A SAMPLING METHOD FOR TUNDRA SWANS IN THE BRISTOL BAY LOWLANDS OF THE NORTHERN ALASKA PENINSULA

A summary of a presentation given at the Refuges and Wildlife Project Leaders' Meeting, U. S. Fish and Wildlife Service, December 8 - 11, 1986.

RANDALL J. WILK

Alaska Peninsula/Becharof National Wildlife Refuges
U. S. Fish and Wildlife Service
Post Office Box 277, King Salmon, Alaska 99613-0277

A "census" of tundra swans occurring in the northern Alaska Peninsula was conducted over 1984-1985, with supplemental information provided from preliminary surveys conducted in 1983. Eighty-seven percent of the 18,023 km^2 (6959 mi^2) survey area was flown in June 1984 with the remaining 13% surveyed in June 1985. The results enabled Alaska Peninsula/Becharof National Wildlife Refuges to develop a sampling method with predictable results. The 1:63360 U.S. Geological Survey topographic quadrangle maps were used to survey swans, and were then subdivided into "1/4 maps" for subsequent sampling (Fig. 1).

Paired and single swans were used as the basis for stratifying 1/4 sampling units (SU's) (a posteriori). Three density strata, low (0-0.1 swans/km^2), medium (0.1-0.2) and high ($\geq$ 0.20) (Fig. 2), were developed.

To estimate sample sizes needed for future surveys, it was necessary to estimate the variability of swans in each stratum. The stratum variances, s_{dh}^2 (i=1, 2, 3), were computed from the 1984-1985 "base-year" results (Table 1).

Unlike other areas in the tundra swans range in Alaska, many of the SU's in the northern Alaska Peninsula were not contiguous potential swan habitat, thus areas within 1/4 maps were unequal-sized (individual SU areas of swan habitat ranged from 5km^2 (2mi^2) to 159km^2 (61mi^2)). This information lends itself to calculations for a ratio estimate (Cochran 1977:164).

For a specific sample size, n, it is possible to select the number of SU's, n_h (h=1, 2, 3), which should be sampled in each stratum to minimize the uncertainty about the estimate of total swans. This uses optimum allocation of sampling effort with a ratio estimate (Cochran 1977:172), and the strata sample sizes are,

$$n_h = \frac{n\left(\frac{N_h S_{dh}}{\sqrt{C_h}}\right)}{\sum_{h=1}^{3}\left(\frac{N_h S_{dh}}{\sqrt{C_h}}\right)}$$

where N_h = No. of 1/4 maps in stratum h

S_{dh} = Standard deviation in stratum h

C_h = Mean area of a 1/4 map in stratum h (mean cost of surveying)

By specifying the projected total number of paired and single swans, Y, (using the 1984-1985 total), and the degree of precision desired (size of the 95% confidence interval (CI) about the estimated number of swans), the required sample size can be estimated (Table 2). Since sample sizes within strata become small beyond $\pm$ 0.10, no other data were calculated. Small sample sizes may bias estimates of the true variance.

If one were estimating paired and single swans in the northern Alaska Peninsula, a CI of $\pm$ 5% could beaccomplished by sampling 87 (46.8%) of the 186 SU's (Tables 2-3). The sample size is reduced to 37 (19.9%) when the CI increases to $\pm$ 10%. The projected sample sizes, n = 87, n = 37, were calculated with (Hodges et al. 1986),

$$n_h = \frac{\sum_{h=1}^{3}\left(\frac{N_h S_{dh}}{\sqrt{C_h}}\right)\sum_{h=1}^{3}\left(\sqrt{C_h}\, N_h S_{dh}\right)}{.25\, P^2 \hat{Y}^2 + \sum_{h=1}^{3} N_h S_{dh}^2}$$

where, S_{dh} = standard deviation for stratum h

C_h = Mean area of an SU in stratum h

P = proportional error (precision)

