



# Point Blue Report

## Population size and reproductive success of California Gulls at Mono Lake: 2025



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**Cover photo:** Adult California Gull foraging in Mono Lake in 2025. Photo by Annie Schmidt.

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## EXECUTIVE SUMMARY

Point Blue conducted the 43<sup>rd</sup> consecutive year of monitoring the California Gull (*Larus californicus*) breeding population on Mono Lake in 2025. 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 2025 we utilized the same UAVs as in 2024, an upgraded smaller platform over earlier years, with increased flight time capabilities. We continued to hone our use of machine learning algorithms to count nesting gulls from aerial imagery.

Gull nesting numbers remained low in 2025 while productivity rebounded from the historically low levels we documented in 2024. In 2025, we estimated the gull nesting population as 21,130 based on a nest count of 10,565, an increase of 436 nests over 2024, but the second smallest breeding population in the 43 years of this study. In comparison, the 1983 – 2023 average was 42,575 and the 2013 – 2023 average was 31,729 gulls. Twain islet continued to support the majority of the nesting population with 65% of all nests in 2025, an increase of 417 nests over 2024, the first year in the last five that the nest number increased on Twain over the previous year. The other islets with the next highest nest counts had nest numbers very similar to 2024 they were: Little Tahiti (1934), Pancake (838), and Little Norway (429). Coyote Islet, which had complete nest failure in 2022 and 2024, has seen nest numbers decline from 1015 in 2022 to 168 in 2024, and only 41 in 2025.

In 2025, we estimated chick production (chicks/nest) was 0.52, a large increase from the historically low 2024 chick production, but still well below the long-term average of 0.81 (1983 – 2024). Due to the small nesting population and below average productivity, total chick production in 2025 was the 9<sup>th</sup> lowest recorded across the 43 -year study. Total chick production has only eclipsed 10,000 once in the last ten years (2023).

## 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 2025, we conducted the 43rd 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, and have since refined, to assist in counting nesting gulls in 2025. In this report we provide results of the 2025 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. Gull nesting in 2025 was limited to Negit & Paoha islets.



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<sup>2</sup>, 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<sup>2</sup> 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 2025 gull nesting season was approximately 6383 feet (1945.5m) above sea level (Mono Lake Committee data), about a foot lower than the previous year and 9 feet below the State Water Board management level of 6392 feet (1948.3m).

### Nest Counts

#### *Aerial Surveys*

In 2025, we continued to monitor the gull nesting population and reproductive output using images captured by uncrewed aerial vehicles (UAVs). Prior to 2017, the data collected for this study was gathered solely using ground-based counts. In 2017, we began piloting a new standardized method 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 maintained visual contact with the UAVs during flights. UAVs maintained a minimum altitude of 30 m above ground and approached each nesting islet 70 m above 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 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 5 & 6). Final images in 2025 had ~ 0.7 cm per pixel resolution. In 2025, imagery was captured for the nest count on May 27 and on July 8, for the chick survey.



Figure 5. Mosaicked images from UAV flight over Twain islet from July 7, 2025 chick survey.



Figure 6. Zoomed (1:30 resolution) UAV captured image of Twain nesting grounds (Twain South Nest Plot) on July 7, 2025. Red arrows point to several of the near fully grown chicks. Note the skeletons of dead *Bassia* and adjacent (green) new growth.

### *Counting Nests from Aerial Images*

In 2025, we continued our use of deep learning for automated nest detection, employing a YOLOv8-large architecture (CAGU\_YOLOv8l\_512\_20250917) trained over 150 epochs. Image processing and model training were conducted on an Amazon Web Services

g5.2xlarge instance equipped with a single NVIDIA A10G Tensor Core GPU (24GB memory).

To improve model performance and reduce ambiguity, we simplified the classification scheme used in previous years. While prior models distinguished between "nesting," "sitting," and "standing" gulls, the 2025 model was trained on a single class: "occupied nest." We utilized a custom R script (`get_CAGU_validation_tiles_from_S3_and_filter.R`) to pre-process the training labels, merging the "nesting" and "sitting" classes into this single target category and removing all "standing" gull labels.

The training dataset was generated using a semi-supervised approach. We applied the 2024 model to the 2025 imagery to generate initial label predictions. These predictions were then rigorously validated and corrected by a human expert using the MakeSense.ai platform. This new 2025 data was combined with re-validated training data from 2024 to create a cumulative training set. The final model demonstrated strong generalization on a held-back test set (64 images, 137 instances), achieving a Precision of 0.908, Recall of 0.883, and a mean Average Precision (mAP@.50-.95) of 0.722.

