TABLE 5. The calling rate before, after, and between parental feedings observed during the first 4 weeks after hatching.

	Resulted in feeding	No feeding ensued	After a feeding
n	70	64	35
$\bar{x}$[a]	0.8574	0.4103	0.2534
SE	0.0370	0.0354	0.0329
95% CL	0.7336–0.9312	0.3395–0.4811	0.1867–0.3202

[a] Means (calls/sec/chick) for n observations.

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EFFECTS OF HUMAN ACTIVITY ON EGG AND CHICK MORTALITY IN A GLAUCOUS-WINGED GULL COLONY

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Colville Island, located at the south end of Lopez Island, 11.7 km west of Rosario Beach, Skagit County, Washington is a part of the San Juan National Wildlife Refuge, and contains one of the largest breeding colonies of the Glaucous-winged Gull (*Larus glaucescens*) in the San Juan Islands. Thoresen and Galusha (1971) estimated that 1,486 pairs of gulls utilized the island during the summer of 1970. In addition to gulls, Colville supports smaller breeding populations of the Pelagic Cormorant (*Phalacrocorax pelagicus*), Pigeon Guillemot (*Cephhus columba*), Black Oystercatcher (*Haematopus bachmani*) and Song Sparrow (*Melospiza melodia*).

Experiments and observations on the behavior of the Glaucous-winged Gull have been conducted on Colville almost every summer between 1963 and 1973. The effect of our activity on egg and chick mortality has been of considerable interest to us and the refuge management. It is well known how chicks scatter in response to disturbance within the territory (Paynter 1949, Emlen 1956, Harris 1964, Kadlec et al. 1969). As the result of such displacement, chicks often enter other territories and are attacked by the owners of these adjacent territories. Young chicks are unable to retaliate and may be killed before they can return to their own territories.

Our research activities on the island necessitated entry into the territories resulting in chick displacement. This paper describes studies undertaken during 1972 and 1973 to determine the extent of our effects on egg and chick mortality and our influence on the full population.

Colville Island is situated in the southern part of the breeding range of the Glaucous-winged Gull. Colville is 445 m long and 128 m wide at its widest point. The total area was estimated at 3.82 ha. The vegetation consists mainly of two dominant species of grasses *Horedum murinum* and *Bromus carinatus*.

Blinds were set up at four locations on the island. Observations and experiments were usually conducted from the protection of one of the blinds. The experiments on the aggressive communication of the Glaucous-winged Gull involved placing models in gull territories (Stout et al. 1969, Stout and Brass 1969, Gillett 1973, Hayward 1974). Models were moved from territory to territory between experiments which resulted in walking through a number of territories each time. This activity, in addition to disturbances caused when we moved from blind to blind, resulted in chicks scattering to neighboring territories, thus exposing themselves to attack by the neighboring adult birds. This disturbance occurred intermittently for periods of a few seconds to one or two minutes. A given territory might be entered as often as two or three times in a day. The blinds in experimental plots were used daily.

In 1972, two plots measuring approximately 4045

TABLE 1. A comparison between mortalities of eggs before hatching in experimental and control plots during 1973 experimental period.

	No. eggs	No. dead eggs	% dead eggs	
Experimental	406	22	5.42	$\chi^2 = 0.76$
Control	222	16	7.21	

m² were staked out. The plot at the east end of the island contained our main blind and most of our activity occurred in this area. The second plot was located at the western end of the island and served as a control. On 21 June counts were made of all the nests, eggs, and chicks occurring in each plot. Thereafter, dead chicks and eggs were counted periodically in the experimental plot for the extent of the study. A final count in the control plot was made only at the end of our activities, so as to minimize disturbances. Upon finding a dead chick or egg we removed it immediately so that it would not be counted again on subsequent counts.

In 1973, four plots were staked out in areas where research activity was most prevalent. Each of these areas had a blind situated approximately at its center. Three other plots without blinds were chosen away from all research activity for control areas. Each plot measured approximately 929 m² except one of the control plots which was irregularly shaped and measured approximately 790 m².

