Point Blue Report

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

Annual Report

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**Cover photo:** UAV image of Coyote islet in Mono Lake as the unmanned aircraft approached to capture images of nesting gulls in early June 2020.

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# EXECUTIVE SUMMARY

Point Blue conducted the 38th year of monitoring the California Gull (*Larus californicus*) breeding population on Mono Lake in 2020. The population size was estimated by counting nesting gulls from high resolution aerial photographs obtained from unmanned aerial vehicles (UAV's). Aerial imagery was first employed in 2017 from fixed winged aircraft. This year represented the first year UAV's were used to census the colony and the first year that all data, including chick counts were conducted remotely.

In 2020, the estimated gull nesting population was 29,450. This represented the highest nesting population estimate since 2016. This increase is almost completely attributable to a 3136 nest increase on Twain islet from 2019 to 2020 following clearing of the invasive weed Bassia hyssopifolia in Fall 2019. Twain islet supported 73% of the nesting population in 2020. Though 2020 represented a substantial increase over the 2018 and 2019 nesting population numbers it was still well below the 1983 – 2015 average nesting population of 46,395 ± 1324.

Average reproductive success in the sample plots was 0.46 ± 0.08 chicks fledged per nest, which is well below the 1983 – 2019 average of 0.87 ± 0.06 chicks fledged per nest, but similar to the 2019 average. Because of the increased number of nests in 2020, the estimated number of chicks fledged from Mono Lake in 2020 increased to 6,523 ± 1619 still well below the long-term average

The transition to an entirely UAV based remote survey in 2020 allowed us to significantly reduce field effort and most importantly significantly reduce disturbance to breeding gulls at Mono Lake.

# 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 numbers of birds. Mono Lake supports one of the largest breeding colonies of California Gulls in the world (Winkler 1996).

In 1983, Point Blue Conservation Science (founded as Point Reyes Bird Observatory) began standardized monitoring of the population size and reproductive success of California Gulls at Mono Lake. The goal of the project is to use gulls as an indicator to help guide long-term management of the lake ecosystem. Specifically we aim to track the long-term reproductive success and population size of the gulls through 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 is a powerful tool for assessing the conditions at Mono Lake and can be an invaluable tool in understanding how wildlife populations respond to ecological change that manifests over longer periods (e.g. climate change).

In 2020, we conducted the 38th consecutive year monitoring the population size and reproductive success of California Gulls (*Larus californicus*) at Mono Lake. We continued to collect information on nest numbers and reproductive success, fully transitioning to remotely sensed data collection to reduce disturbance to the gulls. In this report we provide a detailed summary of the 2020 results with reference to historical conditions.


Fig. 1. Locations of islands and islets within Mono Lake.


Fig. 2. View of the nesting islets within the Negit Islet complex.


Fig. 3. The Paoha Islet complex.

# 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 primarily 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, and on 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 2020 nesting season was similar to that of the previous two years at about 1945.4 m upon nest initiation in the spring.

## Nest Counts

*Aerial Surveys*

In 2017, a new standardized method using aerial photography to count gull nests was adopted. This new methodology allows for the population size to be accurately measured without the disturbance involved in ground counts. This switch came following two years of calibrating aerial photography results with the traditional ground counts. Aerial photo-based nest counts were found 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.

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 two DJI Matrice 100 quadcopters each equipped with a Zenmuse X5 camera. The UAVs followed pre-programmed flight paths uploaded to the UAVs 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 UAV's at any time during the survey. The UAV's were launched from Java islet for surveys of all of the Negit Islets and from Paoha for all of the Paoha Islets (Figures 4 &5). Pilots maintained visual contact with the UAV at all times during the flight. UAV's maintained a minimum altitude of 35 m above the ground and approached each nesting islet 70 m above the ground, before descending, to minimize disturbance to the gulls. All pilots were FAA licensed during flight operations.

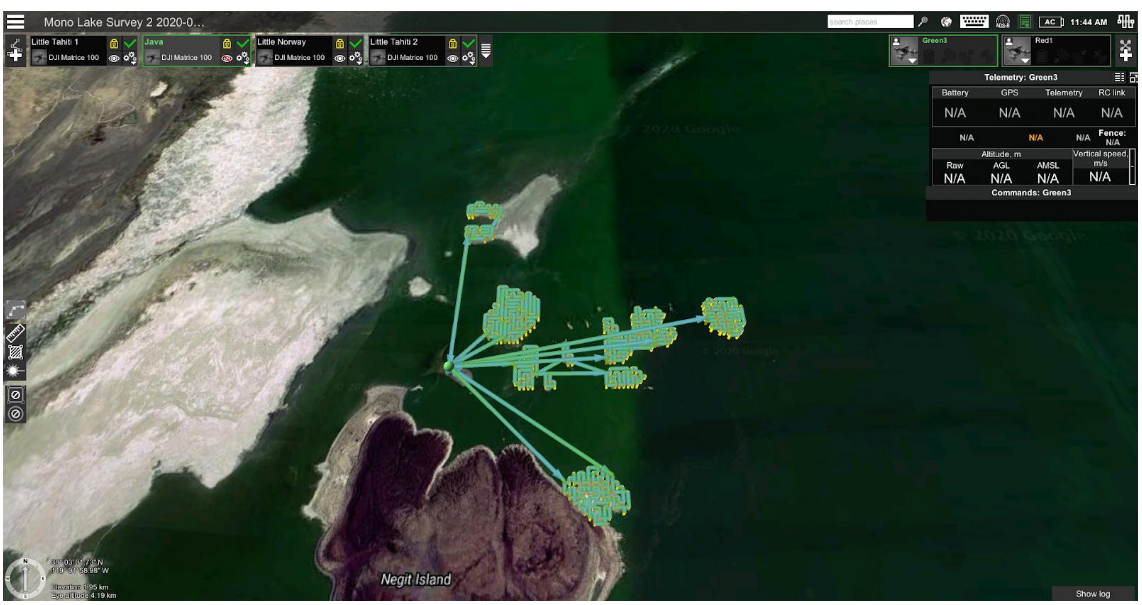


Figure 4. Flight planning routes and coverage of the Negit nesting islets from the base on Java islet in 2020.

