mono Lake, detectability tends to extend much farther, but the lack of landmarks increases the difficulty of estimating distance. On July 11 and 12 and August 1 we enumerated birds as far as we could see them, whereas on August 2 and subsequent surveys we constrained counts to a 400 m radius. August 1 counts were $2,377 \pm 886$ Wilson's phalaropes, $1,588 \pm 732$ red-necked phalaropes, and $28,826 \pm 1,158$ unidentified phalaropes (counts adding boat and shore totals together). The high count of unidentified birds on August 1 was due to the unconstrained count radius that day; we were counting birds farther away, but as distance grew birds were more difficult to identify. This problem is exacerbated at sites counted later in the day, when heat waves interfere with visibility. It is probable that August 1 totals were inflated by double counting, especially in dense concentrations of phalaropes in the north/northeast part of the lake, where points are only 400-600 m apart, less than the radius in which we were enumerating birds at each point. The unconstrained count radius appeared to be less problematic during July counts, when fewer birds were present and they were more spatially concentrated in flocks that were either very large (i.e. thousands of Wilson's phalaropes) or very small (i.e., tens of red-necked phalaropes).

Comparing the present numbers with previous counts involving one of us (Rubega and Keimel 2017) illustrates the difficulty of standardizing distance estimation across observers, and its effect on estimation of the number of birds present. The present protocol was based on one devised and used by Rubega and Keimel in the 1990s and in 2017, which called for a count radius of 75 m. Total 2019 boat counts of all phalaropes using the 75 m count radius metric ranged from 78 individuals on July 11 to 1,187 on September 2 (Appendix 1, Table A1.1). The 75 m radius count recorded on average $10 \pm 7\%$ SD of the birds registered on simultaneous 400 m radius counts ($n = 6$ surveys; Fig. 6), and $5 \pm 2\%$ of the birds registered during surveys with unconstrained count radii ($n = 3$ surveys). Comparing our 75 m count radius totals with surveys reported from the 1990s using a 75 m count radius (Rubega and Keimel 2017), 2019 high counts of all phalaropes (1,146 on August 1 and 1,187 on September 2) were far below the count totals from the nearest-to-same dates in 1990 and 1991 (24,538 on August 7 1990, 13,800 on August 1 1991, and 10,800 on September 5 1991). This disparity seems likely to be the result of the difficulty, and variance among observers, in estimating a 75m counting radius; Rubega and Keimel (2017) did not have a range finder, and so likely misjudged the actual distance, but clearly converged on a comparable distance estimate, since their individual counts are highly similar to each other's. Moreover, our counts using a 400 m or greater radius appear more similar to the results from their counts in the 1990s, suggesting that they were actually using count radii that were closer to 400 m. This underscores a significant problem for standardizing the estimation of distance, not only at Mono Lake, but across sites important to phalaropes. In the open water habitats used by phalaropes, where landmarks that would aid distance estimation are frequently absent, we suggest that a way forward may be calibration of the apparent size of phalaropes at distances established using range finders where landmarks are available, with photo documentation. Observers could then be trained, both within and across seasons, and across sites, to estimate distance based on apparent size of the birds they are looking at. .

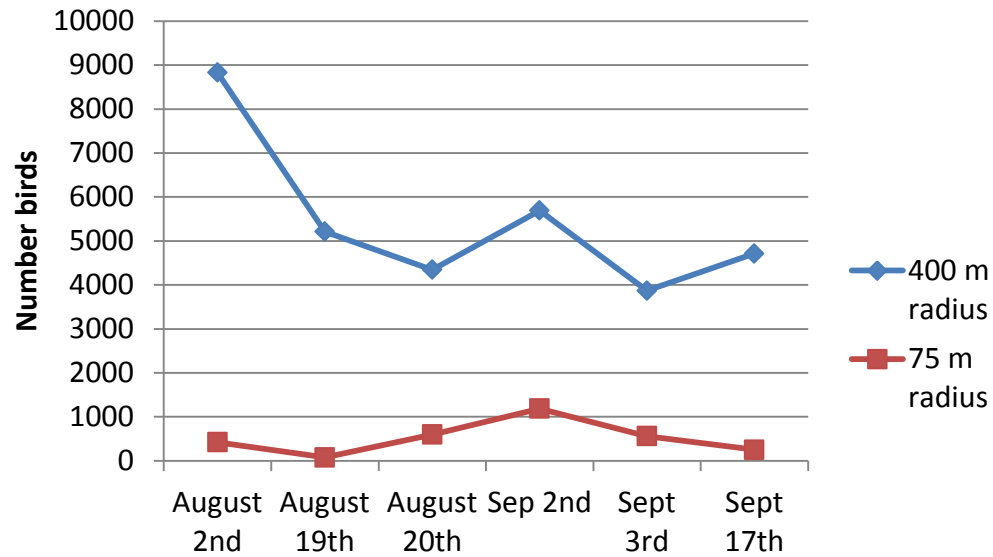


Figure 6. Comparison of 400 m radius and 75 m radius total boat survey counts made on the same day by a single observer. The single observer counting at both distances differed across days. The 75 m radius count recorded on average $10 \pm 7\%$ SD of the birds registered on simultaneous 400 m radius counts.

