11.5 mg N/day, which is 43% above maintenance re-
tention. Feather synthesis accounts for the retention
of roughly 6.0 mg N/day [(2.0 g of new plumage plus
a correction factor of 105 mg for replacement of rec-
trices damaged and lost during growth) multiplied
by 0.1522 N; Murphy and King 1984a, b]. Synthesis
of sheaths adds appreciably to this quantity and ac-
counts for at least an additional 10% of the nitrogen
retained during molt. About 4 mg N/day retained
during molt is still not accounted for quantitatively.
Some of it undoubtedly is deposited in other integ-
umentary structures that are renewed during the molt,
and in accessory structures such as pulp, increasing
numbers of erythrocytes, increases in peptide stores
(Murphy and King 1985), and perhaps in accretion
of other body proteins.

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NOTE ADDED IN PROOF

Analysis of feather parts completed after this report was in press
suggested larger losses of serine during hydrolysis than reported by
Rattenbury (1981). By analyzing the amino acid composition of sam-
ples of rachis hydrolyzed from 12 to 24 h, we found that as much as
35% of serine and 14% of threonine was destroyed between 12 and 24
h. The other amino acids were stable. We used 24-h hydrolysates in
the analysis reported in Table 2.

Estimating Nest Detection Probabilities for White-winged Dove Nest Transects in Tamaulipas, Mexico

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Nest transects in nesting colonies provide one
source of information on White-winged Dove (*Ze-
naida asiatica asiatica*) population status and reproduc-
tion. Nests are counted along transects using stan-
dardized field methods each year in Texas and
northeastern Mexico by personnel associated with
Mexico's Office of Flora and Fauna, the Texas Parks
and Wildlife Department, and the U.S. Fish and
Wildlife Service. Nest counts on transects are com-
bined with information on the size of nesting colo-

nies to estimate total numbers of nests in sampled colonies. Historically, these estimates have been based on the actual nest counts on transects and thus have required the assumption that all nests lying within transect boundaries are detected (seen) with a probability of one. Our objectives were to test the hypothesis that nest detection probability is one and, if rejected, to estimate this probability.

STUDY AREA AND METHODS

Fieldwork was conducted during June 1985 at two whitewing nesting colonies in Tamaulipas, Mexico. The Parras de la Fuente Colony lies adjacent to the Río Soto la Marina about 80 km northeast of Ciudad Victoria. The colony became established in the mid-1970's in response to increased food (grain sorghum) and water (irrigation) and now consists of several million nesting adults in an area approximately 4 × 20 km. The Escandón Colony is a remnant of a much larger colony that existed at least as early as the mid-1960's. Clearing of brush vegetation for agricultural purposes has restricted the colony to an area of about 2 × 4 km, but the nesting population is estimated to be about 1 million whitewings (Tomlinson et al. in prep.). Nesting habitat in both colonies consists of a vegetative complex that is referred to as Tamaulipan thorn scrub. The vegetation is composed of a dense entanglement of small trees (2–5 m in height), shrubs, and cacti, largely impenetrable to humans (Cottam and Trefethen 1968). Whitewing nesting densities in these locations sometimes reach an estimated 1,500 nests/ha.

When we first considered the problem of estimating nest detection probability, it seemed that formal line transect estimators (see Gates 1979, Burnham et al. 1980) would be most appropriate for estimating numbers of nests on transects. Even though nests were located in relatively low vegetation (nest heights seldom exceeded 3–4 m on our transects), however, we were concerned about the critical line transect assumption of seeing nests on the transect line with probability one. We thus used multiple observers in conjunction with capture-recapture model estimators to estimate nest detection probability.

Field methods.—Transects to estimate whitewing nesting densities commonly sample plots of either 0.25 acre or 0.1 ha. Quarter-acre (~0.1 ha) transects are normally 121 yards (110.6 m) long by 10 yards (9.1 m) wide, whereas 0.1-ha transects are 100 m long by 10 m wide. Because earlier studies used the English system, we retained it in this study. Whitewinged Dove nesting transects are established by cutting a narrow and relatively straight line through the heavy brush and stretching a premeasured length of cord (121 yards, 110.6 m) at chest level to mark the center line of the transect. Two observers then travel the length of the cord, one on each side, counting all nests within 5 yards (4.6 m) of the line. This pro-

cedure results in a count of all nests seen within the 0.25-acre (0.1 ha) transect. Data from several transects are combined with an estimate of land area covered by the colony to estimate the total number of nests in a colony.

Our sampling experiments were designed to estimate the probability that an average nest lying within the boundaries of a nest transect is actually detected by observers (call this detection probability, p). Each of 5 observers was provided with a number of small washers painted a distinguishing color (red, black, white, blue, or yellow). We initiated the exercise by cutting a path and laying out the cord in the standard manner. Then a single observer searched for nests on one side of the cord, placing a colored washer in each nest found. When the first observer had proceeded approximately 30 yards (27.4 m) and was well out of sight, a second observer began the same procedure on the same side of the string. This was repeated until the fifth observer had completed his search and washer placement. At the end, all five observers searched the area once again, retrieved the washers, and recorded the different colors found in each nest. Thus, we generated a list of nests with a record of which observers found each one. This exercise was conducted once at the Parras de la Fuente Colony and once at the Escandón Colony, with the same 5 observers participating at each location.

