Population Size and Reproductive Success of California Gulls at Mono Lake, California, in 2004

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ABSTRACT

In 2004, nest counts in late May estimated 51,908 adult California Gulls (*Larus californicus*) breeding at Mono Lake, which was slightly above the 1983-2003 average of 48,600 ± 1700. Roughly 76% nested on the Negit Islets, 20% on the Paoha Islets, 2% on Negit Island, and 2% on Old Marina Islet. Twain Islet remained the most populous, holding 44% of the Mono Lake total, followed by Little Tahiti and Coyote A islets each with 13%. The number of nests on Negit Island increased by 30% over the total in 2003, continuing a steady increase since the island was recolonized in 1999.

Average clutch size was 2.35 ± 0.04 eggs per nest, among the highest it has been in the 22 years of this study. Reproductive success in the 11 fenced plots ranged from 0.88 to 1.88 chicks fledged per nest, except on Little Norway Islet where the low rate of 0.20 chicks per nest likely reflected the effects of a tick outbreak limited to that site. Excluding the unrepresentative data from Little Norway, estimates of the number of chicks fledged per nest were 1.53 on the Negit Islets as a whole, 1.51 on the Paoha Islets, and 1.53 at Mono Lake overall. An estimated 38,928 ± 3562 chicks fledged from all the lake's nesting islands in 2004, which is 66% higher than the 1983-2003 average of 23,500 ± 2400 chicks.

Of the 837 chicks banded from 2-6 July, 836 were scored for infestation levels of the endemic bird tick *Argas monolakensis*. Overall mortality did not differ significantly between chicks with and without ticks, nor did chicks with high levels of ticks show increased mortality, as they did in 2002 and 2003. For these 837 chicks, weight at banding was significantly greater for those that survived to fledging than for those that did not, and the difference between the average weights of each group was much larger than in 1998, 2002, and 2003. The failure of all 511 nests on Old Marina Islet sometime between late June and early July was probably due to coyote (*Canis latrans*) predation. A period of meromixis (persistent salinity stratification) that began at Mono Lake in 1996 had almost completely broken down in 2003 but still had not done so in 2004. However, large amounts of nutrients released into the water column following the near-breakdown in 2003, combined with exceptionally warm spring temperatures, apparently led to the

rapid development of a large population of brine shrimp in spring 2004. By contrast, in spring 2003, despite comparable levels of nutrients in the water column with the near-breakdown of meromixis, spring temperatures were cooler and the brine shrimp hatch was delayed. This suggests that when adequate nutrients are available that spring temperatures strongly affect brine shrimp productivity and thus play a significant role in the timing and extent of California Gull nest initiation and possibly reproductive success.

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 2004. 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, a parallel study focused on the foraging ecology of nesting adults was carried out from 2000 to 2003 (Hite et al. 2004a) but discontinued in 2004. In this report, we summarize data on the size of the nesting gull population and its productivity in 2004 and discuss possible explanations of the patterns observed.

STUDY AREA AND METHODS

The study area at Mono Lake has previously been described (Shuford et al. 1984, Shuford 1985), but because conditions that potentially could affect nesting gulls have changed considerably over time, some aspects of the study area are reviewed here. 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 Islet. 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. Since 1985, the Negit Islands have supported 71% to 91% of the total, the Paoha Islets 9% to 29%. In 2002, at least five pairs of gulls began nesting at Old Marina Islet, an isolated mound of rock adjacent to the Old Marina on the western shoreline. In 2003, the strait that separated this island from shore was only 21 m wide and 0.7 m deep. In 2004, however, researchers could hop from tufa mounds to the islands without getting their feet wet. The distances from shore of other islets were calculated from a map showing the current lake level (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 6381.7 feet in May 2004.

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 (measured as grams of carbon per cubic meter) dropped by two-thirds. Productivity remained low until 1986, then began to rise, and reached its highest level in the winter of 1988-89 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 – the depth threshold between the monolimnion, or deeper saltier waters, and mixolimnion, or fresher surface waters – at a depth of 31 m. Both episodes of meromixis eroded in response to drought, though continuing high water diversions also helped quicken the end of the first episode. Following the near-breakdown of meromixis in 2003, primary productivity rose to the highest recorded level at Mono Lake, which was almost twice that following the breakdown in 1989, and may even represent the highest level of primary productivity recorded in the limnological literature (R. Jellison pers. comm.).

During the winter of 2003-04, the lake did not turn over and this second episode of meromixis did not completely end. Large amounts of nutrients were recycled throughout the water column, however, and, combined with exceptionally warm spring temperatures, this led to the rapid development of a large spring generation of brine shrimp (*Artemia monica*). This was followed by a clear-water phase as the shrimp grazed away the lake's algae, which in turn led to a rapid die-off of the first generation of brine shrimp and the highest August chlorophyll levels recorded (R. Jellison pers. comm.). This shrimp die-off, however, occurred late enough in the season to be at a time when juvenile gulls were already feeding themselves and likely preying predominantly on alkali flies (*Ephydra hians*) (see Elphick and Rubega 1995), and thus we believe it was of little consequence to California Gull productivity in 2004.

Nest Counts

We counted active nests on Negit Island, the Negit Islets, and the Paoha Islets from 25 to 29 May, and on Old Marina Islet on 30 May. Field workers walked through all the colonies tallying each nest and marking them with a dab of water-soluble 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 also recorded the number of nests containing at least one fully hatched chick on all islets except Old Marina Islet. 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, two on Piglet Islet) (see Table 1). We calculated mean clutch size at Mono Lake in 2004 by averaging the average clutch sizes of each plot, excluding data from the Little Norway (LN) plot for reasons discussed below.

Table 1. Names, abbreviations, and locations of the eleven fenced plots used to estimate reproductive success.