Shore counts vs. boat counts: Shore counts registered more birds than the nearest corresponding boat count station on most, but not all, days when both survey types were carried out (Table 4). Even with an unconstrained count radius on July 11, 12, and August 1, boat surveys picked up fewer birds because we could not see large groupings of phalaropes behind tufa groves.

Table 4. Combined total number of Wilson's and unidentified phalaropes from locations with both boat and shore based counts at Mono Lake, 2019. Boat counts on July 11, 12, and August 1 used an unconstrained count radius and boat counts from August 2 on used a 400 m count radius. See Table 1 for total estimated count areas of shore counts (all of which were less than the 0.50 km^2 area of each individual boat point). Red-necked phalarope totals are not shown because they were only registered on one day at one shore count point (8 birds at South Tufa on September 2) and were never registered at these boat count points.

Date	South Tufa Boat	South Tufa Shore	LV tufa boat	LV tufa shore	Old Marina Boat	Old Marina Shore	County Park Boat	County Park Shore
July 11	2100	3900	No data	300	0	No data	No data	50
July 12	640	1740	No data	2600	0	No data	No data	No data
August 1	5800	9400	0	40	0	0	0	0
August 2	600	8500	24	33	0	0	0	0
August 19	0	0	0	0	7	0	0	46
August 20	24	0	55	0	7	48	16	102
September 2	0	4	0	0	0	0	0	0
September 17	0	No data	0	No data	0	No data	No data	No data

Shore counts were also important for registering flocks of hundreds to thousands of unidentified birds (probably Wilson’s phalaropes) at Lee Vining Tufa in July (Figs. 7, 8, Table 4), before we added a boat count station there during the August 1 survey. On the other hand, boat counts may be important for detecting smaller flocks of birds at tufa groves, as well as determining species identification, because shore count locations were relatively distant from birds. After large flocks of Wilson’s phalaropes had departed, boat counts sometimes registered groups of 7-55 Wilson’s phalaropes at South Tufa, Lee Vining Tufa, and Old Marina on days when shore counts registered zero birds there (Figs. 7, 8, Table 4).