Statistical methods.—The above exercises yielded data that were analyzed using the closed capture-recapture methods of Otis et al. (1978). We initially hoped that the data could be analyzed using the heterogeneity model, M_h, of Burnham and Overton (1978). The test results from program CAPTURE, however, indicated the presence of both heterogeneity and observer variation (equivalent to temporal variation in the capture-recapture context) in both data sets (Parras de la Fuente and Escandón). The appropriate model for both data sets was thus M_{th}, for which no estimator is available (Otis et al. 1978). We removed observer variation by restricting the data sets to observers who found similar numbers of nests. By doing this we were able to estimate total nests using model M_h with data from 4 observers at Parras de la Fuente and 3 at Escandón. Note that this restriction of data to subsets of observers was necessary only for the estimation of total nests. Nest detection probabilities were estimated for all observers.

The detection probability, p_i, for each observer, i, was estimated as:

$$\hat{p}_i = n_i/\hat{N}_h, \qquad (1)$$

where n_i is the number of nests found by observer i and $\hat{N}_h$ is the estimated total number of nests based on model M_h. The variance was estimated as:

$$\widehat{\text{var}} \; \hat{p}_i = [(n_i/\hat{N}_h)^2 \; (\widehat{\text{var}} \; \hat{N}_h/\hat{N}_h{}^2)] + \hat{p}(1 - \hat{p})/\hat{N}_h, \quad (2)$$

where $\widehat{\text{var}} \; \hat{N}_h$ is based on model M_h. Note that (2) is

TABLE 1. Nest detection probability estimates $(\hat{p}_i)$ for 5 observers during sampling experiments at the Parras de la Fuente and Escandón colonies, 1985.

Observer (i)	Parras de la Fuente[a]		Escandón[b]		Both colonies[c]	
	Nests seen	$\hat{p}_i$ (SE)	Nests seen	$\hat{p}_i$ (SE)	Nests seen	$\hat{p}_i$ (SE)
1	56	0.69 (0.055)	44	0.81 (0.058)	100	0.74 (0.040)
2	75	0.93 (0.038)	43	0.80 (0.059)	118	0.87 (0.033)
3	61	0.75 (0.052)	34	0.63 (0.068)	95	0.70 (0.042)
4	66	0.81 (0.048)	42	0.78 (0.061)	108	0.80 (0.038)
5	56	0.69 (0.055)	31	0.57 (0.069)	87	0.64 (0.043)
All observers	314	0.78 (0.029)	194	0.72 (0.034)	508	0.75 (0.022)

[a] Total number of different nests found by all observers, $M_{t+1} = 78$. Total estimated nests, $\hat{N}_h = 81$, $\widehat{SE}(\hat{N}_h) = 2.19$.

[b] $M_{t+1} = 52$, $\hat{N}_h = 54$, $\widehat{SE}(\hat{N}_h) = 1.50$.

[c] $M_{t+1} = 130$, $\hat{N}_h = 135$, $\widehat{SE}(\hat{N}_h) = 2.65$.

written as the sum of two components, the first representing sampling variation associated with the estimation of N and the second representing nonsampling binomial variation.

Equations (1) and (2) were used to estimate p_i for each observer, i, at each colony. An overall $\hat{p}_i$ for each observer was obtained by summing the n_i, $\hat{N}_h$, and $\widehat{var}\,\hat{N}_h$ on the two transects and using these sums in conjunction with (1) and (2). Estimates for all observers pooled were obtained by computing the following values:

$$n^* = \sum_{i=1}^{5} n_i, \tag{3}$$

$$\hat{N}_{h\cdot} = 5\hat{N}_h, \text{ and} \tag{4}$$

$$\widehat{var}\,\hat{N}_{h\cdot} = 25 \,\widehat{var}\,\hat{N}_h \tag{5}$$

for use in conjunction with (1) and (2).

RESULTS AND DISCUSSION

The hypothesis of $p_i = 1.0$ was rejected for every observer, as none found all of the nests located by all observers. The estimated total number of nests at the Parras de la Fuente Colony was 81 (Table 1). Although 78 of these nests were seen by at least one observer, the number seen by individual observers ranged from 56 ($\hat{p}_i = 0.69$) to 75 ($\hat{p}_i = 0.93$). The total nest estimate at Escandón was 54, 52 of which were seen by at least one observer. The number of nests found by individual observers ranged from 31 ($\hat{p}_i = 0.57$) to 44 ($\hat{p}_i = 0.81$). The ranges in $\hat{p}_i$ illustrate the CAPTURE test results showing individual variation in p_i.

