Point Blue Report

Population size and reproductive success of California Gulls at Mono Lake: 2024

Annual Report

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Cover photo: Java islet (foreground) and Negit Island (midground) in Mono Lake in late May 2024 with the snow-capped Sierra Nevada in the background. Annie Schmidt.

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EXECUTIVE SUMMARY

Point Blue conducted the 42nd consecutive year of monitoring the California Gull (*Larus californicus*) breeding population on Mono Lake in 2024. We estimated the breeding population size and chick production by counting nesting gulls from high resolution aerial imagery obtained from uncrewed aerial vehicles (UAV's). In 2024 we utilized new smaller UAVs with upgraded flight and battery capabilities. We continued to hone our use of machine learning algorithms to count nesting gulls from aerial imagery.

Following a record 2023 snowpack and high runoff, Mono Lake remained deeply stratified into the Spring of 2024, resulting in reduced lake productivity. In 2024, we estimated the gull nesting population was 20,258 based on a nest count of 10,129, a decrease of 4,362 birds from the active breeding population compared to 2023. The 2024 breeding population was the smallest recorded over the 42 years of the study, following significantly below the 1983 – 2023 average of 42,575 or the 2013 – 2023 average of 31,729. Twain islet continued to support the majority of the nesting population with 64% of all nests in 2024, a nearly 2000 nest decrease from 2023 and the fourth consecutive year the Twain nest numbers have declined. The other islets with the next highest nest counts were: Little Tahiti (1915), Pancake (816), and Little Norway (463). Coyote Islet, which had complete nest failure in 2022, saw nest numbers decline from 1015 in 2022 to 244 in 2023 to 168 in 2024.

In 2024, chick production (chicks/nest) from our sample plots was the lowest ever recorded at Mono Lake. We estimated 0.033 ± 0.02 chicks fledged per nesting attempt. This number eclipsed the previous historic low from 2022 of 0.09 chicks/nest. The record low nest numbers combined with record low productivity resulted in by far the fewest estimated fledged chicks at Mono Lake over the 42-year study of a projected 375 fledged young lake wide in 2024.

INTRODUCTION

Mono Lake in eastern California is a large hypersaline lake of great ecological importance (Winkler 1977). Its large seasonal populations of endemic brine shrimp (*Artemia monica*) and alkali flies (*Ephydra hians)* provide important food resources for a large number of breeding and migratory birds. Mono Lake supports one of the largest breeding colonies of California Gulls (*Larus californicus*) in the world (Winkler 1996).

In 1983, Point Blue Conservation Science began standardized monitoring of the population size and reproductive success of California Gulls at Mono Lake. The goal of the project has been to use gulls as an indicator to help better understand the ecosystem and help guide long-term management of the lake. Specifically, we aim to track the long-term reproductive success and population size of the gulls through annual changing lake conditions and identify the ecological factors influencing fluctuations in these metrics. This study represents one of the longest-term ongoing studies of birds in North America. It serves as an important tool for evaluating the conditions at Mono Lake and holds immense value in comprehending how wildlife populations adapt to ecological changes that unfold gradually over extended periods, such as changing lake levels and climate change.

In 2024, we conducted the 42nd consecutive year monitoring the population size and reproductive success of California Gulls at Mono Lake. This marked the 5th year of censusing the gull nesting population and chick production by using high-resolution images captured using uncrewed aerial vehicles (UAVs). We continued to use the machine learning algorithm we developed in 2023 to assist in counting nesting gulls in 2024. In this report we provide results of the 2024 breeding season and provided updated long-term trends in the gull nesting population size and productivity.

Fig. 1. Locations of islands and islets within Mono Lake. The Negit Islets and the Paoha Islets had breeding gulls in 2024.

Fig. 2. Negit islets where the majority of California Gulls nest at Mono Lake (image from September 13 2019).

Fig. 3. The Paoha Islets with the western edge of Paoha island (image from September 13, 2019).

METHODS

Study Area

Mono Lake, California, USA, is located at 38.0° N 119.0° W in the Great Basin of eastern California at an altitude of 1945 m. The lake has a surface area of approximately 223 km^2, a mean depth of about 20 m, and a maximum depth of about 46 m. As a terminal lake with no outlet, it is high in dissolved chlorides, carbonates, and sulfates, and has a pH of approximately 10.

Gulls nest on a series of islands located within an approximately 14-km^2 area in the north-central portion of the lake. At various times the gulls have nested on Negit (103 ha) and Paoha (810 ha) islands. Over the last four decades, they have largely been confined to two groups of smaller islets referred to as the Negit and Paoha islets, which range in size from 0.3–5.3 ha (Figures 1-3; Wrege et al. 2006). The surface elevation of Mono Lake during the 2024 gull nesting season was approximately 6384 feet (1945.8m) above sea level (Mono Lake Committee data), higher than the previous three years but 8 feet below the State Water Board management level of 6392 feet (1948.3m).

Nest Counts

Aerial Surveys

In 2017, we began piloting a new standardized methods using aerial photography to count gull nests and chicks while continuing ground-based counts for calibration. This new methodology allowed for the population size to be measured without the disturbance involved in ground counts and with less effort. We used the ground-based counts to evaluate the accuracy of aerial counts and found aerial counts to be a good alternative to the ground counts, with results reflecting 90% - 100% of ground count tallies when photographs with sufficient detail were used for nesting adults. Thus, in

2020 we switched to remotely sensed data only, to minimize disturbance to nesting gulls and reduce effort to complete data collection to ensure this long-term study continued.