$\hat{Y}$ = estimated population index = 2862

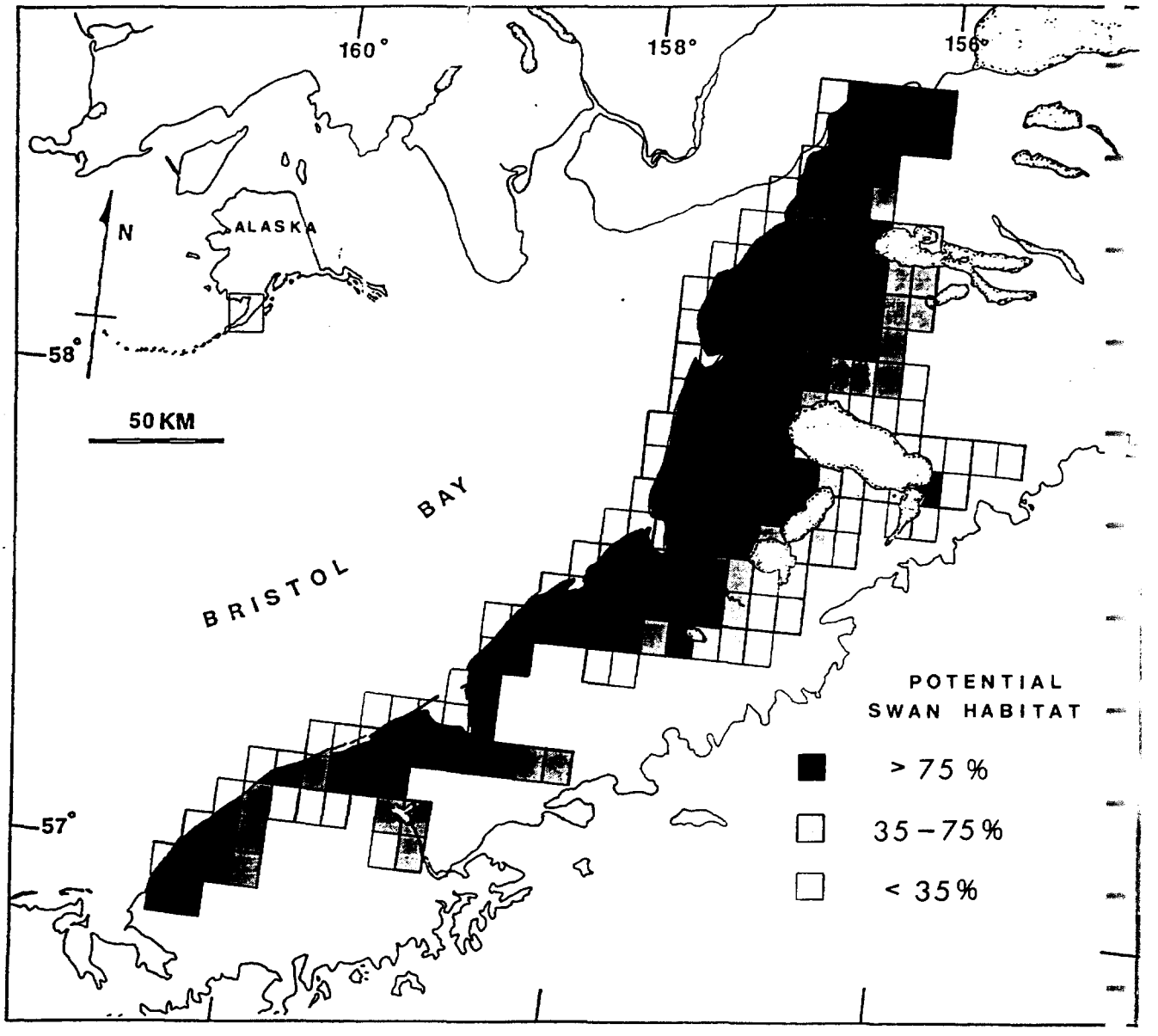

Fig. 1. Sampling units and swan habitat in northern Alaska Peninsula survey area

