# Population Size and Reproductive Success of California Gulls at Mono Lake, California, in 2003

Justin M. Hite, Miguel A. Berrios, and Tricia Wilson

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PRBO Conservation Science
4990 Shoreline Highway
Stinson Beach, CA 94970

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**ABSTRACT**

In 2003, nest counts estimated 39,830 adult California Gulls (*Larus californicus*) were nesting at Mono Lake in late May, the second lowest number of breeders in 21 years of monitoring. Of these, roughly 78% nested on the Negit Islets, 19% on the Paoha Islets, 2% on Negit Island, and 1% on Old Marina Island. Twain Islet remained the most populous, holding 47% of the Mono Lake total, followed by Little Tahiti Islet with 13% and Coyote A Islet with 12%. The number of nests on Negit Island continued to increase, by 16% compared to 2002, though the rate has slowed over that in other years since last recolonized in 1999. Reproductive success in the fenced plot on Little Norway Islet was 0.03 chicks per nest, the lowest fledging rate for any plot in the 21 years of this study, and far lower than rates of 0.82 to 1.29 chicks per nest in the other 10 fenced plots in 2003. It appears that a tick outbreak limited to Little Norway led to the extreme chick mortality there. Because this islet supported only 1.3% of Mono Lake's breeding gulls, and conditions there were unrepresentative of other islands, fledging rates and other estimates of reproductive success were calculated both with and without data from the Little Norway plot. Excluding Little Norway plot data provides a more reasonable estimate of reproductive success for the entire population in 2003. Excluding these data, the fledging rate on the Negit Islets was 1.11 chicks per nest and the fledging rate on the Paoha Islets was 1.28 chicks per nest. The overall fledging rate on Mono Lake was 1.18 chicks per nest. An estimated 23,500 ± 1,992 chicks fledged from all the lake's nesting islands in 2003 translating to an 11% decrease in gull productivity compared to 2002. Since 1985 an average of 24,500 ± 2,500 chicks have fledged from the lake each season. Calculating the number of chicks fledged at Mono Lake in 2003 including Little Norway plot data decreases the estimate by almost 2,000 chicks, or 8.5%. The 756 chicks banded from 1-5 July were scored for infestation levels of the endemic bird tick *Argas monolakensis*, and overall mortality did not differ significantly between chicks with and without ticks. Chicks with high levels of tick parasitism, however, did suffer higher mortality than chicks with lower levels. Comparing tick data from 2001 to 2003, individual plots showed similar levels of tick infestation across years, though levels varied widely among plots. For 751 chicks banded and weighed on 1-5 July, mass at

banding was significantly greater for those that survived to fledging than for those that did not. A single coyote (*Canis latrans*) was seen on Gaines Island (the former landbridge connecting Negit Island to the lakeshore) on 23 August, though none were seen on any of the gulls' nesting islands. Avian predators observed preying on gull eggs, chicks, or adults in 2003 included the Black-crowned Night-Heron (*Nycticorax nycticorax*), Peregrine Falcon (*Falco peregrinus*), and Great Horned Owl (*Bubo virginianus*). We also observed a rare predation event on 2 July, when an Osprey (*Pandion haliaetus*) grabbed and swallowed a gull egg from a nest on Twain Islet. A period of meromixis (persistent salinity stratification), which began at Mono Lake in 1996 and initially was predicted to last for several decades, gradually and almost completely broke down in the early months of 2003 after several consecutive dry winters and a more complex mixing regime than originally expected. Primary productivity in the spring was the highest ever recorded at Mono Lake, and perhaps for any lake, and the brine shrimp *(Artemia monica)* population also increased. Still, gull fledging success did not increase over that in 2002, and the number of adults initiating nests actually decreased by 13% for unknown reasons.

## INTRODUCTION

The long-term study of California Gull (*Larus californicus*) population size and reproductive success at Mono Lake, California, under the direction of David Shuford of PRBO Conservation Science, was continued between May and August 2003. During this period, spanning most of egg laying through the fledging of young, we obtained three standardized measures of reproductive success of gulls nesting on the Negit and Paoha islets. The objectives of this ongoing study are to measure year-to-year variation in population size and reproductive success and to determine their relationship to changing lake levels.

The effects of recent changes in the Mono Lake ecosystem are of special interest to biologists (Patten et al. 1987, Botkin et al. 1988) and to public agencies charged with protecting the lake's valuable natural and scenic resources (Jones and Stokes 1993).

Because court-mandated protection of the Mono Lake ecosystem will allow the lake's surface elevation to rise to 6392 feet (SCWRCB 1994), there is a continuing need to monitor the lake's resources, including nesting gulls, to document their responses to the changing conditions. To this end, we have again placed a parallel focus on the foraging ecology of nesting adults, continuing the observational study initiated in 2000 (Wrege et al. 2001). In this report, however, we summarize the results obtained from the nest counts and chick banding surveys.

## STUDY AREA AND METHODS

The study area at Mono Lake has previously been described by Shuford (1985) and Shuford et al. (1984), but because conditions that potentially could affect nesting gulls have changed considerably over time, some aspects of the study area are reviewed below. We focused on three main areas at Mono Lake that support nesting California Gulls: Negit Island, the Negit Islets, and the Paoha Islets, though we also counted nests on recently colonized Old Marina Island. Negit Island supported the majority of the lake's gulls until abandoned in 1979. It was recolonized in 1985, and through 1993 it supported up to 13% of the lakewide total until abandoned again in 1994. In 1999 it was recolonized for a second time, and gull numbers there have since increased steadily but slowly. The adjacent Negit Islets have supported the majority of the lake's nesting gulls since the first abandonment of Negit Island, including 71% to 91% from 1985 to the present. The Paoha Islets have supported 9% to 29% of the total since 1985. In 2002 at least 5 pairs of gulls began nesting at Old Marina Island, an isolated mound of rock adjacent to Old Marina at the corner of the southwest shoreline. The straight that separates this island from shore was only 21 m wide and 0.7 m deep when measured on 14 August 2003, and overlies deep muck that makes crossing, at least by researchers, extremely difficult. The distance of other islets from the shore were extrapolated from a map showing the current lake level, using calipers to measure the distance in inches and then converting to kilometers (Tom Harrison Maps, 2003).