Prior to 2017 all data was based on ground-based counts of nesting gull colonies, for methods on these counts see previous reports (Nelson et al. 2016). From 2017 to 2019, we captured aerial images from an open window of a fixed wing aircraft (Cessna TR182) flying above the lake with a typical focal length of 100mm – 140mm used (See Nelson & Livingston 2019 for further details). In 2020, we transitioned to using a small UAV platform, deploying DJI Matrice 100 quadcopters each equipped with a Zenmuse X5 camera. The UAVs followed pre-programmed flight paths to capture complete photographic coverage of the target area. The path planning algorithm (Shah et al. 2020) planned routes that were flown autonomously, provided complete coverage of each islet, and were optimized to limit survey time and allow for safe recall of the UAVs at any time during the survey. The UAVs were launched from Java islet for surveys of the Negit Islets and Paoha for the Paoha Islets (Figures 4 &5). Pilots always maintained visual contact with the UAV during the flights. UAVs maintained a minimum altitude of 30 m above the ground and approached each nesting islet 70 m above the ground before descending to minimize disturbance to the gulls. In 2024, we began the use of DJI Mavic 3 Enterprise UAV's, a small quadcopter with longer battery life and a 20 MP camera.

An observer other than the pilot documented disturbance to gulls, osprey or any other birds from the UAV's for each survey. If disturbance had been noted during a survey, the flight path would have paused until birds had settled or moved away from the UAV. We noted no disturbance of nesting gulls or other birds during our surveys and only minor disturbance of non-nesting gulls which occasionally flushed from shorelines when the drone approached but then settled back quickly.

Figure 4. Flight planning routes and coverage of the Negit nesting islets from the base on Java used to acquire aerial imagery of gull nests and chicks.

Images collected during each survey were stitched together using the program Metashape (Agisoft LLC v1.6.3) to make a single, spatially referenced mosaicked image of each island ("orthomosaics"; Figures 6 & 7). Final images in 2024 had ~ 0.7 cm per pixel resolution. In 2024, imagery was captured for the nest count on May 30 and on July 12, for the chick survey.

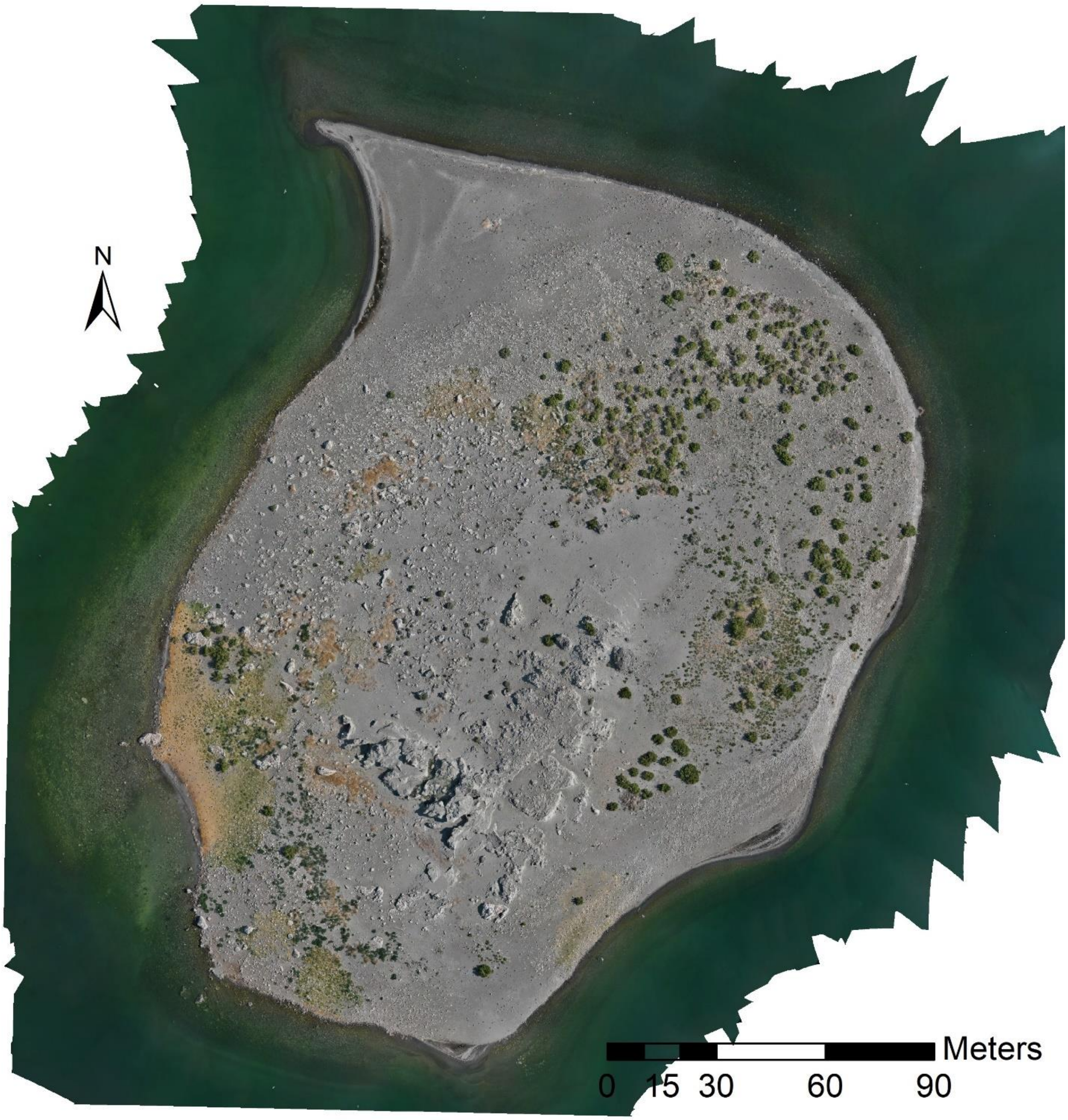

Figure 5. Mosaicked images of all of Twain islet from May 30, 2024 incubation survey.