An initial count of nests, chicks (both dead and alive) and eggs was made in each plot. Following the initial count, a count was made each week of dead chicks or deserted eggs in each experimental plot. In the control plots counts were made only before and after our experimental period.

In order to determine an age-mortality correlation, the manus of ten living chicks of known ages was measured daily. It was then possible to measure dead chicks and determine their approximate ages. We measured the manus as a means of determining age, not weight as is frequently used (e.g. Vermeer 1963). This method allowed us to determine the age of chicks at death even after several weeks of decomposition. Chi-square tests at the .05 significance level were used to compare mortalities of eggs and chicks in experimental and control plots.

Overall island mortalities for 1972 and 1973 were determined by calculations using egg and chick mortality data from the experimental and control plots, assuming that approximately 25% of the colony was affected by our activities.

A mean clutch size for the control plots and experimental plots of 1973 was determined by dividing the total number of chicks and eggs in all the plots by the total number of nests.

Table 1 indicates that there was no significant difference between the number of dead eggs found in the experimental plots and that of the control plots for 1973. Unfortunately, no data for egg mortality alone were available for 1972 since dead eggs and chicks were counted together as mortalities.

Significant differences were shown for chick mortalities between experimental and control plots for 1973 (Table 2). Significant differences were also shown for the combined egg and chick mortalities between control and experimental plots for 1972 (Table 3). Combined egg and chick mortalities for

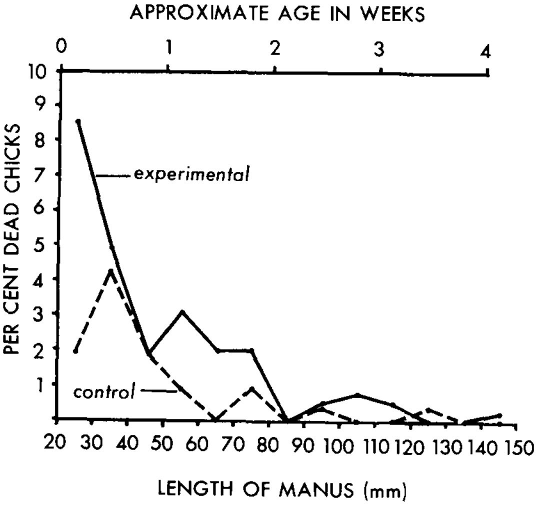

FIGURE 1. The manus length and approximate age at death for Glaucous-winged Gull (*Larus glaucescens*) chicks in experimental and control areas. In each graph mortality is plotted as percentage of total (live and dead) chicks for that group.

the island as a whole were estimated at 12.7% and 20.8% for 1972 and 1973, respectively. Chick mortality alone was estimated at 15.0% for the whole island in 1973.

Figure 1 demonstrates that mortality was most frequent in chicks of ages one to seven days old, both in experimental and control areas.

A mean clutch size for all the plots of 1973 was calculated at 2.33 eggs.

Chick mortality was significantly greater in the experimental plots than in the control plots. Since only about 25% of the colony was disturbed by our activity, however, our impact on the colony as a whole was small. A combined mortality for eggs and chicks for 1972 in undisturbed areas was 8.3%. We estimated the overall island mortality for that year at 12.7%. Thus the colony mortality was 4.4% higher than it would have been had it remained undisturbed. Similarly, in 1973 the combined mortality in undisturbed areas was 17.6% and was estimated at 20.8% for the island as a whole. Thus our activity in 1973 raised the overall mortality of the colony by 3.2%, close to that observed for 1972.

A number of investigators including Paynter (1949), Paludan (1951), Tinbergen (1953), Harris (1964) and Ludwig (1966) have stated that in Herring Gulls (*Larus argentatus*) about one young/pair/year survives to flying age. This represents about 50–67% chick mortality. Kadlec and Drury (1968)

TABLE 2. A comparison between mortalities of chicks after hatching in experimental and control plots during the 1973 experimental period.

