BREEDING BIOLOGY OF A SMALL COLONY OF WESTERN GULLS (*LARUS OCCIDENTALIS WYMANI*) IN CALIFORNIA

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The breeding biology of some gull species has been fairly well studied. A notable exception is the Western Gull (*Larus occidentalis*), a resident of the west coast of the United States, Baja California and Sonora, México, and British Columbia. The difficulty of reaching island nesting colonies has deterred investigators until recently. Reports by Schreiber (1970) and Coulter (1969) have added much to our understanding of the nesting biology of the species, especially the egg-laying and hatching phases.

During 1965 and 1966 I studied a small colony of Western Gulls (*L. o. wymani*) on Bird Rock, Santa Catalina Island, California. Emphasis was given to population ecology of the colony from egg laying through fledging, nest site preference, nest distribution pattern, and territoriality. Also examined were the nesting success of this small colony and the effect of colony size on survivorship for this and other gull species.

THE STUDY AREA

Bird Rock (fig. 1) is a small islet off Santa Catalina Island, 33° 27′ N, 118° 29′ W, approximately 23 mi. SW of Los Angeles Harbor. It is 530 m from the nearest point of land on Santa Catalina Island and about one mile from a boat anchorage and landing. Approximately 20 per cent of the islet's surface is covered by vegetation, the remainder being bare rock. Geologically, the islet can be described as a conglomerate with an intrusion of basalt on its eastern end. The general surface character of the islet is relatively smooth with few fissures or prominent contours. The area between the intertidal zone and the major surface of the islet is characterized by being rough and jagged with numerous crevices and projecting rocks.

Vegetation on the islet consists primarily of a large concentration of plants (vegetation patch) 1–3 ft high located on the south-central portion. It is bordered almost entirely by prickly pear cactus (*Opuntia occidentalis* var. *littoralis*), and is composed largely of tree mallow (*Lavatera assurgentiflora*) and a composite (*Coreopsis maratima*). Along the edge of this concentration of relatively tall plants are ice plants (*Mesembryanthemum crystallinum* and *M. nodiflorum*), goosefoot (*Chenopodium mirrale*), and cheese mallow (*Malva parviflora*). These four species also grew in the larger contours near the vegetation patch and in a few soil-filled crevices on the basalt intrusions. Most gull nests were built in these contours.

Other than *L. o. wymani*, the only birds that nested on Bird Rock were a pair of Black Oystercatchers (*Haematopus bachmani*). They nested on one of the basalt intrusions away from the main gull colony in 1966 (fig. 1a). No sea lions (*Zalophus californianus*) were born on or near the islet although a few were seen resting there. No other mammals and no reptiles were seen on the islet during the study.

During the summers, the Isthmus area around Bird Rock was used extensively for human recreation. Boat and aircraft traffic were particularly intense on weekends and holidays. The effect of these factors and of my occasional visits upon reproductive success was impossible to evaluate, but this species is highly tolerant of noise around the breeding colony, as Schreiber (1970) pointed out.

METHODS

The nesting colony at Bird Rock was visited six times during each nesting season of 1965 and 1966 at about two-week intervals beginning in late May. A census of nests, eggs, and chicks was recorded during each visit. Re-identification of nests was made possible by spray-painting a number near each one. Activities in the colony were then observed from a blind for one to two hours. Chicks were banded with temporary colored leg bands when about 20 days old. At that age, they were large enough to move into the water and back again to their nest without suffering undue injury from neighboring adults. When disturbed, chicks less than a week old often wandered away from their nest and, therefore, were never handled during this study.

BREEDING DATES, NESTS, AND EGGS

Breeding season dates were nearly identical in both years. If the incubation period is assumed to be 26 days, as indicated by Schreiber (1970) for *L. o. wymani* on San Nicolas Island, 60 mi.