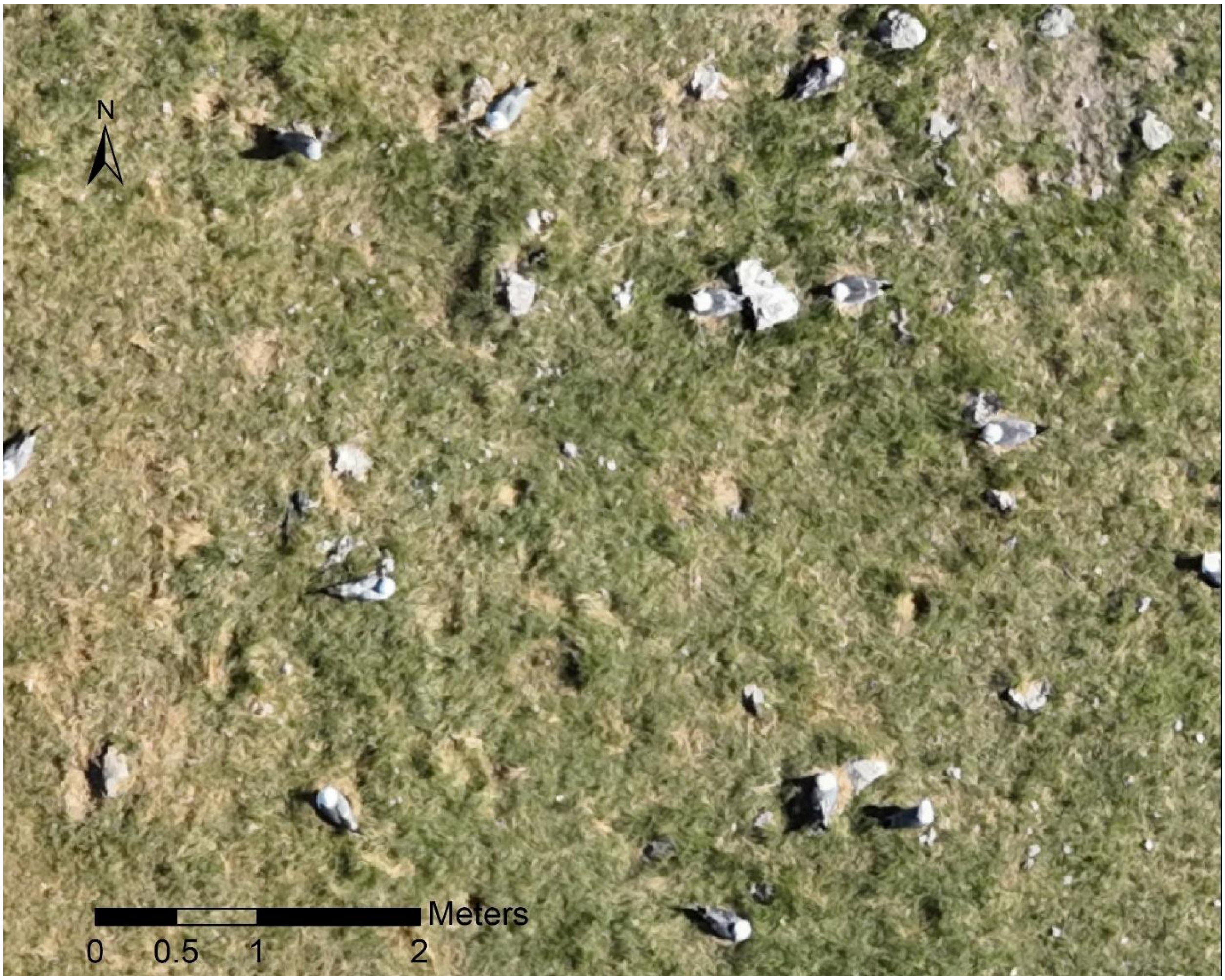

Figure 6. Zoomed image of Twain nesting grounds at the resolution used to count nests from the May 30, 2024 incubation survey. Note a number of adult gulls in incubation posture on nests and also the proliferation of vegetation on Twain islet as of 2024.

Counting Nests from Aerial Images

In 2024, we employed a YOLO v8 deep learning model (Varghese & M 2024) for automated nest detection from aerial imagery. Each orthomosaic was segmented into 512 x 256-pixel tiles with a 20-pixel overlap between neighboring tiles. The model was trained on a dataset comprising 5,469 tiles consisting of mostly 2023 imagery but including 549 newly labeled tiles from 2024 images. All tiles were annotated by the authors and differentiated between nesting, sitting, and standing gulls. Training was conducted over 150 epochs using four Tesla V100-SXM2-16GB GPUs. The trained model consists of 268 layers and 43,608,921 parameters, with a computational complexity of 164.8 giga floating-point operations per second (GFLOPS).

The 2024 model generated over 82,099 labels across these classes, each accompanied by a confidence estimate. More than half of these labels were assigned very low confidence, consisting of "gull-like" patterns in rocks and shadows, etc. Additionally, due to the 20-pixel overlap between adjacent tiles, designed to ensure complete coverage of individual gulls, many predictions were spatially redundant. To address this, we implemented a de-duplication script in R (4.2.1), retaining only the highest-confidence labels and eliminating overlaps.

To determine the optimal confidence threshold for the YOLO model in identifying gull nests, we conducted a visual comparison of predictions against ground truth labels provided by a human expert. The analysis was performed across a range of confidence thresholds from 0.3 to 0.75, based on prior empirical knowledge. Through this evaluation, we aimed to optimize the balance between precision (the proportion of true positive predictions among all positive predictions) and recall (the proportion of true positive predictions among actual positives).

Our findings indicated that a threshold of 0.2 yielded the highest precision without excessively compromising recall. Consequently, we applied a confidence threshold of 0.2, which resulted in a precision of 0.88, a recall of 0.46, and F1score of 0.60. Although this approach was conservative, prioritizing the reduction of false positives, it did result in the exclusion of true positive predictions. This trade-off was considered acceptable to enhance the overall reliability of the model in operational settings.

To enhance the accuracy of our YOLO model for identifying gull nests, we performed manual nest counts on a subset of locations. We counted all nests on Spot, Tie, Hat, Krakatoa, Pancake islets, the established long-term monitoring plots on Twain and

Little Tahiti, and randomly selected 20m x 40m calibration plots on Twain. Overall, this manual counting effort encompassed 1599 machine-counted nests. The manual counting found the model underestimated nest counts by 6.25% with a 0.6% false positive rate. To be consistent with 2023, and because the 0.6% is well within the observer variation we found, and the rate was much lower on Twain, we made no correction for the false positive rate. For the small islets we counted all nests and used exact nest counts. For the remaining we increased the machine counts by 6.25% to account for the false negative rate.