The point estimates of detection probability for individual observers and all observers combined differed to some extent between the two transects. However, none of these differences would be regarded as statistically significant at $\alpha = 0.05$ (based on an

approximate z test). We thus conclude that our best estimates of detection probability are those based on both transects (Table 1). The pooled estimate of p over all observers and both colonies was computed using Eqs. (3)–(5) as $\hat{p} = 0.75$. Thus, on average, members of this team of observers would be expected to locate about 75% of the nests on a specific whitewing transect.

This is the first effort, of which we are aware, to estimate nest detection probabilities in White-winged Dove nest transect studies. Although based on only two transects, we believe that use of our pooled detection probability estimate of $\hat{p} = 0.75$ is preferable to assuming that $p = 1.0$. Until more work on detection probability is done, we can "correct" density estimates from previous years by multiplying by $1/\hat{p} = 1.33$.

In future efforts to estimate number of nests in colonies, it may be desirable to estimate $\hat{p}$ for specific teams of observers in specific colonies (and possibly for different levels of other variables that might affect p_i, e.g. nest density, time of day). However, the capture-recapture exercise described here requires 5 observers and approximately 3 h per transect. At least six standard transects can be run with this allocation of time and effort. We suspect that nest detection probability does not vary much among transects or colonies, and that different observers represent the largest potential source of variation in detection probability. Therefore, capture-recapture exercises in representative habitat might be especially useful in estimating team-specific detection probabilities, which could then be used to "correct" or "adjust" counts on all transects run by specific teams.

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Diving Depths of Atlantic Puffins and Common Murres

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The diving ability of an aquatic bird is an obvious, important determinant of its foraging niche. Piatt and Nettleship (1985), for example, showed that the depths attained by four species of alcids in Newfoundland were correlated positively with body mass, which suggests that these similar, sympatric species might exploit different parts of the water column. The development of miniature gauges to measure depth (Kooyman et al. 1971, 1982, 1983; Wilson and Bain 1984a), speed (Wilson and Bain 1984b), and distance traveled (Wilson and Achleitner 1985) has greatly facilitated studies of diving in birds.

We report maximum diving depths, measured with gauges attached to free-living birds, attained by Atlantic Puffins (*Fratercula arctica*) and Common Murres (*Uria aalge*) off Gull Island (47°16'N, 52°47'W) in Witless Bay, Newfoundland. Piatt and Nettleship's (1985) study, on the depths at which alcids were trapped in fishing nets, was made in the same area.

We used depth gauges similar to those used by Kooyman et al. (1971) and Adams and Brown (1983), comprising lengths of flexible plastic tubing sealed at one end and coated internally with water-soluble powder (icing sugar). As water was forced down the tube when submerged, the powder dissolved, recording the maximum depth attained (Adams and Brown 1983). The tubing used was Intramedic® polyethylene (PE 160, i.d. 1.14 mm, Clay-Adams, Inc., New York) and Tygon® (R-3603, i.d. 1.6 mm, Norton Specialty Plastics Div., Akron, Ohio). The latter type was found to be less likely to leak or to be damaged.

Sample gauges were calibrated by being lowered from a boat to depths up to 150 m in the study area. The coefficient of variation of the readings on 10 gauges was within 4% at any depth. The gauges were not affected significantly by the rate of descent (5 gauges lowered at 1.38 and 5 at 0.40 m/s to depths of 50 and 70 m; $P > 0.10$ in each case, Mann-Whitney U-test), the duration of immersion (6 gauges immersed at 50 m for intervals of 0.5, 1.0, 2.0, 4.0, and 8.0 min; $P > 0.10$, two-tailed Kruskal-Wallis test with tied ranks), or repeated immersions (6 gauges immersed 5 times to 5 m and 5 times to 50 m; $P > 0.10$ in each case, two-tailed Kruskal-Wallis test).

Gauges were 145 mm long for puffins and 200 mm long for murres. They were attached to metal leg bands with short (10 mm) lengths of string. The tubing caused no discernible impediment to the birds during flight or on land, and was not long or flexible enough to entangle their legs. The string would wear through, releasing the gauge, should it not be recovered. These small, trailing gauges were unlikely to have had the same negative effects on the streamlining and swimming of birds as found with harness-mounted devices (Wilson et al. 1986).

All birds studied were breeding adults tending chicks. Puffins were caught in nooses set in their nesting burrows, and murres were caught with a noose pole. Fifteen gauges, of which 10 were undamaged, were recovered from puffins, out of 46 deployed. Two gauges, both undamaged, were recovered from murres out of 29 deployed. The greatest limitation of this technique is the ability to recapture birds without undue disturbance.

The Atlantic Puffins in our sample, totaling 75 bird-days, usually foraged at depths less than 60 m (Table 1). Only one puffin exceeded this depth, diving to 68 m during 17 days of foraging. Piatt and Nettleship

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