Island	Plot Name	Plot Abbreviation
Negit Islets		
Little Norway	Little Norway	LN
Little Tahati	Little Tahiti East	LTE
	Little Tahiti West	LTW
Twain	Twain North	TwNor
	Twain South	TwS
	Twain West	TwW
	Twain New	TwNew
Paoha Islets		
Coyote A	Coyote Cove	CC
	Coyote Hilltop	CH
Piglet Islet	Piglet Islet East	PE
	Piglet Islet West	PW

Chick Counts and Reproductive Success

From 2-6 July, we banded all chicks within 9 of the 11 fenced plots on the Negit and Paoha islets. Chicks were not banded in two plots, Coyote Hilltop (CH) and Piglet West

(PW) on the Paoha islets because their fences were in poor repair and chicks moved freely in and out of the plots. From 10-13 August, we searched the nesting islands to determine the number of banded nestlings that died before fledging.

With the data from nest, chick, and mortality counts, we estimated the fledging rate for each plot and, using the average fledging rate for the entire population, the total number of gulls successfully fledged from Mono Lake in 2004. We calculated the fledging rate for each plot **(f_{plot})** as:

$$f_{plot} = (C_b - C_d) / N_p$$

where **C_b** is the number of chicks banded in that plot in July, **C_d** is the number of chicks from that plot found dead in August, and **N_p** 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 counted at Mono Lake, **P** is the number of plots, and **f_i** is the number of young fledged per nest in each of the Negit Islet fenced plots.

Unlike in 2003 when fledging rates were calculated with and without data from the Little Norway (LN) plot, all estimates for 2004 are calculated only without the LN data. These data are excluded because of an isolated and extreme chick die-off that was limited to Little Norway, an islet that held only 213 nests (0.8% of Mono Lake total) in 2004. The standard method for calculating the fledging rate for the lake's entire breeding population averages the fledging rates from each plot. Thus under that scenario, the LN plot, if used, would account for 9% (1 of 11 plots) and 11% (1 of 9 plots) of the sample used to estimate the fledging rates for the entire lake in 2003 and 2004, 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, however, using plot data from Little Norway would unduly bias calculations of lakewide fledging success downward. We suggest that the low fledging success on LN in 2003 and 2004 was due to high levels of an endemic tick (*Argas monolakensis*), as discussed further in the Results.

Additionally, because all 511 nests on Old Marina Islet in 2004 failed before fledging, probably from coyote predation (see Results), these nests are excluded from the total number of nests when calculating the estimated number of chicks fledged from Mono Lake in 2004.

We used a simple linear correlation calculated by hand to investigate the relationship between the number of nests and chicks fledged per nest across all 22 years of this study after testing the data for normalcy using the Kolmogorov-Smirnov one sample test in SYSTAT 6.0.

Finally, estimates in this report are presented plus or minus one 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 836 of 837 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 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 post-larval 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 of 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% to 8.8% of ticks tested, and neutralizing antibodies to the virus were found in 37% of chicks tested (Schwan et al. 1992). These authors also collected up to 1200 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 all 837 chicks that were banded in 9 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 2004, we found chicks in 215 (0.85%) of the 25,954 nests checked from 25-29 May. During these five days the percentage of nests with chicks rapidly increased from 0.08% to 9.5% (Table 2). By contrast, during counts from 24-28 May 2003 there were no chicks in any of the 19,915 total nests (Hite et al. 2004b). The start of hatching in 2004 appeared to be slightly earlier than the average over the last 21 years of this study, though our methodology does not allow us to easily calculate this. Warm spring temperatures, and their role in seasonal brine shrimp phenology, may be a factor in the timing of laying and hence hatching of California Gull eggs.

Table 2. Percent of gull nests with chicks during nest counts at Mono Lake, 25-29 May 2004.

Date	No. of chicks	Total no. of nests counted	Percent of nests with chicks
25 May	9	11480	0.08
26 May	6	6995	0.09
27 May	160	6140	2.61
28 May	17	587	2.90
29 May	23	241	9.54
Total	215	25443	0.85

There were only a handful of nests with eggs still being incubated during chick banding in early July, though all eggs that were checked were either partially cracked or hollow. Typically there are a dozen or more nests with viable eggs still being incubated in early July, including pipped eggs in the process of hatching. Not only were there no nests with viable eggs still being incubated in 2004, there also were no downy chicks. Of the 837 chicks weighed during banding, the lightest was 205g (compared to approximately 50 g at hatching). This indicates that in 2004 second nesting attempts (due to loss of a first clutch or brood) and late laying did not occur with any noticeable frequency. The abundant early-season food supply alone could explain the apparent lack of late laying. This may also indicate that intraspecific predation, a major cause of failed nests and second nesting attempts (Hite unpubl. data), was much lower than in most years, perhaps in response to the readily available brine shrimp population.

Number of Nests and Breeding Adults

In 2004, late May nest counts recorded a lakewide total of 25,954 California Gull nests for an estimate of 51,908 nesting pairs. Of the total, 76% were on the Negit Islets, 20% on the Paoha Islets, 2% on Negit Island, and 2% on Old Marina Islet (Table 3). Twain Islet alone held 44% of the total, followed by Little Tahiti and Coyote A islets, each with 13%, and Pancake Islet, with 11%. Collectively, the other 14 islands/islets inhabited by gulls in 2004 held only 20% of the total. The estimated 51,908 nesting pairs was the fifth highest in the 22 years of this study but only 7% above the 1983 to 2003 average of 48,600 ± 1700. The 19,722 nests on the Negit Islands was the 8th highest in the 22 years of this study and 4% higher than the long-term average of 19,013 ± 566 nests. The 5134 nests on the Paoha Islets was also the 8th highest since 1983 and 9% higher than the long-term average of 4715 ± 484. The number of nests on Negit Island continued to grow to 587 nests, a 30% increase compared to numbers in 2003. The number of nests on Old Marina Islet, barely insular from the mainland during the nesting season, increased to 511 nests from 178 in 2003. The number of nests increased on every single island or islet above the counts in 2003 except on Little Norway, where the number of nests dropped from 249 to 213, the lowest it has been in the 22 years of this study.

Table 3. Nest counts on Negit Island and the Negit and Paoha islets from 1983 to 2004. Data from the Paoha Islets in all years but 2002 to 2004 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 Islets Total:	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]
Piglet 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

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

[b] Numbers of nests intermittently attributed to Piglet 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. It was formerly known as "Paoha Islet" (Jehl 2001; Hite et al. 2004b) but has been changed to "Piglet Islet" to avoid confusion with Paoha Island.

