POPULATION SIZE AND REPRODUCTIVE SUCCESS OF CALIFORNIA GULLS AT MONO LAKE, CALIFORNIA, IN 1992, WITH EMPHASIS ON THE NEGIT ISLETS

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ABSTRACT

An estimated 64,976 adult California Gulls bred at Mono Lake, California, in 1992, a number slightly higher than the previous high estimate of 61,474 in 1990. This year the Negit Islets supported 71.4% of Mono Lake's breeding gulls, versus 28.6% on the Paoha Islets. Negit Island was not recolonized as a nesting site in 1992 after being abandoned in 1991. An average of 1.32 chicks per nest fledged within the Negit Islet plots, a number toward the high end of the range of 0.94 to 1.43 chicks per nest for the years 1986 to 1991. Approximately 44,000 young fledged from all of Mono Lake's nesting islands in 1992. Brine shrimp appeared to be a major component of the adult diet in May and, as is typical of most years, was the most important item (by volume) fed to chicks in early July. Unless lake level rises substantially before the 1993 nesting season, there is a high probability that Twain Islet -- holding about 50% of the entire lake's nesting population -- will be threatened by coyotes.

INTRODUCTION

In 1992 Point Reyes Bird Observatory (PRBO) completed the tenth year of a study of the California Gull *(Larus californicus)* at Mono Lake, California. The objectives of our ongoing study are to measure year-to-year variation in population size and reproductive success and to determine their relationship to changing lake levels. This report focuses on the Negit Islets, which currently support most of the lake's nesting gulls, and on Negit Island, which supported the majority until the gulls abandoned it in 1979. Negit Island was recolonized in 1985 and abandoned again in 1991.

The effects of recent changes in the Mono Lake ecosystem are of special interest to biologists (Patten et al. 1987, Botkin et al. 1988). Since 1941, the lake has dropped almost 40 vertical feet and nearly doubled in salinity because of water 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 1991-92 were very dry, and lake level during the 1992 gull nesting season ranged from 6374.6 on 1 April to 6374.3 feet on 1 August (P. Vorster pers. comm.), the lowest lake levels since our studies began. In late April, there was no longer a water barrier between the mainland and Negit Island. At that time a water barrier of about 40-50m separated Java Islet from Negit Island and an additional barrier of about 70m separated Twain Islet from Java.

STUDY AREA AND METHODS

The study area at Mono Lake has previously been described in Shuford (1985) and Shuford et al. (1984, 1985).

Nest Counts

Nests on the Negit Islets and Negit Island were counted from 20-24 May 1992. We walked through all the colonies tallying each nest and its contents and marking nests with a dab of spray paint to avoid duplicate counts. For some small, steep-sided islets we counted brooding adults from a small motorboat to estimate the number of nests present; none of these islets had more than 10 apparent nests. Nest totals for the Negit Islands and Negit

Island were added to those for the Paoha Islets and Paoha Island provided by Joseph R. Jehl, Jr., and the numbers of adult gulls breeding at Mono Lake was estimated as twice the total number of nests at the lake.

Separate subtotals were compiled for nests within eight 10 X 20 m fenced plots on four islands (Twain, Little Tahiti, Little Norway, and Spot islets) which were monitored to determine chick production and fledging rates.

Banding

During 1-5 July, 1146 chicks were banded on the Negit Islets. Of these, 760 were from inside the eight fenced plots. On islets without plots the following numbers of chicks were banded, and most were dyed orange on the back with picric acid solution: Java (130), Steamboat (195), and Krakatoa (61).

Chick Censuses

From 1-6 July, we counted all chicks on the Negit Islets and Negit Island. On the smaller islets without fenced plots or dyed chicks, three observers attempted to count all chicks from a small motorboat. Chicks on these islets were sometimes counted several times on successive circumnavigations until observers were satisfied they had obtained the best possible count. The number of dyed and undyed chicks visible by boat on Steamboat, Java, and Krakatoa was counted on two consecutive days after chick dyeing. Dyed-to-undyed ratios from these counts were used to extrapolate the total number of chicks on each of these islets (see below). On the remaining islets, we counted all chicks at the time of banding within each of the eight fenced plots. Data from these plots were used to estimate total chick numbers on each islet with one or more plots, on all the Negit Islets combined, and on all of Mono Lake's nesting islands (see below).

Count of Dead Chicks

From 5-7 August, a thorough search was made for dead banded chicks on all islets on which chicks had been banded, to assess survivorship from banding to fledging.