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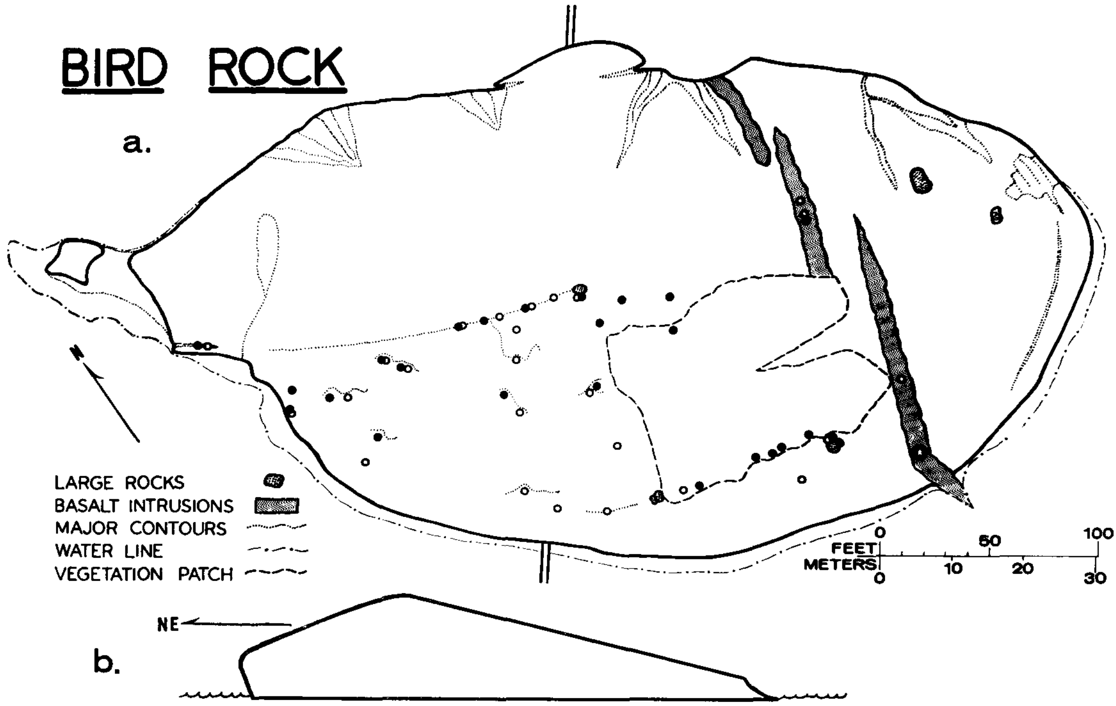

FIGURE 1a. The study area and location of nests of Western Gulls. Solid circles indicate nests in 1965; open circles, 1966. The starred circle was a Black Oystercatcher nest site in 1966. The term contour is used to indicate fissures in the slope. 1b. Cross-section of the islet. The double lines on 1a above indicate the plane of the cross-section.

WSW of Santa Catalina Island, gulls presumably began laying about 6 May. The last clutch in 1965 was started about 15 July, while in 1966 the last laying was on 11 June. Hatching began about 2 June and was completed by 30 June; chicks were banded 29–30 June, respectively. Fledging was presumably complete by early August. These dates were nearly identical to those Schreiber (1970) observed in 1968.

In 1965, 53 nests were counted, 24 of which were active (i.e., contained eggs) and 29 inactive, or "play" nests (Tinbergen 1960). In 1966 only 36 nests were built, 25 active and 11 inactive. No attempt was made to determine if mate specificity or nest site philopatry occurred. The positions of active nests each year are shown in figure 1.

Nests varied from complete cups to slight scrapes, depending on their location on the islet. Those in or near vegetation and on easily leveled or shaped substrates were complete cups. The nature of the plant material in these nests was variable and depended on the species nearby. Stems and leaf stalks of cheese mallow and goosefoot 10–20 cm in length were most frequently used. Ice plant was utilized when other types were absent. Nests constructed on a sloping surface near vegetation often had only a partial cup on the lower side. Nests built away from vegetation often lacked plant material but had feathers and small stones scattered about. A scrape in the soil, much of which was guano from previous years, was the only structural support for the clutch.