[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.)

Table 3. Continued.

Negit Islets	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Twain	11035	12690	13140	9488	10728	11856	11773	10772	9288	11480
L. Tahiti	4021	4570	4092	3846	5108	5076	4309	3831	2632	3303
L. Norway	493	766	794	606	732	887	665	357	249	213
Steamboat	981	459	505	405	381	477	570	621	575	635
Java	4	70	41	65	149	480	611	706	718	915
Spot	422	399	341	191	27	29	36	42	70	98
Tie	264	267	194	81	5	16	23	24	38	49
Krakatoa	116	57	33	16	76	120	141	129	113	181
Hat	19	41	58	47	43	29	23	9	7	9
La Paz	55	44	30	17	0	0	0	0	0	1
Geographic	51	0	0	0	0	0	0	0	0	0
Muir	87	4	0	0	0	0	0	0	0	0
Saddle	21	31	13	1	2	1	1	0	0	0
Midget	2	2	3	0	3	2	0	0	0	1
Siren	16	10	0	0	0	0	0	0	0	0
Comma	0	1	0	0	0	0	0	0	0	0
Castle Rocks	3	4	4	3	3	1	1	1	0	0
Pancake	0	0	1	13	1136	2098	2145	2085	1847	2837
Java Rocks	5	1	0	0	0	0	0	0	0	0
No name	1	0	0	0	0	0	0	0	0	0
Negit Islets Total:	17596	19416	19429	14779	18393	21072	20298	18577	15537	19722
Paoha Islets										
Coyote A	[a]	[a]	[a]	[a]	[a]	[a]	2237	2612	2480	3244
Coyote B	[a]	[a]	[a]	[a]	[a]	[a]	22	26	34	55
Browne	[a]	[a]	[a]	[a]	[a]	[a]	279	261	224	283
Piglet Islet[b]	[a]	[a]	[a]	[a]	[a]	[a]	776	991	1010	1552
Paoha Islets Total:	7331	4334	5708	2687	1858	3478	3314	3890	3748	5134
Negit Island:	0	0	0	0[c]	14	100	271	391	452	587
Old Marina Islet:	--	--	--	--	--	--	--	[d]	178[e]	511
Mono Lake Total:	24927	23750	24957	17466	20265	24650	23883	22858	19915	25954
Nesting Adults:	49854	47500	49914	34932	40530	49300	47766	45716	39830	51908

[d] Number of nests on Old Marina Islet is uncertain in 2002 and unknown in prior years. In 2002, at least five pairs of gulls initiated nests on Old Marina Islet but nesting activity was not discovered until 5 July, making a standardized count of nests 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.

[e] Nests counted without water soluble paints, which typically serve as a counting aid, and counters believe the 178 nests they recorded may be an underestimate.

Clutch Size

Excluding data for Little Noway (see Methods), the average clutch size was 2.35 ± 0.04 eggs/nest for the total 593 nests counted in the other 10 fenced plots at Mono Lake in 2004 (Table 4). Winkler (1983) reported that average clutch size at Mono Lake is approximately 1.8 eggs/nest, which is similar to clutch sizes of 1.89 in 2002 and 1.83 in 2003 (Hite unpubl. data).

Table 4. Clutch sizes of the California Gull in 11 fenced plots at Mono Lake in 2004.

Site	1-egg nest	2-egg nest	3-egg nest	No. nests	No. eggs	Mean clutch size
Negit Islets						
Little Norway *(LN)*	3	13	4	20	41	2.05[a]
Little Tahiti East *(LTE)*	7	26	16	49	107	2.18
Little Tahiti West *(LTW)*	7	35	46	88	215	2.44
Twain North *(TwNor)*	4	26	36	66	164	2.48
Twain South *(TwS)*	14	50	36	100	222	2.22
Twain West *(TwW)*	6	33	40	79	192	2.43
Twain New *(TwNew)*	7	20	24	51	119	2.33
Paoha Islets						
Coyote A Cove *(CC)*	4	18	27	49	121	2.47
Coyote A Hilltop *(CH)*	3	31	22	56	131	2.34
Piglet Islet East *(PE)*	5	9	9	23	50	2.17
Piglet Islet West *(PW)*	3	14	15	32	76	2.38
Mono Lake Total	63	275	275	613	1438	2.35 ± 0.04

[a] We excluded mean clutch size in LN when calculating the overall mean clutch size at Mono Lake for reasons discussed in the Methods.

Clutch size of nests in the plots varied between 1 and 3 eggs. Nests with 1 egg accounted for 10% of the total nests, and nests with 2 eggs and with 3 eggs each accounted for 45%. By contrast, in 2002 and 2003 nests with 3 eggs accounted for only 10% and 6%, respectively, of the total nests (Figure 1). We hypothesize that the dramatic increase in clutch size, reflected mainly in the huge increase in the number of 3-egg clutches over that in 2002 and 2003, indicates that Mono Lake's gull population took advantage of the large brine shrimp population present very early in the season.