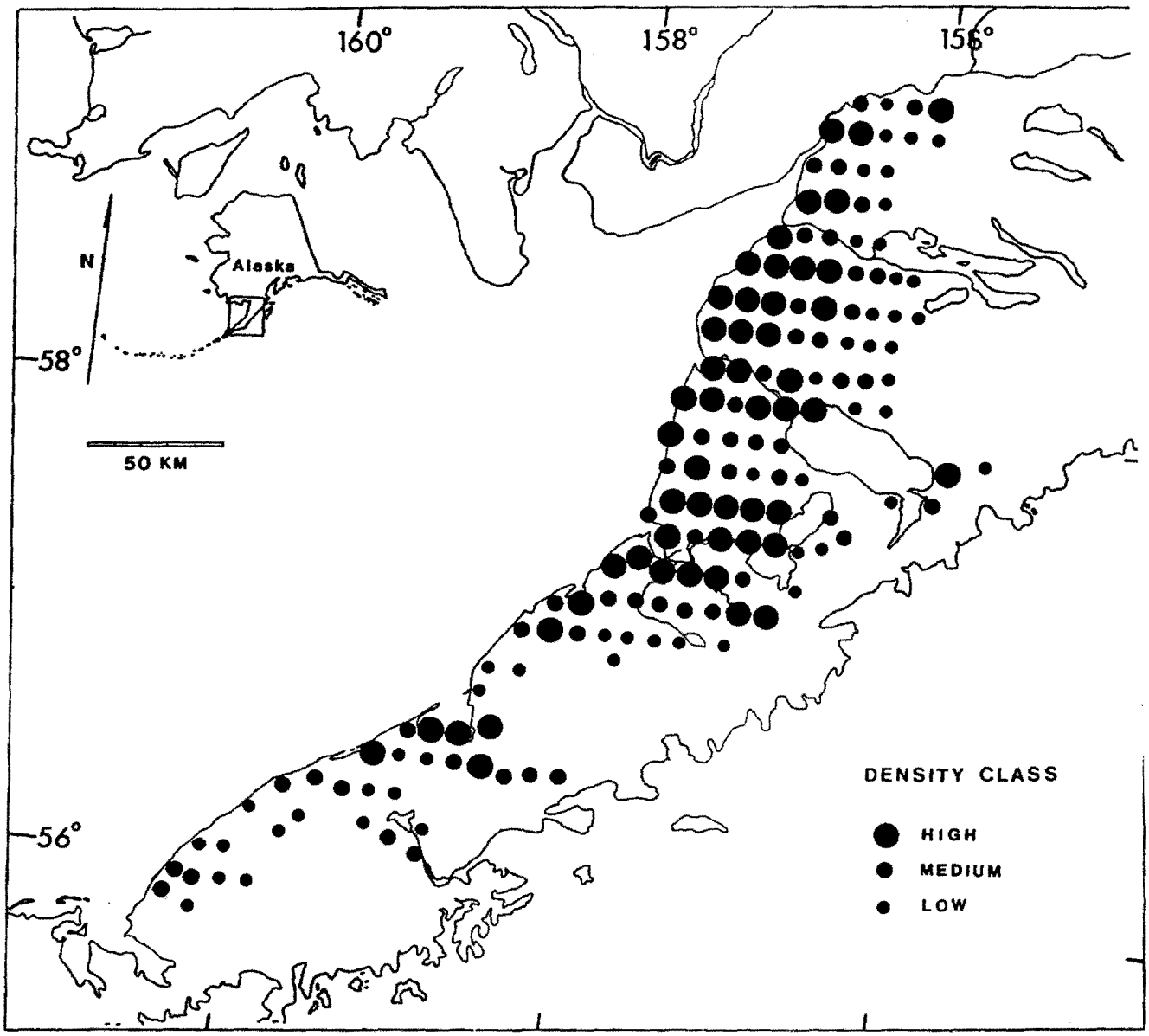

Fig. 2. Preliminary densities of swans by survey sampling unit in the northern Alaska Peninsula.