	No. of chicks	No. dead chicks	% dead chicks	
Experimental	384	102	26.56	$\chi^2 = 15.01$*
Control	206	23	11.17	

* Significant at the .01 level.

TABLE 3. A comparison between overall mortalities of chicks plus eggs in experimental and control plots for the 1972 experimental period.

	No. of eggs	No. dead eggs and chicks	% dead eggs and chicks	
Experimental	224	58	30.54	$\chi^2 = 28.88$*
Control	330	25	8.33	

* Significant at the .01 level.

indicated that the Herring Gull population is on the increase, doubling every 12–15 years. A high chick mortality apparently has had very little effect on the population of this species.

Vermeer (1963) while studying the Glaucous-winged Gull on Mandarte Island, B.C., calculated chick mortalities to be 50% and 30% for the years 1961 and 1962. Drent et al. (1964) reported a chick mortality of 43% for the same island. Thoresen and Galusha (1971) showed in Glaucous-winged Gull colonies situated on Bird Rocks and Williamson Rocks in the San Juan Islands of Washington, mortalities of 8% and 13%, respectively. On Colville Island we demonstrated chick and egg mortalities of the total island to be 12.7% in 1972 and 20.8% in 1973. Our studies did not allow us to follow mortalities until all the young had fledged. Thus, our data are not to be taken as the mortality for the entire breeding season. However, figure 1 shows that the most critical period for the chicks was included in our study. Therefore, our mortality figures are a good estimate of mortality for the entire season. It is apparent from a comparison of our work with those cited above, that the mortality we encountered in the most heavily used experimental areas (26–30%) was low in comparison with most other results. The overall mortality we encountered (13–21%) is among the lowest reported for larids.

Harris (1964) reported that, with human disturbance, egg stealing was common with Herring Gulls. We did not see stealing or damage of eggs or nest material for the Glaucous-winged Gull on Colville Island. Our observations indicated that Glaucous-winged Gulls settle more rapidly than Herring Gulls following disturbance. Thus, defense of eggs by territory owners is probably greater in Glaucous-winged Gulls. It is interesting to note that egg mortalities in Herring Gulls range from 9–30% (Paynter 1949, Kadlec and Drury 1969). In the Glaucous-winged Gull we observed 7.2% egg mortality in control areas. As eggs that do not hatch or are damaged are not usually removed by the birds our technique of measuring egg mortality seems valid. The fact that a greater egg mortality was encountered in the control areas where counts were made only twice, than in the experimental areas where weekly counts were made, substantiates our conclusion that egg mortality was not underestimated by the techniques used. Thus our conclusion that human disturbance did not affect egg mortality is supported by these data.

Chicks often used our blinds as hiding places. Thus, increases in mortalities observed in experimental areas were most likely the result of our movement through territories and were not due to our blinds or our mere presence in the colony.

In a number of cases nests were situated very close to and in one case touching a blind. Eggs in these nests hatched with apparently the same degree of success as eggs in nests located farther from the blinds.

Combined egg and chick mortalities were significantly greater in our experimental plots in 1973 over 1972 (Table 3). Mortalities in the undisturbed areas were also higher in 1973, so the increased mortality of the experimental plots in 1973 over 1972 was not likely due to our presence.

Over 55% of the chick mortalities recorded occurred in birds less than a week of age. A similar trend was observed in other studies (Paynter 1949, Harris 1964, Kadlec et al. 1969). Mortality patterns for chicks in experimental and control areas were similar, although percent mortalities were lower for control areas (fig. 1). There was a decline in mortalities for two-week-old chicks and mortalities for yet older chicks were few and sporadic. Our activities may have caused the slightly earlier peak for mortalities in experimental areas as compared with control areas.