To determine the optimal confidence threshold for the operational count, we performed a validation analysis on the May 27, 2025, orthomosaics. Using a custom R script (`calculate_threshold_v2025.R`), we calculated the threshold that maximized the F1-score (the harmonic mean of precision and recall). This analysis identified a Best Threshold of 0.67, which resulted in a validation Precision of 0.967, Recall of 0.894, and F1-Score of 0.929. Consequently, we applied this 0.67 confidence threshold during the inference phase. As in previous years, we implemented a de-duplication script in R to retain only the highest-confidence labels and eliminate spatially redundant predictions caused by tile overlap.

After predicting nest locations with the model, we conducted a manual count of approximately 8% of all nests. We counted nests within all long-term productivity plots on Twain, Spot, and Little Tahiti and five additional calibration plots on Twain established in 2023. Comparing the manual count to the model predictions, we found a false negative rate (nest was present but model did not detect it) of 3.9% and a false positive (the converse) of 0.9%. Thus, we boosted the machine count by 3% as a correction factor to arrive at our total nest count.

## 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 2025. The fledging rate for each plot (**fplot**) is calculated as:

$$f_{plot} = (Cb) / Np$$

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. We used the manual nest count from the calibration process to get exact nest numbers for each plot.

The post-banding mortality count that entailed counting the number of dead chicks in September that had been banded in early July, was stopped in 2017 when chick banding ceased. We have since used the mean long-term post-banding mortality rate (13.2%) obtained from 2000 – 2016 data. The annual variation in this metric was small and therefore contributed relatively little to variation in annual reproductive success estimates.

In 2025, there were no chicks found on the Paoha Islets, so we excluded those nests and reproductive rate from calculating the fledge rate and total number of fledglings for the lake. Error estimates around means are one standard error.

## RESULTS

### Number of Nests and Breeding Adults

In 2025, we estimated the gull nesting population was 21,130 based on a nest count of 10,565, an increase of 436 nests over 2024, but the second smallest breeding population in the 43 years of this study. In comparison, the 1983 – 2024 average was 42,043 birds or 21,021 nests. The 2025 nesting population represents a 50% reduction in the breeding California Gull population over the long-term average. Twain islet continued to support most of the nesting population with 65% (6904 nests) of the 2025 total. This represented a 417 nest increase from 2024, reversing a trend of annual nest declines on this islet since 2021. Most of the remaining Negit islet nest numbers were similar to those in 2024. The islets with the next highest nest counts were: Little Tahiti (1934), Pancake (838), and Little Norway (429). Steamboat saw a large increase in nests in 2025 with 234 compared to 100 in 2024 and 33 in 2023. The collapse of the Paoha islets breeding population continued in 2025. The only nests were on Coyote islet where nests numbers have fallen from 1015 in 2022 to 41 in 2025.

The nesting population lake wide has been declining on average by 334 nests per year over the 43 years of this study (Figure 8), with most of that decline realized since 2016. The breeding population has now been below 15,000 nests for nine consecutive years. The 2025 breeding population represented a 67% reduction from the largest nest number we have documented during our study of 32,488 nests in 1992.

