Point Blue Report

Population size and reproductive success of California Gulls at Mono Lake: 2023

Annual Report

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Cover photo: Gull flying over Mono Lake in Spring (photo taken in May 2000). Photo by Annie Schmidt

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EXECUTIVE SUMMARY

Point Blue conducted the 41st consecutive year of monitoring the California Gull (*Larus californicus*) breeding population on Mono Lake in 2023. We estimated the breeding population size and chick production by counting nesting gulls from high resolution aerial photographs obtained from uncrewed aerial vehicles (UAV's). In 2023 we piloted the use of a machine learning algorithm we trained to count nesting gulls from aerial imagery.

In 2023, we estimated the gull nesting population was 24,646 based on a nest count of 12,323, a decrease of 1414 breeding birds from the 2022 estimate. The 2023 breeding population was the third smallest recorded in the 41 years of the study and well below the 1983 – 2022 average of 43,024 or the 2010 – 2022 average of 33,418. Twain islet continued to support the majority of the nesting population with 8478 (68.8%) nests in 2023, a 616 nest decrease from 2022 and the third consecutive year the Twain nest numbers have declined modestly. The islets with the next highest nest counts were: Little Tahiti (1680), Pancake (1288), and Little Norway (289). Coyote Islet, which had complete nest failure in 2022, saw nest numbers decline from 1015 in 2022 to 244 in 2023.

In 2023, chick production (chicks/nest) from our sample plots was 0.86 ± 0.1. This was a large increase from the historically low 2022 production of 0.09 chicks/nest. The 2023 productivity was in line with the long-term average from 1983 – 2022 of 0.83 chicks/nest. The average productivity coupled with historically low nesting population resulted in below average total chicks produced but the second most since 2016 and nearly 10,000 more than the unprecedentedly poor 2022 chick production.

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 2023, we conducted the 41st consecutive year monitoring the population size and reproductive success of California Gulls at Mono Lake. This marked the 4th year of censusing the gull nesting population and chick production by using high-resolution images captured using uncrewed aerial vehicles (UAVs). We developed a machine learning algorithm to assist in counting nesting gulls and deployed this tool for the first time in 2023 to assist in the gull count. In this report we provide results of the 2023 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 2022.

Fig. 2. Negit islets where the majority of California Gull at Mono Lake (image from July 2022).

Fig. 3. The Paoha Islets with the western edge of Paoha island (image from July 2022).

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 three 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 2023 nesting season was higher than the previous two years at about 1944.7 m (6380 – 6381 feet) above sea level during the gull nesting season (Mono Lake Committee data), 11 to 12 feet below the State Water Board management level of 6392.