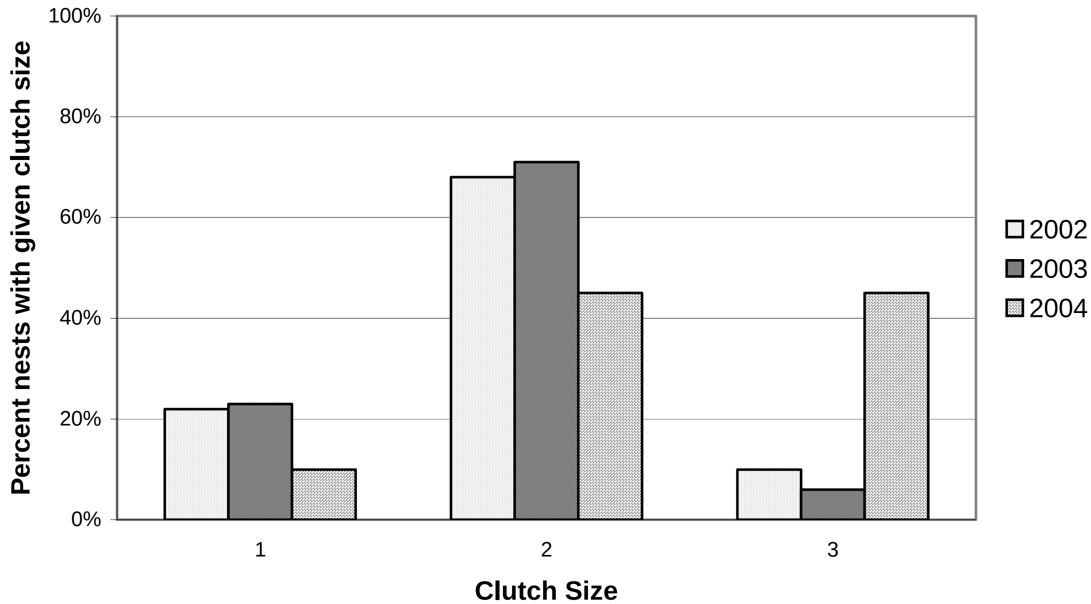

Figure 1. Percent of gull nests with different clutch sizes at Mono Lake from 2002 to 2004.

Fledging Rates in the Fenced Plots

The six fenced plots on the Negit Islets, exclusive of Little Norway, held an average of 72.2 ± 8.4 nests and fledged an average of 1.53 ± 0.16 chicks per nest (Table 5). By comparison, the 1983-2003 average for these islets is 0.94 ± 0.08 (range = 0.26-1.43) chicks fledged per nest. The two fenced plots on the Paoha Islets held an average of 36.0 ± 13.0 nests and fledged an average of 1.51 ± 0.12 chicks per nest (Table 5). Combined, these eight plots held an average of 63.1 ± 10.3 nests and fledged an average of 1.53 ± 0.14 chicks per nest (Table 5). This represents the largest estimate of chicks fledged per nest in the 22 years of study (Figure 2) and is 63% higher than the 1983-2003 average of 0.94 ± 0.08 chicks fledged per nest. The 0.65 chicks fledged per egg in 2004, however, did not differ from comparable estimates in 2002 and 2003 (0.66 each year), when the number of chicks fledged per nest was much lower (1.23 in 2002, 1.19 in 2003).

Table 5. Numbers of gull nests and chicks fledged per nest in fenced plots on the Negit and Paoha islets in 2004.

Site	Nests per Plot 25 – 30 May	Chicks per Nest 2 – 6 July	Chicks Banded (chicks found dead)	Chicks Fledged/Nest
Little Norway *(LN)*	20	0.20	4 (0)	0.20
Little Tahiti East *(LTE)*	49	0.94	46 (3)	0.88
Little Tahiti West *(LTW)*	88	1.93	170 (5)	1.88
Twain North *(TwNor)*	66	1.89	125 (5)	1.82
Twain South *(TwS)*	100	1.34	134 (7)	1.27
Twain West *(TwW)*	79	1.90	150 (10)	1.77
Twain New *(TwNew)*	51	1.73	88 (7)	1.59
Negit Islet Totals: [a]				
Totals =	**433**	**-**	**713 (37)**	**-**
Average =	**72.2**	**1.62**	**-**	**1.53**
SD =	**20.5**	**0.40**	**-**	**0.39**
SE =	**8.4**	**0.16**	**-**	**0.16**
Coyote A Cove *(CC)*	49	1.76	86 (6)	1.63
Coyote A Hilltop *(CH)*	[b]	-	-	-
Piglet Islet East *(PE)*	23	1.48	34 (2)	1.39
Piglet Islet West *(PW)*	[b]	-	-	-
Paoha Islet Totals:				
Totals =	**72**	**-**	**120 (8)**	**-**
Average =	**36.0**	**1.62**	**-**	**1.51**
SD =	**18.4**	**0.20**	**-**	**0.17**
SE =	**13.0**	**1.38**	**-**	**0.12**
Mono Lake Totals: [c]				
Totals =	**505**	**-**	**833 (37)**	**-**
Average =	**63.1**	**1.62**	**-**	**1.53**
SD =	**25.1**	**0.35**	**-**	**0.34**
SE =	**10.3**	**0.14**	**-**	**0.14**

[a] Calculated excluding data from LN plot for reasons discussed in the Methods.

[b] There were 56 nests in CH and 32 nests in PW in 2004. However, because we could not band chicks in these plots because of the poor condition of their fences, we excluded these nest number data from the calculation of average numbers of nests in plots on the Paoha Islets and for Mono Lake as a whole. We did not exclude these nest numbers when calculating average clutch size (Table 4).

[c] All Mono Lake totals are calculated without data from LN, CH, and PW.

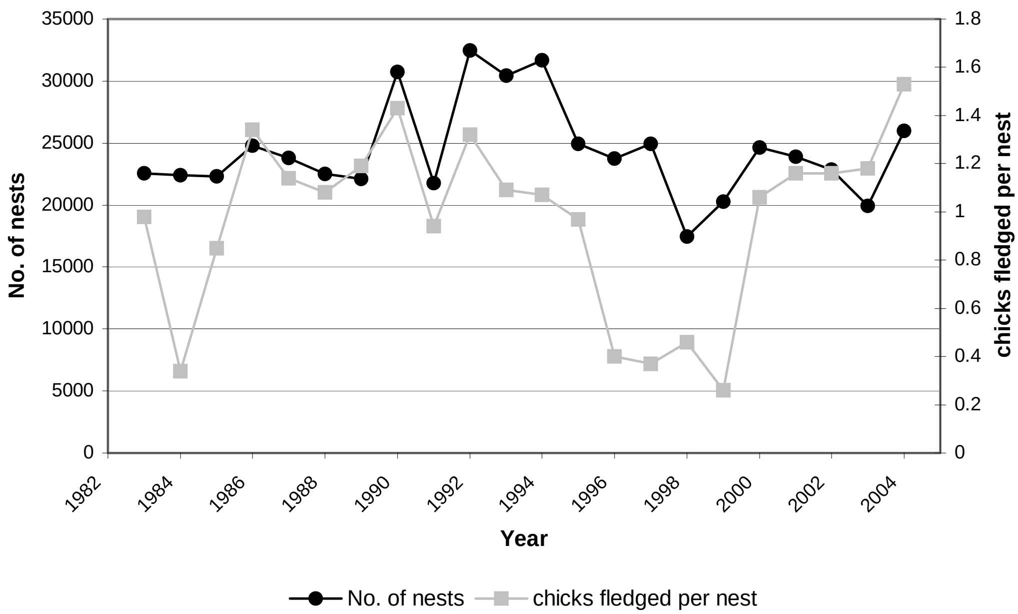

Figure 2. Number of nests and chicks fledged per nest at Mono Lake, 1983 to 2004.