Clutch Size and Reproductive Success

Calculating Average Reproductive Success

We estimated the fledging rate for each plot and applied the average fledging rate to the entire population to estimate the total number of gulls successfully fledged from Mono Lake in 2023. The fledging rate for each plot **(fplot)** is calculated as:

$$fplot = (Cb) / Np$$

where **Cb** is the number of chicks counted in that plot in July, and **Np** is the number of nests counted in that plot in May. We calculated the total number of gulls successfully fledged **(F)** from Mono Lake as:

$$F = (N/P) \sum_{i=1}^{P} f_i$$

where **N** is the total number of nests on Mono Lake, **P** is the number of plots, and **fi** is the number of young fledged per nest in each of the plots (chicks counted and ½ a chick for each brooding adult). Overall chick production was estimated by multiplying the average reproductive success by the total number of nests.

The post-banding mortality count (counting the number of dead, banded gull chicks which had been banded in early July to measure the post-banding mortality rate) was dropped in 2017. We have since used the mean long-term post-banding mortality (13.2%) rate obtained from 2000 – 2016 data, as the annual variation in this metric was small and therefore contributed relatively little to variation in the annual reproductive success estimate. Because the few chicks we found in our July survey were all full grown, we chose not to apply the mortality factor into calculating the total fledged young in 2024. In 2024, there were no chicks found on the Paoha islets so we excluded those nests and reproductive rate from calculating the fledged rate and number of fledglings for the lake. Results are presented with plus or minus one standard error.

RESULTS

Number of Nests and Breeding Adults

In 2024, we estimated the gull nesting population was 20,258 based on a nest count of 10,129, a decrease of 4,362 birds from the active breeding population compared to 2023 and a more than 9,000-bird reduction from the five-year high of 29,450 in 2020. The 2024 breeding population was the smallest recorded in the 42 years of the study and well below the 1983 – 2023 average of 42,575 or the 2013 – 2023 average of 31,729. Twain islet continued to support most of the nesting population with 64% (6487 nests) of the 2024 total. This represented a nearly 2000 nest decrease from 2023, marking the fourth consecutive year the Twain nest numbers have declined from a five year high of 10,737 in 2020. The islets with the next highest nest counts were: Little Tahiti (1915), Pancake (816), and Little Norway (463). Coyote Islet, which had complete nest failure in 2022, saw nest numbers decline from 1015 in 2022 to 244 in 2023 to 168 in 2024.

Other islets with nest number decreases were Spot, Tie, Hat, and Pancake –the nesting area of these islets decreased substantially because of lake level increases in the past year. The nesting population lakewide has been declining on average by 323 nests per year over the 42 years of this study (Figure 8). The breeding population has now been below 30,000 birds for eight consecutive years, less than half the high count of 64,976 in 1992.

With the large recent decline in nests on Coyote islet, the proportion of lake wide breeding population that occurred on the Negit islets increased to 98.3% of the population (Appendix A).

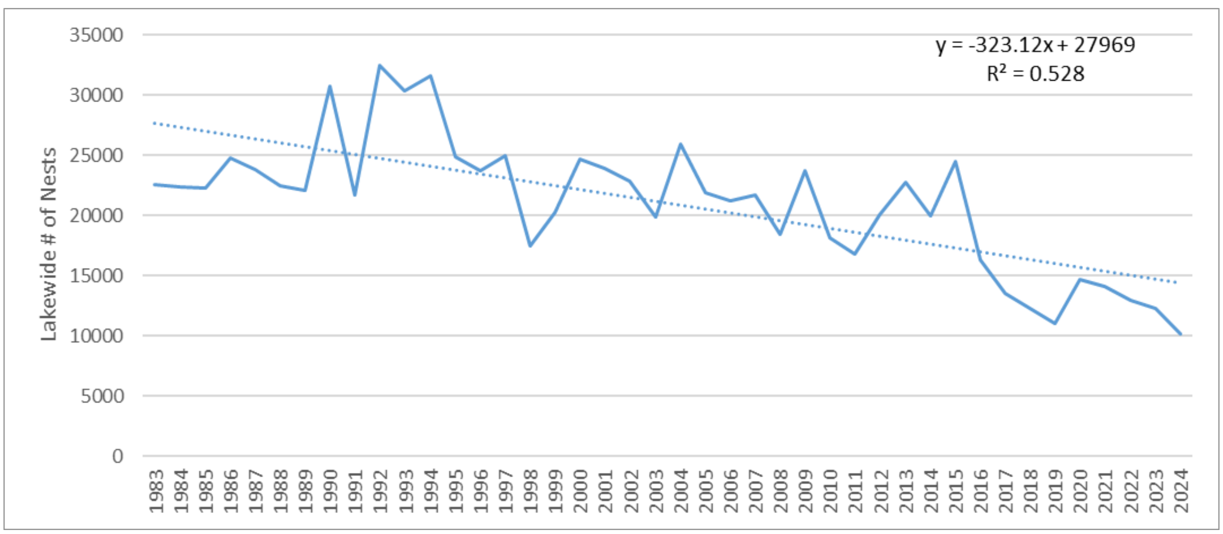

Figure 7. Number of California Gull nests at Mono Lake, 1983 – 2024 with linear trend line and associated regression equation.