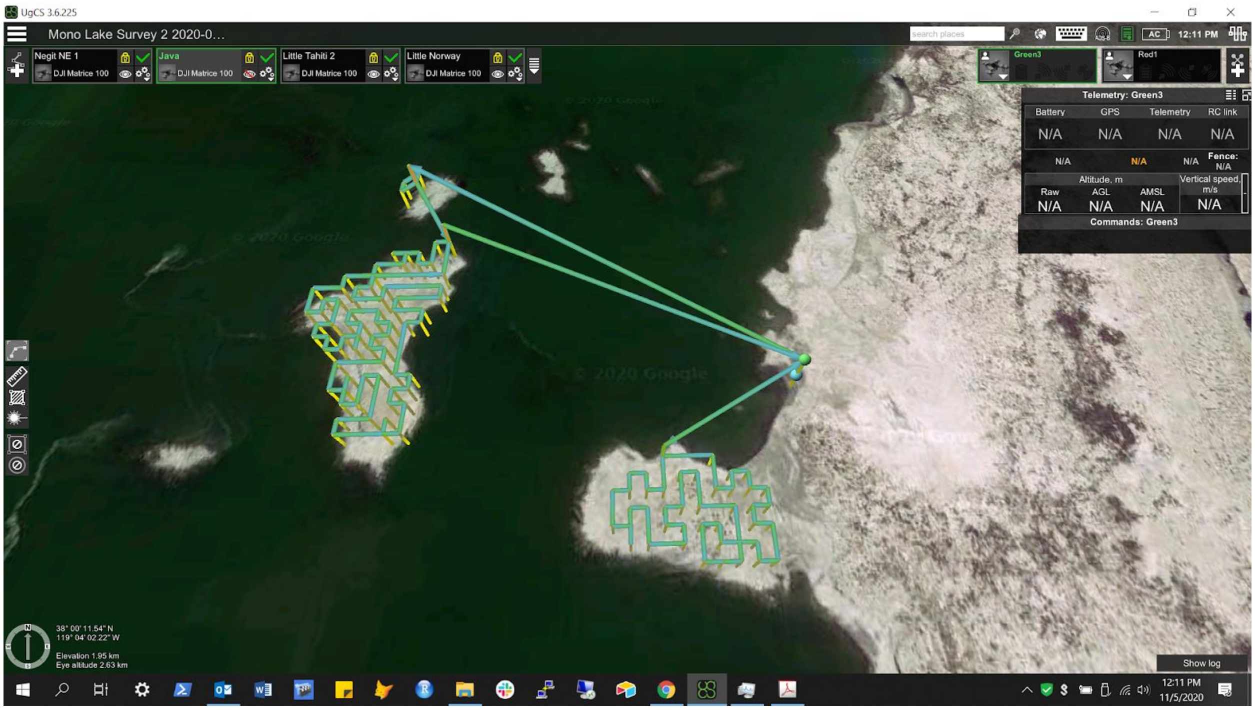


Figure 5. Flight planning routes for the Paoha nesting islets from the base on Paoha island in 2020.

A separate observer documented disturbance to gulls, osprey or any other birds from the UAV's for each survey. If disturbance was noted during a survey, the flight path was paused until birds had settled or moved away from the UAV.

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 (Figures 6 & 7). Final images had approximately 1 cm resolution per pixel. Imagery was captured for the nest count on June 2nd and 3$^{rd}$ in 2020. We then returned to complete chick survey on July 13 and 14 following the same methods outlined above for the nest survey.