Nest Counts

Aerial Surveys

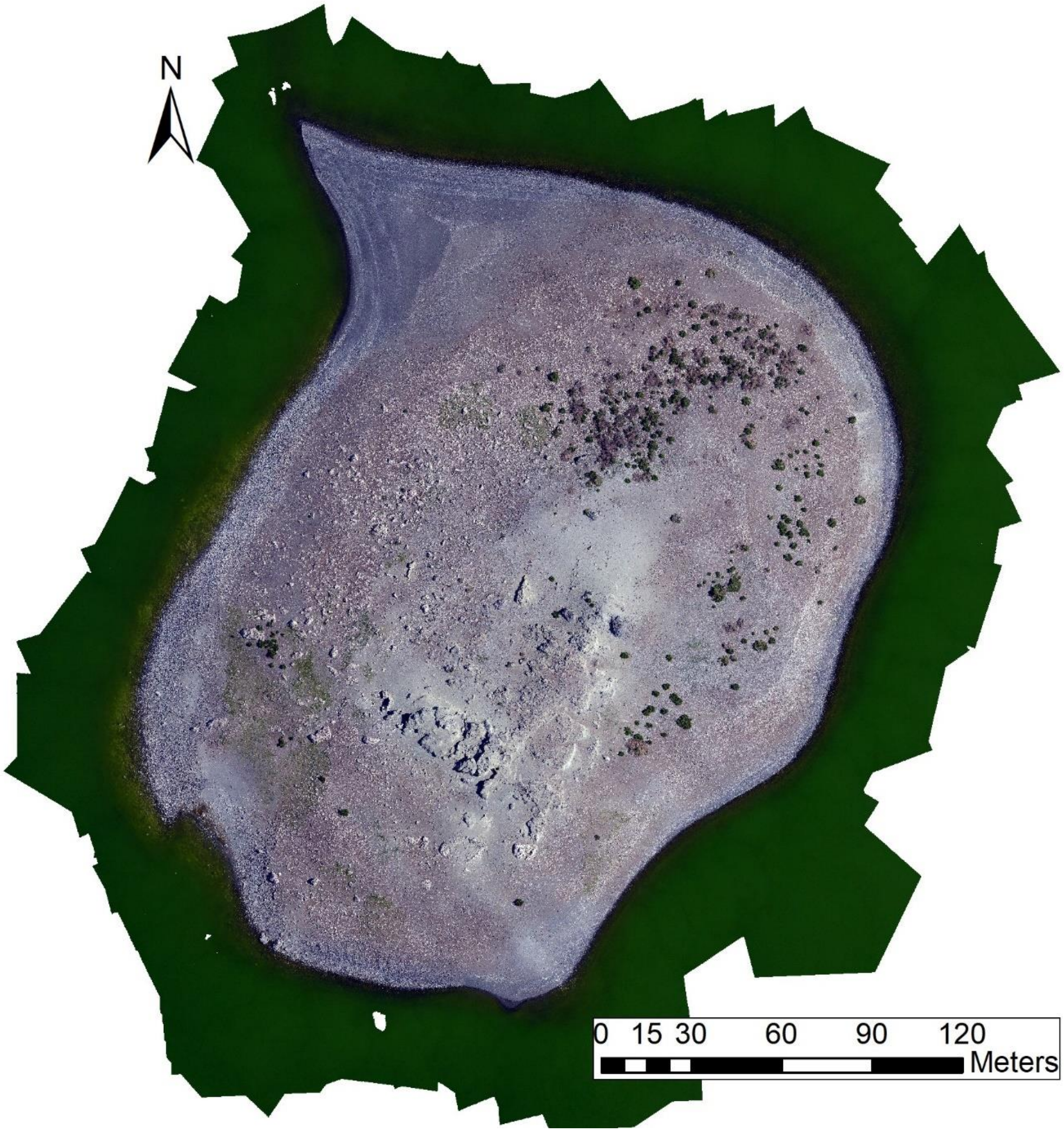
In 2017, we began piloting a new standardized method using aerial photography to count gull nests and chicks while continuing ground-based counts. This new methodology allowed for the population size to be measured without the disturbance involved in ground counts and with less effort. We used the ground-based 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.

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 from Paoha for the Paoha Islets (Figures 4 &5). Pilots maintained visual contact with the UAV at all times 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.

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 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 islet in 2020.