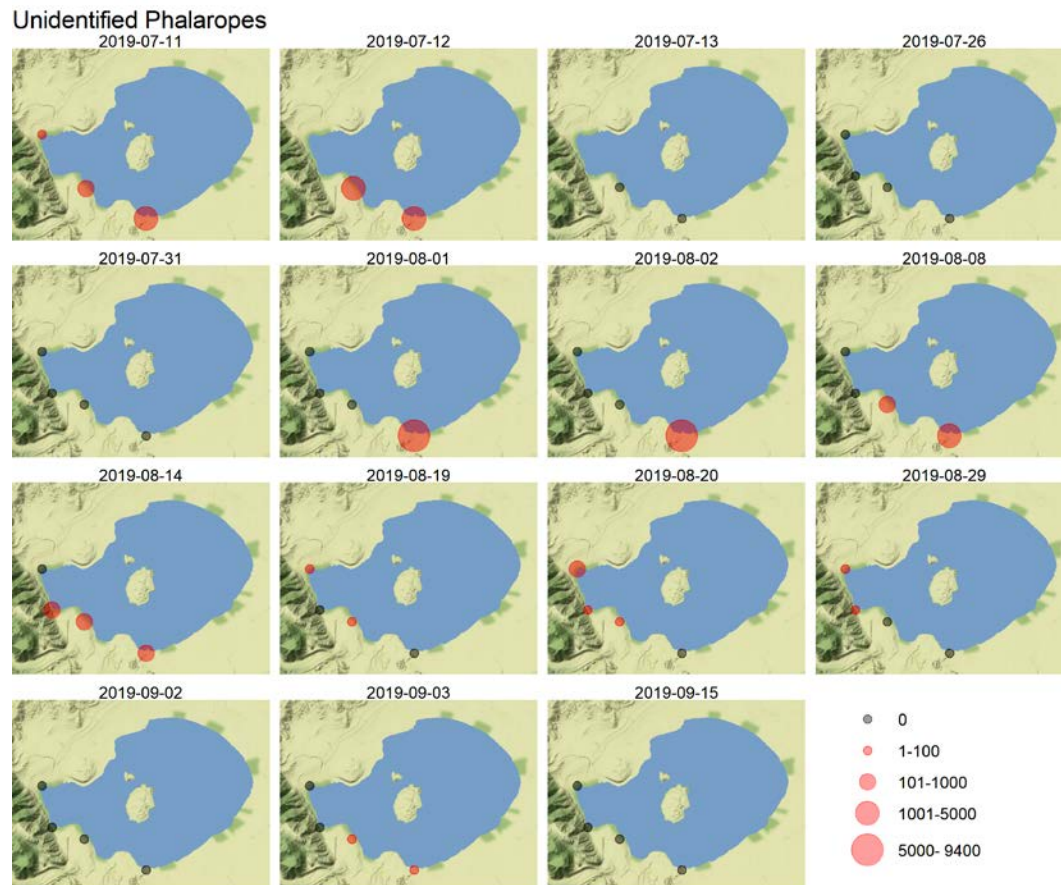


Figure 6: Distribution and magnitude of unidentified phalaropes from shore counts alone during 2019. Size of circles indicates the magnitude of counts at a given location on each date. Note that no unidentified birds were seen on July 26-July 31; this is because birds seen on shore counts on those dates were identified at Wilson’s phalaropes (see Fig. 7). Based on positive Wilson’s phalarope identifications on July 13, 26, and 31, as well as consistent identification of birds at South Tufa as Wilson’s phalaropes during boat surveys, we believe it is likely that the vast majority of unidentified birds in shore counts in late July and early August were Wilson’s phalaropes.

It is important to note that shore counts were critical for capturing numbers of Wilson’s phalaropes at the tufa groves, but would be insufficient by themselves for capturing the total number of either Wilson’s or red-necked phalaropes on the lake. For example, the vast majority of red-necked phalaropes present at Mono Lake in 2019 were in areas inaccessible from shore. Though Wilson’s phalaropes were mostly concentrated at accessible near-shore locations during

2019, this is not always the case year to year, and without coverage of the whole lake from the boat, it would be impossible to know whether flocks were missed from shore.

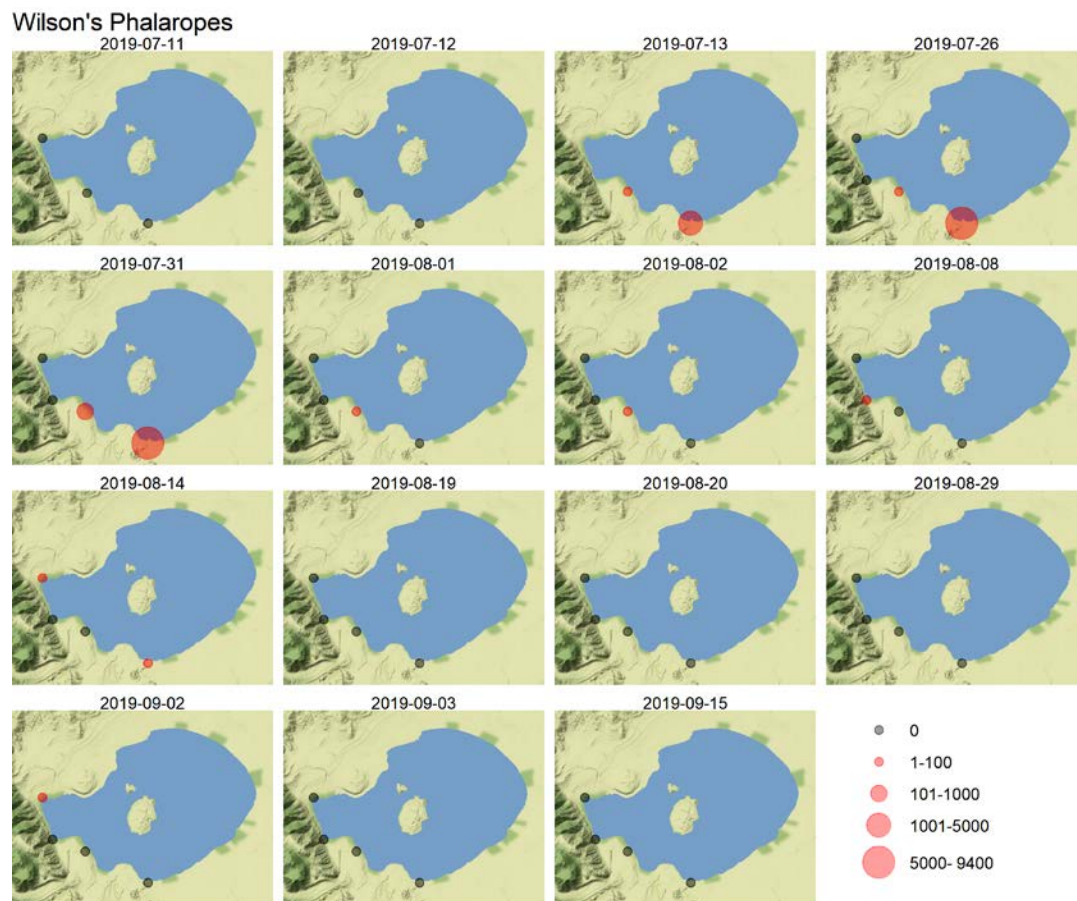


Figure 7. Distribution and magnitude of Wilson's phalaropes from shore counts alone during 2019.

