BREEDING BIOLOGY OF WESTERN GULLS (*LARUS OCCIDENTALIS*) ON SAN NICOLAS ISLAND, CALIFORNIA, 1968

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Although the breeding biology, ecology, and behavior of many gull species are well documented, Western Gulls (*Larus occidentalis*) have received little attention from ornithologists. This lack of data on such a conspicuous bird, the only gull breeding along the California coast, is perhaps not too surprising since Western Gulls nest primarily on islands to which ready access is difficult. Summaries in Bent (1921) and various state bird books, and short articles by Dickey and van Rossem (1925), Ferris (1940), Pearse (1946), Woodbury and Knight (1951), Bartholomew and Dawson (1952), and Bennet and Erickson (1962) are the only references I found to Western Gulls.

As a member of the Smithsonian Institution's Pacific Ocean Biological Survey Program (POBSP), I studied the breeding biology of Western Gulls on San Nicolas Island, Channel Islands, California, on the following days in 1968: 10–23, 27–31 May; 5–10, 14–17 June; 2–5, 16–18 July, and 22 August.

San Nicolas Island, the Channel Island farthest from the mainland, is situated at 33°14′ N, 119°32′ W, 62 statute miles from Point Mugu, California. It is oval in shape, with the long axis (9.8 statute miles) oriented approximately WNW–ESE; the maximum width is 3.6 miles. The island is 21,000 acres in area, with the highest point a broad plateau 906 ft above sea level. The south portion rises abruptly, eroded by deep gullies. The north side is less rugged and the northwest point is a sand dune of 200 ft elevation. Western Gulls nest on the western side of this dune in an area approximately 1 mile by 200 yards on a hillside rising from the beach cliff. This gradual slope is traversed by many gullies eroded to a depth of 20 ft. Water- and wind-eroded boulders up to 5 ft high are scattered across the area. Vegetation in the colony consists of low-growing ice plant (*Mesembryanthemum crystallinum*), ground heliotrope (*Heliotropium currassavricum*, var. *oculatum*), sand verbena (*Abronia maritima*), beach burr (*Franseria chamissonis bipinnatisecta*), alkali heath (*Frankenia grandifolia*), sea blite (*Suaeda californica pubescens*), and lupine (*Lupinus hirsutus*).

An initial survey showed it impossible to census accurately the entire colony, so four study plots were established, comprising approximately one-third of the area and one-half of the nests of the entire colony. In these plots I marked each nest with spray-painted numbers that remained legible throughout the study. I surveyed the entire colony three times and checked marked nests every two or three days during May and early June, and on each visit in July and August.

COLONY SIZE AND NESTING SEASON

On 14–15 May I counted 491 nests in the colony, but the extent and rough terrain made it impossible to find all of them. From the number of unmarked nests found on successive visits, I believe the colony during 1968 contained no more than 600 active nests.

On 11 May, when I first visited the colony, most nests were complete and the egg-laying peak had passed. The first egg hatched on 17 May. Only three per cent of the eggs hatched before 30 May; 96 per cent of the viable eggs hatched 1–12 June. On 2 July only one clutch remained, a nest established after 15 June.

Assuming a 26-day incubation period, first successful eggs were laid about 21 April, with the egg peak occurring between 6 and 16 May. Only a few eggs were laid after this date. Perhaps all laid later than 20 May were replacement clutches.

Young of the year were first seen flying on 2 July, and on 18 July approximately one-fourth could fly. On 22 August all birds of the year could fly and some may have already left the island.

NEST DESCRIPTION AND EGG COLORATION

Cup diameter of 26 nests ranged from 9 to 14 inches (mean, 11 inches). Usually another 2 to 5 inches of material encircled the cup. Cup depth ranged from 2 to 4 inches (mean,

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TABLE 1. Number of eggs per clutch in marked nests of Western Gulls (*Larus occidentalis*) on San Nicolas Island, California, 1968.

No. eggs	15 May		22 May		30 May		6 June		10 June	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	21	9	17	6	16	6	15	10	11	15
2	41	17	40	15	51	18	32	22	24	33
3	181	74	200	73	197	72	93	62	31	42
4	2	1	12	4	6	2	7	5	5	7
5	1	0	3	1	2	1	2	1	2	3
6	0	0	1	1	1	1	0	0	0	0
Totals	246		273		273		149		73	

2.5 inches). Beach burr was the only plant found woven into nests. The amount of plant material in nests varied from none to a 3-inch-thick mat. The few nests constructed on bare ground were invariably under rock ledges, with a minimum 8-inch space above the nest cup top.