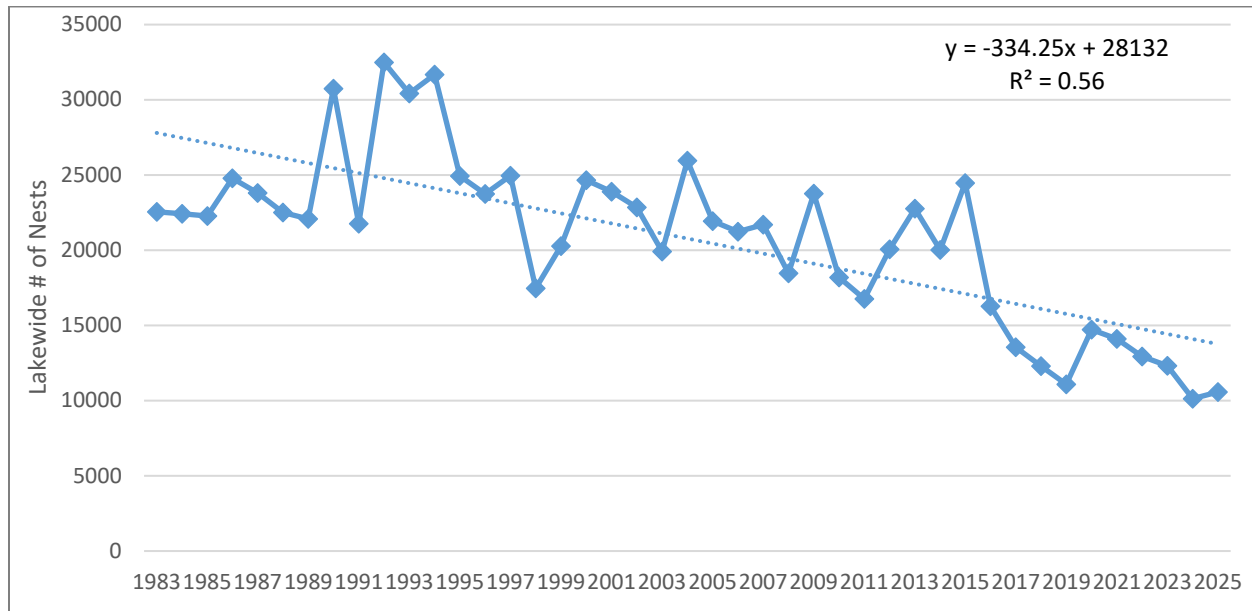


Figure 7. Number of California Gull nests at Mono Lake, 1983 – 2025 with linear trend line and associated regression equation.

### Reproductive Success

The number of young fledged per nest from Mono Lake rebounded in 2025 from an all-time low in 2024 but, was still well below the long-term average. The Negit Islet nest plots averaged 59 nests in 2025 and fledged an average of  $0.52 \pm 0.08$  chicks per nest, below the study long average of 0.83 chicks per nest (Table 2). The Paoha Islet breeding population has crashed with only 7 nests within the two plots in 2025, and as in 2024, no chicks fledged from the Paoha islets in 2025. The long-term reproductive success rate has declined at an average of 0.013 (or 1.3%) chicks fledged per nest per year across the

43 years of this study (Figure 9). Based on the total of 10,565 California Gull nests on May 27th, and an average of  $0.52 \pm 0.08$  chicks fledged per nest, we estimate 5494 ( $\pm 440$ ) young successfully fledged at Mono Lake in 2025. This total chick production is the 9<sup>h</sup> lowest total during the 43-year study, but far greater than the record low documented in 2024.

**Table 2.** Nest and chick counts from long-term nest plots in 2025 at Mono Lake.

Plot	# nests in June	average # chicks/nest in July	# chicks in July	# estimated to die before fledging	Total successfully fledged/nest
Cornell	47	0.66	31	4.0	0.57
L. Tahiti East	19	0.32	6	0.8	0.27
L. Tahiti West	64	0.95	61	8.1	0.83
Twain North	46	0.74	34	4.5	0.64
Twain South	99	0.50	50	6.5	0.43
Twain West	20	0.20	4	0.5	0.17
Twain New	35	0.63	26	3.4	0.63
Spot	74	0.43	32	4.2	0.43
<b>Negit Islet totals/averages:</b>	<b>404</b>	<b>0.60 <math>\pm</math> 0.11</b>	<b>244</b>	<b>32</b>	<b>0.52 <math>\pm</math> .08</b>
Coyote Cove	0	0.00	0	0.00	0.00
Coyote Hilltop	7	0.00	0	0.00	0.00
<b>Paoha Islet totals/averages:</b>	<b>7</b>	<b>0</b>	<b>0</b>	<b>0.00</b>	<b>0.00</b>
<b>Lake wide</b>	<b>411</b>	<b>0.59 <math>\pm</math> 0.11</b>	<b>244</b>	<b>32</b>	<b>0.51 <math>\pm</math> .02</b>