Size of circles indicates the magnitude of counts at a given location on each date. Note that unidentified flocks of similar magnitude were present at the same locations during all dates in July and early August in which Wilson's phalaropes were not identified in shore counts (see Figure 6), likely indicating that those unidentified birds were Wilson's phalaropes. Note that few red-necked phalaropes were registered in shore counts during 2019 (18 total across all surveys), which is why no red-necked phalarope shore count figure is included.

We did not conduct shore counts in the northern and eastern sectors of the lake, where most of the red-necked phalaropes were located on most survey dates, because of inaccessibility. Aerial counts would overcome the problem of relative inaccessibility at some sites, to both boat and shore counters, but present a different set of problems (e.g., expense; distinguishing between the two species at flight elevation). The relative performance of shore counts in this area, if they could be added, is hard to predict: the tufa shoals over which the birds are feeding extend farther from the water's edge than at Lee Vining or South Tufa. Other areas not well covered by the boat survey where shore counts might be useful are parts of the southeastern shoreline of the lake (e.g., between Navy Beach and Sammon's [often called "Simon's"] Springs), the "Black Point shoals" area west of the Negit land bridge in the northern part of the lake, and the Mill/Wilson

Creek delta area. However, shore counts at these areas would require significantly more effort than the current shore count stations, because they are more difficult to access from land. Overall, shore counts at tufa grove areas, especially South Tufa and Lee Vining Tufa, were an important complement to the boat survey protocol that should be included in the future.

Conclusions:

Mono Lake phalarope surveys during the 2019 season provide a strong starting point for establishing sustained annual surveys to evaluate the current status and trends in phalarope behavior and numbers. Historic data exists on phalarope numbers at Mono Lake, Great Salt Lake, Lake Abert, and other sites, but after extensive review of these historical sources for this report, we determined that more work is needed to review the methodologies and coverage of each survey in order to create an adequately standardized dataset to responsibly make comparisons. Nonetheless, just the variation in counts at Mono Lake during 2019 resulting from issues highlighted in this report highlights the need for well-documented standardization and coordination across sites and time.

The 2019 surveys revealed important contemporary patterns in use of the lake habitat by phalaropes. Spatially, red-necked phalaropes were concentrated in the remote north/northeast part of the lake during 2019, as was the case on the few dates surveys were possible in 2017 (Rubega and Keimel 2017). Birds in this north/northeast part of the lake are virtually invisible to the public and casual observers because of the remote shoreline's limited road access and because the birds were often several km from shore on the water. In contrast, during 2019, thousands of Wilson's phalaropes were concentrated at South Tufa, the most visited part of the lake. This underscores the need to conduct full-lake surveys at Mono Lake, because without complete survey coverage, our perception of the number of phalaropes present could be heavily influenced by numbers at a few highly visited and accessible areas. Likewise, relying on Ebird data or other citizen science methods would fail to reliably capture true numbers of phalaropes at Mono Lake because of the inaccessibility of the north/northeast part of the lake, where significant numbers of phalaropes were concentrated.

Our effort to survey bi-weekly in 2019 was useful in assessing whether the timing of migration through Mono Lake has changed in response to changing climate or other factors. While annual variation in timing will still need to be accounted for into the future, Wilson's and red-necked phalarope timing at Mono Lake during 2019 appeared similar to patterns during the 1980s and 1990s, with Wilson's phalarope counts peaking in late July/early August and red-necked phalarope counts peaking from late August through mid-September. Surveys on consecutive days yielded similar orders of magnitude of numbers of birds in similar locations, though there were substantial day to day differences. Though completion of one full lake survey per two-week survey period may be sufficient for understanding general spatial and temporal use of the lake by phalaropes, consecutive day surveys were helpful for capturing high counts and finer-scale variability in locations. Consecutive counts are likely to remain important for estimating the effect of count error rates on estimating total numbers of birds, at least for several years into the future.

Methodologically, we learned that initial use of a range finder to help observers improve their distance estimation, increasing the counting radius from the boat, adding shore counts at select locations, and adding nearshore boat points at tufa groves resulted in registering much greater number of birds than adhering only to the exact survey locations and methods from 1990, 1991, and 2017. Shore counts were essential for capturing large Wilson's phalarope flocks on the

lake that would have otherwise been undetected in 2019. Using the methods reported in Rubega and Keimel (2017) without the shore counts resulted in estimates of far fewer birds than were actually on the lake (Appendix 1, Table A1.1), suggesting that either lake conditions or bird behavior vary substantially from year to year, distance estimation between surveys was inconsistent, or all three. Of these, methods of distance estimation are the only factor potentially within our control, and careful standardization of methods and training of observers is a high priority.