All nests were depressions, usually in mats of ice plant and lupine. Three nests were constructed in hollows on top of large boulders. Distance between nests ranged from 1 to 175 ft. In the densest area of the colony the mean distance between 26 nests was 64 ft. Greater separation occurred on the steep slopes of the colony. Where rock ledges and boulders were common, only a foot or so separated several nests, but the adults on these close nests could not see their nearest neighbors.

Eggs varied in color from an off-white or light-brown ground color with light gray-brown and/or brown spots to a dark ruddy green-brown (light terre-verte) ground color with dark khaki and gray-brown spots. Most spots were oblong, running lengthwise or at a slight angle to the egg's long axis. Eggs with darker ground color had more circular and solid spots than eggs with lighter ground color, which tended to have rather thin, angular, elongated spots.

In 30 nests egg coloration varied within, as well as between, clutches. Seven clutches had all three eggs a similar dark color, 11 clutches had two dark and one light egg, five clutches had one dark and two light eggs, and seven clutches had one dark, one light, and one intermediate-colored egg.

CLUTCH SIZE AND EGG MEASUREMENTS

It was impossible to determine egg loss from clutches during the laying peak before my arrival on the island. The preponderance of 3-egg clutches (72–74 per cent in May, table 1) indicates that this is the modal clutch size for Western Gulls on San Nicolas Island. Clutches of more than three eggs were not common, and the fact that most larger clutches failed to hatch (see Hatching Success) also indicates that three is the optimum clutch size for this species. Analysis of clutches found on 22 May showed that mean clutch size was 2.8 eggs. If clutches with more than three eggs were excluded, mean clutch size was 2.5 eggs. On 15 May mean clutch size was 2.7 eggs. On 30 May mean clutch size was 2.8 eggs; omitting clutches with more than three eggs, it was 2.7 eggs.

Behle and Goates (1957) found 2.93 eggs the mean clutch for California Gulls (*Larus californicus*). Kadlec and Drury (1968 and references therein), studying Herring Gulls (*L. argentatus*), and Vermeer (1963), studying Glaucous-winged Gulls (*L. glaucescens*), found that the more detailed the study the closer the average clutch size is to three. Bent (1921) states that the normal clutch of Western Gulls consists of three eggs. However, Peterson (1961) considers 2–4 eggs normal for this species. Factors affecting clutch size in Kittiwakes (*Rissa tridactyla*), which probably apply to other gulls, were discussed by Coulson (1966).

Bent (1921) gives the mean of 70 *Larus occidentalis wymani* eggs as 72.4 × 50.4, with extremes of 78.0 × 67.5 and 53 × 47 mm. I measured 94 eggs on San Nicolas Island. The mean was 72.7 × 49.7, with extremes of 80.2 × 67.8 and 52.0 × 46.8 mm. Standard deviation of length was 2.448, and of width, 1.070 mm.

INCUBATION PERIOD

I could not determine precisely the time lapse between laying of eggs within a clutch, but it appears to vary. In 11 clutches, approximately 24 hr separated laying of the first two eggs, and 36–56 hr the second and third eggs. Adults may begin incubation after laying the first eggs, but often, I believe, do not begin

TABLE 2. Hatching success of 150 Western Gull clutches, San Nicolas Island, California, 1968.

No. eggs in clutch	No. nests	No. eggs	Eggs hatched/ not hatched	Per cent of eggs hatched
1	10	10	3/7	30
2	24	48	33/15	69
3	99	297	211/86	72
4	12	48	1/47	2
5	4	20	0/20	0
6	1	6	0/6	0
Totals	150	429	248/181	55

until the clutch is complete. Eisner's (1958) note on hormonal changes at onset of incubation indicates that the latter may be the norm, but detailed observations are needed.

In some three-egg clutches, hatching was completed within 12 hr, but in most cases 36–72 hr separated emergence of individual chicks, indicating that incubation may begin after laying of the first egg. In most clutches two eggs hatched within 12–24 hr of each other, with the third chick emerging 24–36 hr later. I heard no vocalization from eggs before they pipped.

Of 44 clutches for which I knew the laying and hatching dates, 12 took 25 days to hatch, 16 took 26, 10 took 27, 5 took 28, and one 3-egg clutch was incubated 29 days before the last chick emerged. No incubation period in a successful clutch lasted longer than 29 days. Adults continued to incubate inviable eggs up to 39 days and might have continued longer had I not destroyed the eggs. Emerson (*in* Bent 1921) states that incubation for Western Gulls takes 24 days, a shorter time than I found for any clutches on San Nicolas Island.