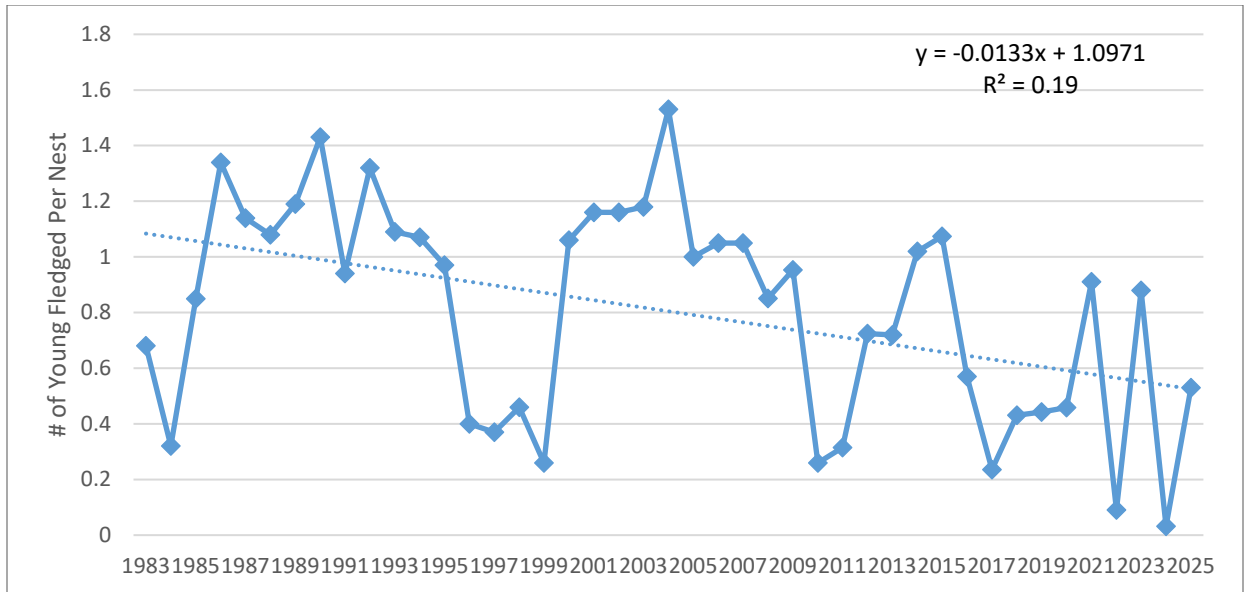


Figure 8. The estimated number of young fledged per nest at Mono Lake from 1983 – 2025 with linear regression line and equation.

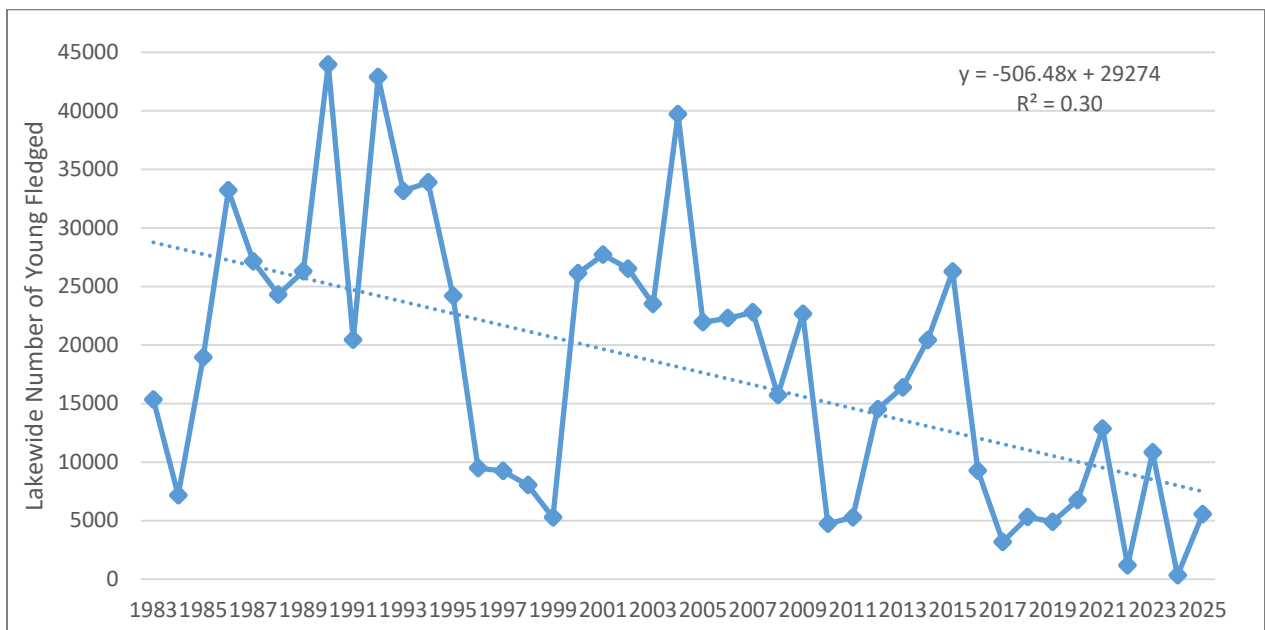


Figure 9. The estimated total number of young fledged from Mono Lake from 1983 – 2025 with linear trend and regression equation.