**Lake Level and Meromixis**

Since 1941, the lake has dropped almost 45 vertical feet and nearly doubled in salinity because of diversions of its inflowing streams. Wet winters in the early and mid-1980s caused a temporary reversal of the downward trend. The winters of 1986-87 through 1993-94 averaged very dry, and the lake level fell to a surface elevation of 6374.5 feet by May 1992. Very wet winters returned in 1994-95, 1996-97, and 1997-98, and, reinforced by reduced diversions of water from the watershed, the lake level rose to 6385.1 feet in July 1999 (P. Kavounas in litt.). Subsequently, lake levels have consistently, though slowly, dropped each year to reach 6,382.3 feet in May2003.

From 1983 to 1988, Mono Lake experienced persistent salinity stratification (meromixis), which lowered the lake's primary productivity (Jellison and Melack 1993). In the first year of this meromictic episode primary productivity dropped by two thirds. It remained low until 1986, then began to rise, and reached its highest level in the winter of 1988-1989 following the breakdown of meromictic conditions (Jellison et al. 1998). In 1996 the lake entered another episode of meromixis, which initially was predicted to last for up to several decades (Jellison et al. 1998). However, it almost completely broke down during the winter of 2002-03, after only seven years, virtually eliminating the chemocline at a depth of 31 m. Both episodes of meromixis ended in response to drought, though continuing high water diversions also helped quickly end the first episode. Declining lake levels rapidly decayed the chemocline, the depth defining the threshold between the monomolimnion, or deeper saltier waters, and mixolimnion, or fresher surface waters. Following the near breakdown of meromixis in 2003, primary productivity rose to the highest recorded level at Mono Lake, and almost twice that following the breakdown in 1989. This may even represent the highest level of primary productivity to be recorded in the limnological literature (R. Jellison pers. comm.).

**Nest Counts**

We counted nests on Negit Island, the Negit Islets, and the Paoha Islets from 24 to 28 May. Field workers walked through all the colonies tallying each nest and marking them with a dab of paint to avoid duplicate counts. For some small, steep-sided islets

incubating adults were counted from a small motorboat to estimate the number of nests present. We kept separate subtotals for nests within seven 10 x 20 m fenced plots on three of the Negit Islets (four plots on Twain, two on Little Tahiti, and one on Little Norway) and four fenced plots of various sizes (described in Jehl 2001) on two of the Paoha Islets (two on Coyote A and two on Paoha Islet). We used these detailed counts to estimate reproductive success.

**Chick Counts and Reproductive Success**

From 1-5 July, we banded all chicks of at least 100g in mass within the eleven fenced plots on the Negit and Paoha islets. From 5-7 August, we searched the nesting islands to determine the number of banded nestlings that died before fledging. On August 27, we returned to do a follow-up mortality count, searching exclusively for 14 banded chicks in five plots that were still alive and had not yet fledged during the 5-7 August mortality count. Using the data from nest, chick, and mortality counts, we estimated the total number of gulls successfully fledged from Mono Lake in 2003. PRBO has calculated the number fledged **(F)** on Negit Island and the Negit Islets as:

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

where **N** is the total number of nests on Negit Island and the Negit Islets, **P** is the number of plots, and $\mathbf{f_i}$ is the number of young fledged per nest in each of the Negit Islet fenced plots. From 1983 to 2001, J. R. Jehl, Jr. conducted similar standardized nest counts, chick bandings, and mortality counts on the Paoha Islets, yet he calculated the number fledged **(F)** as:

$$F = N*(C/P)$$

where **N** is the total number of nests on the Paoha Islets, **C** is the total number of chicks fledged from the islets' four fenced plots, and **P** is the total number of nests within those plots. The PRBO method provides an estimate of fledging success with error bounds reflecting the variation in success among different parts of the colony, whereas Jehl's method produces an average for all nests on the Paoha Islets that does not account for sampling variation.

Researchers have historically calculated the total number of chicks fledged from Mono Lake in a given season by summing these two estimates, even though they are calculated in different manners. In this report, however, estimates of the number of gulls fledged in 2003 are calculated using PRBO's method for all of the lake's plots.

Fledging rates in 2003 are calculated below in two ways, first using all plots (as is the standard method) and second by excluding data from the Little Norway (LN) plot. These data are excluded because of an isolated and extreme chick die off that was limited to Little Norway, an islet that held only 249 nests (1.3% of Mono Lake total) in 2003. The standard method for calculating the fledging rate for the lake's entire breeding population averages the fledging rates from each plot, meaning the LN plot accounts for 14% (1 of 7 plots) and 9% (1 of 1l plots) of the sample used to estimate the fledging rates for the Negit Islets and the entire lake, respectively. One of the reasons for using data from multiple plots to estimate fledging success is to account for variation in success among different islands or breeding areas. In this case, though, using plot data from Little Norway would unduly bias calculations of lakewide fledging success downward. It is hypothesized that the low fledging success on LN in 2003 was due to an endemic tick (*Argas monolakensis*), and this is discussed further in the results.

Estimates in this report are presented plus or minus their standard error.

**Tick Infestations**

Because of its potential effect on gull reproductive success, during banding we recorded the presence and abundance of the bird tick *Argas monolakensis* (endemic to Mono Lake's islands) for all 756 chicks banded. Each bird received a tick score of 0 to 3 based on the approximate proportion of the fleshy part of the legs covered by tick larvae: 0, no ticks; 1, up to one-third covered; 2, up to two-thirds covered; and 3, more than two-thirds covered. We analyzed various effects of ticks on chick survival, including tick data collected in 2001 and 2002, using a nonparametric chi-square test of proportions, calculated by hand.

Ticks take 2-5 years to reach adulthood, and they feed on California Gulls, their only known natural host, during all life stages (larval, 2-5 nymph stages, and adult). Because larvae require 5-8 days to feed and all postlarval stages feed only at night and for only 9-62 minutes (Schwan et al. 1992), all the ticks observed on gull chicks during banding were larvae. We therefore have no way of sampling the relative parasitism by nymphs or adults on any of the chicks or assessing the relative fitness costs to the chicks from these other life stages. Ticks may affect chick fitness directly by feeding on their blood or indirectly by transmitting a virus (Mono Lake virus). Though the fitness costs of this virus are unknown, it was found in 2.2-8.8% of ticks tested and neutralizing antibodies to the virus were found in 37% of chicks tested (Schwan et al. 1992). Schwan et al. (1992) also collected up to 1,200 larvae per bird from chicks that had died of unknown causes, illustrating the extent to which *A. monolakensis* may be affecting chick health.