The major portion of the SW face of the islet was too steep and too hard to allow nest construction. This restriction of potential nest sites should have resulted in a contagious or aggregated distribution pattern. To test this, an analysis of the distribution pattern of nests for the two years was performed as described by Vermeer (1970). The random curve shown in figure 2 was compared with the observed distribution of nests, using the Clark and Evans (1954) nearest-neighbor technique. The observed pattern differed significantly from random. The variance (s^2) was greater than the mean distance between nests, suggesting a contagious distribution on Bird Rock, as suspected (Southwood 1966).

Mean clutch size was 2.41 in 1965 and 2.69 in 1966. Fifty-nine eggs were laid the first year and 67 the second. The hatching success of different-sized clutches is presented in table 1. The average success of the two-egg clutch for the two years was 67 per cent. The higher success of the three-egg clutch (92 per cent)

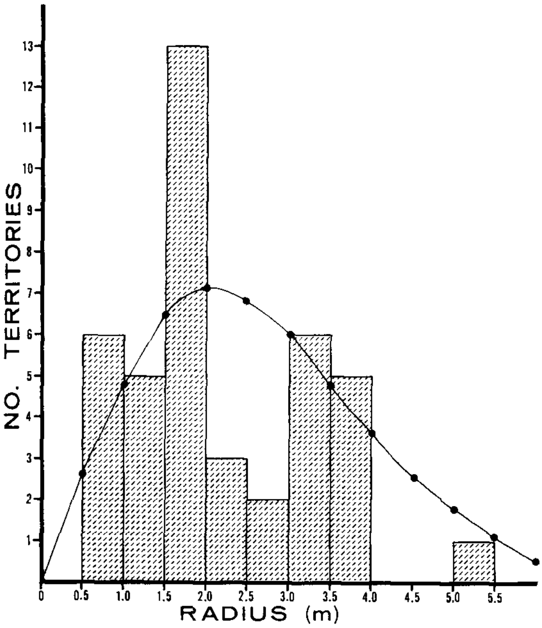

FIGURE 2. The number of territories of various radii, together with a random distribution curve for a colony of this size (5400 m^2, 49 nests). Territories with radii greater than 5.5 m are not shown.

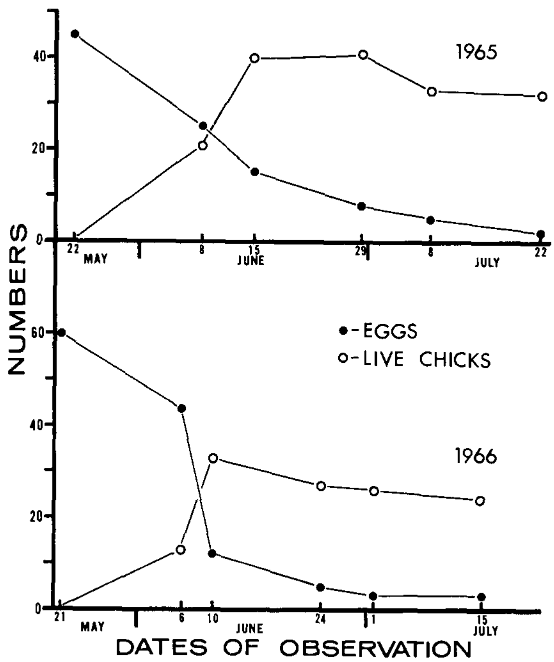

FIGURE 3. Numbers of eggs and chicks of Western Gulls at each visit for the two-year study.

agrees with Schreiber (1970); this is apparently the optimum clutch size in this species.