Reproductive Success

The number of young fledged from Mono Lake was the lowest in recorded history in 2024 as a result of the smallest breeding population and lowest reproductive output in the 42 years of the study. The Negit Islet nest plots averaged 57 nests in 2024 and fledged an average of 0.033 ± 0.02 chicks per nest in 2024, by far the lowest ever documented at Mono Lake. The long-term average prior to 2024 was 0.83 chicks per nest. The previous low was in 2022 when 0.09 chicks fledged per nest. The Paoha Islet breeding population has crashed with only 20 nests within the two plots in 2024 and no chicks on the entire island in the 2024 imagery. The long-term reproductive success rate has declined at an average of 0.013 chicks fledged per nest per year across the 42 years of this study (Figure 9). Based on the total of 10,129 California Gull nests on May 30,

Table 2. Summary of nest and chick counts from all long-term nest plots using aerial surveys in 2024. Chick counts include ½ a chick for each brooding adult observed in imagery during July survey to correct for ground-based counts used in earlier years. We chose not to apply the 13% mortality rate in 2024 due to the advanced development of the chicks counted and the overall small number of chicks present. Lakewide estimates exclude

Plot	# nests in June	average # chicks/nest in July	# chicks in July	# estimated to die before fledging	Total successfully fledged/nest
Cornell	51	0.02	1.5	0	0.02
L. Tahiti East	17	0.00	0	0	0.00
L. Tahiti West	74	0.00	0	0	0.00
Twain North	71	0.00	0	0	0.00
Twain South	99	0.05	6.5	0	0.05
Twain West	23	0.09	5	0	0.09
Twain New	35	0.03	1	0	0.03
Spot	86	0.01	1	0	0.01
Negit Islet totals/averages:	**410**	**0.033 ± .02**	**15**	**0**	**0.033 ± .02**
Coyote Cove	0	0.00	0	0.00	0.00
Coyote Hilltop	20	0.00	0	0.00	0.00
Paoha Islet totals/averages:	**20**	**0**	**0**	**0.00**	**0.00**
Lake wide	**430**	**0.032 ± .02**	**16**	**0**	**0.032 ± .02**

and an average of 0.032± 0.02 chicks fledged per nest, we estimate 324 (± 203) young successfully fledged at Mono Lake in 2024. This total chick production is by far the lowest we have ever documented at Mono Lake. Fledgling production has declined on average by 500 fledglings per year across the 42 years of this study (Figure 10). Over the past 10 years (since 2015 the last time chick production was greater than 1 chick per nest) chick production has declined by 1261 chicks per year.

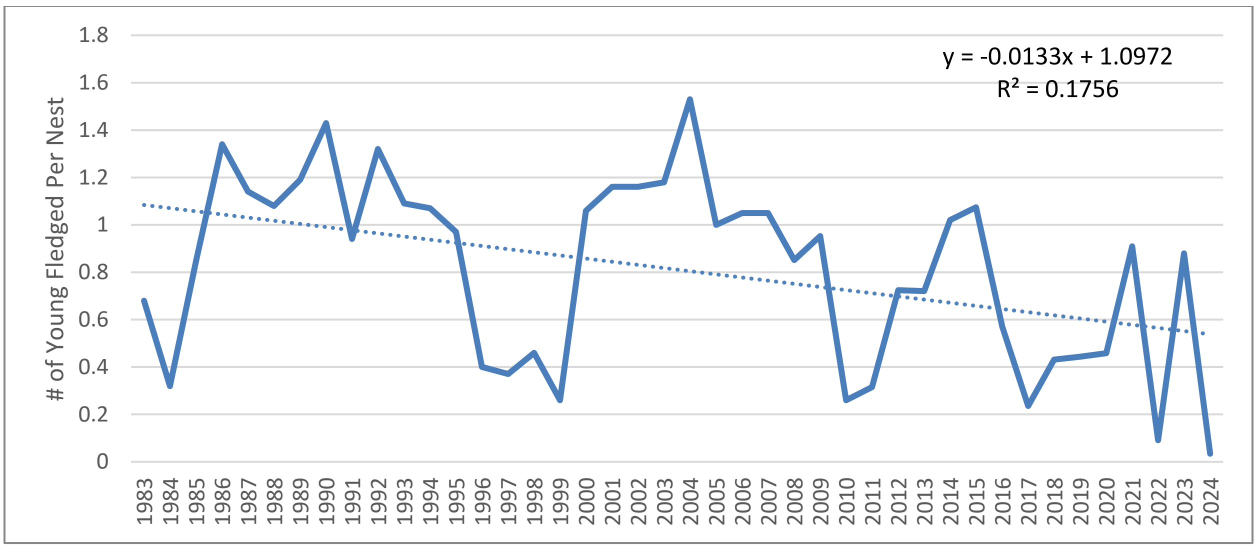

Figure 8. The estimated number of young fledged per nest at Mono Lake from 1983 – 2024 with linear regression line and equation.

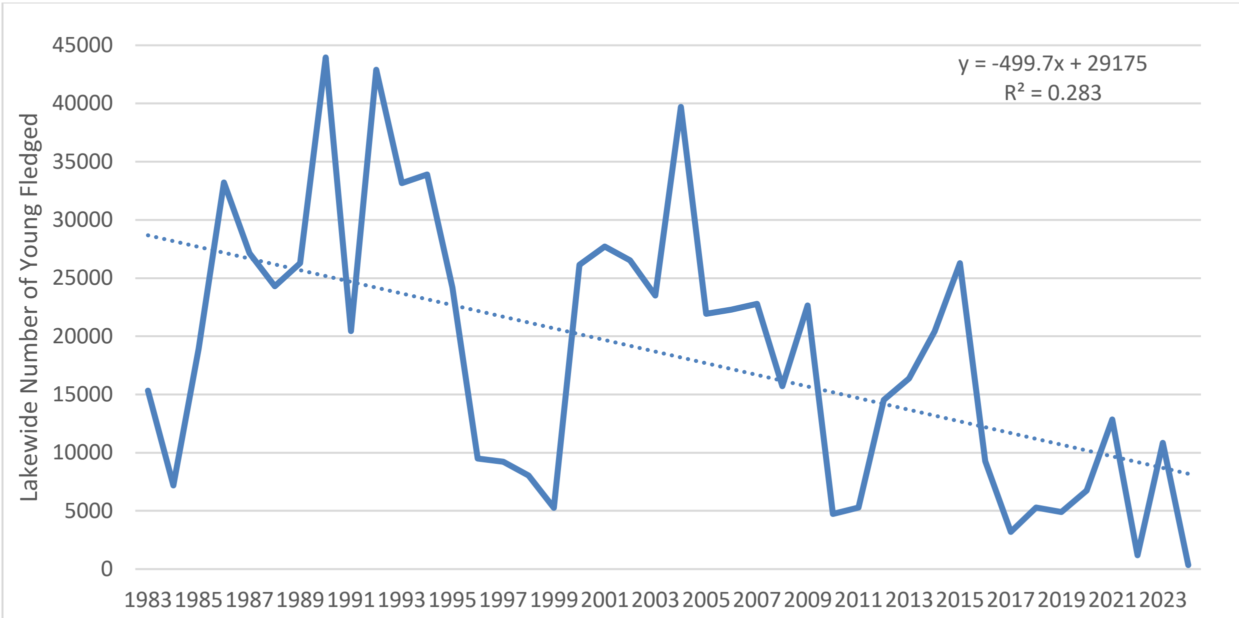

Figure 9. The estimated total number of young fledged from Mono Lake from 1983 – 2024 with linear trend and regression equation.