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 2023 had ~ 0.7 cm per pixel resolution. Imagery was captured for the nest count on June 1 in 2023 and July 12, 2023 for the chick survey.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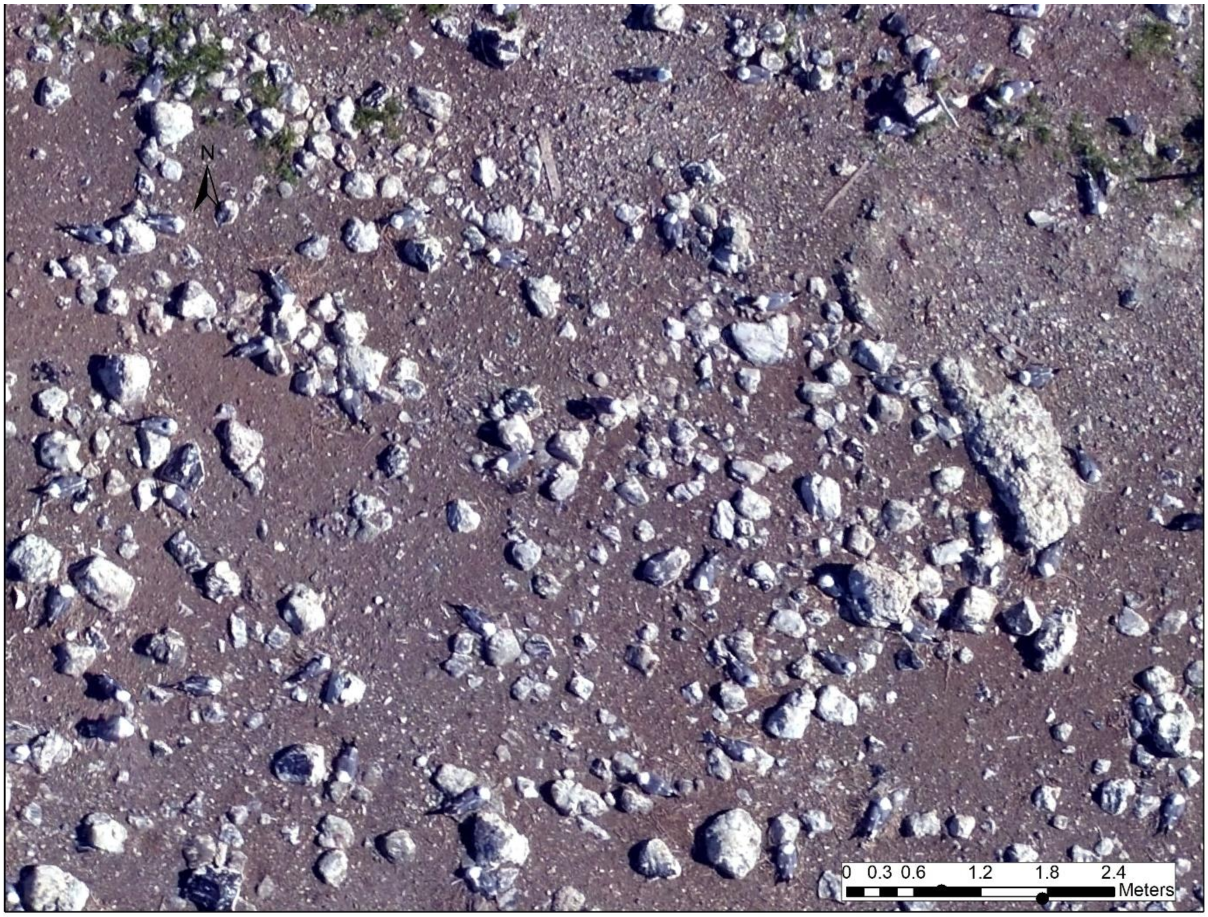

Figure 6. Mosaicked image of Twain islet from June 1, 2023 incubation survey (above) with a zoomed in view (below) showing nesting (and a few standing) gulls in the Twain South nest plot.

Counting Nests from Aerial Images

In 2023, we employed the YOLO v5 machine learning algorithm (Jocher et al. 2020) for an initial gull nest count. The algorithm, trained on 3684 tiles and tested on 788 tiles, was derived from imagery previously annotated for gulls (Burnett et al. 2022). These tiles, measuring 512x256 pixels, were used to train the model to find and distinguish between three gull behaviors: nesting, sitting, and standing.

The model generated over 50,000 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" pattern 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 0.6 yielded the highest precision without excessively compromising recall. Consequently, we applied a confidence threshold of 0.60, discarding all predictions below this value. 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 targeted islets with smaller nesting populations (fewer than 300 nests) and established long-term monitoring plots on Twain and Little Tahiti islets. Additionally, we conducted counts within randomly selected 20m x 40m plots across Twain, Little Tahiti, and Pancake islets, which host the largest nesting numbers. Overall, this manual counting effort encompassed over 800 nests, representing approximately 7% of the total nest number.

The decision to cease manual counting was based on achieving a consistent correction factor—the percentage by which the model underestimated nest counts—which stabilized at 23% across all nesting sites, and specifically 22.2% on Twain Island. The difference between applying these two correction factors to our model's lake wide nest estimates was minimal, less than 100 nests, a discrepancy well within the error margins of traditional aerial or ground counting methods previously utilized.