Number of nests (*mean = 24,370, sd = 3869, p = 0.24*) and chicks fledged per nest (*mean = 0.97, sd = 0.37, p = 0.32*) were both found to be normally distributed. We were therefore able to use a simple linear correlation to test the relationship between these two sets of data and found a significant positive correlation ($r^2=0.22$, $v=20$, $p < 0.05$) (Figure 3). This suggests that the overall conditions that affect nest initiation and fledging success are related within a given year.

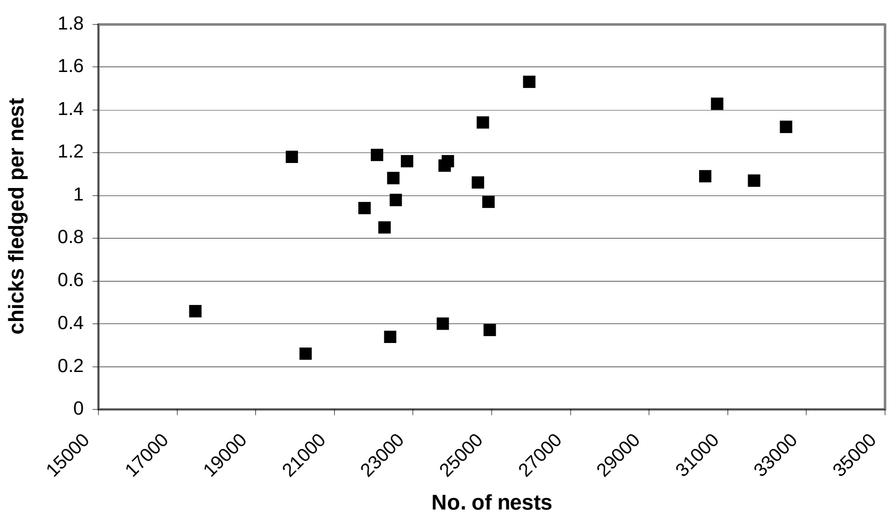

Figure 3. Positive correlation between number of nests and chicks fledged per nest in each of the 22 years of this study.

Reproductive Success

Based on the total of 20,309 nests on the Negit Islets (19,722) and on Negit Island (587) combined (Table 3) and an average of 1.53 ± 0.16 chicks fledged per nest from the six fenced plots on the Negit Islets (Table 5), an estimated 31,073 ± 3249 chicks fledged from the Negit Islets and Negit Island collectively in 2004. Similarly, based on a total of 5134 nests on the Paoha Islets (Table 3) and an average of 1.51 ± 0.12 chicks fledged per nest from the two plots on them (Table 5), an estimated 7,752 ± 616 chicks fledged from these islets. Overall, calculated from a total of 25,443 nests (25,954 nests on the lake minus the 511 that perished on Old Marina Islet; Table 3) and an average of 1.53 ± 0.14 chicks fledged per nest from the eight plots (Table 5), an estimated 38,928 ± 3562 chicks fledged from Mono Lake in 2004. This represents a 66% increase in number of fledglings over the previous year (23,500 ± 1992), and is 66% higher than the 1983-2003 average of 23,500 ± 2400. It is also the third highest number of fledglings in the 22 years of this study, lower only than in 1990 and 1992.

Tick Infestation

Mono Lake 2004. The level of larval tick numbers found on gull chicks varied among nest plots. Only 3 of the 9 surveyed plots (LN, LTE, and TwNew; see Table 1 for plot abbreviations) had any birds with a tick score (TS) > 1. In three plots (CC, PE, and TwNor), no birds had any ticks. LN was the only plot where all birds had ticks, and moreover in high concentrations (all with TS = 2 or 3), though LTE also had a very high proportion of chicks with ticks (only 2 of 45 chicks had a TS = 0). Of the 836 chicks scored for ticks in 2004, 83% (*n* = 691) had a TS = 0, 11% (*n* = 90) had a TS = 1, 1% (*n* = 7) had a TS = 2, and <1% (*n* = 3) had a TS = 3 (Table 6).

Table 6. Relative tick levels on gull chicks in 2004. Data summed from the 9 fenced plots in which chicks were banded (see Methods).

Tick Score	Chicks Fledged	Chicks Found dead	Total (fledged + dead)	% dead (dead/total)
0	691	43	734	5.9%
1	90	2	92	2.2%
2	7	0	7	0%
3	3	0	3	0%
ALL	791	45	836	5.4%

Chick mortality in 2004 was not associated with the degree of tick infestation as it was in 2002 and 2003 (Hite et al. 2004b). In 2004, of the chicks sampled that later died 2.0% had ticks and 5.9% did not, though there was no significant difference (X^2 = 0.5759, *df* = 1, $p > 0.1$) in mortality between these two groups. Neither was there a significant difference in mortality between chicks with low levels of ticks (TS = 0 or 1) and those with high levels of ticks (TS = 2 or 3) ($X^2 = 2.6711$, $df = 1$, $p > 0.1$), though small sample sizes (only 10 chicks with TS > 1) makes meaningful comparison difficult.

In the past, mortality was associated with various tick scores, and it varied among years (Hite et al. 2004b). In 2002 and 2003, there was little difference in mortality between chicks without ticks and those with few ticks (TS = 1). 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 had higher mortality than chicks with TS = 2. In 2001, however, mortality was low for chicks with all tick scores, as was the case in 2004. It is unclear what factors contribute to the differences in mortality with respect to tick numbers in the various years.