DISCUSSION

The nesting population size of California Gulls at Mono Lake has declined dramatically over the course of this long-term study. The 2024 breeding population was the smallest recorded since monitoring began in 1983. Despite substantial annual variation in nesting population at Mono Lake, there is a clear long-term declining trend in the population size. The number of nests has declined on average by 323 per year from 1983 - 2024. The 2024 nest number was just 31% of the high in 1992. We have written about factors that influence gull nesting numbers in past reports (Burnett et al. 2023). The low nest numbers and especially low productivity in 2024 are most likely caused by poor lake ecosystem productivity brought on by strong meromictic conditions. The historic winter 2022/23 snowpack in the contributing watersheds to Mono Lake, when April 1 snowpack exceeded 200% of the long-term average (CDEC 2023), led to a large runoff event and substantial increase in Mono Lakes elevation in 2023 (MLC data). While this lake level increase is critical to ensuring predator free nesting islands (Nelson et al. 2016), it often leads to short-term crashes in gull productivity as we predicted would be the case last year (Burnett et al. 2024). Nelson et al. found lake level increase the previous year explained the greatest amount of variance in the number of chicks produced, with fewer chicks produced following years with large freshwater inputs. While this decreased productivity was expected under the current artificially low lake levels, the magnitude of it was not. In previous periods following large freshwater input years, productivity was between 0.2 and 0.3 chicks fledged per nest. In 2024, chick production was 0.03 per nest, an order of magnitude lower than previous meromictic periods. It is not clear why gulls are less capable of producing young in recent poor lake productivity years than they have in the past. They also seem less capable of reaching the peak productivity levels seen in previous years when more productive lake conditions exist. From 1983 to 2015 productivity exceeded 1 chick per nest in over half of the years. Productivity has not exceeded 1 chick per nest since 2015. Also, the other recent poor productivity year, 2022, was not following a large freshwater input year. Further investigation of factors influencing gull productivity at Mono Lake, especially following the past decade of low productivity, could help inform lake management.

The production of chicks at Mono Lake is almost certainly directly tied to the lake's production of food resources the gulls rely on. In most years, brine shrimp (*Artemia monica*) are the primary source of food used by the gulls to provision their young (Wrege et al. 2001). In 2022 and 2024 the years with the lowest gull chick production on record, the peak abundance of brine shrimp was far lower, and the onset of exponential shrimp population growth was delayed, compared to relatively productive years in 2021 and 2023 (Figure 10). There is also evidence that in 2024 the biomass of the average brine shrimp was far less than in other recent years (Jellison and Melack unpubl. data). The lake conditions that resulted in these patterns in the shrimp population were not compatible with the gull's ability to raise young, leading to a near-complete breeding failure in two of the last three years. Further investigation into the relationship between brine shrimp metrics and gull productivity at Mono Lake and understanding factors that influence shrimp abundance, phenology, and biomass would be valuable to elucidating management strategies to reverse the decline in the gull population.

Springtime temperatures have also been found to influence gull productivity at Mono Lake, with colder springs resulting in lower chick production (Nelson et al. 2014). Spring 2024 was a relatively mild spring with the average daily high temperature for that two-month period equal to the 1981- 2000 average for that same period. In comparison, the average daily high temperature in 2023, a relatively good chick production year, was over 5F colder than 2024 with more than double the number of days with daily highs more than 5 F below the long-term average than 2024. Thus, it seems unlikely spring temperatures were a strong negative influence on gull productivity in 2024.