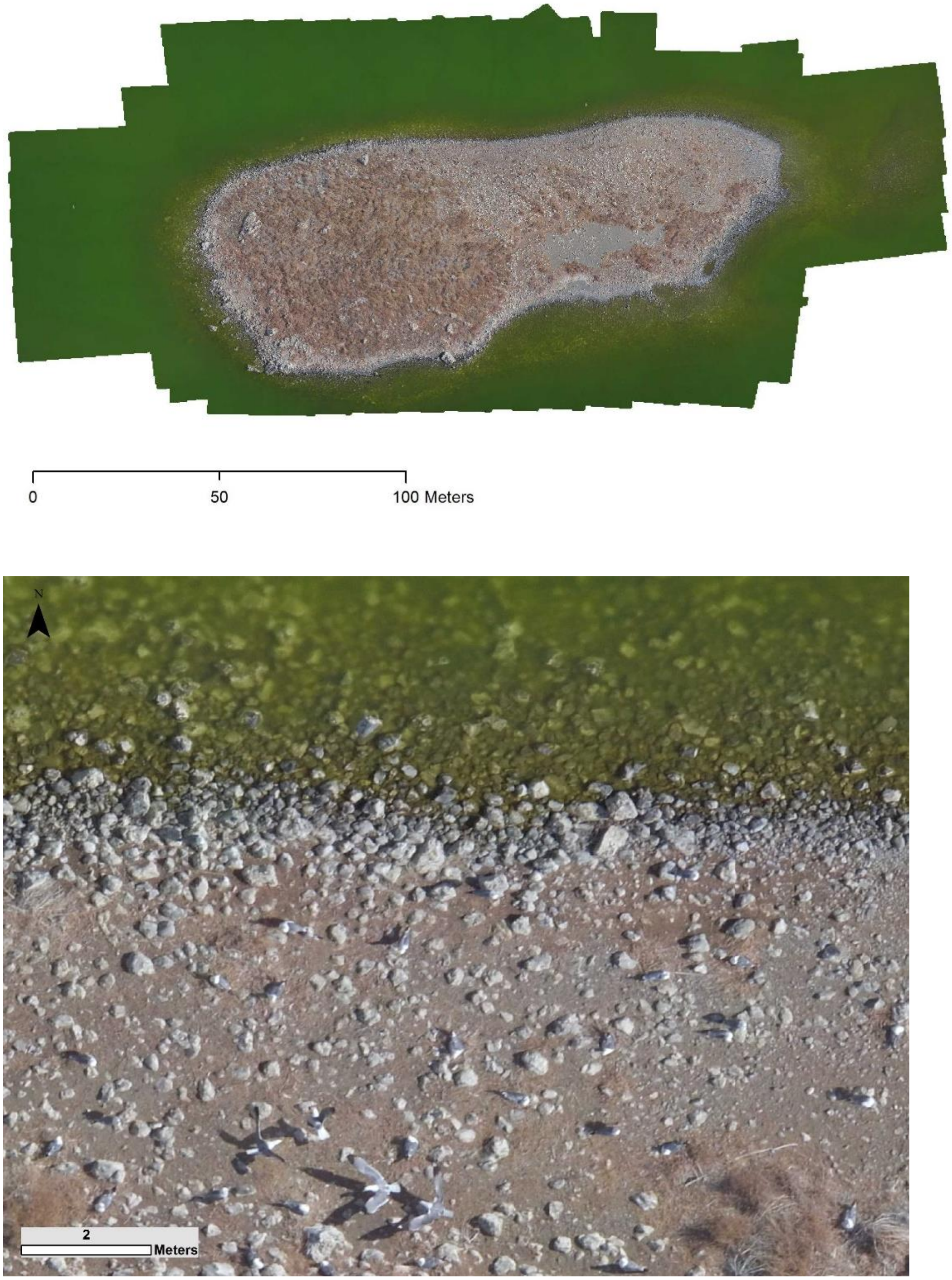


Figure 6. Mosaicked image of Pancake islet from the June, 2020 incubation survey (above) with a zoomed in view (below) showing nesting and non-nesting gulls.

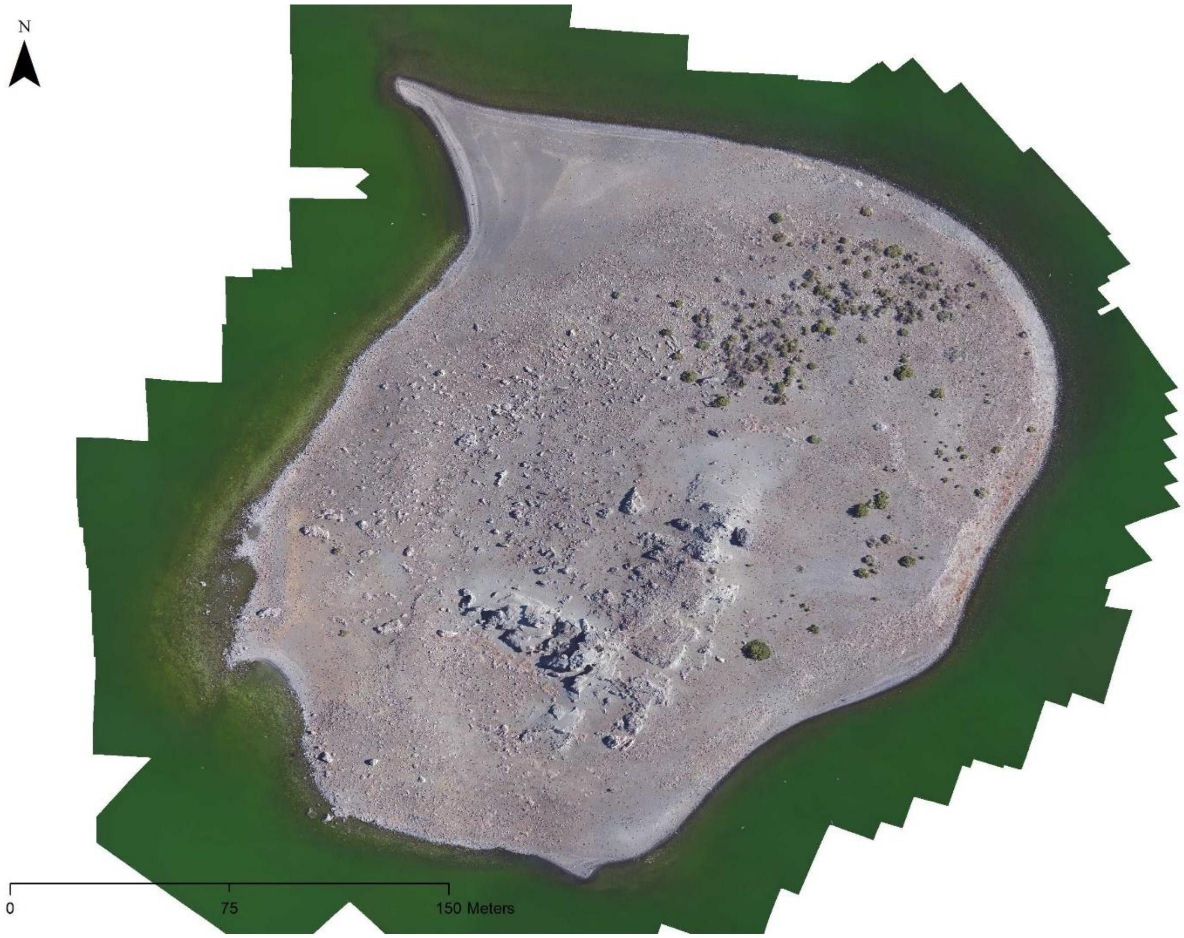


Figure 7. Mosaicked image of Twain Islet from the July 2020 survey.

*Counting Nests from Aerial Images*

Stitched images were viewed in ArcMap (ESRI V10.8.1) and we added a point in a shapefile to mark each nesting adult observed. Each gull or pair was given a color-coded dot indicating whether they were nesting or standing. We used clues such as posture and shadow angle to assist in deciding which category to place the bird in as well as if a bird was standing in very close proximity to another bird, we considered these birds a pair and counted only 1 as nesting (Figure 6). Gulls sitting in an area with a consistent pattern of not supporting nests were considered standing. If it was uncertain if a gull was sitting or standing, it was considered incubating. Results from the pilot study showed that combining “Uncertain”, “Incubating” and “Pairs” consistently provided the closest match to nest numbers obtained by ground counts.

For counting, we enlarged most images to approximately 200% of the original resolution (this varied between 150 – 300%), and systematically scanned side to side or up and down in passes, and gulls were marked with colored points to their corresponding count group. Following this process, the entire image was scanned again for any missed gulls. Images need to be carefully scrutinized to obtain an accurate count. The bright white heads, clear-cut white neck and gray mantle, and overall shape of nesting gulls were useful search images.