The proportion of chicks with ticks varied substantially among plots in all years but relatively little among individual plots across years (Figure 4). From 2001 to 2004, larval *A. monolakensis* have been found on chicks on all islets that hold study plots (Twain, Little Tahiti, Little Norway, Coyote A) except for Piglet Islet, which has been insular from Paoha Island and supporting breeding gulls only since the late 1990s. In 2004, the percentage of birds with ticks (TS > 0) was >8% in 4 of 9 plots (TwW, TwNew, LTE, and LN). These four plots, respectively, had 0%, 3%, 7%, 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 (in 2004 and 2003, and perhaps even 2002, when tick levels have also been noticeably high) has been caused by the effects of ticks. Chicks per nest at the time of banding (2-6 July) in 2004 was already extremely low in the LN plot compared to that in the other 10 plots (Table 5), suggesting that many chicks may have died in LN from the effects of tick parasitism before banding occurred.

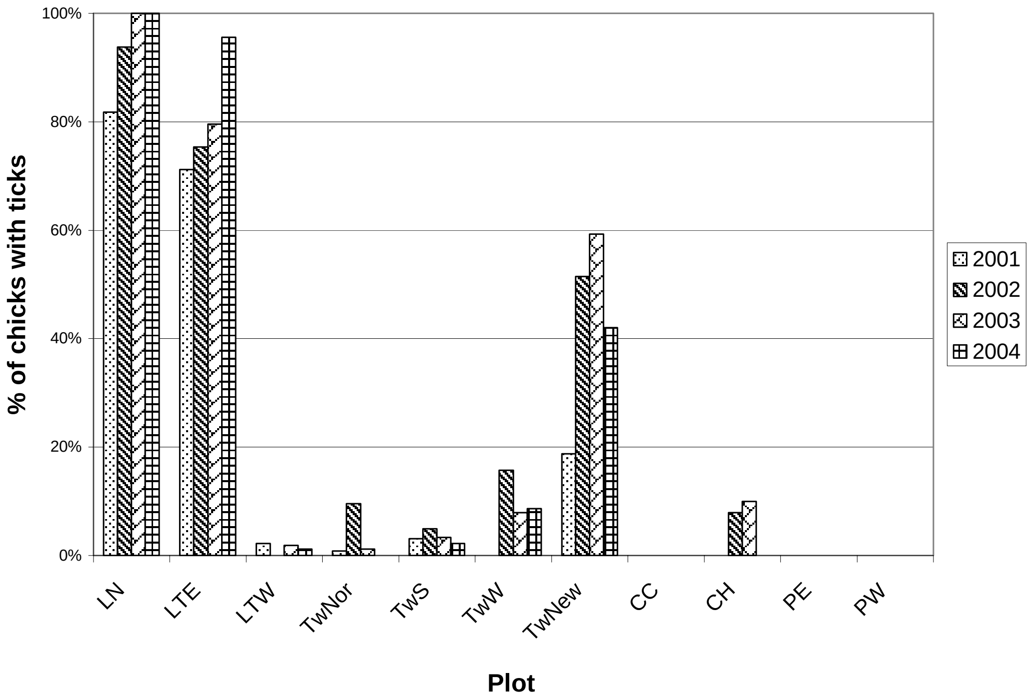

Figure 4. Percent of chicks with ticks (TS > 0), in each of the seven Negit Islet plots from 2001 to 2004 and in each of the four surveyed Paoha Islet plots from 2002 to 2004.

Finally, from 2001 to 2004, the three Negit Islet plots with high tick concentrations (LN, LTE and TwNew; Figure 4) also had the lowest number of nests, and hence nest densities, and ranked among the lowest in terms of fledging success (see Table 5 in Hite et al. 2004b and Table 5 in this report for numbers). This further suggests that ticks have a negative effect on gull reproduction.

Little Norway 2004. Number of nests and estimate of fledging success in the Little Norway plot in 2004 were the lowest and second lowest, respectively, in 22 years of study. Only four chicks survived to banding in July out of 20 nests counted in May. All chicks had tick scores of 2 or 3, though none of these chicks were found dead in the August mortality count indicating that they did succeed in fledging. In 2003 there were 32 nests in May, 5 chicks in July, and only one chick that survived to fledge (0.03 chicks/nest) (Hite et al. 2004b).

Several factors indicate that ticks play a role in the recent changes in the Little Norway plot. In the LN plot from 2001 to 2004 the percent of chicks with a TS = 0 or 1 decreased at a similar rate as chicks fledged per nest (Figure 5). We have found that chick mortality may increase with higher tick scores (see above), and therefore an increasing tick population during this time period (indicated by a decreasing proportion of chicks with low tick scores) is likely driving the falling fledging rates in this plot. We have not found abnormal numbers of dead adult gulls on Little Norway, indicating that unlike chicks they are not experiencing heightened mortality from ticks. Tick parasitism on nesting adults, however, may be causing them to simply abandon their nest or broods. The average clutch size in LN was also the lowest of any of the plots in 2004. This may be related to prior abandonment of older or higher quality adults, which tend to lay larger clutches (Pugesek 1981). Finally, as noted below, the average mass of chicks at banding at LN was the highest in any of the 9 plots surveyed in 2004. Although the sample size is too low for reliable analysis, this indicates that all or most of the chicks that were doing poorly, and thus would have weighed less, succumbed to tick parasitism and were already dead by the time of banding.

