A RE-EVALUATION OF MORTALITY RATES IN ADULT HERRING GULLS

By John A. Kadlec

Recent work on band losses from adult Herring Gulls (*Larus argentatus*) (Kadlec, 1975) also permits a re-evaluation of mortality rates. Kadlec and Drury (1968, 1969) argued that adult mortality rates based on recoveries of standard aluminum bands, ca. 18-30 percent per year, were inconsistent with population age structure and reproductive rate. They concluded the true mortality rate was between 4 and 9 percent and that the discrepancy was probably due to band loss. However, Kadlec (1975) showed band loss was very low for at least four years and was only about 3 percent (1.0-6.9 percent, 95 percent limits) at seven years. This paper re-estimates adult mortality rates based on new data and compares the results with the earlier work.

METHODS

In 1967, 1,958 adult Herring Gulls were double-banded on Milk Island, Massachusetts. Each bird received an aluminum band on one leg and either a titanium band (958 birds) or an incoloy band (1,000 birds) on the other leg. An additional 10 birds received each band combination in 1968. These 20 birds have been ignored in the analysis. Approximately one-third of the 6,000 ± breeding adults were double-banded. This made it possible to examine breeding adults with telescopes for band numbers and missing bands in 1968, 1969, 1971, and 1974. In this colony, the gulls are accustomed to people and permitted very close approach. We also recorded the numbers of double-banded, single-banded (whether aluminum vs. incoloy or titanium in 1974), and unbanded adults in sample counts in each year of sampling.

These data permit calculation of estimates of numbers of double-banded birds present each year and therefore mortality rates as well. All of the techniques are fundamentally capture-recapture methods, although the sample counts give banded-unbanded ratio data. The band-reading data are classic capture-recapture type and permit simple pairwise calculations (Lincoln Index) of population sizes in 1968, 1969, and 1971, multiple recapture average estimates (Schnabel, 1938), or direct estimates of mortality via multiple capture-recapture methods.

RESULTS AND DISCUSSION

Based on Band Reading

The basic data and the population estimates based on pairs of years are shown in Table 1. The data for the two cohorts are similar but great disparity exists among estimates for cohort size in a given year. For example, the titanium-banded cohort in 1969 was estimated as 482 based on 1971 data and 988 based on 1974 data. Several potential reasons exist for such variation: non-random sampling, random error, and non-return of breeding adults.

Non-random sampling might be a problem in the 1971 and 1974 data sets which were partly done by the same observers in the same areas. Even so, after three years it is not possible to seek out deliberately the same gulls to reread the band numbers. Among the other years, bias in reading numbers seems unlikely.

TABLE 1.

Estimated sizes of double-banded cohorts.

Year	No. bands read	Repeats from 1968	Repeats from 1969	Repeats from 1971	Population est. 1968	Population est. 1969	Population est. 1971
A. Incoloy and Aluminum, 1,000 banded							
1968	185	—					
1969	168	64	—		486[1]		
1971	132	28	32	—	872[1]	693[1]	
1974	99	23	18	35	796[1]	924[1]	373[1]
Average					642[2]	776[2]	373[1]
B. Titanium and Aluminum, 958 banded							
1968	132	—					
1969	152	44	—		456[1]		
1971	92	19	29	—	639[1]	482[1]	
1974	65	12	10	16	715[1]	988[1]	378[1]
Average					543[2]	611[2]	374[1]

[1]Lincoln Index estimate
[2]Schnabel method

Random error for these estimates, as with most capture-recapture data, is large. The 95 percent confidence limits for the population estimates in Table 1 range approximately 20 to 90 percent of the estimates, with most in the area of 30 to 50 percent. Another approach to evaluating the random error is the comparison of two cohorts. We would expect no difference between them and most of the comparisons based on the same pair of years suggest small errors.

If non-random sampling and random error are not the major causes of the erratic results, perhaps non-return of adults was important. The ratio of banded to unbanded was low in 1968, suggesting a non-return. Previous studies (Kadlec and Drury, 1968) suggested a substantial fraction, perhaps as much as 20 percent, of the adult breeding population may not breed in a given year. Our data suggest that these birds do not nest on other islands, but really do not breed. In either case, the effect on the data considered here is the same — adults "marked" in one year may be alive but not present to be sampled in a subsequent year. In the following year they return but others depart, and so on. The net effect of such behavior is an underestimate of cohort size by an amount approximately equal to the number of absentee "marked" birds.

TABLE 2.

Approximate annual (not instantaneous) mortality rates from banding, based on data in Table 1.