Death of young chicks was most frequently caused by neighboring gulls. Chicks one week old have little defense against adult harassment and death was usually rapid. A number of chicks were also observed to be partly or completely eaten though cannibalism was uncommon. However, cannibalism has been observed frequently in the Herring Gull (Tinbergen 1959). Death also resulted from other causes. Parasites were seen in a number of individuals although death by parasitism is not thought to be very widespread. On a number of occasions a Bald Eagle (*Haliaeetus leucocephalus*) flew over the island and was chased away by adult gulls. On one occasion we observed an eagle flying from the island with a chick in its talons. Judging by the amount of harassment eagles received, we think that predation by these birds is not significant. A number of Northwestern Crows (*Corvus caurinus*) were also seen on the island and may prey on the nests. Weather was also responsible for mortality in some young chicks on hot days. The continued absence of the adults from a nest was responsible for chicks not receiving enough shade. This had a lethal effect on small chicks.

The population of the Glaucous-winged Gull in the Rosario Strait region has increased by 15.3% between 1963 and 1970 (Thoresen and Galusha 1971). The Colville Island colony has increased by 426 birds and indications are that it is still on the increase. Our presence, therefore, indicates no harmful effect on the maintenance of the colony resulting from our previous work from 1964–1968.

In summary, our presence on Colville Island increased chick mortality in areas where we worked. However, our presence had no effect on egg mortality. There is no overall population decline on Colville. Instead the population is on the increase. Compared with other gull colonies the mortality is small. The observed chick mortality on Colville is near the range of chick mortality (8–13%) on totally undisturbed colonies in the same area. Fifty-five percent of the mortality occurred during the first week after hatching. The increase in mortality resulted largely from chicks moving into adjacent territories and being attacked by neighboring adults as the result of our entering the chicks' home territory.

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EFFECTS OF HUMAN DISTURBANCE ON THE BREEDING SUCCESS OF GULLS

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A number of factors have been suggested as affecting reproductive success in gulls. In this study we have attempted to isolate the effect of human disturbance on breeding success. We held other factors such as age of birds, terrain, and density of colony as constant as was practicable with a varied colony environment. There have been several previous discussions of the possible effect of human disturbance on the breeding success of birds. However, no study has documented this effect with controls. Reid (1968) found that in the Adélie Penguin (*Pygoscelis adeliae*) "banding and close observation during seven summers caused the breeding populations in six colonies . . . to decrease by more than 90%." Nelson (1966), commenting on nests on the fringe of colonies, stated that their lower success rates did not take full account of artifacts introduced by human disturbance. Working with the Sooty Tern (*Sterna fuscata*), Ashmole (1963:324) said that "mortality caused by the pecking of chicks by adults was increased enormously by any human disturbance of the colony." Kadlec and Drury (1968: 657) provided some information on the effect of human disturbance, and compared islands visited occasionally with those being studied in detail. Although they acknowledged an effect, they considered it insignificant compared to environmental variables. Hunt (1972), in studying four small Herring Gull (*Larus argentatus*) colonies, found that two colonies, frequently disturbed by picnickers, had lower hatching success than two undisturbed colonies. He found no difference in the ability of parents to raise young. These latter two studies most systematically approach the problem, but each compares totally different colonies that are, of course, under a variety of environmental conditions.

In 1968 we studied the effects of human disturbance on parts of a single colony of gulls on Southeast Farallon Island, California. Our study demonstrated the quite dramatic effect on breeding success caused by an investigator entering a nesting colony.

THE FARALLON GULL COLONY

The Farallon Islands are a small group located 43 km west of San Francisco, California. The colony of Western Gulls (*Larus occidentalis*) occupies a large proportion of Southeast Farallon Island, the largest of the Farallones, and adjacent Maintop Island, which have a combined land area of about 40 ha (see map in Bowman 1961).

The Western Gull is a maritime species. Its breeding is almost entirely restricted to islands along the Pacific Coast from Washington to Mexico. There are three described races, the subject of this study being the nominate form.

The species is the only gull nesting, or known to have nested, on the Farallones. At present we estimate the colony population at 20,000 individuals. During the breeding season, adults were seen spaced out as if on territory on about 70 per cent (28 ha) of Southeast Farallon and Maintop islands. On study plots

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