Given these findings, we adjusted the YOLO model's nest counts upward by the determined correction factors to refine the reported nest numbers. This adjustment ensures that our model's estimates closely reflect actual nest counts.

Clutch Size and Reproductive Success

Calculating Average Reproductive Success

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. We conducted a visit to both Twain and Little Tahiti islets in early September 2023 to assess chick morality and check islets for any signs of predation following the poor chick production in 2022. We walked each nest plot and counted the number of dead chicks within the plot and scanned shorelines for mortality among birds that would have fledged. We found a small number of dead chicks (3 – 8) per nest plot, but almost all of these were small and would have died prior to the July 12th UAV survey. Based on observations on Twain and Little Tahiti, it appeared the number of dead fully feathered young was below the 13% long-term average we have used in determining 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:

$$fplot = (Cb - Cd) / Np$$

where **Cb** is the number of chicks counted in that plot in July, **Cd** is the number of chicks from that plot that were estimated to have died after being counted 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 fenced plots. In 2021 the fledging rate for Paoha and Negit plots was similar, so we used all plots to estimate the number of young fledged from all nests. Overall chick production was estimated by multiplying the average reproductive success by the total number of nests. Results are presented with plus or minus one standard error.

RESULTS

Number of Nests and Breeding Adults

The orthomosaics generated from the UAV surveys are available from https://mono-lake-gulls.s3.us-west-2.amazonaws.com/Mono_Lake_2023/2023-06-01/orthomosaics/ . In 2023, the estimated gull nesting population was 24,646 based on doubling the nest count of 12,323 compared to 12,930 nests in 2022 and 14,111 nests in 2021. The 2023 nest number represented the third lowest nest number in the 41-year history of this study, ahead of only 2018 and 2019 where 12,291 and 11,075 nests were counted respectively.

Nest numbers by islet varied more in 2023 compared to recent years with a 7% decrease on Twain from 2022, a 76% reduction on Coyote, a 70% increase on the Pancake and a 37% increase on Little Tahiti. The small colonies on Krakatoa and Steamboat also continued their recent declines. The 1983 – 2022 average nesting population was 43,023 ± 1575. The nesting population has been declining on average by 307 nests per year over the 41 years of this study (Figure 8). The breeding population has now been below 30,000 birds for seven consecutive years, less than half the high count of 64,976 in 1992.

Twain continued to support the largest nesting concentrations on the lake with 68.8% of all nests in 2023, followed by Little Tahiti with 13.6%, and Pancakes with 10.46%. Steamboat, which supported over 1000 nests as recently as 2013, had only 33 nests in 2023, continuing the decline of this islet's nesting numbers.

With the large decline in nests on Coyote islet, the proportion of lake wide breeding population that occurred on the Negit islets increased to 97.9% of the population (Appendix B).