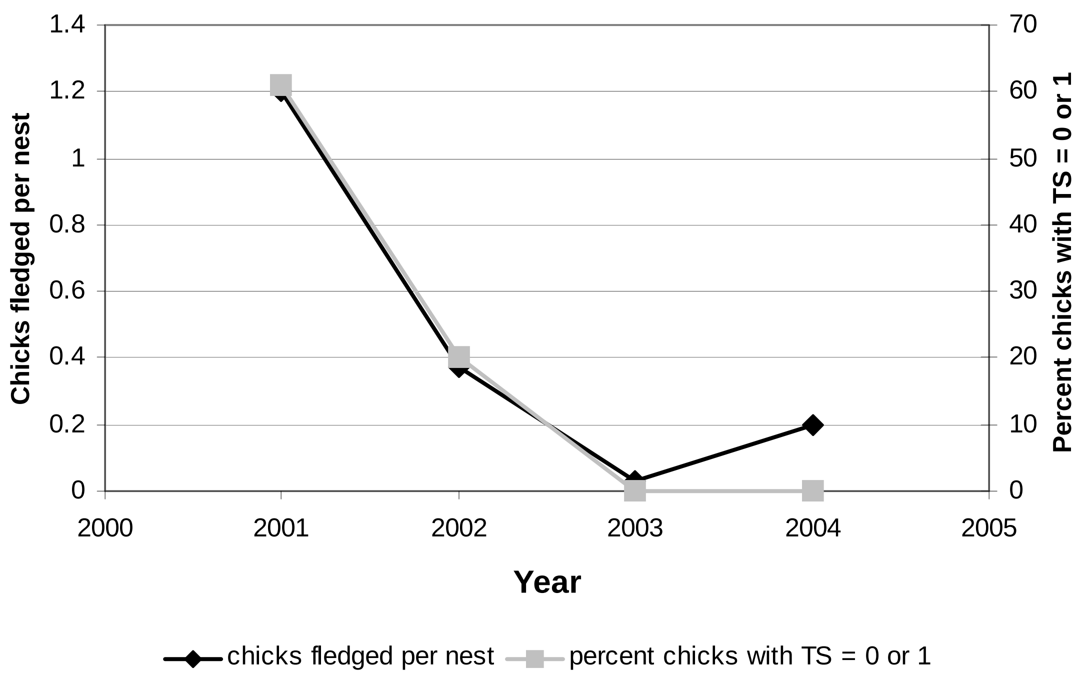

Figure 5. Chicks fledged per nest and percent chicks with TS = 0 or TS = 1 in the Little Norway plot from 2001 to 2004.

Little Norway's gull population declined dramatically in the late 1980s as well, falling from 2218 pairs in 1983 to 254 in a span of 5 years (Table 3). This was at a time when the lake was stable and hence available nesting substrate was not decreasing. Nest numbers slowly increased to a high of 887 in 2000, after which they dropped again to the new low of 213 nests in 2004. Other islets to show such rapid decreases in numbers of nests include Twain, Java, Pancake, and Negit – which declined in response to coyote predation – and several of the smallest and lowest islets (Spot, Tie, Hat, La Paz, Geographic, Muir, and Saddle) – which declined in response to complete or near-complete flooding with rising lake levels. The two periods of decline on Little Norway were not caused by either of these factors: the islet was never reached by coyotes and the decline in nest numbers occurred at times when lake level was either steady or falling. It is possible that a prior period of heavy tick parasitism similar to the current episode may have played a significant role in the decline in nest numbers on Little Norway in the mid-1980s.

Mass at Banding

The average mass of 837 chicks weighed from 2-6 July 2004 was 551 ± 4 g (range = 205-840; Table 7). Of these, 45 were found dead on their natal islet on 10-13 August, indicating that 792 chicks succeeded in fledging. The average mass at banding was 561 ± 4 g and 391 ± 19 g, respectively, for chicks that ultimately did or did not survive to fledging; this difference was significant (X^2 = 58.13, *df* = 1, $p < 0.001$).

Overall, there were a number of noticeable differences in the population of chicks banded in 2004 compared to previous years. First, there were no "downy" chicks, i.e., those with a fairly extensive amount of downy feathers still on the body and, especially, the head. The lack of downy chicks during banding in 2004 contrasts with 26 downy chicks out of a total of 950 (3%) in 2002 and 47 downy chicks out of 756 (6%) in 2003. While this is by no means an exact qualifier for chick age, it does help separate light chicks into two categories, those that are small because they are young (downy chicks) and those that are small because they are developing slowly or are poorly fed (not downy). Second, the lightest chick of the 837 banded in 2004 weighed 205 g. Typically there are at least five to ten chicks that we feel are too small to band (generally those that weigh <100 g). Finally, during banding in early July there are often some chicks in the process of hatching and some pipped eggs. In 2004, there was none of this, indicating that late re-nesting and nest establishment did not occur or was minimal.

Table 7. Chick weight data at Mono Lake in 2004.

Plot	# of chicks	Average Weight	SD	SE	Max	Min
LN	4	574	67.2	33.6	655	470
LTE	46	513	114.5	17.1	695	255
LTW	170	562	103.9	8.0	760	275
TwNor	125	564	108.9	9.8	795	260
TwS	134	556	113.1	9.8	840	250
TwW	150	557	104.4	8.5	765	205
TwNew	88	541	114.0	12.2	750	230
CC	86	519	113.2	12.2	780	260
PE	34	567	78.8	13.5	730	425
Negit Islets	717	555	109.2	4.1	840	205
Paoha Islets	120	533	106.8	9.8	780	260
Mono Lake	837	551.43	109.11	3.78	840	205

In all four years in which chicks were banded and weighed (Figure 6), those that survived to banding weighed significantly more than those that did not. In 2002 and 2003, the difference in average mass between chicks in these groups was 80 g and 57 g, respectively, and the average masses for each of the two groups were similar between years. In 1998, the difference in mass between chicks in the two groups was 74 g, comparable to 2002 and 2003, but the average masses for each the two groups were noticeably higher than in 2002 and 2003. In 2004, however, the difference in average mass between those that survived and those that did not was 170 g, and the average weights of the two classes of chicks were higher and lower, respectively, than those in 1998, 2002, and 2003.