TERRITORY SIZE

The area of each nesting territory was estimated as a circle with a radius half the distance to the nearest active nest. In 1965, territories were 20.6 ± 8.4 m^2 (95 per cent confidence interval), while in 1966, territories averaged 24 ± 6.1 m^2. The average for both years was 22.3 ± 5.0 m^2. A major source of variation in these values was the previously mentioned limitation on nest sites due to the surface character of the islet.

The most commonly measured territorial radius (fig. 2) fell in the interval of 1.5–2.0 m (7.1–12.6 m^2). Half of the territories had radii of less than 2.0 m. This range of movement agrees with those I observed from the blind. The second peak (in the 3.0–3.5 m and 3.5–4.0 m intervals) includes, primarily, nests which were built on the sloping face of the islet. Birds at these nest sites did not defend all of the area indicated by my artificial measuring method. Because of the restrictions I assumed on marking small chicks, I was unable to demonstrate an optimum territory size for maximized infant survival.

TABLE 1. Clutch size and hatching success of Western Gulls.

	Clutch size	No. clutches	% hatching
1965	1	6	33
	2	3	33
	3	14	88
	4	1	75
1966	1	4	50
	2	3	100
	3	19[a]	96

[a] Includes one nest in which two clutches were laid.

NATALITY, MORTALITY, AND FLEDGING

Hatching success was 76 per cent in 1965 and perhaps as high as 80 per cent in 1966 (see below), compared with a 55 per cent natality on San Nicolas Island in 1968 (Schreiber 1970). Figure 3 shows the temporal pattern of hatching on Bird Rock each year. Of nine eggs taken by a parasitologist in 1965 for work unrelated to this study, only two hatched. These eggs are included in the natality figure for that year.

Chick mortality was 29 per cent in 1965 and 45 per cent in 1966. On 4 July 1965 a small bonfire was set on the islet by unknown persons. Ten dead chicks were found on 8 July, all in territories other than their own. These chicks were nearly a month old and probably would have fledged had it not been for the disturbance. Chick mortality might have been as low as 7 per cent. The 1966 value is also

TABLE 2. Mortality as related to territory size in various gulls (*Larus*).

Species (source)	Mortality[a] (%)	Territory ($\bar{x}$ m²)	Distance between nests	Dead chicks per nesting territory
L. delawarensis (Emlen 1956)	88	1.2	Many 0.45 m apart	1.5
L. occidentalis (this study)	46 64	20.6 24.0	Average 2.5 m	0.58 0.64
L. glaucescens (Vermeer 1963)	42	16.0		

[a] Chicks and eggs.

questionable, for during that summer I was informed by a California Fish and Game warden that people had molested the colony. Examination of figure 3 reveals a marked reduction in the number of chicks between 6–10 June. It is conceivable that eggs were removed as well, but my visits were too infrequent to determine this. In 1966, 27 chicks and/or eggs disappeared; in 1965, all individuals were accounted for at the end of the season. In 1965, 14 chicks were found dead and 16 in 1966.

Total mortality from egg to fledging was 46 per cent in 1965 and 64 per cent in 1966. Both of these figures are probably elevated due to human disturbance. Thirty-two chicks were presumed fledged in 1965 and 24 in 1966, giving fledging rates of 1.33 and 0.96 per nest, respectively.

DISCUSSION

Preferred nest sites centered around the ridge along the central east–west axis of the islet (fig. 1). Territories here were smaller and renesting the second year was more prevalent. At the same time, the natality was 96 per cent in this region. This ridge provided a level spot with nesting material available and loose soil in which to dig. This region also provided an overview of the rest of the colony and was the most isolated from the shore. The latter factor proved to be a small disadvantage, however, when frightened chicks fled to the sea, as they had to cross several territories and suffered severe attacks from adults in returning to their nests. This factor was a minor source of mortality, though, since chicks had reached a size where they were fairly hardy before moving far from the home territory.

The only region where natality was markedly lower was in the vegetation patch (56 per cent). Nesting in this region dropped from five nests in 1965 (14 eggs) to one nest in 1966 (two eggs). The shift of nest sites in 1966 to the open face of the islet away from the vegetation patch suggests that it may have been avoided by those birds which had nest failures there in 1965.