Chick production has declined on average by 506 fledglings per year across the 43 years of this study (Figure 9).

## DISCUSSION

In 2025, the California Gull population productivity rebounded from the historically poor 2024 productivity. The snowpack in Spring 2025 was slightly below average in the Eastern Sierra (CDEC 2025) and was slightly above average in 2024, after a record setting 2023 April 1 snowpack that led to meromictic conditions at Mono Lake.

The nesting population size of California Gulls at Mono Lake has declined dramatically over the course of this long-term study. The 2025 breeding population was the second smallest documented during this 43 yearlong study, second only to 2024. Despite substantial annual variation in nesting population at Mono Lake, there is a clear long-term declining trend in the population size that is largely driven by precipitous declines since 2016. The decline in chick production at Mono Lake has been largely driven by this decline in nest numbers, with a reduction in chicks produced per nest contributing a smaller amount.

The production of chicks at Mono Lake is likely a combination of adult fitness prior to and during the breeding season and food resources available to provision chicks from June – July (Nelson et al. 2014). In most years, brine shrimp (*Artemia monica*) are the primary source of food provisioned to chicks (Wrege et al. 2001). Brine Shrimp biomass in 2025 was very similar in magnitude and timing to 2024 (Figure 10). Yet, gull chick production in 2025 was far higher than the unprecedentedly poor 2024. The link between brine shrimp density, size, and the timing of the onset of rapid population growth and California Gull productivity warrants further study.

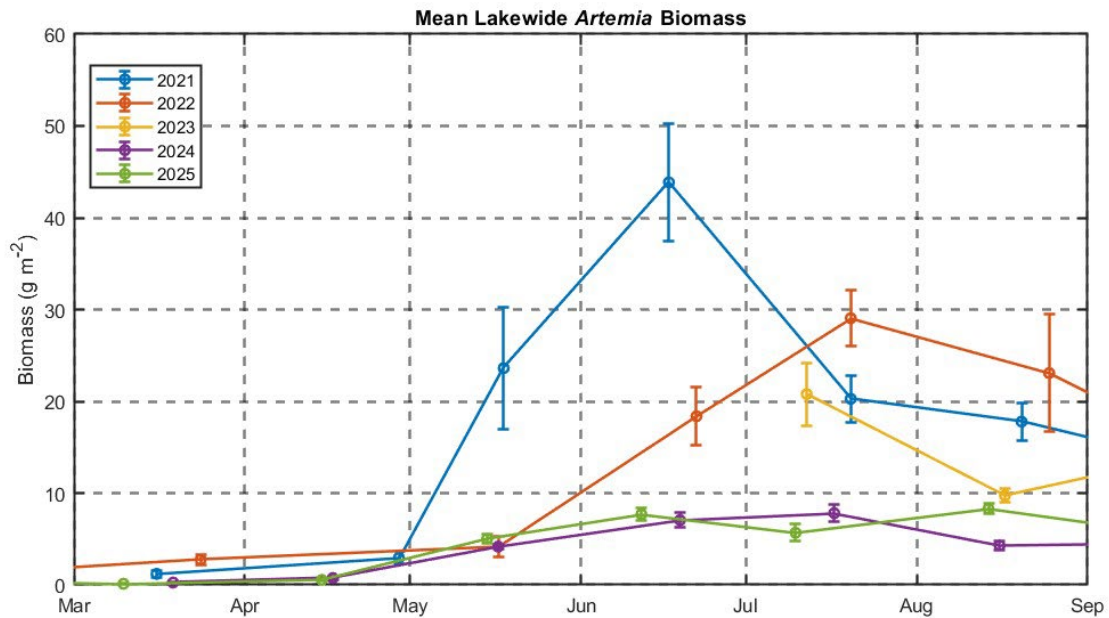


Figure 10. Mono Lake Brine Shrimp (*Artemia monica*) biomass (total adult shrimp mass per square meter) from 2021 through 2025 at Mono Lake (Figure courtesy of R. Jellison & J. Melack).