Determining whether a gull is standing or incubating can be a challenge, and requires experience. In 2020, K. Nelson has counted thousands of gulls from images, and has been able to ground truth aerial photo-based plot-counts with ground-count tallies of nests within the plots. Useful characters associated with standing birds is that their bodies are angled upwards and the white circles of their breast show prominently. Incubating birds are often nestled down in nests with their gray backs showing prominently. Some postures appear somewhat intermediate and require extra scrutiny. If the observer was uncertain, we considered those birds to be incubating as the vast majority of birds counted were incubating.

## 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 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 2020. 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 years such as 2020 in which the average fledging rate for the Paoha Islets (which represents less than 9% of the total population) is considerably lower than the rate for the Negit Islets, it is prudent to adjust the lakewide average reproductive success estimate to eliminate the bias caused by over-sampling the Paoha Islets, which frequently have much lower reproductive success than the Negit Islets. This correction is done by multiplying the average fledging rate for the Negit and Paoha Islets by their proportion of the population, and combining the totals. Overall chick production is estimated by multiplying the average reproductive success by the total number of nests. Results are presented with plus or minus one standard error.

*Calibrating Aerial Chick Counts with Ground Based Counts*

Unlike nest count results, chick count results obtained from aerial photography generally produced results which were lower than ground counts. Very small chicks, those brooded by adults, and those obscured by vegetation are missed in aerial photography. In the three years of available comparative data, the average accuracy of aerial plot counts compared to ground plot counts varied between 41% and 101% (Table 1, Appendix A). This variation is likely due to vegetative cover, the relative proportion of very small chicks, topography, and photo quality/angle. The imagery captured in 2020 was of far higher resolution than that obtained from previous airplane imagery. In 2019 aerial chick counts were quite accurate, likely due to the large size and advanced age of the chicks. In 2019 there were no very small or downy chicks in the plots, which is unusual.

**Table 1.** Comparison of chick counts obtained from ground surveys and aerial photography from 2016 - 2019. Accuracy is the combined average of aerial totals divided by the ground totals for each plot. Also provided is the average reproductive success value (RS) calculated with ground based and air based count data, including aerial nest counts.

| | **2016** | | **2017** | | **2019** | | |
|---|---|---|---|---|---|---|---|
| Plot | Ground | Air | Ground | Air | Ground | Air | **Avg. Accuracy** |
| Corn | 55 | 38 | 4 | 0 | 2 | 2 | **85%** |
| LT ea | 28 | 17 | 0 | 0 | 1 | 1 | **87%** |
| LT we | 71 | 26 | 19 | 6 | 26 | 16 | **43%** |
| Tw We | 65 | 24 | 26 | 16 | 65 | 59 | **63%** |
| Tw No | 17 | 7 | 25 | 9 | 21 | 15 | **50%** |
| Tw So | 31 | 18 | 5 | 2 | 26 | 18 | **56%** |
| Tw Nw | 48 | 13 | 23 | 11 | 57 | 42 | **50%** |
| CH | 13 | 13 | 4 | 2 | - | 8 | **75%** |
| CC | 23 | 16 | 8 | 6 | - | 5 | **72%** |
| | | **0.23** | | **0.12** | | **0.41** | |
| RS value | **0.57** | 41% | **0.23** | 55% | **0.40** | 101% | **66%** |

Using aerial counts in the future to calculate reproductive success, in most years, will produce an under count that likely reflects approximately 65% of the actual value. A regression analysis indicated that adding chicks for half the number of brooding adults in the plot during the chick survey provided a stronger correlation with ground counts than counting chicks only. Based on this information and ground estimates that approximately 50% of brooding adults were sitting on chicks during chick counts has led us to adjust the chick count by this amount to allow for comparison to previous years.

# RESULTS

**Number of Nests and Breeding Adults**

In 2020, the estimated gull nesting population was 29,450 based on doubling the nest count of 14,725. This represented the highest nesting population estimate since 2016. This increase was mostly attributable to the 3,136 nest increase on Twain islet from 2019 to 2020 following clearing of the invasive weed Bassia hyssopifolia in fall 2019. Though 2020 represented a substantial increase over the 2018 and 2019 nesting population numbers it was still well below the 1983 – 2015 average nesting population of 46,395 ± 1324. The nesting population has been declining on average by 276 nests per year over the course of the 38 years of this project (Figure 8).

Java Islet, Old Marina, and Negit Islands continued to not support nesting gulls in 2020 following Coyote presence in recent years, though Piglet, which had no nests in recent years, had 81 nests in 2020. Nests on Steamboat continued to decline. In 2013 it hosted 1,175 nests and by 2020 only 115 were counted, down 5 nests from 2019 (Appendix B). Nest numbers increased on Little Norway from 220 in 2019 to 467 in 2020.

Ninety-two percent of the gulls nested on the Negit Islets and 8% nested on the Paoha Islets in 2020, similar to the ratio in 2019 (Appendix B). Of the individual islets, Twain was the most populous, supporting 10,737 nest or 73%, of the lake-wide nests. Little

Tahiti and Coyote continued to support the next highest nesting numbers in 2020, containing 1,291 (9%) and 1014 (7%) of the nests respectively. Moderately higher than 2019 numbers of 1230 and 892 nests respectively. The number on Pancake islet continued to decline from 1814 in 2017 to 778 in 2020.