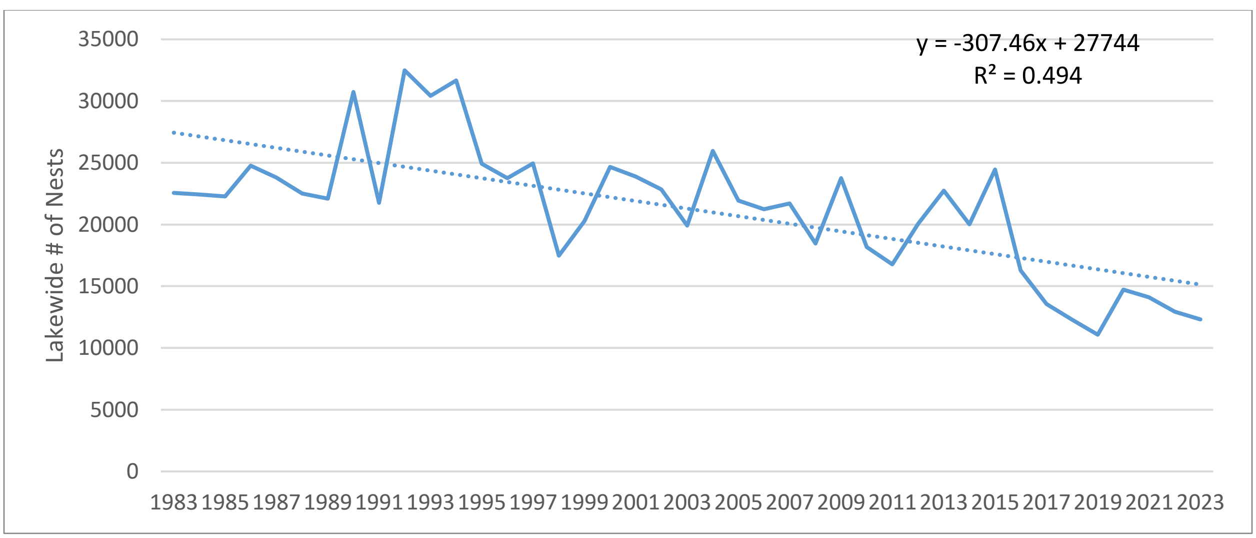

Figure 8. Number of California Gull nests at Mono Lake, 1983 – 2023 with linear trend line and associated regression equation.

Reproductive Success

The Negit Islet plots averaged 79.2 nests per plot in 2023, an increase of seven nests per plot from 2023. The Negit Islet plots fledged an average of 0.88 ± 0.05 chicks per nest in 2023, above the 40-year long-term average of 0.83, and a large increase from the historically low 2022 production. The Paoha Islet plots (both on Coyote) averaged 17.5 nests per plot in 2023 with 0.25 chicks fledged per nest. The lake-wide estimate of chick production was 0.86 ± 0.09 chicks fledged per nest.

The long-term reproductive success rate has declined at an average of 0.01 chicks fledged per nest per year across the 41 years of this study (Figure 9).

Table 2. Summary of nest and chick counts from all Negit islet plots using aerial surveys in 2023. Chick counts include ½ of the brooding adults observed in imagery during July survey to correct for ground-based counts used in previous years.

Plot	# nests in June	average # chicks/nest in July	# chicks in July	# estimated to die before fledging	Total successfully fledged/nest
Cornell	73	0.92	67	8.58	0.80
L. Tahiti East	12	0.83	10	1.32	0.72
L. Tahiti West	97	1.13	109	14.39	0.98
Twain North	71	0.92	65	8.18	0.80
Twain South	107	1.24	132	17.29	1.08
Twain West	26	0.87	22	2.64	0.76
Twain New	64	0.83	53	7.00	0.72
Spot	184	0.99	182	24.02	0.86
Negit Islet totals/averages:	**634**	**1.00 ± .10**	**641**	**83.42**	**0.88 ± .045**
Coyote Cove	11	0.27	3	0.40	0.24
Coyote Hilltop	24	0.29	8	0.92	0.25
Paoha Islet totals/averages:	**35**	**0.28 ± .001**	**11**	**1.32**	**0.25 ± .008**
Lake wide	**669**	**0.98 ± .10**	**652**	**84.74**	**0.86 ± .09**