### Chick Mass at Banding

We used hand-held Pesola scales to weigh 751 chicks that were banded in 10 of the 11 fenced plots. We analyzed effects of mass at banding on survival to fledging using a nonparametric test (Wilcoxon/Kruskal-Wallis) in Intercooled Stata 7.0.

## RESULTS AND DISCUSSION

### Phenology

In 2003, we found no chicks in any of the 19,915 nests checked from 24-28 May, indicating that nest initiation began later than in most years of the study. However, there were few (18) nests with eggs or newly hatched chicks in plots during the chick-banding period (1-5 July), indicating that the hatching period in 2003 may not have been protracted. In a typical year no chicks are found in plots during the mortality count, and the 14 alive and unfledged chicks found in 5 of the 11 fenced plots from 5-7 August may reflect the dates of the 2003 mortality count being earlier than normal or a delayed hatch period.

**Number of Breeding Adults**

In 2003, late May nest counts estimated that 31,074 (78%) of Mono Lake's gulls were nesting on the Negit Islets, 7,496 (19%) on the Paoha Islets, 904 (2%) on Negit Island, and 356 (1%) on Old Marina Island for a lakewide total of 39,830 nesting adults (Table 1). This represents the second lowest number of breeding adults in the 21 years of this study (Figure 1). Twain Islet alone held 47% of the total, followed by Little Tahiti Islet with 13% and Coyote A Islet with 12%. The estimated number of nesting pairs on Mono Lake in 2003 was 2,943 (13%) fewer than in 2002. This decline was restricted mainly to the Negit Islets, where nest numbers decreased on 8 of the 11 islets that held nesting gulls in 2002. Overall numbers on the Negit Islets dropped by 3,040 (16.4%) versus only 142 (3.7%) on the Paoha Islets. Nesting numbers on Twain were the lowest there since 1985, when it was still recovering from a 1982 invasion of coyotes that had decimated its nesting population. Nesting numbers on Little Tahiti and Little Norway were the lowest recorded in the 21 years of this study. The number of nests on Negit Island, however, increased by 16%, slowing from the rates of increase of 171% in 2001 and 44% in 2002.

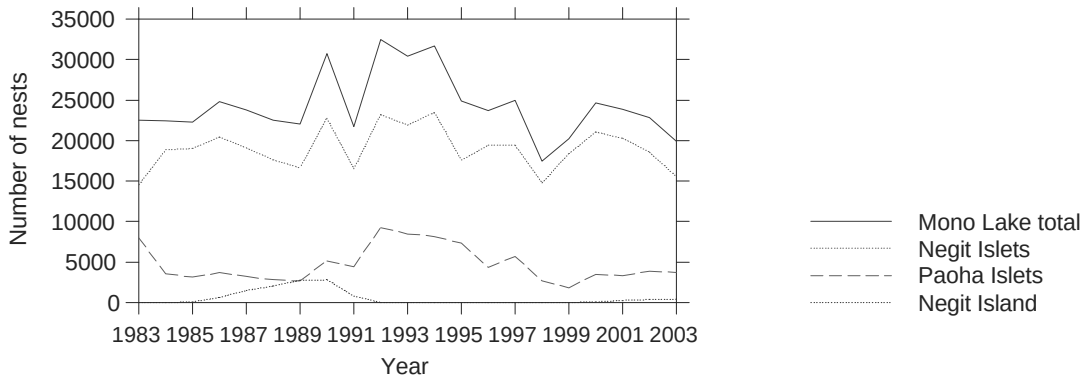


**Figure 1.** Number of nests in May from major breeding areas at Mono Lake (1983-2003)

In 2002, at least five pairs of gulls initiated nests on Old Marina Island. Nesting activity was not discovered until 5 July in 2002, making a standardized count of nests there impossible. The pre-fledged chicks were observed from shore using spotting scopes, and hence this count was a conservative estimate of the total actually there. In 2003, this majority of nests were found along the northeast end of the island, farthest from shore.

**Table 1.** Nest counts on Negit Island and the Negit and Paoha Islets from 1983 to 2003. Data from the Paoha Islets in all years but 2002 and 2003 from J. R. Jehl, Jr. (in litt.).