We believe that 2019 boat surveys with a 400 m count radius captured the correct order of magnitude of birds at Mono Lake and provide a useful index for future comparisons using the same methods. However, we are equally confident that both boat and shore-based methods are limited in their ability to account for all the phalaropes on Mono Lake on a given day. Visibility limitations arising from lack of elevation of the observers above the birds, difficulty in estimating distance over open water, and heat waves all contribute error to the estimate. Birds also move about the lake over the time required to complete a full boat survey. Aerial surveys hold promise for overcoming all of these issues; simultaneous aerial and boat surveys would make it possible to estimate boat survey error, and assess whether planes or drone surveys would be a more accurate and/or cost- and time-efficient survey method. We coordinated one aerial plane survey with the 2019 boat surveys. On July 19th, volunteer pilot Ivan Stanojevic and photographer Rick Kattleman flew and photographed phalaropes from different heights, evaluating disturbance effects and quality of photographs. We learned from this flight that the phalaropes were undisturbed by flight elevations of 1,000-500 feet. However, we also learned that a fixed-focus lens, which was not used on this flight, is needed to get crisp images of phalaropes from the air, thus it remains to be seen whether phalaropes can be identified to species based on aerial photos.

Wilson's phalaropes concentrate at just a few locations in the Great Basin, providing a unique opportunity to create an index of their world population trends. However, greater coordination and standardization of count methods among surveys and sites is needed to capture all the birds in as short a window as possible, and critical evaluation of historical data is needed to create a standardized index using data collected with consistent methods.

Although the counts of red-necked phalaropes presented in this report are an important starting point, we still have no way to even estimate the total number of red-necked phalaropes using Mono Lake, Great Salt Lake and other sites, because we do not know their residency time. If residency times are short, the total number of red-necked phalaropes using Mono could be many times that represented by our peak counts. Without residency time estimates, we can neither estimate population size, nor accurately assess population trends. Movement studies of both phalaropes would yield valuable insights, but are desperately needed for red-necked phalaropes.

Finally, our work during 2019 showed that through collaborative efforts, we can quickly make strides in advancing our understanding of phalarope conservation status. During 2019 and early 2020, we formed an International Phalarope Working Group, which met twice, at Mono Lake and at the Western Hemisphere Shorebird Group conference in Panama; multiple surveys were coordinated at the major Great Basin staging sites; a coordinated phalarope survey was carried out across four countries in the South American altiplano in February 2020; and the Western Hemisphere Shorebird Reserve Network committed to updating the Wilson's phalarope Conservation Plan (Lesterhuis & Clay 2009). 2019 and 2020 have represented an unprecedented international coming-together for the sake of phalarope research and conservation. We are

putting this momentum toward future objectives of continuing coordinated surveys, comparing North American and South American trends, and tracking phalaropes, with the overarching goal of a well-informed understanding of the conservation status and needs of Wilson's and red-necked phalaropes.

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Red-necked Phalaropes at Mono Lake

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Appendix 1.

Table A1.1. Mono Lake 2019 boat count full-survey totals from each observer. Top section shows counts with an unconstrained or 400 m counts radius, bottom shows results of 75 m counts taken immediately after 400 m radius counts.

Boat count totals										
Date	Count Radius	WIPH Obs. 1	WIPH Obs. 2	WIPH Obs. 3	RNPH Obs. 1	RNPH Obs. 2	RNPH Obs. 3	Unident. Phal. Obs. 1	Unident. Phal. Obs. 2	Unident. Phal. Obs. 3
7/11/2019	Unconstrained	1907	2127		76	57		39	39	
7/12/2019	Unconstrained	1220	1130		83	83		15	20	
8/1/2019	Unconstrained	1711	2964	2252	1070	2105	1228	20244	18607	20253
8/2/2019	400 m	2681	2783		1232	3991		6577	2056	
8/19/2019	400 m	309	326		4990	4851		30	33	
8/20/2019	400 m	271	294		4167	4031		19	19	
9/2/2019	400 m	0	0		5439	5690		0	0	
9/3/2019	400 m	2	2		3919	3868		0	0	0
9/17/2019	400 m	0	0		4701	4713		0	0	0
75 m radius boat count totals										
Date	Count Radius	WIPH Obs. 1	WIPH Obs. 2	WIPH Obs. 3	RNPH Obs. 1	RNPH Obs. 2	RNPH Obs. 3	Unident. Phal. Obs. 1	Unident. Phal. Obs. 2	Unident. Phal. Obs. 3
7/11/2019	75 m	1	1		76	77		0	0	
7/12/2019	75 m	0	0		83	83		0	0	
8/1/2019	75 m		888			258			0	
8/2/2019	75 m		112			310			0	
8/19/2019	75 m		0			79			0	
8/20/2019	75 m		95			503			0	
9/2/2019	75 m	0			1187			0		
9/3/2019	75 m	0	0		382	560		0	0	
9/17/2019	75 m	0			251			0		

Table A1.2. Shore counts totals on dates with boat surveys. Totals shown are the sum of counts at South Tufa, Lee Vining Tufa, Old Marina, and County Park. Each shore count area had a different total count area (see Table 1 in main text), but all shore areas had smaller total count areas than each boat point.