Eggs with the shortest incubation periods usually had short time intervals between first cracking and emergence of chicks. The first hole in an egg is about 2 mm in diameter; after about 24 hr (range, 6–40) fissures radiating from the hole are large enough for the chick to emerge.

HATCHING SUCCESS

To calculate hatching success (table 2) I used 150 clutches in which the number of eggs laid was known. Of 429 eggs laid, 248 (55 per cent) hatched. However, clutches with more than three eggs were almost completely unsuccessful (one of 74 eggs hatched), while nests with one, two, or three eggs were 70 per cent successful. Incubating Western Gulls have only three brood patches and thus are unable completely to cover all eggs in larger clutches and apparently none receives proper incubation. Egg coloration within large clutches suggests that the eggs were laid by more than one female, but conclusive support for this is lacking.

Of the 108 eggs in "normal" sized clutches, 37 disappeared or were broken before term. Of the remaining 71 eggs, I broke 55 and found that 51 showed no development, and I presumed that they were infertile. Four embryos died after about 15 days of incubation. Of the 37 eggs that disappeared or were broken, eight were from three clutches at the edge of the colony and were destroyed by an island fox (*Urocyon littoralis dickeyi*) on the night of 18 May. Foxes were common in the main portion of the island, but this was the only instance I noted of their predation on gull eggs. The other 22 broken or missing eggs were destroyed by adult gulls, whether by the parents or not is unknown. No shell thinning and crumbling, characteristic of chlorinated hydrocarbon pesticide contamination, was noticed in over 400 eggs handled.

The gull colony on San Nicolas Island is adjacent to a military recreational fishing area and near a missile range operational area, so it is disturbed almost daily by vehicles and men. These disturbances, along with my survey work, certainly increased egg loss, but to what extent is not known. Personnel of the Point Reyes Bird Observatory currently are studying the effects of human disturbance on Western Gull nesting success.

WESTERN GULL BREEDING IN RELATION TO CALIFORNIA SEA LION PUPPING

Peterson and Bartholomew (1967) found May and June the peak months of pupping by California sea lions (*Zalophus californianus*) on San Nicolas Island in 1965. In May–June 1968 I counted sea lions on a small beach adjacent to the gull colony. This beach contained only a small proportion of the sea lions associated with the gull colony, but it could be censused accurately and conveniently and these data give a good indication of the total *Zalophus* population breeding in 1968 (table 3). This information indicates that the peak in sea lion pupping occurred in the second week of June. Between 1 and 12 June, 96 per cent of the viable Western Gull eggs hatched.

Gulls actively fed on placentae, and 50–75 gulls squabbling for afterbirth within seconds after a pup emerged was not unusual. Dead pups also were eaten by gulls, with the eyes, umbilicus, and intestines taken first. I saw no attempt by the gulls to feed on a live pup.

TABLE 3. Counts of California sea lions (*Zalophus californianus*) on a small beach adjacent to a Western Gull (*Larus occidentalis*) colony, San Nicolas Island, California, 1968.

Date	Males	Females	Pups	
			Alive	Dead
11 May		a few		
21 May		20–		
29 May	3	76	55	22[a]
6 June	6	110	97	not counted
17 June	16	213 ± 10%	197	32
2 July	19	261 ± 10%	222[b]	8
16 July	9	125 ± 25%	160	not counted
22 Aug.	1	25	50	30

[a] All carcasses found on beach, some buried.
[b] Few births observed during this survey of the colony.

Regurgitation samples from either adult or young gulls were difficult to collect, but I found sea lion fetal matter present in less than 20 per cent of 20 samples collected in June.