Calculating Fledging Rate in Fenced Plots

The number of chicks fledged per nest in a plot was calculated as: **(b-d)/n** where **b** is the number of chicks banded in the plot, **d** is the number of those that are found dead at the end of the season, and **n** is the total number of nests in the plot in May. The chicks that escaped from plots before being banded (12 of 772 chicks) were assumed to have survived in the same proportion as the banded chicks.

Reproductive Success

Three methods were used to estimate the number of chicks fledged in 1991 (see Shuford 1985):

I. **Islet-by-Islet Method.** Depending on the islet, the number of chicks fledged was determined in one of three ways:

a. On each of the smallest islets, chick counts from 1 July were multiplied by the proportion of birds surviving to fledging of those banded on all Negit Islets from 1-5 July.

b. For moderate-sized islets without plots, using the Lincoln Index method, the total number of chicks at the time of banding and dyeing **(n)** was estimated as **bt/m** where **b** is the total number of chicks that were dyed, **m** is the average number of dyed chicks counted on two consecutive days after dyeing, and **t** is the average number of all chicks (dyed and undyed) on the two counts. Total chicks fledging was **[(b-d)/b]n** where **d** is the number of dead banded chicks found on the island after the nesting season had ended.

c. For the largest islets, the number of chicks fledged per nest in the fenced plot(s) was multiplied by the total number of nests on the islet in May.

The Negit Islet and Negit Island totals were added to those for the Paoha Islets and Paoha Island (data from J. Jehl in litt.) to provide an estimate of the total number of chicks fledged at Mono Lake.

II. **Fenced Plot Method.** In this method the number of fledged chicks at Mono Lake **(F)**

is calculated as: $(N/8)\sum_{i=1}^{8} f_i$ 1 where **N** is the total number of nests at the lake and $\mathbf{f_i}$ is the number of young fledged per nest in the eight Negit Islet fenced plots.

III. **Combined Fenced Plot and Islet-by-Islet Method.** This method provides a lakewide estimate of the number of chicks fledged by combining an estimate of the number of chicks fledged on the Negit Islets based on the fenced plot method with an estimate from the Paoha Islets based on the islet-by-islet method.

RESULTS AND DISCUSSION

Phenology

In contrast to 1991 when nesting began much later than usual, the timing of nesting events in 1992 was similar to most other years of our study. In 1992 we observed the first newly-hatched chicks on 21 May and the first flying young during banding from 1-5 July.

Number of Breeding Adults in 1991

An estimated 46,400 adult gulls nested on the Negit Islets and 8 on Negit Island (Table 1). An additional 18,566 nested on the Paoha Islets and 2 nested on Paoha Island (J. Jehl in litt.). The lakewide estimate of 64,978 nesting adults in 1992 is the highest total since our studies began in 1983, but taking into account census error it is comparable to the estimate of 61,474 nesting adults in 1990.

In 1992, the Negit Islets and Negit Island supported 71.4% of Mono Lake's breeding gulls, down from 83.3% in 1990. Twain remained the most important colony, harboring 48.9% of the entire Mono Lake population. At current lake levels Twain and Java, of all the lake's nesting islets, are the most at risk to predation by mainland predators. Despite the presence of four nests on Negit Island in 1992, for all practical purposes it was completely abandoned as a nesting island, apparently as a result of the presence of coyotes on the island each year since 1989 (including 1992).

Fledging Rate in the Fenced Plots

The eight fenced plots held an average of 64.25 nests (SE=7.49) and fledged an average of 1.32 chicks (SE=0.06) per nest (Table 2). Although fledging rates were low in the early 1980s, the fledging rate in 1992 was toward the high end of the range of 0.94 to 1.43 chicks fledged per nest for the years 1986 to 1991. The fledging rate within fenced plots was used to estimate the number of fledged chicks on islets with plots (Table 3) and to estimate the total number of chicks fledged at Mono Lake in 1992 (Table 4). Of all the chicks banded on the Negit Islets, 10.6% were found to have died before fledging.

Table 1. Nest counts on the Negit Islets from 1983 to 1992. Data for Paoha Islets from Jehl (in litt. and previous reports). Numbers are raw nests counts except for 1991 when raw nests counts were adjusted upward to account for low counts because of late nesting (see Dierks and Shuford 1992).