Shore Count Totals on days with boat surveys			
	WIPH	RHPH	Unident. Phal.
7/11/2019	0	0	4250
7/12/2019	0	0	4390
8/1/2019	40	0	9400
8/2/2019	33	0	8500
8/19/2019	0	0	75
8/20/2019	0	0	154
9/2/2019	0	4	8
9/3/2019	0	0	8
9/17/2019	No count	No count	No count

Table A1.3. Total phalarope counts from combined boat and shore counts at Mono Lake during 2019, with boat observers' totals averaged. September 17 total is the boat count alone, as no shore count was carried out that day. Totals from July 11, 12, and August 2 (shown in gray) had unconstrained boat count radii and are unadjusted for overlap with shore points. Counts from August 2 onward used a 400 m boat count radius and are adjusted for areas where boat and shore counts overlapped. Approximately 8,000-9,000 of the unidentified birds on August 2 were likely Wilson's phalaropes based on results of shore counts on July 31.

Date (month/day)	Wilson's phalarope	Red-necked phalarope	Unidentified phalarope
7/11	2017 ± 156	67 ± 13	4289 ± 0
7/12	1175 ± 64	83 ± 0	4408 ± 4
8/1	2378 ± 886	1588 ± 732	28826 ± 1158
8/2	2712 ± 75	2612 ± 1951	12817 ± 3197
8/19	312 ± 14	4921 ± 98	107 ± 2
8/20	264 ± 15	4099 ± 96	173 ± 0
9/2	4 ± 0	5573 ± 177	0 ± 0
9/3	2 ± 0	3894 ± 36	8 ± 0
9/17	0 ± 0	4707 ± 8	0 ± 0

Appendix 2: Shore count methods

Standardized shore counts began on July 26 at South Tufa, Lee Vining Tufa, Old Marina and County Park. One to two observers conducted the shore count by driving between points. Points were marked with GPS. See Figure 1 in the main text for shore count locations relative to the whole lake. At each site, observers used the maps below to identify count area boundaries (Fig A2.1, A, B,C, D). These boundaries worked well with the same people consistently being the observers this year, but should be further defined and elaborated on maps during the 2020 season.

Figure A2.1. Count boundary maps used by shore count observers during 2019.

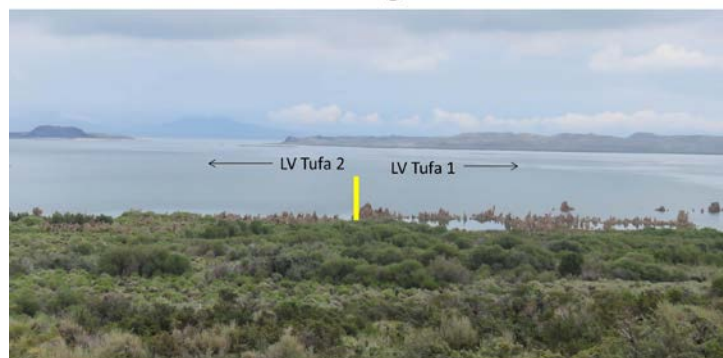
- A.** County Park. County Park counts were conducted at the viewing platform at the end of the County Park boardwalk.

County Park



- B.** Lee Vining Tufa. Lee Vining Tufa counts were conducted from Test Station Road.

Lee Vining Tufa



- C.** South Tufa. Note the “pirate ship” is a cluster of tufa that is currently an island but used to be an isthmus near the “grotto” on the South Tufa interpretive trail. Shore count observers were familiar with this name for the geographical landmark. South Tufa counts were conducted from Test Station Road (view in image below) and the connector road between South Tufa and Navy Beach.

South Tufa



- D.** Old Marina. Old Marina count was conducted from the top of the paved road into Old Marina off 395.