Table 1. Strata variances using the swans and SU areas from 1984-1985 base-year census.

	Stratum		
	Low	Medium	High
N_h = No. SU's	68	58	60
Sdh^2 = Variance (Cochran 1977:173)	13.0	16.6	72.5
C_h = Mean area (cost) of swan habitat flown	78.1	109.5	106.1

Table 2. Sample sizes and allocation of SU's to obtain various 95% CI's on total paired and single swans in the northern Alaska Peninsula.

	Sampling units (n)				
	Low	Medium	High	Total	%
Interval					
± 0.0	68	58	60	186	
± 0.05	24	20	43	87	(46.8%)
± 0.10	10	9	18	37	(19.9%)

Table 3. Estimates of the index of the number of paired and single tundra swans from "back-calculation" to 1984 data according to the allocations listed in Table 2.

	Stratum			
	Low	Medium	High	Total
1984-85 base yr. "census"	305	904	1653	2862
Area (km^2)	5310 (29.5)	6350 (35.2)	6363 (35.3)	18023 (100.0%)
No. 1/4 SU's	68	58	60	186
No. SU's flown	10	9	18	37
No. km^2 flown	759	1061	2049	3869 (21.5%)
No. swans seen	41	133	542	716
Swans/km^2	0.0540	0.1254	0.2645	0.1851
Est. pop. index	287	796	1683	2766
Est. SE	53.2	63.1	116.6	142.9 (5.2%)
95% CI of est.	± 104	± 124	± 229	± 280 (10.1%)
No. SU's flown	24	20	43	87
No. km^2 flown	4641	2358	1997	8996 (49.9%)
No. swans see	1215	320	114	1649
Swans/km^2	0.0571	0.1357	0.2618	0.1833
Est. pop. index	303	862	1666	2831
Est. SE	36.7	48.2	44.1	74.9 (2.6%)
95% CI of est.	± 72	± 94	± 86	± 147 (5.2%)

Once the stratified sample has been flown and the data collected, the analysis is as follows:

The subscript h denotes the stratum and i the SU within the stratum. The following symbols all refer to stratum h.

N_h = total number of sampling units

n_h = number of units sampled

y_{hi}= number of swans in the ith unit

$\bar{y}_h$ = mean number of swans per unit sampled

syh^2= variance of numbers between sampled units

$\hat{Y}$ = estimate of total number of animals in all strata

Designating the area of a sampled unit (area of potential habitat within a 1/4 map) as z_i and total area under survey as Z,

$$\hat{Y} = \frac{\sum_h N_h \bar{y}_{hi}}{\sum_h N_h \bar{z}_{hi}} Z$$

To calculate the SE of $\hat{Y}$, we first define

$$\hat{R} = \hat{Y} / Z$$

and

$$s_{hzy} = \frac{1}{n_h - 1} \sum_i z_{hi} y_{hi} - \frac{\left(\sum_i z_{hi}\right)\left(\sum_i y_{hi}\right)}{n_h}$$

$$\widehat{\text{Variance}}_{\hat{Y}} = \frac{N_h (N_h - n_h)}{n_h} syh^2 - 2Rshzy + R^2 szh^2$$

$$\widehat{SE}_{\hat{Y}} = \sqrt{\text{Variance}_{\hat{Y}}}$$

with s_{yh}^2 being the variance of numbers per sampled unit in the hth stratum and s_{zh}^2 the variance of the sampled units in the same stratum.

The population index estimate pools the stratum estimates to provide an overall estimate of swans and its SE (Caughley 1977b:31).