| Negit Islets | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Twain | 3808 | 7372 | 9309 | 11985 | 12422 | 11057 | 10573 | 15045 | 10883 | 15896 | 15431 | 15792 |
| L. Tahiti | 5260 | 7051 | 6572 | 5763 | 4261 | 3692 | 2983 | 4218 | 3205 | 3810 | 3616 | 4505 |
| L. Norway | 2218 | 1956 | 1407 | 810 | 360 | 254 | 269 | 432 | 355 | 473 | 428 | 533 |
| Steamboat | 997 | 1016 | 721 | 722 | 467 | 359 | 314 | 704 | 671 | 862 | 958 | 1217 |
| Java | 143 | 396 | 195 | 400 | 439 | 458 | 543 | 789 | 586 | 1040 | 399 | 199 |
| Spot | 505 | 358 | 296 | 311 | 248 | 247 | 231 | 309 | 311 | 335 | 356 | 449 |
| Tie | 511 | 231 | 196 | 150 | 84 | 87 | 95 | 167 | 160 | 220 | 210 | 320 |
| Krakatoa | 319 | 272 | 178 | 173 | 185 | 197 | 174 | 283 | 181 | 209 | 146 | 175 |
| Hat | 146 | 109 | 73 | 56 | 14 | 18 | 10 | 19 | 10 | 21 | 21 | 14 |
| La Paz | 105 | 58 | 43 | 30 | 22 | 21 | 23 | 46 | 49 | 70 | 77 | 57 |
| Geographic | 140 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 10 | 68 | 84 | 69 |
| Muir | 170 | 0 | 0 | 0 | 0 | 1 | 10 | 61 | 84 | 139 | 131 | 116 |
| Saddle | 175 | 46 | 41 | 29 | 14 | 13 | 10 | 18 | 8 | 14 | 10 | 11 |
| Midget | 5 | 3 | 3 | 4 | 4 | 2 | 3 | 3 | 2 | 2 | 3 | 2 |
| Siren | 51 | 0 | 1 | 0 | 0 | 0 | 1 | 7 | 7 | 19 | 20 | 14 |
| Comma | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| Castle Rocks | 2 | 3 | 4 | 3 | 4 | 6 | 5 | 4 | 5 | 5 | 3 | 3 |
| Pancake | 0 | 0 | 0 | 7 | 570 | 1216 | 1395 | 651 | 0 | 0 | 0 | 0 |
| Java Rocks | 0 | 0 | 0 | 0 | 4 | 3 | 0 | 4 | 2 | 13 | 15 | 9 |
| No name | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 3 | 3 |
| **Negit IsletsTotal**: | 14557 | 18872 | 19040 | 20444 | 19098 | 17631 | 16641 | 22765 | 16530 | 23200 | 21912 | 23488 |
| Paoha Islets | | | | | | | | | | | | |
| Coyote A | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] |
| Coyote B | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] |
| Browne | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] |
| Paoha Islet[b] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] | [a] |
| **Paoha Islets Total**: | 8001 | 3546 | 3153 | 3694 | 3208 | 2833 | 2682 | 5145 | 4442 | 9284 | 8498 | 8182 |
| Negit Island: | -- | -- | 92 | 636 | 1502 | 2037 | 2765 | 2827 | 788 | 4 | 12 | 0 |
| **Mono Lake Total**: | 22558 | 22418 | 22285 | 24778 | 23808 | 22501 | 22088 | 30737 | 21760 | 32488 | 30422 | 31670 |
| **Nesting Adults**: | 45116 | 44836 | 44570 | 49556 | 47616 | 45002 | 44176 | 61474 | 43520 | 64976 | 60844 | 63340 |

**Table 1.** Continued.

| Negit Islets | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|
| Twain | 11035 | 12690 | 13140 | 9488 | 10728 | 11856 | 11773 | 10772 | 9288 |
| L. Tahiti | 4021 | 4570 | 4092 | 3846 | 5108 | 5076 | 4309 | 3831 | 2632 |
| L. Norway | 493 | 766 | 794 | 606 | 732 | 887 | 665 | 357 | 249 |
| Steamboat | 981 | 459 | 505 | 405 | 381 | 477 | 570 | 621 | 575 |
| Java | 4 | 70 | 41 | 65 | 149 | 480 | 611 | 706 | 718 |
| Spot | 422 | 399 | 341 | 191 | 27 | 29 | 36 | 42 | 70 |
| Tie | 264 | 267 | 194 | 81 | 5 | 16 | 23 | 24 | 38 |
| Krakatoa | 116 | 57 | 33 | 16 | 76 | 120 | 141 | 129 | 113 |
| Hat | 19 | 41 | 58 | 47 | 43 | 29 | 23 | 9 | 7 |
| La Paz | 55 | 44 | 30 | 17 | 0 | 0 | 0 | 0 | 0 |
| Geographic | 51 | 0 | 0 | 0 | 0 | - | - | - | - |
| Muir | 87 | 4 | 0 | 0 | 0 | - | - | 0 | 0 |
| Saddle | 21 | 31 | 13 | 1 | 2 | 1 | 1 | 0 | 0 |
| Midget | 2 | 2 | 3 | 0 | 3 | 2 | 0 | 0 | 0 |
| Siren | 16 | 10 | 0 | 0 | 0 | - | - | - | 0 |
| Comma | 0 | 1 | 0 | 0 | 0 | - | - | 0 | 0 |
| Castle Rocks | 3 | 4 | 4 | 3 | 3 | 1 | 1 | 1 | 0 |
| Pancake | 0 | 0 | 1 | 13 | 1136 | 2098 | 2145 | 2085 | 1847 |
| Java Rocks | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No name | 1 | 0 | 0 | 0 | 0 | - | - | - | - |
| **Negit Islets Total**: | 17596 | 19416 | 19429 | 14779 | 18393 | 21072 | 20298 | 18577 | 15537 |
| Paoha Islets | | | | | | | | | |
| Coyote A | [a] | [a] | [a] | [a] | [a] | [a] | 2237 | 2612 | 2480 |
| Coyote B | [a] | [a] | [a] | [a] | [a] | [a] | 22 | 26 | 34 |
| Browne | [a] | [a] | [a] | [a] | [a] | [a] | 279 | 261 | 224 |
| Paoha Islet[b] | [a] | [a] | [a] | [a] | [a] | [a] | 776 | 991 | 1010 |
| **Paoha Islets Total**: | 7331 | 4334 | 5708 | 2687 | 1858 | 3478 | 3314 | 3890 | 3748 |
| Negit Island: | 0 | 0 | 0 | 0[c] | 14 | 100 | 271 | 391 | 452 |
| Old Marina Island: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [d] | 178 |
| **Mono Lake Total**: | 24927 | 23750 | 24957 | 17466 | 20265 | 24650 | 23883 | 22858 | 19915 |
| **Nesting Adults**: | 49854 | 47500 | 49914 | 34932 | 40530 | 49300 | 47766 | 45716 | 39830 |

[a] Data published elsewhere by J. R. Jehl, Jr.

[b] Numbers of nests intermittently attributed to Paoha Islet are from a piece of land immediately adjacent to the other Paoha Islets, which in various years is either partially or completely connected to the mainland of Paoha Island by a landbridge.

[c] No nesting gulls were seen on Negit Island in late May, but a nearshore boat survey on 8 July 1998 found five adults apparently incubating and one pre-fledging chick (J. R. Jehl, Jr. pers. comm.)

[d] Number of nests on Old Marina Island in 2002 (and in years before) is uncertain and discussed further in the text.

On 28 June, 12 chicks were counted from the shore using spotting scopes, and on 13 July, 36 chicks were counted from the boat using binoculars. Both counts are underestimates. Shore vantage points suffered from a very limited view of the far end of the island, whereas boat counts had an obscured view of much of the island's interior (also home to many of the nesting gulls). It is likely that far more than five pairs initiated nests in 2002 considering that in 2003 only 12 chicks were seen from shore when an earlier nest count revealed 178 nests.