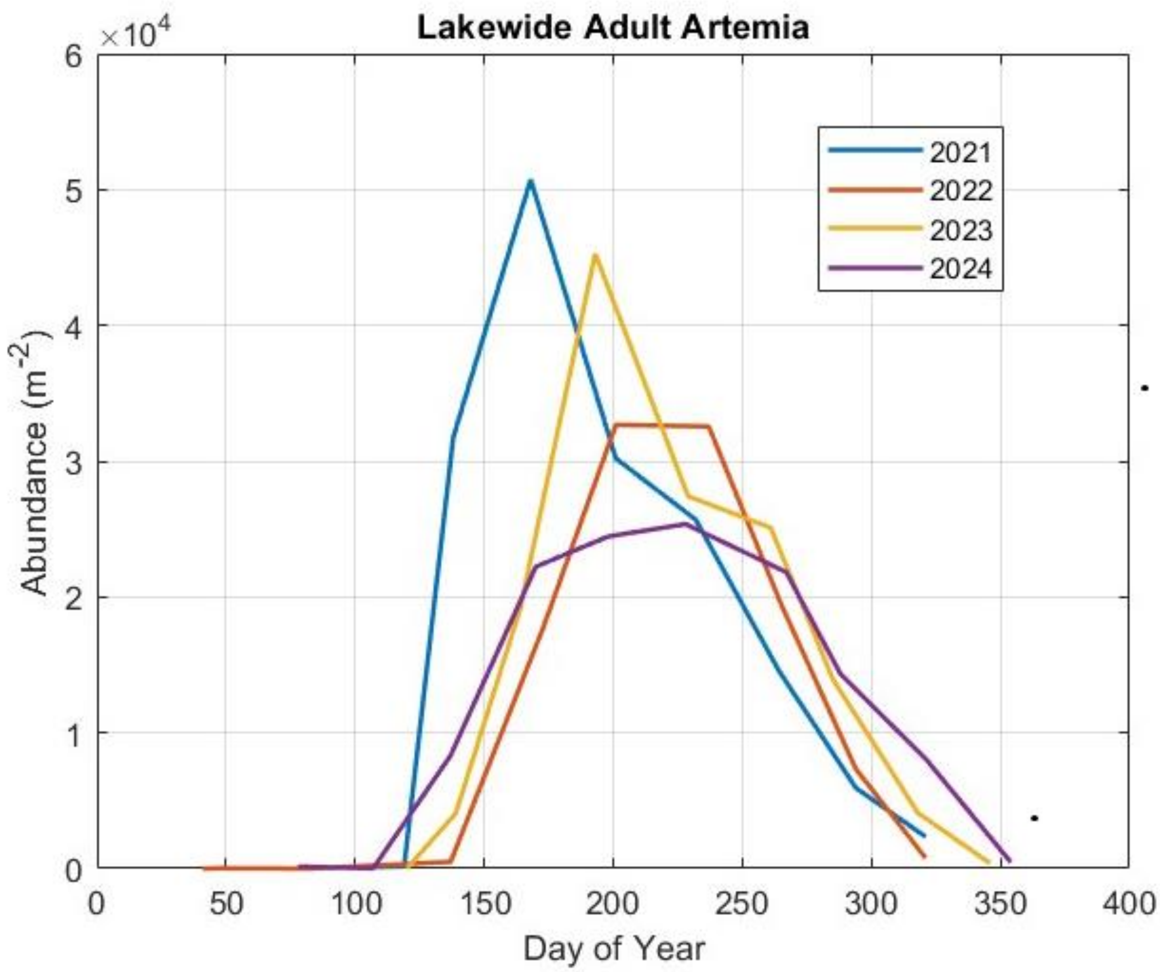

Figure 10. Abundance of adult brine shrimp (*Artemia monica*) in Mono Lake in 2021 – 2024 by day of year at Mono Lake. (Figure courtesy of R. Jellison & J. Melack)

There have been three pronounced meromictic related gull productivity crashes at Mono Lake since 2010. The frequency of meromictic conditions is likely a result of climate change driven increases in the frequency of extreme precipitation years in California coupled with lower lake levels that increase the sensitivity of the lake to stratification (Melack et al. 2017). In the last decade the Mono Basin has been swinging between extreme drought with occasional extremely high precipitation winters. The effect of freshwater export-driven lowered lake levels (increased salinity & reduced overall lake volume/surface area) likely increases the lakes’ vulnerability to stratification and may affect the persistence of it once it occurs.

We observed an increase in Bassia cover on nesting islets, especially Twain and Pancake in 2024. Twain has now seen annual decreases in nest numbers the last four years following a large increase in 2020 following *Bassia* removal in late 2019. Almost all of the nesting area above water levels on Pancake was covered in weeds, presumably *Bassia* in 2024 imagery and it has had a resurgence on Twain. Actions to remove the weed to increase suitable nesting substrate should be a priority in 2025.

We found some evidence that gulls fledged young earlier in 2024 than in previous years. We conducted the chick survey during the same period as previous years (July 12). The few chicks we did find in our reproductive plots were at an advanced stage of development (fully feathered). To evaluate if the low chick numbers could be the result of earlier than normal fledging, we counted all juvenile gulls along the shoreline of Twain, where the majority of recently fledged young congregate. We found 103 juveniles along the shoreline, greater than most years. We then conducted a cursory scan of the entirety of Twain islet where we found similarly low densities as on our reproductive plots. We also found very few juveniles on the shorelines of the other breeding islands. Thus, we conclude that early fledging may have contributed some to our productivity estimate but does not change our interpretation that 2024 was the lowest chick production on record. Considering over 6000 nests on Twain and that our plots sampled about 10% of all nests, if those 103 chicks were still at their nests, it would increase our chick count by less than 2 per plot and increase the overall chicks per nest from 0.033 to 0.059 and increase our estimate of chicks fledge across the lake from just 324 to just over 600. This still represent the lowest productivity year for the gulls in the long-term study. We also accounted for some of this early fledging by not reducing fledged numbers by the long-term post-survey chick mortality rate of 13.2%. We chose not to include this since the chicks we counted on the plots were almost all at fledging size, so that mortality would have largely occurred prior to our image capture in July. We plan to conduct the chick survey in 2025 a week earlier than we did in 2024, assuming spring conditions are like those in 2024, to avoid missing early fledged young. As climate conditions change at Mono Lake, tracking phenology of nesting will be important to properly monitor chick production. As we develop a machine learning model for chicks, we will be less reliant on plot specific data to extrapolate the reproductive output of the gulls.

We had intended to build an initial machine learning chick counting model with the 2024 data. Due to the extremely low number of chicks, the effort to complete this would not have been productive, as would have to scour the images in small tiles and record all the chicks as well as mark all those that have no chicks. Since we began flying new UAVs in 2024, we plan to build the model using data from both the old UAVs (2020 – 2023) and the new ones to improve predictive performance. We plan to work on this task following the 2025 season assuming there are sufficient chicks present to build the model.

We instead chose to work on improving the nest predictive model in 2024 because our false negative rate in 2023 was relatively high at 23%. We also began flying new UAV's with new cameras in 2024 that could affect model performance based on training with the old UAV images. We labeled 549 new tiles from the 2024 nest images combined with the thousands we marked previously from 2023. The result of this effort and fine tuning the parameters resulted in a model that was far more precise in 2024 at identifying gull nests. Based on manual count (lead author counting nests in random plots) we determined the false negative rate for the new model was 6% and the false positive rate was still under 1%. This is a large improvement from the 23% false negative rate from 2023. We will continue to refine the model in future years to continue to improve its accuracy.

While the large freshwater inputs from 2023 have affected productivity, the increase in lake levels in 2023 has raised lake levels such that the probability of terrestrial predator access has been diminished for the time being. Sustaining these higher lake levels and ensuring lake levels will remain higher through the inevitable next drought, will be important to efforts to reverse the long-term decline in California Gull breeding population at Mono Lake.