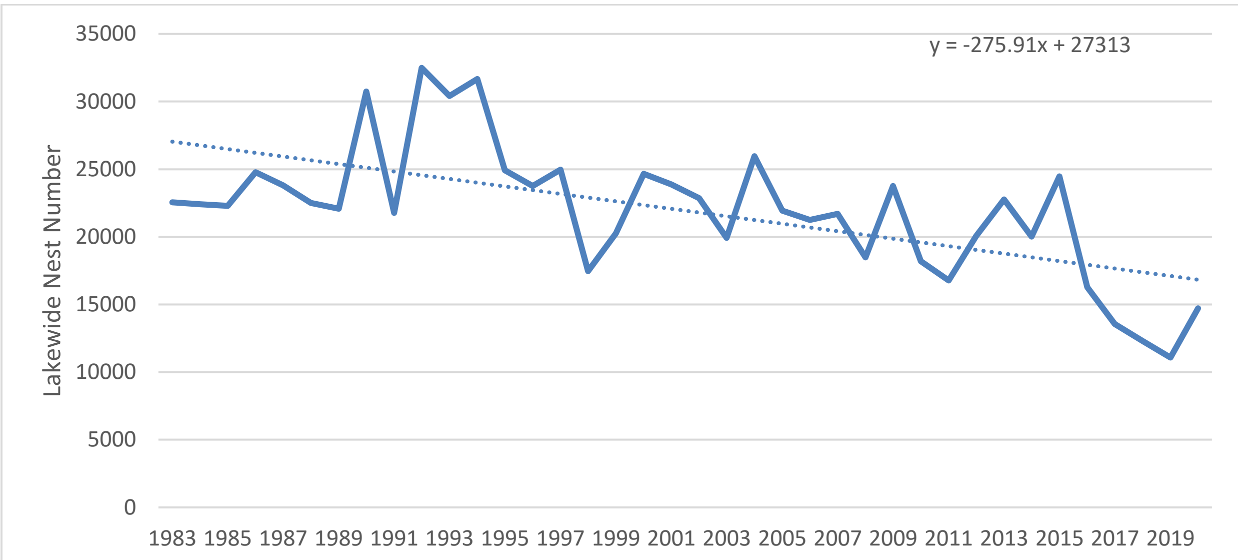


Figure 8. Number of California Gull nests at Mono Lake, 1983 – 2019 with linear trend line and associated regression equation.

**Reproductive Success**

The Negit Islet plots averaged 60 ± 13.2 nests per plot. The Negit Islet plots fledged an average of 0.459 ± 0.08 chicks per nest, virtually the same as we estimated in 2019 (Table 2). Our nest count imagery of the Paoha islets resulted in several small gaps in the imagery that unfortunately were centered on our reproductive plots, thus we do not have total nest numbers to calculate reproductive success for those plots in 2020. The Paoha Islet plots had 46 chicks in them in July compared to only 13 in 2019 suggesting either a large increase in number of nests, reproductive success, or both.

**Table 2.** Summary of nest and chick counts from all negit islet plots using aerial surveys in 2020. 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 (# in July x 0.132) | Total successfully fledged/nest |
|---|---|---|---|---|---|
| Cornell | 27 | 0.52 | 14 | 1.85 | 0.45 |
| L. Tahiti East | 13 | 0.08 | 1 | 0.13 | 0.07 |
| L. Tahiti West | 69 | 0.51 | 53 | 6.89 | 0.67 |
| Twain North | 26 | 0.77 | 18 | 2.34 | 0.60 |
| Twain South | 97 | 0.46 | 41 | 5.33 | 0.37 |
| Twain West | 66 | 0.51 | 40 | 5.2 | 0.53 |
| Spot | 104 | 0.55 | 55 | 7.15 | 0.46 |
| **Negit Islet totals/averages:** | 402 | **0.52 ± .14** | **198** | **3.73 ± 1.23** | **0.46 ± .08** |

The reproductive success rate has declined at an average of 1.17% per year across the 38 years of this study, though 2020 represented a second consecutive year of increase following the all-time low recorded in 2017 (Figure 9).

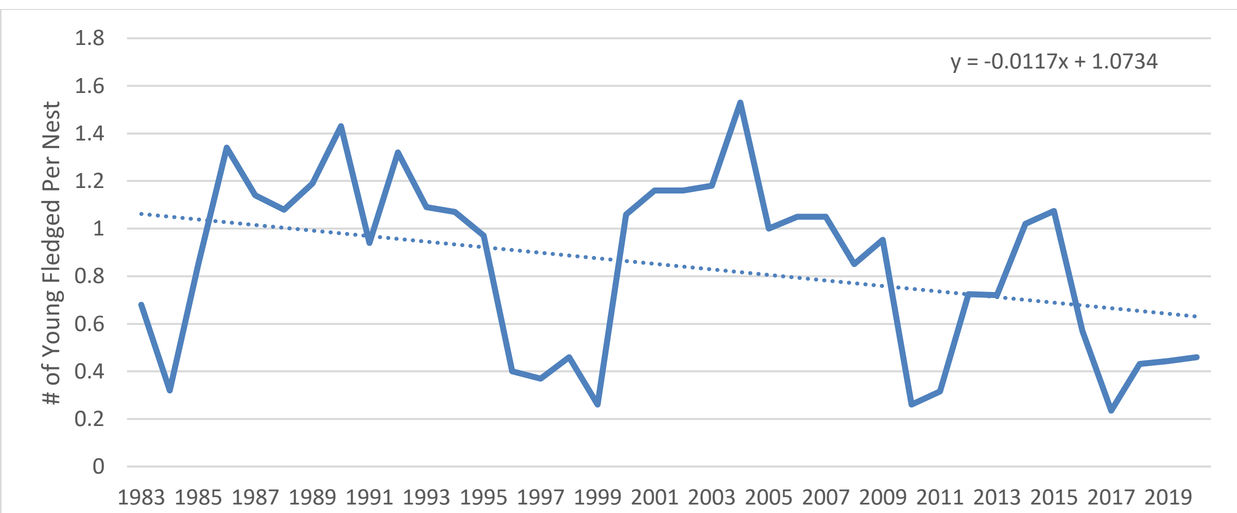


Figure 9. The estimated number of young fledged per nest at Mono Lake from 1983 – 2020 with linear regression line and equation.