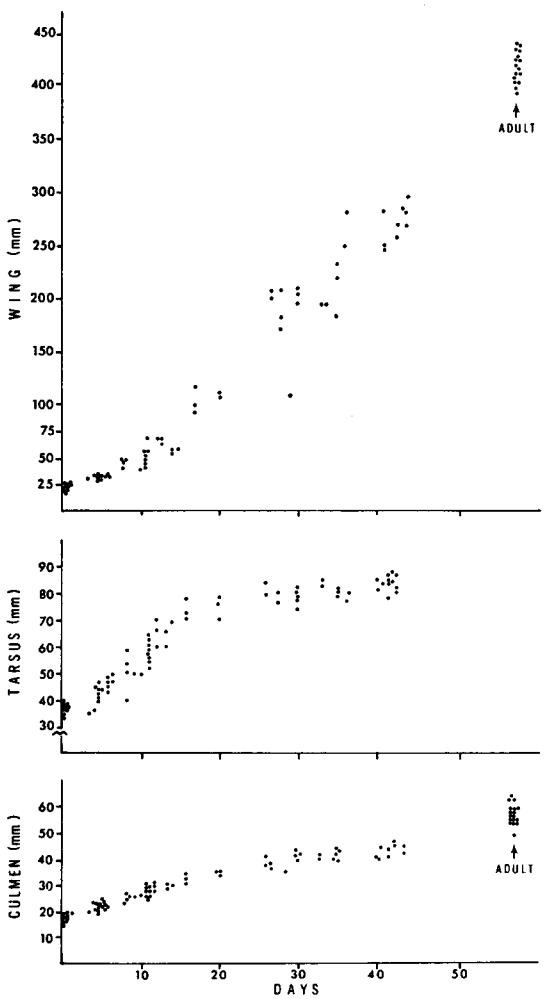

FIGURE 1. Measurements at different ages of individually marked Western Gulls (*Larus occidentalis*), San Nicolas Island, California, June–July 1968.

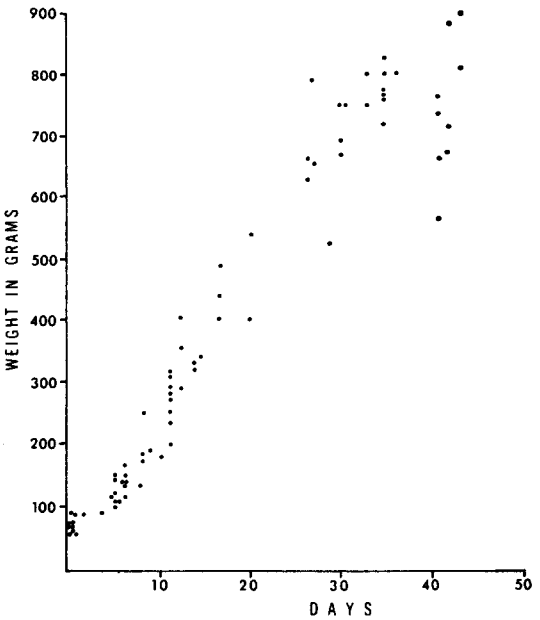

FIGURE 2. Weight and age of individually marked Western Gulls (*Larus occidentalis*), San Nicolas Island, California, June–July 1968.

Regurgitated fish, crabs, snails, squid, etc., were abundant around nests during all my surveys.

The synchrony of gull hatching and sea lion pupping on San Nicolas Island does not necessarily indicate a direct interrelationship between the two events. Further detailed information on the ecology and feeding patterns of both populations is needed to clarify the possible mechanisms regulating their time of breeding.

WESTERN GULL BREEDING SEASON ON THE CALIFORNIA COASTAL ISLANDS

POBSP data indicate that the Western Gull breeding seasons on Santa Catalina, Santa Barbara, Anacapa, San Miguel, and San Nicolas of the Channel Islands were in close synchrony in 1968. I observed gulls nesting on East Farallon Island (off San Francisco) on 26 June and at Point Lobos (Monterey Co., mainland) on 14 July and found that nesting by the Channel Island gulls was about two weeks ahead of nesting by these more northern birds. On Isla Natividad and Islas San Benitos (Mexican islands situated south of San Diego) during the last two weeks of April, the POBSP found no Western Gull eggs. The state of nest construction and courtship behavior indicated that first eggs would not be laid until mid-May, but before the June POBSP visit, the human inhabitants had collected all the gull eggs, so

we were unable to determine precisely the timing of breeding. Nesting on Los Coronados, which we visited 2 May and 30 June, was intermediate in timing between the Channel and Mexican Islands.

To summarize, our data indicate that Western Gulls on the Channel Islands nested at least two weeks before the southern Mexican islands populations; Los Coronados birds are intermediate both in location and timing. This is the reverse of the usual pattern exhibited by a species along a north-south gradient. More details on the nesting season over several years and throughout the breeding range of the species are needed to explain these differences in timing of breeding between the various populations. Data should also be collected on possible regulatory factors such as food supply (e.g., oceanic food items, the role of sea lion pupping, and the breeding season of other birds nesting on the islands upon which the gulls prey), and local climatological phenomena (e.g., winds, ocean currents, and temperature).