**Fledging Rates in the Fenced Plots**

While the estimates in this and the next section are presented both including and excluding data from the Little Norway plot, excluding these data provide a more reasonable estimate of fledging rates and reproductive success for the whole population in 2003.

*Paoha Islets.* In 2003, the four fenced plots on the Paoha Islets held an average of 37.5 ± 9.1 nests and fledged an average of 1.28 ± 0.22 chicks per nest (Table 2) versus 38.3 ± 10.6 and 1.13 ± 0.18, respectively, in 2002 (Hite et al. 2002).

*Negit Islets.* In 2003, all seven fenced plots on the Negit Islets held an average of 66.6 ± 10.2 nests and fledged an average of 0.96 ± 0.17 chicks per nest (Table 2). Excluding data for the Little Norway plot, the six remaining fenced plots on the Negit Islets held an average of 72.3 ± 9.9 nests and fledged an average of 1.11 ± 0.07 chicks per nest (Table 2). By comparison, the long-term (1985-2002) average for these islets is 0.96 ± 0.08 (range = 0.26 to 1.43) chicks fledged per nest.

*All of Mono Lake.* Combined, the 11 plots (4 on Paoha Islets, 7 on Negit Islets, held an average of 56.0 ± 8.3 nests and fledged an average of 1.08 ± 0.14 chicks per nest (Table 2). Excluding the data from the Little Norway plot, the remaining 10 plots held an average of 58.4 ± 8.7 nests and fledged an average of 1.18 ± 0.10 chicks per nest (Table 2).

**Table 2.** Summary of Nest Counts, Chick Banding, and Mortality Counts on the Negit and Paoha Islets in 2003. "w/ LN" and "w/o LN" refer to inclusion and exclusion of all data from the Little Norway plot in calculating reproductive success for the Negit Islets and for all of Mono Lake.

| Site | Nests/Plot | | Chicks/Nest (in July) | | Chicks Banded (died) | | Fledged/Nest | |
|---|---|---|---|---|---|---|---|---|
| Little Norway *(LN)* | 32 | | 0.16 | | 5 (4) | | 0.03 | |
| Little Tahiti East *(LTE)* | 50 | | 0.88 | | 44 (3) | | 0.82 | |
| Little Tahiti West *(LTW)* | 86 | | 1.26 | | 108 (3) | | 1.22 | |
| Twain North *(TwNor)* | 63 | | 1.35 | | 85 (11) | | 1.17 | |
| Twain South *(TwS)* | 108 | | 1.11 | | 120 (16) | | 0.96 | |
| Twain West *(TwW)* | 83 | | 1.37 | | 114 (7) | | 1.29 | |
| Twain New *(TwNew)* | 44 | | 1.23 | | 54 (1) | | 1.20 | |
| **Negit Islet Totals:** | *w/ LN* | *w/o LN* | *w/ LN* | *w/o LN* | *w/ LN* | *w/o LN* | *w/ LN* | *w/o LN* |
| **Totals =** | **466** | **434** | **-** | **-** | **530 (45)** | **525 (41)** | **-** | **-** |
| **Average =** | **66.6** | **72.3** | **1.05** | **1.20** | **-** | **-** | **0.96** | **1.11** |
| **SD =** | **26.9** | **24.3** | **0.43** | **0.18** | **-** | **-** | **0.44** | **0.18** |
| **SE =** | **10.2** | **9.9** | **0.16** | **0.07** | **-** | **-** | **0.17** | **0.07** |
| Coyote A Cove *(CC)* | 47 | | 1.77 | | 83 (4) | | 1.68 | |
| Coyote A Hilltop *(CH)* | 57 | | 1.58 | | 90 (1) | | 1.56 | |
| Paoha Islet East *(PE)* | 16 | | 1.31 | | 21 (2) | | 1.19 | |
| Paoha Islet West *(PW)* | 30 | | 1.07 | | 32 (11) | | 0.70 | |
| **Paoha Islet:** | | | | | | | | |
| **Totals =** | **150** | | **-** | | **226 (18)** | | **-** | |
| **Average =** | **37.5** | | **1.43** | | **-** | | **1.28** | |
| **SD =** | **18.2** | | **0.31** | | **-** | | **0.44** | |
| **SE =** | **9.1** | | **0.15** | | **-** | | **0.22** | |
| **Mono Lake Totals:** | *w/ LN* | *w/o LN* | *w/ LN* | *w/o LN* | *w/ LN* | *w/o LN* | *w/ LN* | *w/o LN* |
| **Totals =** | **616** | **584** | **-** | **-** | **756 (63)** | **751 (59)** | **-** | **-** |
| **Average =** | **56.0** | **58.4** | **1.19** | **1.29** | **-** | **-** | **1.08** | **1.18** |
| **SD =** | **27.4** | **27.6** | **0.42** | **0.25** | **-** | **-** | **0.45** | **0.30** |
| **SE =** | **8.3** | **8.7** | **0.13** | **0.08** | **-** | **-** | **0.14** | **0.10** |

### Reproductive Success

*Paoha Islets.* Based on a total of 3,748 nests (Table 1) and an average of 1.28 ± 0.22 chicks fledged per nest for the four fenced plots (Table 2), an estimated 4,797 ± 825 chicks fledged from the Paoha Islets in 2003.

*Negit Islets.* Using the average of 0.96 ± 0.17 chicks fledged per nest from the seven fenced plots (Table 2) (and the total of 15,537 ± 452 nests (Table 1), an estimated 15,349 ± 2,718 chicks fledged from the Negit Islets and Negit Island . Excluding data for the Little Norway plot, and using the average of 1.11 ± 0.07 chicks fledged per nest from the remaining six fenced plots on the Negit Islets (Table 2) and the total number of 15,537±452 nests (Table 1), an estimated 17,748 ± 1,119 chicks fledged from the Negit Islets and Negit Island.

*All of Mono Lake.* Overall, based on the average of 1.08 ± 0.14 chicks fledged per nest from all 11 plots (Table 2) and the total number of 19,915 nests on the lake (Table 1), an estimated 21,508 ± 2,788 chicks fledged from Mono Lake in 2003. Excluding data for the Little Norway plot, and using the average of 1.18 ± 0.10 chicks fledged per nest from the remaining 10 plots (Table 2) and the total of 19,915 nests on the lake (Table 1), an estimated 23,500 ± 1,992 chicks fledged from Mono Lake in 2003.