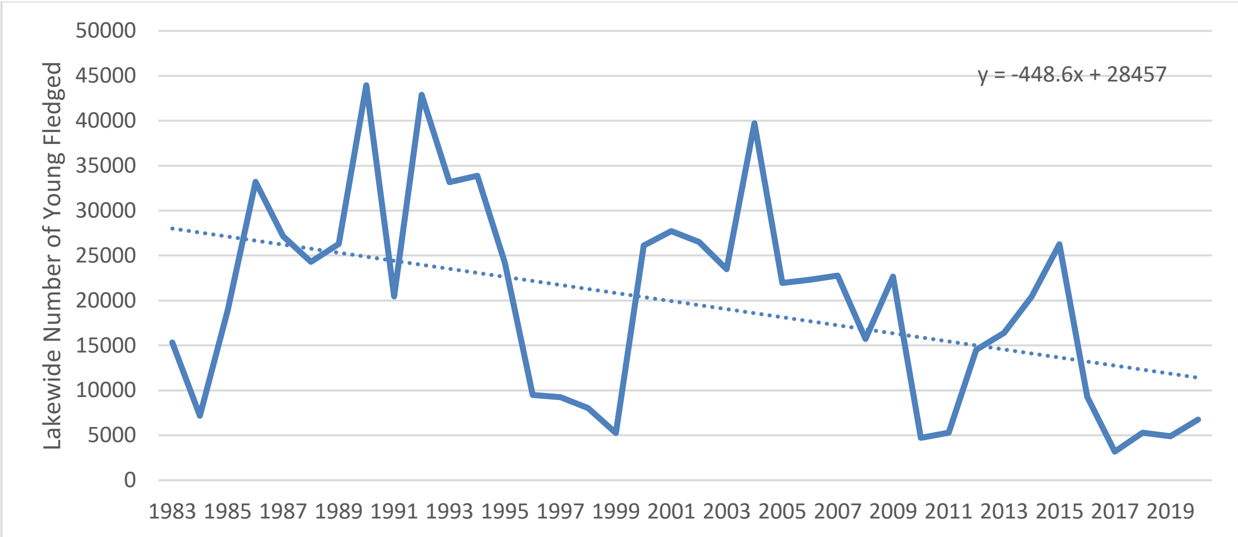


Figure 10. The estimated number of young fledged from Mono Lake from 1983 – 2020 with linear trend and regression equation.

Based on the total of 14,725 California Gull nests counted in early June, and an average of 0.459 ± 0.08 chicks fledged per nest, with an estimated 6,759 (± 1,178) chicks fledged at Mono Lake in 2020, a large increase from the estimate of 4,909 ± 518 in 2019. The 2019 estimate was the third lowest estimate in the 38 year history of the project. The long term average chick production between 1983 and 2018 was 20,480 ± 1838 ($n$ = 36 years). Fledgling production has declined on average by 449 fledgling's pear year across the 38 years of this project (Figure 10).

# DISCUSSION

## Population Size

The nesting population size of California Gulls at Mono Lake has declined dramatically over the course of this long-term study. However, the three year steep decline in the nesting numbers from 2016 – 2019, reversed in 2020. One of the major factors contributing to nest population decline in recent years was the invasion of the nesting islets by the weed *Bassia hyssopifolia.* Almost all of the increase in gull nests in 2020 was from Twain islet which realized a 41% increase in the number of nests over 2019 numbers following a large scale effort to remove Bassia from this islet by the MLC and Inyo National Forest. These efforts appear to have been highly successful in restoring suitable nesting habitat for gulls on Twain islet in 2020.

The breeding population size of California Gulls at Mono Lake is known to vary based on lake productivity (Wregge et al. 2006). Mono Lake has been in a period of meromixis since 2016. Meromixis is a condition where the lake waters do not mix depressing nutrient cycling and thus primary productivity. Meromixis occurs following high levels of runoff, which creates a stratification of fresh and salty waters. This disrupts nutrient cycling in Mono Lake and depresses lake productivity. Large runoff in 2017, and then reinforced in 2019, are driving this prolonged period of lake stratification.

The gulls primary food source at the lake is bring shrimp (Wregge et al. 2001). Long-term monitoring has shown that in recent years, average brine shrimp abundance in Mono Lake has been low compared to long-term averages (LADWP 2020). The 5 year running mean and median average of adult shrimp abundance from 2014 – 2018 was the lowest on record, and in 2015 and 2016 peak shrimp densities were the lowest recorded since monitoring began in 1979 (LADWP 2019).

Besides low lake productivity and weed invasion, the enduring impact of Coyote invasion of nesting islets is likely influencing gull nesting numbers at Mono Lake. Gulls, and other members of the Laridae family show high nest site fidelity (e.g. Gonzalez-Solis et al. 1999, Stenhouse et al. 2005). Our observations at Mono Lake suggest that the gulls are slow to re-inhabit nesting islets where widespread coyote predation has occurred in the past (Appendix B). This disruption may result in birds taking multiple years to decide to nest on another island. Habitual coyote predation thus may result in fewer gulls nesting as the effect of a single coyote predation event may have lasting effects on gull nesting effort. Though water levels were sufficiently high in 2020 to minimize risk of coyote predation, sites such as the old marina that had been depredated in recent years, was void of nesting gulls. The low reproductive success from 2010 - 2013 may also be affecting the Mono Lake gull breeding population as those productivity values are likely insufficient to support a stable or positive population growth rate. It is important to note that the number of birds attempting to nest is not necessarily an index of the gull population size. When lake productivity is low, these long-lived birds are likely making choices to forego breeding until conditions improve, as is evidenced by the rapid changes in breeding population from year to year that is correlated with lake productivity measures (Wregge et al. 2001). The culmination of all these factors, and potentially other unmeasured ones, is a significant decline in the breeding gull population at Mono Lake since the early 1980's.

**Reproductive Success**

The average of 0.46 chicks fledged per nest in 2020 remains well below the 1983 – 2018 mean average of 0.87 chicks fledged per nest, and typical of the rate observed during this most recent meromictic event. Previous analysis has found that annual average reproductive success of California Gulls at Mono Lake is negatively correlated with meromictic conditions (Nelson et al. 2014). Although we expect average reproductive success to remain low during meromictic periods, when meromixis finally ends and proper nutrient cycling resumes, productivity in Mono Lake would be expected to spike above average based on previous events. Reproductive success and chick production for California gulls at Mono Lake has also been relatively high during these post-meromictic periods (Fig. 10).