In attempting to assess the success of the small colony at Bird Rock, I compared it with data from other colonies and from other species of gulls, since so little is known of Western Gulls. Mortality as related to colony size was discussed by Harris (1964), who reexamined Darling's theory that mortality of young is lower in larger colonies of gulls, as a result of increased social stimulation and better breeding synchronization. A linear regression analysis of the pooled data from this and Harris' study for colonies of 1–100 pairs, gives a line with a slope not significantly different from zero. Average mortality for colonies in this size range was about 65 per cent, while the Bird Rock colony averaged 55 per cent for the two year study. More data are needed before the relationship between colony size and breeding success can be clearly established.

Infant mortality rate may, however, be more a function of crowding than of absolute colony size. Data are presented in table 2 which suggest that, in the species shown, smaller territory sizes are associated with higher mortality rates. The rise in mortality in crowded colonies could be due largely to the increased probability of small chicks wandering into a nearby territory and being killed or seriously injured. The high average mortality values (about 85 per cent) from the larger colonies reported by Harris support this hypothesis. However, Patterson (1965), working with the Black-headed Gull (*L. ridibundus*), and Vermeer (1963), working with the Glaucous-winged Gull (*L. glaucescens*), could find no significant difference in infant mortality as related to various territory sizes within the main nesting colonies. In another study, Fordham (1970) reports a marked increase in pre-fledging mortality in Dominican Gull (*L. dominicanus*) colonies studied between 1959 and 1967; he attributed this increase to a reduction in local food availability. The increase was unrelated to the degree of crowding and is a further factor complicating analysis of the relationship of crowding and infant mortality.

The fledging rates of 1.33 and 0.96 per nest (the latter of which is low because of the theft of eggs or chicks) are generally above average when compared with other larid colonies. Paynter (1966) found a production of 0.92 sufficient to maintain a stable population of *L. argentatus* on Kent Island, New Brunswick. Ludwig (1969) reports that a recruitment rate of 0.63 is sufficient to maintain a stable population of Ring-billed Gulls (*L. delawarensis*) on the Great Lakes. Ludwig (1966) also found that, between 1960 and 1965, *L. argentatus* populations on Lakes Huron and Michigan increased at an annual rate of 13 per cent with a mean fledging rate of 1.47. This was due to the unusual abundance of the alewife (*Alosa pseudoharengus*), a major food source. At the same time, *L. delawarensis* populations on these lakes were increasing 30 per cent per year with a mean fledging rate of 1.74. Other recruitment values, as summarized by Paynter, ranged from 0.5 to 1.77.

The Bird Rock colony of Western Gulls appears to have been doing well compared to data for other larid species. However, recruitment data for other colonies, as well as information on post-fledging population dynamics, are needed before the long term population trends of *L. occidentalis* can be learned.

SUMMARY

Information is presented on the reproductive ecology of Western Gulls on Bird Rock, Santa Catalina Island, California, for 1965 and 1966. Nesting began about 6 May in both years. The completeness and composition of nests was related to the nature of the surface on which they were constructed (slope and firmness) and the presence or absence of nearby terrestrial plants; several nests located far from plants consisted of only a scrape with small stones and feathers around it. A contagious or aggregated pattern of nest distribution was observed, owing, in part, to the steep, hard nature of the southwest face of the islet.

The most frequently observed territory size ranged from 7.1 to 12.6 m^2 (mean = 22 m^2).

Hatching success was 76 per cent in 1965; chick mortality was 29 per cent in 1965, and *ca.* 45 per cent in 1966; human disturbance of the colony both years increased chick mortality above its probable normal rate. Total observed mortality from egg to chick was 46 per cent in 1965, and 64 per cent in 1966; 32 chicks fledged from 24 clutches in 1965 and 24 chicks from 25 clutches in 1966; fledging rates were 1.33 and 0.96 per nest, respectively.

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