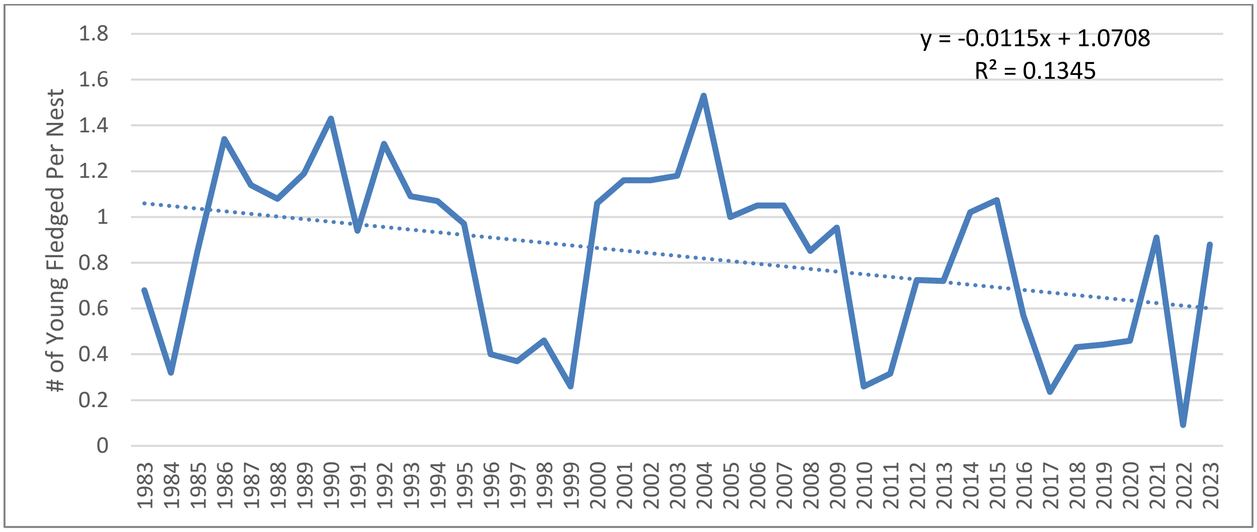

Figure 9. The estimated number of young fledged per nest at Mono Lake from 1983 – 2023 with linear regression line and equation.

Based on the total of 12,323 California Gull nests in early June, and an average of 0.88 ± 0.05 chicks fledged per nest, we estimate 10,844 (± 1789) young successfully fledged at Mono Lake in 2023. This total chick production is the second highest since 2015 exceeded only by 2021 during that time frame. Fledgling production has declined on average by 471 fledglings per year across the 41 years of this study (Figure 10).

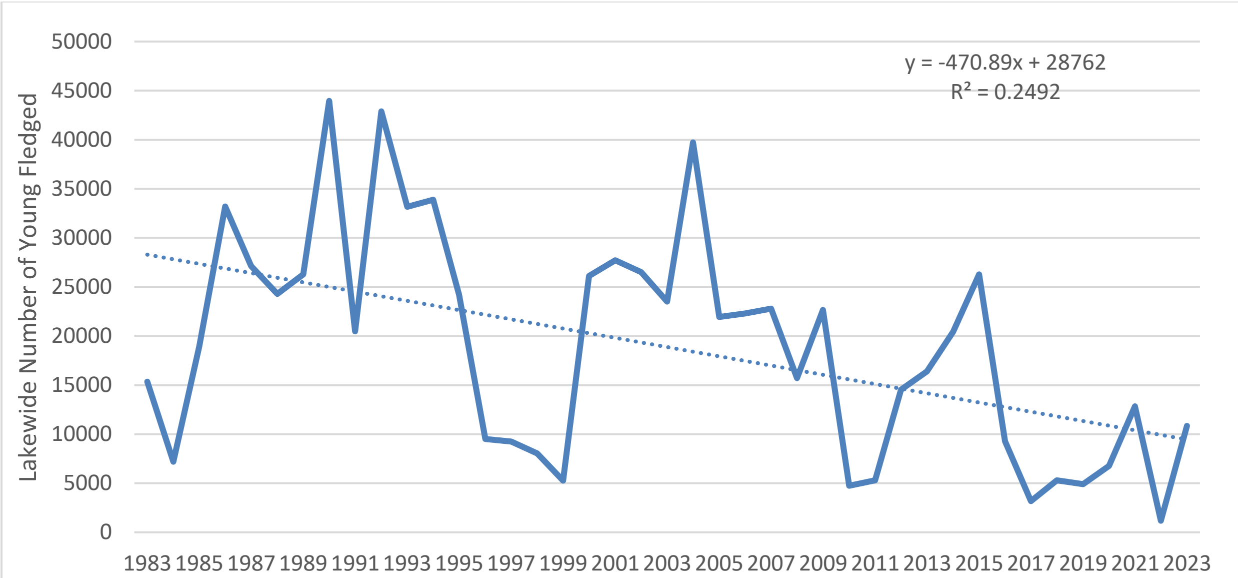

Figure 10. The estimated total number of young fledged from Mono Lake from 1983 – 2023 with linear trend and regression equation.