The estimated 6759 chicks that successfully fledged from Mono Lake in 2020, though considerably higher than in 2019 is still well below the long-term average of 20,480 ± 1838 (1983 – 2018). For comparison, the 10-year average chick production between 1985 and 1995, a particularly productive period for Mono Lake California Gulls, was 29,854 ± 2641 chicks fledged annually. The average chick production over the past 10 years (2009 – 2019) is only 12,084 ± 2630. In six of the past 10 years annual chick production has been under 10,000 – half the long-term average (Fig. 10). By comparison, over the initial 26-year time period of 1983 – 2008, only 5 years had annul chick production estimates below 10,000.

Annual chick production is driven by both the reproductive success value and to a population size. The past decade has experienced two meromictic periods, which are likely the primary drivers behind reduced reproductive success and chick production. The extremely low population sizes associated with *Bassia* encroachment, and coyote depredation of several islets during the 2012 – 2015 drought have exacerbated these low reproductive success values and driven chick production lower still. Thus the combination of frequent meromixis, the loss of nesting habitat due to weed encroachment, and episodic coyote predation during low lake level periods are combining to greatly reduce chick production. This will reduce future recruitment of new breeding adults and contribute to population decline unless continued action is taken to remove *Bassia,* other weeds, and ensure coyote free nesting habitat.

**UAV Survey Methods**

The UAV only survey method deployed in 2020 had several large advantages over previous monitoring approaches, but several drawbacks. The greatest benefit of this approach is a significant reduction in the disturbance to nesting gulls, reducing researcher caused nest failure to apparently zero. We observed only minor disturbance of gulls during our surveys. Upon the first approach to an islet, what appeared to be the non-breeding loafing birds flushed, returning within 2 minutes to the islet. The incubating birds almost entirely sat tight. If we returned to an islet we had already flown over few, if any, gulls flushed. This is a large decrease in disturbance compared to ground based counts of the colony which would result in agitated gulls for an extended period of time. Our UAV methods, also helped us realize significant efficiencies in carrying out this long-term study and increased the quality of images we were able to capture to count nests and chicks. With one good weather day we were able to survey every nesting island for both incubating adults and chicks. We were also able to streamline the stitching, or mosaicking, of images which in previous years was a tedious process done by hand. The process in 2020 still required manual counting of the nearly 15,000 nests, and chicks from within each of the plots, which required several days of tedious effort. Our intent is to automate the counting in the coming years by developing a machine learning algorithm to detect nesting gulls and chicks. This will also allow us to use all of the nesting birds to assess reproductive success and chick production, which may be important for assessing effects of weed removal on not just nest numbers but reproductive success. The drawbacks of the UAV approach included errors in our flight planning procedure that resulted in several holes in our mosaicked imagery for the incubation imagery that resulted in us being unable to calculate reproductive success for several plots that overlapped the imagery gap. This issue was rectified and our chick count imagery was complete. We have found discrepancy in the variation between ground and aerial counts of chicks across the three years we conducted both methods. It appears that aerial detection probability of chicks is strongly correlated with chick size at the time of the survey, which varies each year. Our recommendation is to try to conduct aerial surveys as late as possible before the oldest birds fledge to maximize detection probability to minimize bias imparted between the two different methods. In 2020, chicks were relatively large during our chick count and resolution of images was higher from the UAV's than previous fixed wing aircraft images, so we feel confident there was not large bias in the 2020 reproductive success measure.

# Conclusion

As meromictic conditions continued at Mono Lake the recent trend of low reproductive success, low chick production, and small breeding population continued in 2020. However, the bright spot was a large increase in nest and chicks from Twain islet. The removal of Bassia from this islet had a large positive impact on nesting gulls at Mono Lake in 2020. Continued eradication of this weed from other highly impacted nesting islets and follow up treatments on Twain, if weeds return, should be a priority. Controlling Bassia can help reduce one of the multiple stressors impacting the gull breeding population at Mono Lake.

The Mono Lake California Gulls appear to be stuck in a conundrum between low lake productivity but predator free places to nest, and high lake productivity but risk from terrestrial predators. In recent drier years the freshwater inputs have been less and lake productivity is higher but when this has extended for several years lake levels declined to a point where predators were able to access the nesting islets. In years when lake levels rise, lake productivity lowers, and though nesting islets are free of predators, there is insufficient resources to support large numbers of nests and produce large number of young. Increasing lake levels, preferably incrementally, to an elevation where they would stay sufficiently high to thwart predator access, even following several years of drought, would be prudent to ensuring the long-term viability of this population in a future where more extreme swings in annual climate variation are predicted (Swain et al. 2018).