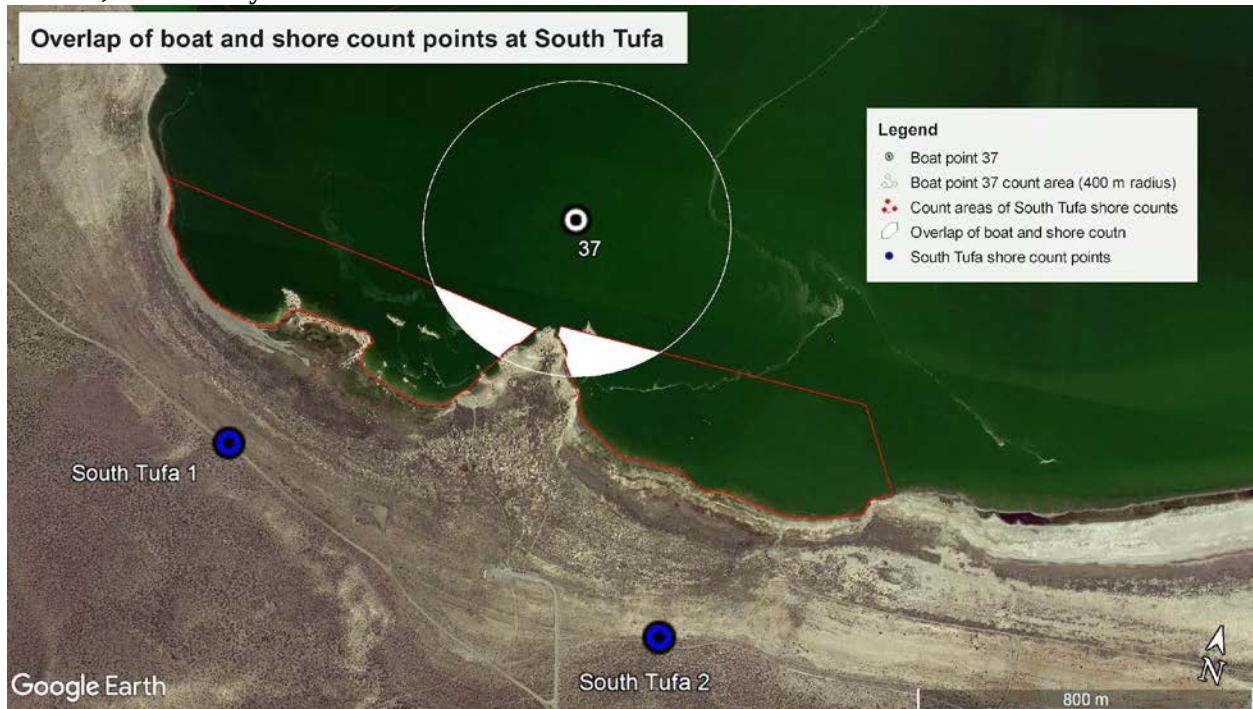
Old Marina



Calculation of shore count areas and overlap with boat points

To calculate the area of shore counts we used Google Earth Pro to draw polygons based on the field maps of shore count boundary areas (Fig. A2.2). We used the “measure” tool in Google Earth Pro to calculate the total area of each shore count area polygon. To calculate the area of overlap with boat points, we first projected a 400 m radius circle around the closest boat point to each shore count, and then made polygons of the overlapping area with the shore count (Fig. A2.2). We used the “measure” tool to calculate the total area of overlap at each shore count/boat count location (Fig. A2.2, Table A2.1). We also drew polygons around the land area covered by each boat point that overlapped with a shore count, and subtracted land area from the total count area to determine “total water count area” (Table A2.1). We divided by the total overlap area with the shore count by the total water area of each boat count point to determine the percentage of the boat count area that overlapped with the shore count (Table A2.1). Finally, we subtracted the percentage of overlap between the shore and boat count from the boat count total of each category of phalaropes (Wilson’s, red-necked, and unidentified) for that point (Table A2.1). The entire shore count result was included in the whole-lake totals, as well as the adjusted boat count sums.

Figure A.2.2. Maps of overlap between boat and shore points at South Tufa, Lee Vining Tufa, Old Marina, and County Park.