NEGIT ISLETS	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Twain	3808	7372	9309	11985	12422	11057	10573	15045	10883	15896
L. Tahiti	5260	7051	6572	5763	4261	3692	2983	4218	3205	3810
L. Norway	2218	1956	1407	810	360	254	269	432	355	473
Steamboat	997	1016	721	722	467	359	314	704	671	862
Java	143	396	195	400	439	458	543	789	586	1040
Spot	505	358	296	311	248	247	231	309	311	335
Tie 511	231	196	150	84	87	95	167	160	220	
Krakatoa	319	272	178	173	185	197	174	283	181	209
Hat	146	109	73	56	14	18	10	19	10	21
La Paz	105	58	43	30	22	21	23	46	49	70
Geographic	140	0	0	0	0	0	2	4	10	68
Muir	170	0	0	0	0	1	10	61	84	139
Saddle	175	46	41	29	14	13	10	18	8	14
Midget	5	3	3	4	4	2	3	3	2	2
Siren	51	0	1	0	0	0	1	7	7	19
Comma	2	1	1	1	0	0	0	0	1	1
Castle Rocks	2	3	4	3	4	6	5	4	5	5
Pancake	0	0	0	7	570	1216	1395	651	0	0
Java Rocks	0	0	0	0	4	3	0	4	2	13
No name	0	0	0	0	0	0	0	1	0	3
Negit Islet Totals:	14557	18872	19040	20444	19098	17631	16641	22765	16530	23200
Paoha Islet Totals:	8001	3546	3151	3596	3208	2833	2682	5145	4442	9283
Negit Island:	--	--	92	636	1502	2037	2765	2827	788	4
Paoha Island:	--	--	2	102	0	0	0	0	0	1
Mono Lake Totals:	22558	22418	22285	24778	23808	22501	22088	30737	21760	32488
Nesting Adults:	45116	44836	44570	49556	47616	45002	44176	61474	43520	64976

Table 2. Reproductive success of gulls in eight fenced plots in 1992.

PLOTS	NESTS PER PLOT	CHICKS PER NEST AT BANDING	CHICKS FLEDGED PER NEST
Little Norway	28	1.14	1.00
Spot	55	1.25	1.11
Little Tahiti West	80	1.59	1.41
Little Tahiti East	44	1.57	1.41
Twain North	86	1.50	1.42
Twain South	62	1.61	1.45
Twain Northeast	88	1.50	1.32
Twain West	71	1.61	1.45
$\bar{x}$ 2 =	64.25	1.47	1.32
SD =	21.20	0.18	0.17
SE =	7.49	0.06	0.06

Reproductive Success

I. **Islet-by-Islet Method.** Using the production data from individual islets, an estimated 30,090 chicks fledged from the Negit Islets in 1992, and 13,948 from the Paoha Islets (J. Jehl in litt.), for a lakewide total of 44,038 fledged chicks (Tables 3 and 4). No chicks were known to have fledged from the four nests on Negit Island or from the one nest on Paoha Island.

II. **Fenced Plot Method.** Based on the average number of young fledged per nest in eight fenced plots on the Negit Islets (Table 2) and the total number of nests at Mono Lake, an estimated 42,925 young fledged at Mono Lake in 1992 (Table 4).

Table 3. Chick production on individual Negit Islets and Negit Island in 1992. Paoha Islets total from J. Jehl (in litt.).

ISLAND	CHICKS AT BANDING	SURVIVAL RATE	# OF CHICKS FLEDGED
*Twain	24798	0.90	22318
*Little Tahiti	6020	0.90	5418
*Little Norway	539	0.88	474
**Steamboat	606	0.95	576
**Java	512	0.78	399
*Spot	419	0.88	369
Tie	128	0.89	114
**Krakatoa	124	0.90	112
Hat	8	0.89	7
La Paz	76	0.89	68
Geographic	65	0.89	58
Muir	130	0.89	116
Saddle	20	0.89	18
Midget	2	0.89	2
Siren	27	0.89	24
Castle Rocks	5	0.89	4
Java Rocks	12	0.89	11
No Name	2	0.89	2
Comma	0	-	0
Pancake	0	-	0
Negit	0	-	0
	33493		30090
Paoha Islets			13948
Mono Lake Total			44038

*Chick estimates extrapolated from mean number of chicks/nest inside fenced plots (4 plots on Twain, 2 on Little Tahiti, and 1 each on Little Norway and Spot).

**Chick estimates from Lincoln Index as described in Methods.

Chick numbers for all other islets are direct counts adjusted for mortality between counting date and fledging.

Table 4. Estimates of the number of chicks fledged (± 1SE) at Mono Lake from 1983 to 1992 based on
three methods. Sample sizes in parentheses.