GROWTH AND DEVELOPMENT OF CHICKS

A chick, as here designated, is a bird from time of hatching until departure from the nesting island. Chicks are well camouflaged, "expert" at hiding, and difficult to find after they leave nests when about two to five days old. On 30 May and 5 June, I banded 75 chicks of known age, and on each succeeding visit to the colony never found more than 15. Eleven of these chicks were measured three or more times and were used to illustrate the patterns of growth and development in figures 1 and 2 and table 4.

TABLE 4. Notes on development of known-age young Western Gulls (*Larus occidentalis*) on San Nicolas Island, California, 1968.

Age (days) Weight (g)	Plumage and soft parts	Behavior
1–2 60–80	Down damp 12–24 hr, dark brown to gray-fawn ground color with light chocolate spots. Bill black with outer ¼–⅜ dull pink. Egg-tooth present for ca. 64 hr. Legs and feet pink-brown.	Remain in nest for ca. 64 hr, although able to run at 5 hr. Do not always "freeze" when alarm call sounds.
5–6 110–170		"Freeze" when alarm call sounds; remain frozen until handled; run on release; this behavior continuing for 4 weeks, until they run when potential predator approaches.
10–11 180–310	Primary quills 1 inch, feathers ⅜ inch. Secondary quills ½ inch. Greater coverts ⅜ inch. Lesser coverts show. Bill almost all black.	
20 400–600	Primary quills one inch, feather one inch. Greater primary covert quills ¾ inch, feather ½ inch. Secondaries ¾ × ½ inch. Secondary coverts slightly shorter than primary coverts but out of sheaths, tan colored. Bill and nails black. Rectrices just show. Scapulars ¾ × 1 inch. Full cover on back.	Well able to bite. Run well.
25	Primaries 1½ × 1½ inches, greater primary coverts 1 × 1½ inches. Secondaries 1 × 1 inch, greater secondary coverts 1 × 1½ inches. Alula 1 × ¾ inch. Rectrices 1 inch. Scapulars 1 inch. Some down remains on tips of most feathers.	
30 500–750	Primaries 2 × 2½ inches, greater primary coverts 1 × 3 inches. Secondaries 2 × 2½ inches. Rectrices ½ × 1½ inches. Most down gone except on wing linings, legs, head, and neck.	
40–43 560–900	Primary quills 2 inches, feathers 5 inches. Secondaries full length. Rectrices 2 inches. Down remains only in wing linings. Belly white and gray barred. Base of tail white. Plumage looks same as immatures away from colony.	

Culmen measurement was of the exposed culmen. Leg measurement was made by bending the tibiotarsus and phalanges at right angles to the tarsometatarsus and measuring the maximum length thus exposed. I found this the most accurate and convenient leg measurement to make under field conditions. The wing measurement was of the unflattened wing from bend of wrist to distal end of the manus, or the primaries as they develop. I weighed birds on a Chatillon hanging spring scale, accurate to within 10 g. Culmen and wing measurements from 17 adults banded in late May are included in figure 1. While individual variation in growth of chicks occurs, the figures illustrate the basic growth patterns for Western Gulls on San Nicolas Island in 1968.

Bill length increased at a steady rate of 4–5 mm per week until the end of the fourth week when growth slowed (fig. 1). Bills apparently do not reach full adult length until after birds depart from the island; adult bills measure 49–63 mm, but chicks fledged with bill lengths varying from 40–47 mm.

Rapid tarsometatarsus growth of 10–14 mm per week occurred during the first three weeks after hatching, and 4–5-week-old chicks have apparently achieved full leg length. Unfortunately, I did not have adult measurements, but I believe little growth occurs after four or five weeks of age.

Wing growth during the first 10 days was minimal. However, as the primary quills emerged, a growth rate of nearly 35 mm per week occurred, and at fledging the length of the wing was 240–280 mm. While chicks can fly with this length of wing, they do so only under stress; probably before leaving the island they have achieved adult wing lengths of 390–450 mm.

Little weight increase occurred during the first 4–6 days, then a steady increase of 100 ± 15 g per week occurred until the chicks were 5–6 weeks old (fig. 2). I have no adult weights to use as comparison, but young birds probably lose some weight before leaving the island.

Because of the difficulty in catching birds older than 4–5 weeks, it was not possible to document exactly the growth patterns beyond this age. The chicks that hatched between 17–20 May were flying well by 2 July. While most chicks were able to fly at six weeks, they did so only when forced. By the end of seven weeks, many left the colony during the day, returning to their nest area at night, where adults fed them.