In 1986, we randomly chose 30 SU's to survey, optimally allocated, estimating the number of units we could survey in one week. We were able to survey 28 (Table 5). Concurrent with standard surveys, we used an intensive survey method (Fig. 3) to compare the number of swans seen and estimate a simple preliminary "sightability correction factor". The results are seen in Tables 4 and 5.

This method for sampling numbers of swans can be used to estimate the number of swans in flocks, and recruitment. This paper presents a summary of only swans seen in pairs or as singles.

Table 4. Preliminary results from tundra swan aerial surveys conducted by two different methods in the northern Alaska Peninsula, 1986.

Swans	152m	75m	% not seen	P value	Simple VCF
JUNE					
In pairs	188	248	24.2	P<0.005	
Singles	62	80	22.5	NS	
Potential breeders	250	328	23.8	P<0.002	1.31
JULY					
In pairs	82	118	30.5	P<0.02	
Singles	14	17	17.6	NS	
Potential breeders	96	135	28.9	P<0.05	1.41

Table 5. Results from June 1986 aerial survey of tundra swans in the northern Alaska Peninsula.

	Stratum			
	Low	Medium	High	Totals
Area (km^2)	5310	6350	6363	18023
No. SU's	68	58	60	186
No. SU's surveyed	7 (8)[a]	9 (6)	12 (14)	28 (15.1%)
No. km^2 surveyed	784	1017	1426	3192 (17.7%)
No. swans seen	49	122	398	569
(x SCF	64	159	521	744)
Swans/km^2	0.0625	0.1200	0.2803	0.1783
(x SCF	0.816	0.1563	0.3654	0.2331)
Estimated pop. index	332	762	1783	2877
(x SCF	433	993	2325	3751)
SE	103.7	100.1	212.6	256.8 (8.9%)
(x SCF	136.0	132.1	278.3	336.9)
95% CI	± 203	± 196	± 417	± 503 (17.5%)
(x SCF	± 267	± 259	± 545	± 660)

[a]Number of units that should have been surveyed based on optimum allocation is in parentheses. The number of units actually surveyed in each stratum was adjusted to minimize bias from the small sample size in 1986.