	FENCED PLOTS	ISLET-BY-ISLET	PLOTS AND ISLETS
1983	14212 ± 2933 (2)	--	13521
1984	6402 ± 1210 (4)	6319	5859
1985	18942 ± 1337 (6)	17653	18411
1986	33202 ± 1487 (6)	32684	33019
1987	27141 ± 1428 (8)	26440	26721
1988	24203 ± 811 (8)	22920	23712
1989	26375 ± 2499 (8)	25117	26247
1990	43928 ± 3597 (8)	45778	46630
1991	20436 ± 1427 (8)	22304	22043
1992	42925 ± 1973 (8)	44038	44577

III. **Combined Fenced Plot and Islet-by-Islet Method.** Based on the average number of young fledged per nest on the Negit Islets (Table 2) and the total number of nests on the Negit Islets and Negit Island (Table 1), an estimated 30,629 young fledged from these islands. Combining this total with the 13,948 young fledged from the Paoha Islets gives an estimate of 44,577 young fledged from Mono Lake in 1992 (Table 4).

Evaluation of the Three Methods of Measuring Reproductive Success. The three methods used to estimate lakewide chick production all produce similar results (Table 4), perhaps because they are not entirely independent of each other.

The islet-by-islet method as used on the Negit Islets relies on three census methods depending on the size and constraints of individual islets: (1) fenced plots are used on the larger islets, (2) a Lincoln Index method for moderate-sized islets, and (3) direct chick counts

for the smallest islets. The main limitation of the islet-by-islet method as used on the Negit Islets is the unknown (probably low) accuracy of the Lincoln Index method used on moderate-sized islets without fenced plots. Jehl (1991) described limitations of his islet-by-islet method in some circumstances on the Paoha Islets. The advantage of the islet-by-islet method is that reproductive success is measured directly in some manner on each of the islets; this would be most advantageous in a case where reproductive success on one (or more) of the islets without a fenced plot was very different than on other islets.

The fenced plot method calculates lakewide chick production by multiplying the average fledging rate of eight plots on the Negit Islets times the total number of nests on all of Mono Lake. The main limitation of this method is that it may give inaccurate results if reproductive success on the Paoha Islets is much different than on the Negit Islets; the degree of inaccuracy would be a function of the magnitude of difference in reproducitve success between the two sets of islets and the proportion of the lake's population of adult gulls that was nesting on each of the two sets of islets. Because in the last ten years reproductive success annually has varied little between the two sets of islets and because the Negit Islets support the large majority of the nesting gulls, the limitations of this method have not appeared to be great. The advantage of this method is the limited amount of time needed to measure reproductive success once nests counts have been made on all the lake's islands.

Using a combination of a fenced plot method for the Negit Islets and an islet-by-islet method for the Paoha Islets probably provides the best estimate of lakewide reproductive success. A fenced plot method seems the best method to use on the Negit Islets because most of the Negit Islet population nests on large islets on which fenced plots are the only viable alternative for measuring reproductive success and because of the limitations mentioned above for the Lincoln Index method. Jehl (1991) in most years has preferred an islet-by-islet method for estimating reproductive success on the Paoha Islets, though he does use fenced plots and in 1991 relied more heavily upon them to estimate reproductive success.

Ecological Factors

Food. With a warm spring, the first hatch of brine shrimp was early, but overall shrimp abundance in the lake was not exceptional in 1992 (G. Dana pers. comm). The early hatch, though, may explain why adult gulls were feeding heavily on brine shrimp in May. Typically during our nest counts in late May we do not collect any food samples, but in 1992 we noted many adults spontaneously regurgitating food when we were counting nests during daylight hours. The composition of 32 adult food samples examined on 22 and 23 May 1992 was 99.3% brine shrimp.

Of 46 morning food samples from chicks examined at the time of banding, 78.3% were dominated by brine shrimp, 8.7% by alkali flies, and 6.5% by other food items; 6.5% of the samples were co-dominated by brine shrimp and alkali flies. Of 70 night samples, 57.1% were dominated by shrimp, 11.4% by alkali flies, and 17.1% by other items; 12.9% of the samples were co-dominated by shrimp and flies and 1.4% by shrimp and other items. See Table 5 for comparisons of percent occurrence and percent dominance of prey fed to chicks between morning and evening samples.