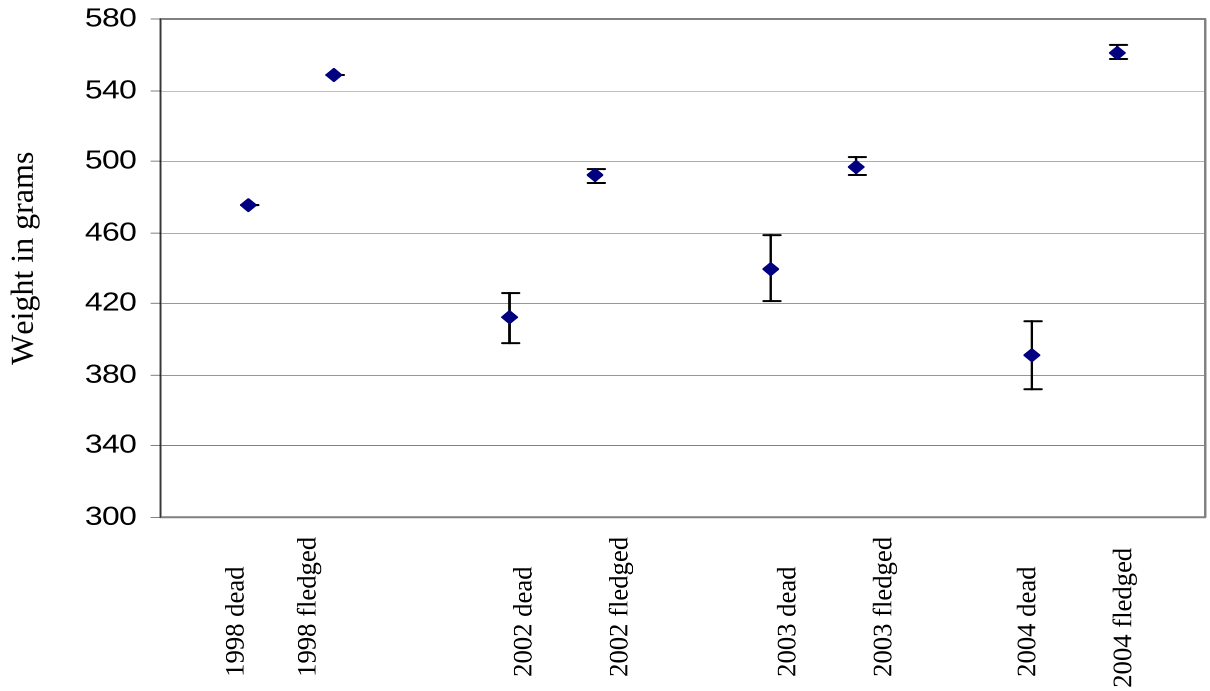

Figure 6. Weight of chicks at banding that ultimately died compared to those that fledged in 1998, 2002, 2003, and 2004. Bars show standard errors.

Gull Predators

Coyotes probably caused the disappearance of the entire California Gull nesting population on Old Marina Islet in 2004. On 30 May, volunteers counted 511 nests on this island, which they were able to reach by jumping from tufa mound to tufa mound without getting their feet wet. Large numbers of pre-fledged chicks were observed repeatedly until late June. On 6 July, we noticed that there seemed to be few adults on the island and no chicks visible from a distance with binoculars. On July 12 we visited the island on foot and confirmed that the colony was no longer active. There were no living chicks, dead chicks, or parts of chicks. There were, however, the remains of 8 or 9 adult gulls. Some of these carcasses still had heads attached to necks but necks separated from bodies, whereas others consisted only of individual or paired wings with broken breast bones attached. About a third of the nests (their linings still visible) had lots of egg shell fragments in them. It is likely that these were eaten by coyotes because adult gulls typically remove eggshells from the nest or consume them if the eggs successfully hatched. No coyote tracks or scat were found, but the hard-packed soil and abundance of tufa made tracks difficult to find.

On 23 August 2003, a single coyote was seen on Gaines Island after it flushed several thousand foraging California Gulls and American Avocets (*Recurvirosta americana*) (Hite et al. 2004b), though no coyotes were seen on Gaines Island in 2004. If the lake level continues to decline, it will be increasingly easy for coyote to cross the channel to Gaines Island and perhaps from there to Negit Island or the Negit Islets. The channel between Gaines Island and Negit Island is 0.4 km in width. The three Negit Islets closest to Gaines Island are Pancake (0.70 km), Java (0.77 km), and Twain (0.90 km), which, respectively, accounted for 11%, 4%, and 44% of the lake's breeding pairs in 2004.

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*), Prairie Falcon (*Falco mexicanus*), Great Horned Owl (*Bubo virginianus*), and Common Raven (*Corvus corax*). We observed Prairie Falcons killing adult gulls twice, once over Little Tahiti on 24 May and then over Negit Island two days later. The second attack happened moments after the Prairie Falcon was spotted soaring high above the lake, after which it suddenly stooped downward to slam into an adult California Gull flying with four others about 50 m over Negit; the falcon then grappled with the load until it disappeared out of sight behind Negit. Adult Golden Eagles (*Aquila chrysaetos*) were seen twice in the vicinity of the islands, perched on top of Twain Islet after flushing the entire island. Osprey (*Pandion haliaetus*) – of which we observed an adult swooping down onto Twain Islet to steal a gull egg in 2003 (Hite et al. 2004b) – were again present in the vicinity of the Negit Islets. We observed them primarily flying toward the active nest on Like-A-Man tufa or perching on Midget Islet where they occasionally left a few bits of nesting material.

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). The effects of meromixis on alkali flies (*Ephydra hians*), another major prey source of gulls, are unclear, but these flies may benefit (in body size and population size) from the lower relative salinity of the lake's surface waters (D. Herbst pers. comm.). Long-legged flies (*Hydrophorus plumbeus*), a third major prey item in some years, appear to have a lower salinity tolerance than do alkali flies. Though Herbst and Bradley (1988) found that the larvae of *H. plumbeus* can survive at high salinities that would kill *E. hians* larvae, they noted that other life stages may not be as salt tolerant, which would in turn reduce the species' overall salt tolerance. *H. plumbeus* have been recorded in large numbers only during the first (D. Herbst pers. comm.) and second (Hite et al. 2004a) episodes of meromixis, indicating a lower salt tolerance relative to *E. hians*. Meromixis may enhance *H. plumbeus* 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 and mixing increased over time (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 2004, 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 greater frequency compared to pre-diversion rates if the lake is managed, as planned, at the lower than natural level of 6392 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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