Using all plot data except Little Norway the 2,943 fewer pairs of adults initiating nests in 2003 than in 2002 fledged approximately 2,787 chicks, an 11% decrease in productivity.

**Ticks Infestations**

*Mono Lake 2003.* The level of larval tick numbers found on gull chicks varied among nest plots. Only 2 of the 11 plots (LN and LTE; see Table 2 for plot abbreviations) had any birds with a tick score (TS) > 1. In three plots (CC, PE, and PW), all located on the Paoha Islets, no birds had any ticks. LN was the only plot where all birds had ticks, and moreover in high concentrations (TS = 2 or 3). Of the 756 chicks scored for ticks in 2003, 87% (n = 659) had a TS = 0, 10% (n = 79) had a TS = 1, 1% (n = 10) had a TS = 2, and 1% (n = 8) had a TS = 3.

Chick mortality was associated with the degree of tick infestation. While there was no apparent difference in survival between birds with ticks (8.3%) and birds without ticks (8.2%), there was a significant difference ($X^2 = 18.536$, $df = 3$, $p < 0.001$) in mortality between chicks with different tick scores. This likely reflects the high mortality of chicks

with TS = 2 (30.0%) and those with TS = 3 (37.5%) (Table 3). Chicks with no ticks or very few (TS = 0-1) suffered much less mortality than those with TS = 2-3, suggesting that ticks do not increase mortality unless present on chicks in high concentrations.

**Table 3.** Relative tick parasitism of chicks in 2003. Data summed from all 11 fenced plots.

| Tick Score (TS) | Chicks Fledged | Chicks Found dead | Total (fledged + dead) | % dead (dead/total) |
|---|---|---|---|---|
| 0 | 604 | 55 | 659 | 8.3% |
| 1 | 77 | 2 | 79 | 2.5% |
| 2 | 7 | 3 | 10 | 30.0% |
| 3 | 5 | 3 | 8 | 37.5% |
| No (TS = 0) | 604 | 55 | 659 | 8.3% |
| Yes (TS = 1-3) | 89 | 8 | 97 | 8.2% |
| Total (TS = 0-3) | 693 | 63 | 756 | 8.3% |

*Negit Islets 2001-2003.* For the Negit Islets, mortality was associated with various tick scores and it varied among years (Figure 2, Table 4). Mortality between chicks with different tick scores was significant in both 2002 ( $X^2 = 34.208$, $df = 3$, $p < 0.001$) and 2003 ($X^2 = 17.487$, $df = 3$, $p < 0.001$) but not in 2001 ($X^2 = 1.928$, $df = 3$, $p > 0.5$).

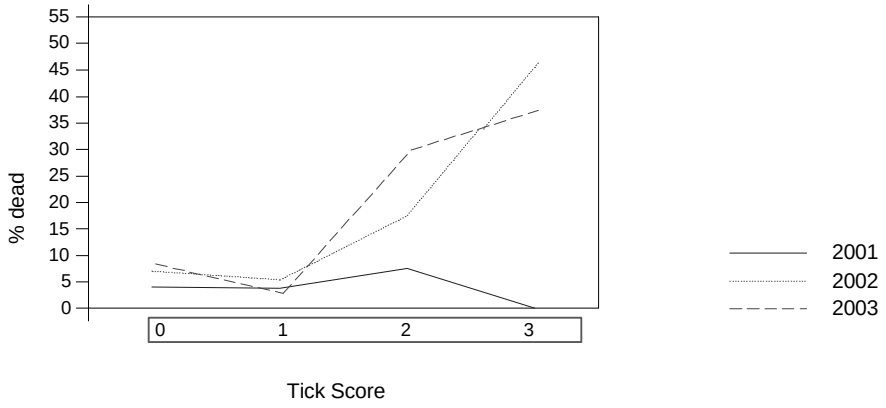


**Figure 2.** Percentage of chicks with a particularly tick score found dead, from data for seven Negit Islets plots, 2001-2003.

In 2002 and 2003, there was little difference in mortality between chicks without ticks and those with few ticks (TS = 1) (Table 4). Also, mortality was higher for chicks with high tick scores (TS = 2 or 3) than for those with no ticks or low scores (TS = 0 or 1), and chicks with TS = 3 suffered higher mortality than chicks with TS = 2. In 2001, however, mortality was low for chicks with all tick scores. It is unclear what factors contributed to the differences in mortality with respect to tick numbers in the various years.

**Table 4.** Relative tick parasitism of chicks, summed from the seven Negit Islet fenced plots, from 2001 to 2003.

| Year | Tick Score (TS) | Chicks Fledged | Chicks found dead | Total (fledged + dead) | % dead (dead/total) |
|---|---|---|---|---|---|
| **2001** | 0 | 630 | 26 | 656 | 4.0% |
| | 1 | 76 | 3 | 79 | 3.8% |
| | 2 | 37 | 3 | 40 | 7.5% |
| | 3 | 16 | 0 | 16 | 0% |
| | No (TS = 0) | 630 | 26 | 656 | 4.0% |
| | Yes (TS = 1-3) | 129 | 6 | 135 | 4.4% |
| | Total (TS = 0-3) | 759 | 32 | 791 | 4.0% |
| **2002** | 0 | 543 | 41 | 584 | 7.0% |
| | 1 | 89 | 5 | 94 | 5.3% |
| | 2 | 47 | 10 | 57 | 17.5% |
| | 3 | 8 | 7 | 15 | 46.7% |
| | No (TS = 0) | 543 | 41 | 584 | 7.0% |
| | Yes (TS = 1-3) | 144 | 22 | 166 | 13.3% |
| | Total (TS = 0-3) | 687 | 63 | 750 | 8.4% |
| **2003** | 0 | 405 | 37 | 442 | 8.4% |
| | 1 | 68 | 2 | 70 | 2.9% |
| | 2 | 7 | 3 | 10 | 30.0% |
| | 3 | 5 | 3 | 8 | 37.5% |
| | No (TS = 0) | 405 | 37 | 442 | 8.4% |
| | Yes (TS = 1-3) | 80 | 8 | 88 | 9.1% |
| | Total (TS = 0-3) | 485 | 45 | 530 | 8.5% |