Based on past years, we expected more brine shrimp in morning than evening samples and more large items and alkali flies in evening than morning samples. Ignoring 3 morning and 10 evening samples collected in 1992 in which different prey items were co-dominant, we did not find a difference between morning and evening samples in the dominance of brine shrimp, brine flies, or other prey (Chi-square=4.25, d.f.=2, p=0.119).

Table 5. Percent occurrence (% of samples containing food item) and percent dominance (% of samples in which a food item was dominant or co-dominant) of prey in morning and evening food samples from chicks in 1992. N is sample size.

	BRINE SHRIMP	ALKALI FLY	GARBAGE	FISH
Morning (n=46)				
% occurrence	93.5	54.3	10.9	4.3
% dominance	(84.8)	(15.2)	(4.3)	(4.3)
Night (n=70)				
% occurrence	84.3	77.1	20.0	7.1
% dominance	(71.4)	(24.3)	(15.7)	(2.9)

Tick Infestation. From 1985 to the present, chicks handled for banding have been assigned a level of tick infestation ranging from 0 (no ticks) to 3. In 1992, of 1142 chicks banded and checked for ticks, 287 (25.1%) were infested with ticks to one degree or another (Table 6). For previous years, the percentage of chicks with ticks has ranged from 70% (n=185) in 1984 to 10% (n=1144) in 1989 (Shuford 1985, 1986; Shuford et al. 1985; Strauss 1987; Dierks 1988, 1990, 1991). In 1992, chicks without ticks suffered 9.5% mortality from banding to fledging, whereas chicks with ticks suffered 14.3% mortality; this difference is statistically significant (Chi-square=5.21, d.f.=1, p=0.022) but its significance biologically, if any, is unclear.

Table 6. Comparison of banded chicks found dead on nesting islets versus fledged chicks for three categories of tick infestation (increasing from 0 to 2-3) in 1992 (see Shuford 1985).

		CATEGORY OF TICK INFESTATION		
	N	0	1	2-3
Dead Banded	122	66.4%	33.6%	0.0%
Fledged Banded	1020	75.9%	23.4%	0.7%

Mammalian Predators. On a 23 May visit to Negit Island to search for gull nests we saw fresh canid tracks. After recolonization of Negit Island in 1985, coyote presence has been documented on Negit Island every year since 1989, and is the most likely cause of a decline in numbers of nesting gulls there from 1990 to 1991, the abandonment of Negit by nesting gulls in 1991, and the failure of gulls to recolonize Negit in 1992.

On 6 August 1992, Dave Calleri and co-workers observed canid tracks on the north end of Java Islet; no coyote sign had been observed on Java during surveys there in late May and early July 1992. On 6 August, Calleri also observed several gull chick corpses that had been predated. One corpse had the head, wings, and legs still connected but all the flesh removed; some of the corpses were disarticulated. The mortality rate of chicks from the time of banding in early July to fledging later in the month differed among the islands (Table 7; Chi-square=27.14, d.f.=6, p=0.0001). Contributing the most to the difference was the high number of banded dead chicks found on Java (contributing 17.0 to Chi-square) and the low number found on Steamboat (contributing 6.5 to Chi-square). The high postbanding mortality on Java was probably caused at least in part by the late season predation of gull chicks by coyotes. The cause of low mortality on Steamboat is unclear.

Table 7. Comparison of postbanding mortality rates on various Negit Islets in 1992.

	BANDED CHICKS			
	CHICKS FOUND DEAD	CHICKS FLEDGED	TOTAL	PERCENT MORTALITY
ISLAND				
Java	29	101	130	22.3%
Steamboat	9	186	195	4.6%
Krakatoa	6	55	61	9.8%
L. Norway	4	28	32	12.5%
Spot	8	61	69	11.6%
L. Tahiti	21	174	195	10.8%
Twain	44	420	464	9.5%
TOTALS	121	1025	1146	$\bar{x}$ 3 =10.6%

Access of coyotes to Java and reduced productivity there in 1992 may well be a predictor of much greater problems that the gulls will face in 1993. The last time that Java was invaded by coyotes was in 1982 when Twain Islet was also invaded and abandoned, greatly lowering lakewide gull production. Because both islets are vulnerable to land predators at the same lake elevation, it is very likely that both will be visited in 1993 if the winter of 1992-93 is another dry one and if, consequently, the lake elevation is lower in the 1993 breeding season than it was in 1992. The potential consequences of access of mammalian predators to nesting islands in 1993 could be very great, as Twain Islet has in

recent years been supporting about 50% of Mono Lake's entire nesting gull population.

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