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 moved our chick survey up by one week to account for earlier chick hatching that we have observed in recent years. Based on chick size and lack of fledgling gulls stacking up on the shoreline, it appears our timing in 2025 better captured the phenology of the gulls. We intend to continue to conduct the chick surveys around 6 – 8

July in future years. As climate conditions change at Mono Lake, tracking phenology of nesting will be important to properly capture chicks when they are large enough to be readily counted but have not yet fledged. 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 realized substantial improvement in the performance of our nest counting model in 2025. This shift to a single-class architecture, combined with the expanded training dataset, resulted in a marked improvement in model performance. While the change in classification schema limits direct performance comparison with the 2024 multi-class model, the operational metrics improved substantially. The 2024 model yielded a Recall of 0.46 at a low confidence threshold of 0.20, whereas the 2025 model achieved a Recall of 0.894 at a much stricter confidence threshold of 0.67. This indicates that the 2025 model was far more robust at detecting nests without requiring an artificially low confidence floor, effectively addressing the high false negative rate encountered in the previous years. The use of the model has reduced the time required to estimate the gull nesting population by at least 30 hours annually. We made progress in developing a model to automate chick counting, similar to our nest model. We labeled over 1000 chicks from the 2025 data; we will add more training data in 2026 and intend to deploy this model to assist in chick counting in 2026. This will allow us to expand our chick production calculation to all nests, instead of relying on the existing plot sampling approach. The counting of chick production from all nests at Mono Lake compared to the current method of sampling 5% of the population will increase confidence in our estimates.

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 has been sharply declining over the last two decades. Continued steep declines in the number of nests and number of young fledged over the 43-year period of the study have resulted in a gull population that is half the size that it was during the peak period in the mid-90'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 their natural saline lake habitat in California. The species is an iconic symbol of the Mono Lake environment, where it has likely occurred for millennia. 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 ensuring this populations persistence.

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**Appendix A. Nest number by islet, 2010 – 2025.**

Negit Islets	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Twain	8219	8704	9396	9567	9144	12263	7760	7672	7639	7601	10737	9936	9094	8478	6487	6904
L. Tahiti	2429	2049	3366	3995	3899	4258	2923	1795	1860	1230	1291	1530	1229	1680	1915	1934
L Norway	114	171	390	493	384	505	284 <sup>c</sup>	163	220	185	467	496	356	289	463	429
Steamboat	509	579	871	1175	1076	1010	675	217	143	120	115	114	61	33	100	234
Java	367	432	325	234	216	439	60	0	0	0	0	0	0	3	0	7
Spot	122	151	39	95	162	184	144	55	36	59	104	163	208	184	86	74
Tie/Hat	55	65	54	86	94	206	191	51	63	38	23	69	47	53	29	40
Krakatoa	2	0	12	9	12	84	38	40	73	50	81	59	27	13	4	23
L. Tahiti Minor	151	162	253	282	255	202	116	64	64	63	62	68	68	40	60	41
Pancake	1894	1741	1972	2450	1903	3159	2497	1814	1099	778	709	558	756	1289	816	838
<i>Negit Islets Total</i>	13862	14054	16678	18386	17149	22317	14704	11890	11215	10128	13589	12993	11846	12062	9960	10524
<b>Paoha Islets</b>																
Coyote	1711	929	1393	2093	2618	2042	1432	1505	1038	892	1014	1063	1015	244	168	41
Browne	116	50	60	75	110	87	146 <sup>c</sup>	152	38	55	41	49	69	17	1	0
Piglet	997	599	344	148	38 <sup>b</sup>	0	0	0	0	0	81	6	0	0	0	0
<i>Paoha Islets Total:</i>	2824	1578	1797	2316	2766	2129	1578	1657	1076	947	1136	1118	1084	261	169	41
<i>Negit Island:</i>	0	0	7	8	28	16	0	0	0	0	0	0	0	0	0	0
Old Marina	1496	1133	1541	1665	9 <sup>b</sup>	0	0	0	0	0	0	0	0	0	0	0
O.M. So.	4	9	36	380	70 <sup>b</sup>	0	0	0	0	0	0	0	0	0	0	0
<i>Lake wide Total</i>	18186	16774	20059	22755	20022	24462	16282	13547	12291	11075	14725	14111	12930	12323	10129	10565
<i>Nesting Adults</i>	36372	33548	40118	45510	40044	48924	32564	27094	24582	22150	29450	28222	25860	24646	20258	21130