DISCUSSION

The nesting population size of California Gulls at Mono Lake has declined dramatically over the course of this long-term study, a period where lake levels have fluctuated from 6372 – 6385, well below the management level agreed upon for a healthy lake ecosystem of 6392. The 2023 nesting population was the third lowest recorded during the 41 years of this study. 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 307 per year and the population is now less than half its historic high. Wregge et al. (1996) evaluated factors influencing gull nesting population size at Mono Lake and found abundance of shrimp, the number of chicks produced 4 years prior, April temperatures, and the phase of the Pacific Decadal Oscillation were significant predictors of gull nest numbers. The April temperatures this year were anomalously cold, with Mono Basin daily maximum temperatures 3 to 5 degrees F colder than historic averages (PRISM data), following a historic snowpack last winter.

These cold temperatures likely contributed to the reduction in nesting gulls this year. As of writing this report, shrimp abundance data were not available for Spring 2023, but we know in 2022 spring shrimp peak abundance was delayed and a likely factor in the historically poor reproductive success we found last year (Burnett et al. 2023). The potential for trophic mismatches due to altered phenology, in particular spring shrimp abundance, may very well be playing a role in the decline of the Mono Lake California Gull nesting population. Understanding when these mismatches occur and the drivers of them is worth further study for a system that is being altered by both climate change and a century of water diversions. A greater understanding of the drivers of shrimp phenology and its importance to gull productivity could help better manage the system for a sustainable California Gull population and overall lake ecosystem.

As a long-lived species, with delayed onset of first breeding (Winkler 1986), poor chick productions effects on the population size lags. Wrege et al. (1996) found that the number of chicks produced 4 years prior was a significant predictor of the gull nesting population at Mono Lake. Four years ago (2019) chick production was the second lowest on record (prior to 2022) and 2018 and 2017 were very poor as well. We don't know the current age structure of the Mono Lake California Gull population but poor productivity from 2017 – 2019 is likely a major contributing factor to the population's decline in the last two years. The unprecedented low productivity in 2022 is likely to apply further downward pressure on the trend in gull nesting population starting in 2026.

While the historic low productivity in 2022 would not directly contribute to lower nest numbers in 2023, poor conditions for chick rearing in 2022 could have led to reduced nesting populations this year. Lingering fitness costs to adults trying to raise young with insufficient resources last year could influence gull decisions to breed in 2023. Parental effort to raise chicks comes at a direct cost to adults. Higher levels of reproductive effort have been found to be associated with higher adult mortality in California Gulls (Pugesek 1983). We observed an elevated rate of dead adults in July 2022 images of the nesting islands with over 40 dead adults on Twain islet alone (Burnett et al. 2023). This elevated mortality may have been an indicator of the costs of trying to raise young in conditions with insufficient resources. Additionally, reproductive related stress resulting in lowered adult fitness, could carry over to the following breeding year thus reducing the number of gulls attempting to breed. Lake productivity has both short and long-term effects on the California gull population at Mono Lake.

The negative trend in the number of chicks fledged per nest at Mono Lake over the 41 years of the study is one likely driver of population decline. Chick production has been reduced by both a decrease in the amplitude of high productivity years and an increased frequency of poor productivity years. Since 2010, in only 2 years has gull productivity been above 1 chick per nest. In the 27 years prior, productivity exceeded this value 55% of the time. Since 2010 chick production has been below 0.5 chicks per nest 36% of the time (5 years). Prior to 2010 it was below this level 5 out of 27 years or 19% of the time. The poor years are almost all associated with meromictic conditions (except 2022), with two prolonged periods in the last 13 years (Nelson et al. 2014). The frequency of meromictic conditions is likely a result of climate change driven increases in the frequency of extreme precipitation years in California. 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) is not known but likely increases the lake vulnerability to stratification and may affect the persistence of it once it takes place.