Year of band reading	Estimated annual mortality to 1968	1969	1971	Multiple recapture method*
A. Incoloy and Aluminum cohort (1,000 birds)				
1969	.51			
1971	.13	.17		
1974	.20	.04	.22	.23
		**	.31***	
B. Titanium and Aluminum cohort (958 birds)				
1969	.52			
1971	.33	.29		
1974	.25	****	.21	.24
		**	.22***	

*From Coulson and White 1957
**Not feasible—1969 estimate larger than 1968
***Based on Schnabel estimates, Table 1
****Estimate exceeds number banded

Mortality rates based on the population estimates of Table 1 are presented in Table 2. A high degree of variability is evident. One might suggest that the longer term averages based on the multiple recapture methods (Schnabel, 1938; Coulson and White, 1957) and the 1968–1974 pair of data converge on 20-25 percent per year mortality (discrete, not instantaneous).

Based on Banded-Unbanded Ratio

Observations of the fraction of the breeding population carrying both an aluminum and a new band could be directly expanded to estimates of the cohort size if one is willing to assume a constant breeding population. The change of ratio can be used directly, which is the approach used in Table 3, but this also requires the assumption of a constant total breeding population.

A major problem in the interpretation of the data is that the fraction double-banded was higher in 1969 than in 1968. The 95 percent confidence limits of that fraction are so broad that an inference of "no change" is possible; so is an inference of a small *decrease* (10 percent) from 1968 to 1969. All trends are possible, considering both mortality and the possibility of temporary absences. The ratio in 1968 was low — approximately one-third of the birds marked in 1967 were not present in 1968. As discussed previously, this was very likely an artifact resulting from the disturbance of the banding operations. Comparisons among 1969,

TABLE 3.

Banded-unbanded ratios.

Year	Sample size	Fraction double-banded 95% (limits)	Pair-wise annual mortality rate[1] mean (extremes)[2]
1967		.3333 (est.)	.34
1968	2,387 (528)	.2212 (.2045–.2379)	—* (—*–.10)
1969	893 (216)	.2419 (.2138–.2700)	.13 (—*–.18)
1971	1,193 (219)	.1836 (.1483–.2189)	.22 (.12–.31)
1974	1,571 (137)	.0872 (.0732–.1012)	

[1]Assumes a stable breeding population
[2]Mortality rate extremes calculated from lower bound of one year and upper bound of other year
*Fraction increased; no calculation possible

1971, and 1974 are unlikely to be so affected, as long as a similar amount of non-return was present each year. The mean and extreme estimates of mortality (Table 3) in those years suggest an average somewhat less than 20 percent, which is lower than suggested by the band-reading data. It is, however, still much higher than Kadlec and Drury (1968) inferred. Using their upper estimate of 9 percent mortality per year, 56 percent of the double-banded gulls should have been alive in 1974. Instead, the fraction double-banded suggested only 26 percent were alive and present; even allowing for 20 percent non-breeding absentees increases this to only 32 percent (or a 15 percent per year mortality).

CONCLUSIONS

The data presented here are not compatible with the earlier analysis of Herring Gull population structure (Kadlec and Drury, 1968). Two alternatives seem possible: (1) there has been a change in adult mortality rates, or (2) the earlier paper was in error. We have elsewhere (Drury and Kadlec, 1974) suggested that a change did occur in the dynamics of the population in the late 1960's. The rate of growth of the population slowed, perhaps to zero, but the low proportion of young in the population suggested a decrease in reproduction rather than an increase in adult mortality. The data on age ratio are limited to a local sample, so the conclusion is not firm.

For the adult mortality rate to have been as high as suggested by the data presented here, the previous analysis (Kadlec and Drury, 1968) would have erred in the estimates of both reproductive rate and age ratio. For example, if the mortality rate for birds over 22 months old was 15 percent per year but other mortality was as suggested by Kadlec and Drury (1968), the reproductive rate in the growing population would have averaged 1.5 chicks per pair (80 percent of adults breeding) in September. Furthermore, the age ratio would have been 53 percent adults, 26 percent intermediates, and 21 percent chicks rather than the 68 percent, 17 percent, and 15 percent observed (Kadlec and Drury, 1968, Table 25). A stable population was projected to have an age composition of 61 percent adults, 22 percent intermediates, and 17 percent chicks. Given the acknowledged bias of the observed age ratio reported in 1968 in favor of adults, this latter interpretation is within the bounds of the reliability of the data. This re-examination, then, in conjunction with other evidence (Drury and Kadlec, 1974) suggests that the errors in the 1968 paper were: (1) the assumption that population growth was still in progress; (2) an underestimate of reproductive rate, perhaps because it was measured during a time the population growth rate was changing; and (3) an overestimate of the bias in the mortality data due to band loss.

A major inconsistency still exists in our data and understanding: the age ratio observed in 1972 is still inconsistent with an adult mortality rate of 15 to 20 percent. Additional age-ratio data are needed to resolve this issue.

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Department of Wildlife Science, UMC 52, Utah State University, Logan, Utah 84322. Received 16 July 1975, accepted 1 October 1975.