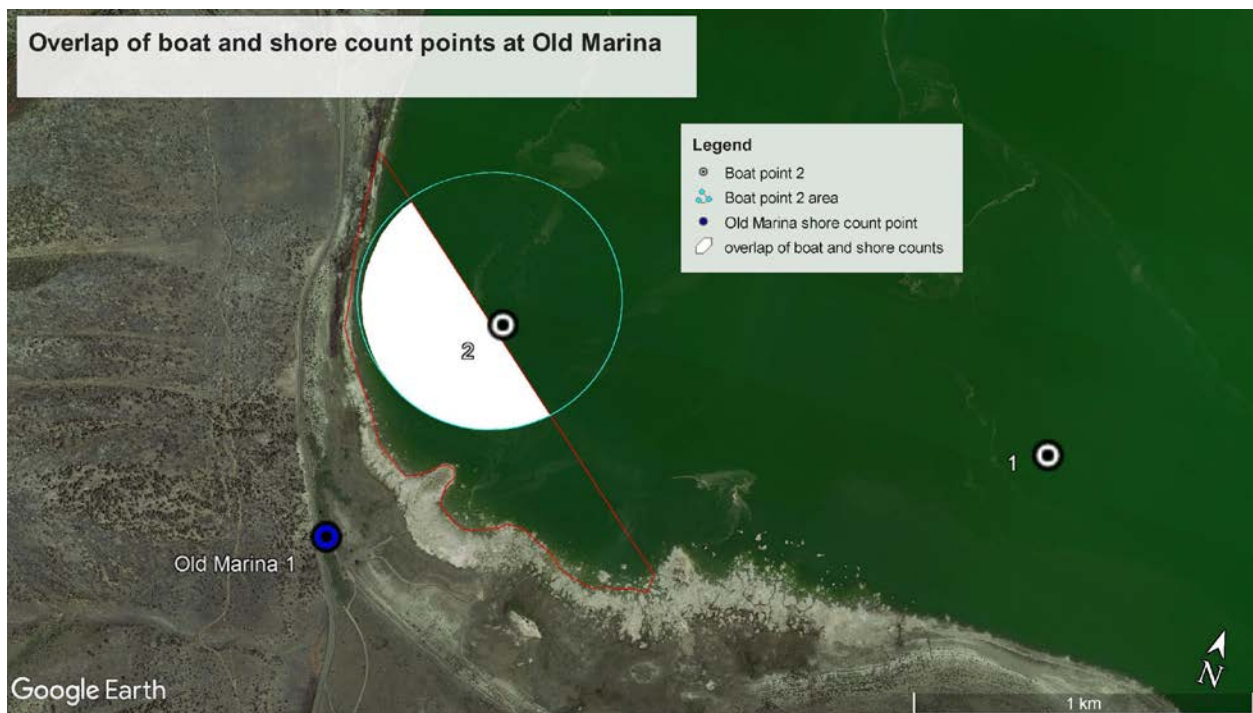
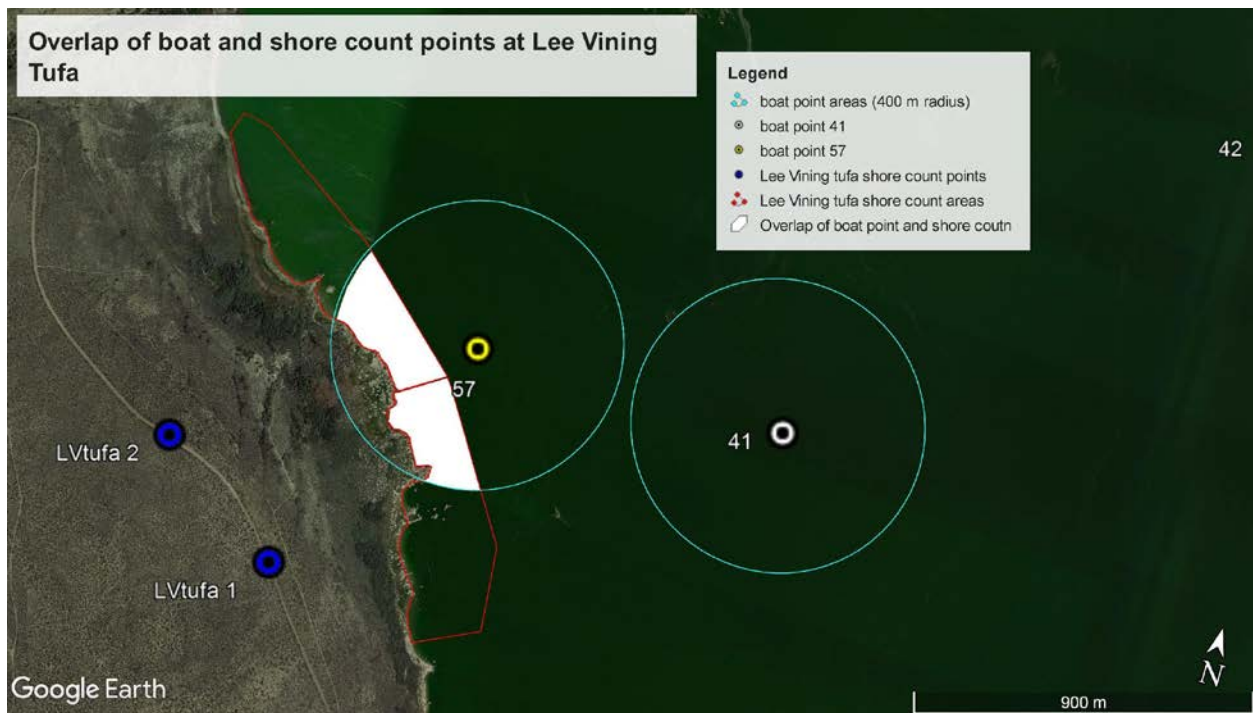




Table A2.1. Calculations of area of overlap of shore counts and nearby boat count points.
To determine total proportion of overlap, the area of water overlap between the shore and boat points was divided by the total water area of each boat point.

Boat Point	Shore count area	Area of overlap between boat and shore point (m ²)	Area of boat point	Land area in boat point	Water area of boat point (total area minus land)	Proportion of boat point water overlapping with shore point
Point 38	South Tufa (points 1 and 2 combined)	37,316	503,000	12,344	490,656	0.076
point 57	Lee Vining Tufa (points 1 and 2 combined)	97,261	503,000	44,163	458,837	0.212
Point 2	Old Marina	215,119	503,000	0	503,000	0.428
Point 55	County Park	113,563	503,000	46,283	456,717	0.249