The proportion of chicks with ticks varied substantially among plots in all years but relatively little among individual plots across years (Figure 3). From 2001 to 2003, larval *A. monolakensis* have been found on chicks on all islets that hold study plots (Twain, Little Tahiti, Little Norway, Coyote A) except for Paoha Islet, which has only been insular from Paoha Island and supporting breeding gulls since the late 1990s. In 2003,

the percentage of birds with ticks was >8% in only 3 of 1l plots (TwNew, LTE, and LN). These three plots, respectively, had 0%, 29.4%, and 100% of chicks, with a TS > 1. As LN was the only plot where all chicks had a TS > 1, it seems likely that the very low fledging success there was due to ticks. Chicks per nest at the time of banding (1-5 July) was already extremely low in the LN plot compared to that in the other 10 plots (Table 2), suggesting that many chicks may have died in LN from the effects of tick parasitism before banding occurred. The eight fresh chicks found dead from unknown causes in the LN plot during banding, compared to <3 in any of the remaining 10 plots, all with relatively low tick infestations, further suggests a link between the degree of tick infestation and mortality.

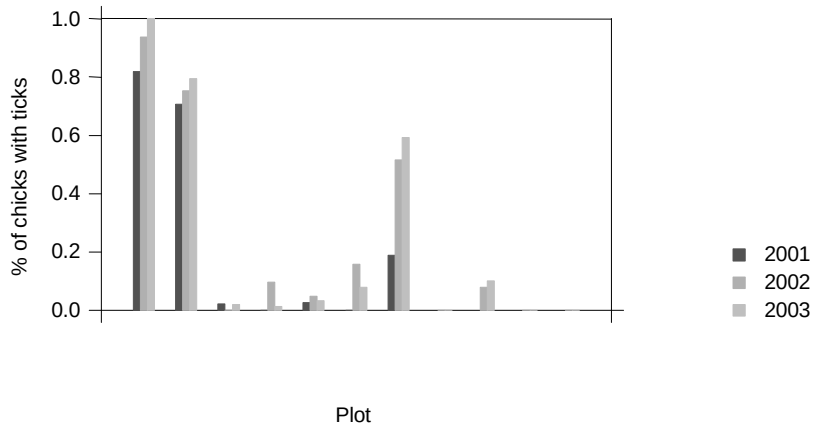


**Figure 3.** Percent of chicks with ticks (TS > 0), in each of the seven Negit Islet plots from 2001 to 2003 and in each of the four Paoha Islet plots from 2002 to 2003.

Finally, from 2001 to 2003, the three Negit Islet plots with high tick concentrations (LN, LTE and TwNor; Figure 3) also had the lowest number of nests (and hence nest densities (Table 5). In addition to low nesting density, these plots rank among the lowest in terms of fledging success in all three years (Table 5), further suggesting that ticks have a negative effect on gull reproduction.

**Table 5.** Number of nests per plot and estimate of chicks fledged per nest per plot from 2001 to 2003. The three plots where chicks consistently had high levels of tick parasitism are in **bold** (see Figure 3 for levels of tick parasitism from 2001 to 2003).

| Plot | Nest Count | | | Chicks Fledged per Nest | | |
|---|---|---|---|---|---|---|
| | 2001 | 2002 | 2003 | 2001 | 2002 | 2003 |
| **Little Norway** | **71** | **51** | **32** | **1.20** | **0.37** | **0.03** |
| **Little Tahiti East** | **69** | **61** | **50** | **0.81** | **1.15** | **0.82** |
| Little Tahiti West | 111 | 93 | 86 | 1.20 | 1.33 | 1.22 |
| Twain North | 78 | 73 | 63 | 1.49 | 1.37 | 1.17 |
| Twain South | 135 | 122 | 108 | 1.14 | 1.43 | 0.96 |
| Twain West | 111 | 106 | 83 | 1.28 | 1.27 | 1.29 |
| **Twain New** | **70** | **56** | **44** | **0.86** | **1.18** | **1.20** |

**Mass at banding**

Of 751 chicks banded and weighed on 1-5 July, 59 were found dead on their natal islet on 5-7 August, indicating that 692 chicks succeeded in fledging. The average mass at banding was 497 ± 4.7 g and 440 ± 18.1 g, respectively, for chicks that ultimately did or did not survive to fledging was; this difference was significant ($X^2 = 11.48$, $df = 1$, $p < 0.001$). Average mass at banding of chicks that did not fledge in 2002 (n = 72, mean = 411 ± 13.9) (Hite et al. 2002) was 29 g lower than in 2003, but this difference was not significant ($X^2 = 2.533$, $df = 1$, $p = 0.11$).

Chicks were not weighed each year, but researchers did so in 1998, the year with the lowest nest count and fourth lowest fledging success since at least 1985. In 1998, average mass at banding of fledged chicks was 549 g and that of non-fledgeed chicks was 475 g, both noticeably higher than weights in 2002 and 2003. This may indicate that in years of higher gull productivity chicks of all size and age classes are more likely to survive to fledging whereas fewer relatively lighter chicks survive in years of poor productivity, thus shifting upwards the average weight in poor years.

**Gull Predators**

A single coyote (*Canis latrans*) was seen by Justin Hite on Gaines Island on 23 August 2003 after it flushed several thousand foraging California Gulls and American Avocets (*Recurvirosta americana*). Gaines Island is surrounded by water on all sides, though the

currently declining lake level has reduced the channel between it and the mainland shore to 0.4 km in width. This channel is shallow, averaging about 1 m in depth near its south end, and is thickly dotted with mounds of tufa. The channel between Gaines Island and Negit Island is also 0.4 km in width, though considerably deeper and without tufa mounds a swimming coyote could potentially use when crossing. The three Negit Islets closest to Gaines Island are Pancake (0.70 km), Java (0.77 km), and Twain (0.90 km), which accounted for 9%, 4%, and 47%, respectively, of the lake's breeding pairs in 2003.