The drivers of the decreased amplitude of peak productivity are less clear but may be a more important indicator of the health of Mono Lake. We don’t know if gulls are laying fewer eggs, fewer eggs are hatching, or if fewer young are surviving to be counted in July; this information would provide important clues to identify the cause. However, a likely factor is a reduction in adult gulls' ability to efficiently procure food for their young. California Gull diet fed to chicks is quite diverse at Mono Lake and can vary between years (Wregge et al. 2001). Primary prey fed to chicks in that study; in order of frequency fed; included brine shrimp, alkali flies, cicadas, long-legged flies, and garbage. Repeating this diet study would provide insight into potential effects of food availability. While garbage was a relatively small portion of the gull diet fed to chicks, it is not known how of their diet it comprised prior to changes in landfill management that made it more difficult for gulls to acquire human garbage. These changes in landfill management occurred in the late 1990's prior to the diet study (Bartshe Miller pers. Comm.). Gulls are well known to be opportunistic feeders that readily forage at landfills and food availability at landfills has been shown to be a predictor of gull population growth rates in other species (Duhem et al. 2007). Changes in landfill management in the Mono Basin in the last two decades may be a factor in reduced gull productivity at Mono Lake.

The 2022/2023 winter produced a record-setting snowpack in the Mono Basin watershed with all stations reporting April 1 snowpacks over 200% of normal (CDEC 2023), resulting in very high runoff and an over four-foot rise in Mono Lake water elevation by the end of 2023 (MLC data). While these lake level increases are important to protecting nesting islands from terrestrial predators (Nelson et al. 2016), Mono Lake is almost certain to enter another period of persistent stratification in Spring 2024. The freshwater inputs were so substantial and the lake level prior to these inputs was so low (increasing salinity and the salinity gradient between the lake and freshwater) that we would predict the lake to incur stratification that is likely to last multiple years based on previous similarly large freshwater input years (e.g. 2017). These periods of meromixis result in decreased gull productivity at Mono Lake (Nelson et al. 2014). They found the single strongest predictor of gull productivity at Mono Lake was a negative relationship with freshwater inputs (lake level rise) the previous year. As we have written before, the gulls appear stuck between a rock and a hard place. Good mixing occurs in years when freshwater inputs are low to moderate, but lake levels decline and probability of predators accessing the nesting islands increase (e.g. 2016) and years in which lake levels have risen sufficiently to minimize the predator access but the lake productivity is poor (e.g. 1984, 1998 – 2000, 2018 – 2020). It will be important to sustain these higher lake levels to reap the benefits of protected nesting habitat once lake mixing occurs and gull productivity increases. In this period of extreme swings in annual precipitation managing lake levels at the management level would provide a buffer against future droughts and potentially reduce the lakes susceptibility to prolonged stratification.

The declining trend in Mono Lake California Gull nesting population may be influenced by other factors besides the decline in chick production. Survival (adult and juvenile) and emigration away from the colony may be contributing to the population decline, without further study it is not possible to evaluate the importance of these vital rates on population decline. But, if gulls are choosing not to return to natal grounds to breed, or adults that previously have bred at Mono lake choose to leave it is an indicator that habitat quality has declined.

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. To those ends, we have been developing a machine learning algorithm to automate the tedious task of counting individual gulls and chicks from aerial images. We were able to realize a 75% reduction in effort to count nests in 2023 by using the predictions from the algorithm to assist in this task. The algorithm will need further improvements going forward as its precision is still below what we would prefer (80% accuracy) which required a manual ground truthing of 7% of all nests to confidently determine the error rate and correction factor. We will continue to refine the algorithm going forward and build one for identifying chicks that would allow us to estimate productivity using all nests not just those from long-term study plots.

Conclusion

The Mono Lake California Gull population is declining. Continued steep declines in the number of nests and number of young fledged over the 41-year period of the study have resulted in a gull population that is about half the size that it was during the peak during this study (mid 1990's). Mono Lake, with its permanent protected status as part of the Inyo National Forest and Mono Lake Tufa State Natural Preserve, 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 to reverse recent declines.

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Appendix B. Nest number by islet, 2010 – 2023.

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