This is one of the longest continuous studies of birds in North America and its value to avian ecology extends beyond its utility to informing management of the Mono Lake ecosystem. Sustaining these long-term studies is challenging. We continue to innovate solutions to continue this study effectively and efficiently.

CONCLUSIONS

The Mono Lake California Gull population is declining. Continued steep declines in the number of nests and number of young fledged over the 42-year period of the study have resulted in a gull population that is about half the size that it was during the peak numbers (mid 1990's). Mono Lake, with its State Water Board public trust water right provisions and its permanently protected status as part of the Mono Basin National Forest Scenic Area and Mono Lake Tufa State Natural Reserve, is of critical importance for the persistence of California Gulls in California. Measures taken to ensure high quality nesting habitat (predator & weed free) and high lake productivity to provide ample food for the gulls, including increasing the resilience of the lake to meromictic conditions, may help reverse declines in this population and ensure California Gulls can thrive at Mono Lake. Additional studies to evaluate factors influencing these declines (food availability, lake phenology, predator activity, disease) would be useful for prioritizing management actions.

LITERATURE CITED

CDEC 2023. DWR (California Department of Water Resources). Snow Course Measurements for April 2023. Accessed from the California Data Exchange website on December 4, 2023. https://cdec.water.ca.gov/reportapp/javareports?name=COURSES.202304

Melack, J.M., R. Jellison, S. Macintyre, and J.T. Hollibaugh. 2017. Mono Lake: Plankton dynamics over three decades of meromixis or monomixis. 10.1007/978-3-319-49143-1_11.

Nelson, K. N., L. J. Roberts, W. D. Shuford, and R. D. Burnett. 2014. Environmental influences on reproductive success of California gulls at Mono Lake, California, U.S.A. Contribution No. 1981, Point Blue Conservation Science, 3820 Cypress Dr. #11, Petaluma, CA 94954.

Nelson, K. N. 2016. Population size and reproductive success of California Gulls at Mono Lake, California. Contribution No. 2108, Pt Blue Conservation Science, 3820 Cypress Dr. #11, Petaluma, CA 94954.

Nelson, K.N. & N. Livingston. 2019. Population size and reproductive success of California Gulls at Mono Lake, California. Contribution No. 2269, Pt Blue Conservation Science, 3820 Cypress Dr. #11, Petaluma, CA 94954.

Shah, K., G. Ballard, A. Schmidt, M. Schwager. 2020. Multidrone aerial surveys of penguin colonies in Antarctica. Science Robotics 5: eabc3000.

Varghese and S. M., "YOLOv8: A Novel Object Detection Algorithm with Enhanced Performance and Robustness," 2024 International Conference on Advances in Data Engineering and Intelligent Computing Systems (ADICS), Chennai, India, 2024, pp. 1-6, doi: 10.1109/ADICS58448.2024.10533619.

Winkler, D.W. 1977 (ed.). An ecological study of Mono Lake, California. Institute of Ecology Publication 12. University of California, Davis.

Winkler, D. W. 1996. California Gull (*Larus californicus*). *In* The Birds of North America, No. 259 (A. Poole and F. Gill, eds.) The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Wrege, P.H., J.M. Hite, & D.W. Winkler. 2001. The diets of California gull nestlings at Mono Lake: seasonal and diurnal variation. Point Reyes Bird Observatory. 4990 Shoreline Hwy. Stinson Beach, CA. Contribution No. 939.

Wrege, P. W., W. D. Shuford, D. W. Winkler, and R. Jellison. 2006. Annual variation in numbers of breeding California Gulls at Mono Lake, California: The importance of natal philopatry and local and regional conditions. Condor: 108:82-96.

Appendix A. Nest number by islet, 2010 – 2024.

Negit Islets	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Twain	8219	8704	9396	9567	9144	12263	7760	7672	7639	7601	10737	9936	9094	8478	6487
L. Tahiti	2429	2049	3366	3995	3899	4258	2923	1795	1860	1230	1291	1530	1229	1680	1915
L Norway	114	171	390	493	384	505	284 [c]	163	220	185	467	496	356	289	463
Steamboat	509	579	871	1175	1076	1010	675	217	143	120	115	114	61	33	100
Java	367	432	325	234	216	439	60	0	0	0	0	0	0	3	0
Spot	122	151	39	95	162	184	144	55	36	59	104	163	208	184	86
Tie/Hat	55	65	54	86	94	206	191	51	63	38	23	69	47	53	29
Krakatoa	2	0	12	9	12	84	38	40	73	50	81	59	27	13	4
L. Tahiti Minor [c]	151	162	253	282	255	202	116	64	64	63	62	68	68	40	60
Pancake	1894	1741	1972	2450	1903	3159	2497	1814	1099	778	709	558	756	1289	816
Negit Islets Total	13862	14054	16678	18386	17149	22317	14704	11890	11215	10128	13589	12993	11846	12062	9960
Paoha Islets															
Coyote	1711	929	1393	2093	2618	2042	1432	1505	1038	892	1014	1063	1015	244	168
Browne	116	50	60	75	110	87	146 [c]	152	38	55	41	49	69	17	1
Piglet	997	599	344	148	38 [b]	0	0	0	0	0	81	6	0	0	0
Paoha Islets Total:	2824	1578	1797	2316	2766	2129	1578	1657	1076	947	1136	1118	1084	261	169
Negit Island:	0	0	7	8	28	16	0	0	0	0	0	0	0	0	0
Old Marina	1496	1133	1541	1665	9 [b]	0	0	0	0	0	0	0	0	0	0
O.M. So.	4	9	36	380	70 [b]	0	0	0	0	0	0	0	0	0	0
Lake wide Total	18186	16774	20059	22755	20022	24462	16282	13547	12291	11075	14725	14111	12930	12323	10129
Nesting Adults	36372	33548	40118	45510	40044	48924	32564	27094	24582	22150	29450	28222	25860	24646	20258