DETERMINATION OF INCUBATION STATE BY EGG FLOTATION

I tested flotation characteristics using the Clapp Egg Flotation Technique (Clapp et al., in prep.), gently releasing eggs into approximately five inches of fresh water in an aluminum can. I checked only two clutches from laying to hatching, floating the eggs five times. However, I floated 100 other eggs whose hatching dates were known; 27 of these eggs were floated four times. The following summarizes my observations.

During the first three days, eggs sank immediately, resting with their long axis parallel to the bottom of the level can. By 4–5 days, sinking occurred more slowly and eggs floated with the large rounded ends upward at 25° from the bottom. By the seventh day, the small ends of the eggs rested on the bottom of the can with the long axis upright at about 50°. On the 10–11th day, the small ends of the eggs rested on the bottom with the long axis upright at 75°. On the 13th day, eggs floated straight. On the 14–15th day, eggs floated suspended straight upright, neither touching the bottom nor breaking the surface. On the 16–18th day, eggs bobbed up and down upon release and settled just below or just breaking the water surface. Embryos at this age had feather quills about 3 mm long. By the 19–20th day, eggs floated with as much as 10 mm showing above water, the long axis straight up and down. Between 20–26 days, eggs floated with as much as 25 mm above water and the long axis to one side at 20–40°. The air bubble was located on the side out of water and first cracks invariably appeared here.

The problem with this system was its relative subjectivity and the fact that rotten or infertile eggs exhibited essentially the same pattern as viable eggs during early stages. During the last ten days, however, rotten eggs did not float with the long axis to one side, but continued to float straight up and down. With practice, these rotten eggs can be readily identified. Flotation may kill some embryos and this mortality factor needs further investigation.

Some variation exists among eggs but the stages described above are easily identified. This method is useful, not only in determining the incubation state of individual eggs, but in determining laying dates for the colony, especially if only one visit can be made to a colony. It would be valuable to compare egg flotation characteristics of other species in order to develop a workable flotation scale for various incubation periods.

AGE STRUCTURE OF THE CALIFORNIA WESTERN GULL POPULATION

In the colony on San Nicolas Island 95 per cent of the gulls present were adults, but along the California sea lion hauling beaches and in gull loafing areas away from the colony, one-third of all birds counted on approximately 25 surveys were immature and subadult birds. In surveys made along the California mainland coast between Santa Barbara and Los Angeles, at beaches, harbors, and refuse dumps, I found the population of Western Gulls throughout the summer to consist of 75 per cent immature and subadult birds. This indicates that adults breeding on islands off the coast are either feeding directly on the islands or in the surrounding waters and are not visiting the coast to feed. Bird watchers in California whom I contacted had no data on changes in the age-class percentages throughout the year. Age-classing gulls takes little more time than counting total birds seen, and this information would be extremely valuable in determining and understanding population movements in the state (cf. Kadlec and Drury 1968; Schreiber 1968).

SUMMARY

Information on the 1968 Western Gull (*Larus occidentalis*) nesting season on San Nicolas Island, California, is presented.

A maximum of 600 nests was present. First eggs hatched on 17 May, and 96 per cent of the viable eggs hatched between 1 and 12 June. By 2 July the first chicks could fly, and by 22 August all birds of the year could fly.

Nest descriptions and egg measurements are presented. Distinct variation in egg color exists. The possible correlation between intensity of color and sequence of laying within a clutch needs investigation.

Incubation periods ranged from 25 to 29 days, with 26 days the usual length. There was great variation between time of first cracking and pipping to emergence of chicks.

The usual clutch size for Western Gulls is three eggs.

Data on hatching success show that clutches with two and three eggs were 69 and 72 per cent successful, that one-egg clutches were only 30 per cent successful, and that clutches with more than three eggs were almost wholly unsuccessful. Mortality factors of eggs are considered.

The temporal correlation between the gull nesting cycle and pupping of California sea lions needs further study. The San Nicolas Island population of Western Gulls appeared to breed at least two weeks before those of the more southern Mexican islands. Further data on the regulatory factors of gull breeding are needed.

Growth and development of known-age chicks are shown by measurements and notes on plumage and behavior. Chicks flew under stress at six weeks of age, and by the end of seven weeks they were flying readily.

A method to determine state of incubation by water flotation of eggs is given.

The age structure of the Western Gull population on the island and along the California coast is briefly described.

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