Avian predators seen or heard repeatedly throughout the season in the vicinity of the Negit Islets were the Black-crowned Night-Heron (*Nycticorax nycticorax*), Peregrine Falcon (*Falco peregrinus*), and Great Horned Owl (*Bubo virginianus*). Two other avian predators, Prairie Falcon (*Falco mexicanus*) and Golden Eagle (*Aquila chrysaetos*), were seen only once each among the Negit Islets, though both were observed on several occasions from the nearby Black Point shoreline and Gaines Island. Finally, an Osprey (*Pandion haliaetus*) was observed taking a gull egg from a shoreline nest on Twain on 2 July 2003. It quickly swallowed the egg in flight and flew north among a cloud of attacking gulls toward Like-A-Man tufa, where a pair of Osprey were brooding an active nest. Osprey were seen at least once a week throughout the season, typically perching on Midget Islet (where they occasionally leave a few bits of nesting material) or commuting over the islets. Noticeably absent from the islets in 2003 were Common Ravens (*Corvus corax*), which in 2002 were observed in the vicinity several times a week throughout the season, once grabbing a small chick and twice grabbing gull eggs.

**Overview**

The reasons for year-to-year variation in the number of adult gulls breeding at Mono Lake and their nesting success remain imperfectly known. During the tenure of this long-term monitoring program, low reproduction has been associated with the early years of each period of meromixis. During these meromictic episodes, the productivity of Mono Lake has been reduced and brine shrimp phenology has been delayed (Jellison and Melack 1999). Effects of meromixis on alkali flies (*Ephydra hians*), another major prey

source, are unclear, but they may benefit (in body size and population size) from the lower relative salinity of the surface waters. Long-legged flies (*Hydrophorus plumbeus*), a third major prey item, have a lower salinity tolerance than do alkali flies, and meromixis may actually also enhance their abundance by reducing surface salinity to levels lower than those during monomictic (fully mixed) years at the same lake level.

During the previous period of meromixis from 1983 through 1988 (Jellison and Melack 1993), gull productivity on the Negit Islets was low in 1983 and 1984, increased in 1985, and increased further to above average levels from 1986 through 1988 (PRBO unpubl. data) as meromixis weakened with falling lake levels (R. Jellison pers. comm.). These events suggest that over the course of the prior period of meromixis, invertebrate food supplies increased or the gulls otherwise adapted to the meromictic conditions. The four years of poor reproduction from 1996 to 1999 followed by relatively high reproductive success from 2000 to 2003, mirrors the pattern in the previous meromictic event. As meromixis weakened, some of its typical effects were at least partially absent: adult shrimp were available in the water column three to four weeks earlier than in preceding years, and shrimp population density increased rapidly during the early chick hatching period (R. Jellison pers. comm., P. Wrege unpubl. data).

Although it warrants concern, the long-term effect of meromixis on gull productivity at Mono Lake is uncertain. Meromixis, will, however, occur with increasing regularity compared to pre-diversion rates if the lake is managed, as planned, at the lower than natural level of 6,392 feet above sea level as mandated by the State (SCWRCB 1994; decision 1631). The lake will become meromictic if its surface elevation rises 0.8 m in one year (R. Jellison pers. comm.), and such a rise will occur with relatively lower volumes of runoff when the lake is at or below target level compared to its pre-diversion level because of the lake's relatively higher salinity and lower level.

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**Literature Cited**

Botkin, D., W. S. Brocker, L. G. Everett, J. S. Shapiro, and J. A. Wiens. 1988. The future of Mono Lake. University of California Water Resources Center Report 68.

Hite, J. M., E. G. O'Hara, T. Wilson, and M. T. Hite. 2002. Population size and reproductive success of California Gulls at Mono Lake, California, in 2002. Contribution No. 1013, PRBO Conservation Science, 4990 Shoreline Highway, Stinson Beach, CA 94970.

Jehl, J. R., Jr. 2001. Breeding of California Gulls on the Paoha Islets, Mono Lake, California, 2001. Hubbs-Sea World Research Institute Technical Report No. 2001-318.

Jellison, R., and J. M. Melack. 1993. Meromixis in hypersaline Mono Lake, California. Part 1: Stratification and vertical mixing during the onset, persistence, and breakdown of meromixis. Limnol. Oceanogr. 38:1008-1019.

Jellison, R., and J. M. Melack. 1999. Mixing and plankton dynamics in Mono Lake, California. 1999 annual report to the Los Angeles Department of Water and Power and the National Science Foundation.

Jellison, R., J. Romero, and J. M. Melack. 1998. The onset of meromixis during restoration of Mono Lake, California: Unintended consequences of reducing water diversions. Limnol. Oceanogr. 41:706-711.

Jones and Stokes Associates. 1993. Environmental impact report for the review of Mono Basin water rights of the City of Los Angeles. Draft. May. (JSA 90-171). Sacramento, Calif. Prepared for California State Water Resources Control Board, Div. of Water Rights, Sacramento.

Patten, D. T. et al. 1987. The Mono Basin ecosystem: Effects of changing lake level. National Academy Press, Washington, DC.

Schwan, T. G., M. D. Corwin, and S. J. Brown. 1992. Argas (Argas) monolakensis, New Species (Acari: Ixodoidea: Argasidae), a parasite of California Gulls on islands in Mono Lake, California: Description, biology, and life cycle. J. Med. Entomol. 29(1): 78-97.

Shuford, W. D. 1985. Reproductive success and ecology of California Gulls at Mono Lake, California in 1985, with special reference to the Negit Islets: An overview of three years of research. Contribution
No. 318, Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970.

Shuford, W. D., E. Strauss, and R. Hogan. 1984. Population size and breeding success of California Gulls at Mono Lake, California in 1983. Final report for contract #14-16-0009-83-922 to the U.S. Fish and Wildlife Service. Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970.

Shuford, W. D., P. Super, and S. Johnston. 1985. Population size and breeding success of California Gulls at Mono Lake, California 1984. Contribution No. 294, Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970.

State of California Water Resources Control Board. 1994. Mono Lake Basin water right decision 1631. State water Resources Control Board, Division of Water Rights, 901 P St., 3rd Floor, Sacramento, CA 95814.

Tom Harrison Maps. 2003. The Mono Lake Map. Tom Harrison Maps, 2 Falmouth Cove, San Rafael CA 94901-4465.

Wrege, P. H., J. M. Hite, and D. W. Winkler. 2001. The diet of California Gull nestlings at Mono Lake: Seasonal and diurnal variation. Contribution No. 939, Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970.