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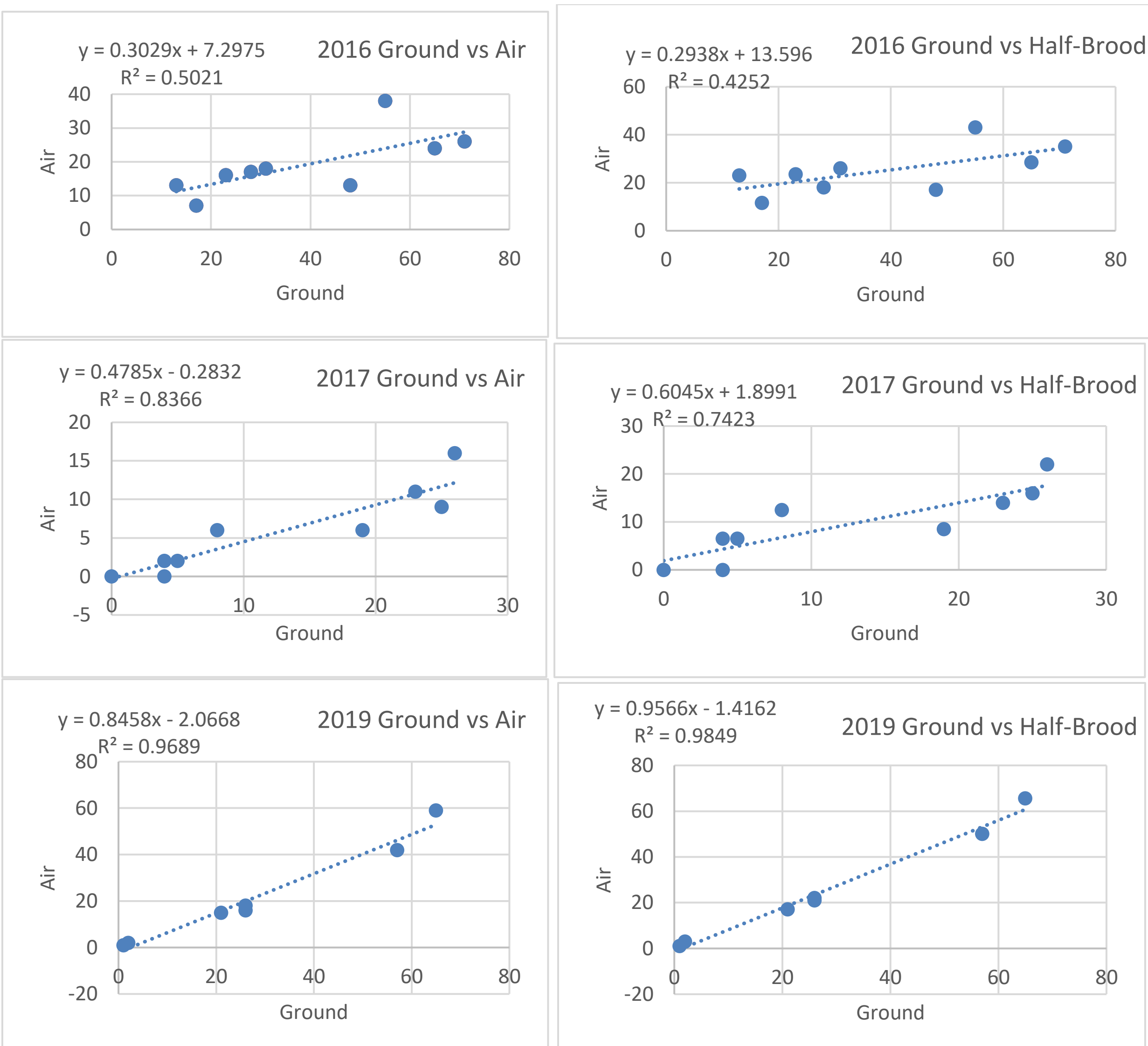
**Appendix A.** Regression analysis comparing aerial and ground chick count results for available years. Also tested was whether adding half the number of sitting or brooding adults ("half-brood") counted by aerial photography within the plots improved the result, which it did not. Aerial counts in 2019 were highly accurate relative to 2016 and 2017 results, perhaps because there were fewer small young chicks.



**Appendix B.** Nest number by islet, 2010 – 2020.

| **Negit Islets** | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 [a] | 2018 [a] | 2019 [a] | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Twain | 8219 | 8704 | 9396 | 9567 | 9144 | 12263 | 7760 | 7672 | 7639 | 7601 | 10737 |
| L. Tahiti | 2429 | 2049 | 3366 | 3995 | 3899 | 4258 | 2923 | 1795 | 1860 | 1230 | 1291 |
| L Norway | 114 | 171 | 390 | 493 | 384 | 505 | 284 [c] | 163 | 220 | 185 | 467 |
| Steamboat | 509 | 579 | 871 | 1175 | 1076 | 1010 | 675 | 217 | 143 | 120 | 115 |
| Java | 367 | 432 | 325 | 234 | 216 | 439 | 60 | 0 | 0 | 0 | 0 |
| Spot | 122 | 151 | 39 | 95 | 162 | 184 | 144 | 55 | 36 | 59 | 104 |
| Tie | 55 | 58 | 30 | 56 | 65 | 181 | 170 | 49 | 55 | 36 | 22 |
| Krakatoa | 2 | 0 | 12 | 9 | 12 | 84 | 38 | 40 | 73 | 50 | 81 |
| Hat | 0 | 7 | 24 | 30 | 29 | 25 | 21 | 2 | 8 | 2 | 1 |
| La Paz | 0 | 0 | 0 | 0 | 4 | 7 | 16 | 19 | 0 | 4 | |
| L. Tahiti Minor [c] | 151 | 162 | 253 | 282 | 255 | 202 | 116 | 64 | 64 | 63 | 62 |
| Pancake | 1894 | 1741 | 1972 | 2450 | 1903 | 3159 | 2497 | 1814 | 1099 | 778 | 709 |
| ***Negit Islets Total*** | **13862** | **14054** | **16678** | **18386** | **17149** | **22317** | **14704** | **11890** | **11215** | **10128** | **13589** |
| **Paoha Islets** | | | | | | | | | | | |
| Coyote | 1711 | 929 | 1393 | 2093 | 2618 | 2042 | 1432 | 1505 | 1038 | 892 | 1014 |
| Browne | 116 | 50 | 60 | 75 | 110 | 87 | 146 [c] | 152 | 38 | 55 | 41 |
| Piglet | 997 | 599 | 344 | 148 | 38 [b] | 0 | 0 | 0 | 0 | 0 | 81 |
| ***Paoha Islets Total:*** | **2824** | **1578** | **1797** | **2316** | **2766** | **2129** | **1578** | **1657** | **1076** | **947** | **1136** |
| **Negit Island:** | 0 | 0 | 7 | 8 | 28 | 16 | 0 | 0 | 0 | 0 | 0 |
| **Old Marina** | 1496 | 1133 | 1541 | 1665 | 9 [b] | 0 | 0 | 0 | 0 | 0 | 0 |
| **O.M. So.** | 4 | 9 | 36 | 380 | 70 [b] | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Lakewide Total*** | **18186** | **16774** | **20059** | **22755** | **20022** | **24462** | **16282** | **13547** | **12291** | **11075** | **14725** |
| ***Nesting Adults*** | **36372** | **33548** | **40118** | **45510** | **40044** | **48924** | **32564** | **27094** | **24582** | **22150** | **29450** |

**a.** Nest numbers obtained through aerial surveys and photographs
**b.** Number of nests known to be depredated by Coyote or abandoned from Coyote activity; likely an underestimate.
**c.** Nest numbers for Little Tahiti Minor were previously included within the Little Tahiti Total