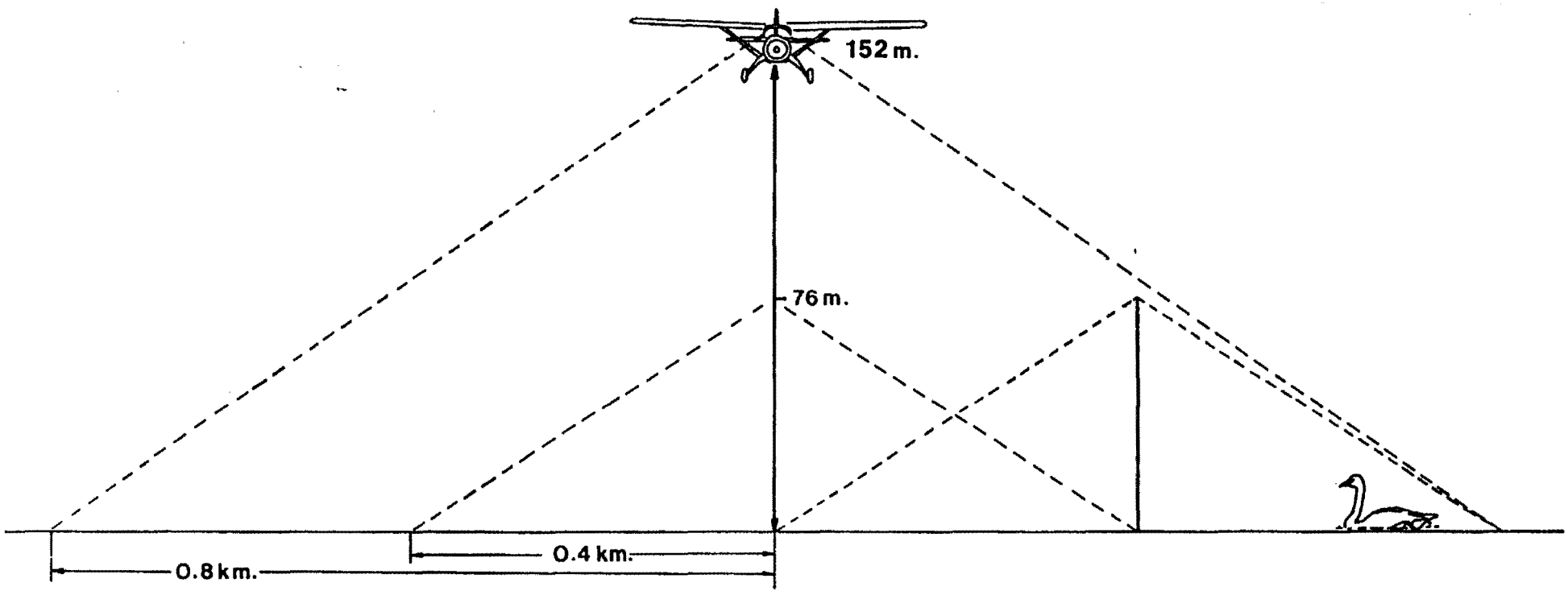

Fig. 3. Depiction of two survey procedures used to estimate a tundra swan sightability correction factor for northern Alaska Peninsula study. 152m (500ft.) is the standard method; 76m (250ft.) is the intensive search method. Aircraft speed was also reduced during the intensive search. Dashed lines are the observers' viewing distance.

BENEFITS
are axiomatic

* Statistically valid method for estimating tundra swan populations with predictable precision, based on a sample of < 1/5 the cost of a census (for a $\pm$ 0.10 95% CI about the estimate)

* Since tundra swan densities in Alaska are much higher than trumpeter swans' (which use large map units for estimating populations), plot sampling of tundra swans lends itself to the smaller 1/4 maps which reduces the variance of swan numbers in strata, especially high-density strata, thus providing more precise estimates

* Estimates of swans in flocks (non- or failed breeders), and recruitment can be calculated using the same methods

* Estimate based on areas of actual swan habitat provides way to monitor waterfowl habitat conditions in small land blocks with tundra swan as the "indicator species"

* Per unit surveyed, 1/4 units are cheaper and quicker to survey than larger maps - has psychological spin-off for pilots and observers

* Method could be readily applied to other areas of Alaska and throughout the species range - 1/4 maps could be stratified, a priori, based on pond / wetland densities (see King, J. G., and J. I. Hodges. 1981. A correlation between **Cygnus columbianus** territories and water bodies in western Alaska. Pages 26 - 33 **in** Matthews, G. V. T., and M. Smart, eds. Proc. 2nd Int. Swan Symp., Int. Waterfowl Res. Bur., Slimbridge, England.)

REFERENCES

used as guides and background information in developing this sampling method

Caughley, G. 1977a. Sampling in aerial survey. J. Wildl. Manage. 41:605-615.

Caughley, G. 1977b. Analysis of vertebrate populations. John Wiley & Sons, New York. 234pp.

Caughley, G., and G. C. Grigg. 1981. Surveys of the distribution and density of kangaroos in the pastoral zone of south Australia, and their bearing on the feasibility of aerial survey in large and remote areas. Aust. Wildl. Res. 8:1-11.

Cochran, W. G. 1977. Sampling techniques. John Wiley & Sons, New York. 428pp.

Gasaway, W. C., S. D. DuBois, S. Harbo, and D. J. Reed. 1984. Estimating moose demography from aerial surveys. Alaska Dep. Fish Game, Fairbanks. (Manuscript in press.)

Hodges, J. I., B. Conant, and S. L. Cain. 1986. Alaska trumpeter swan status report 1986. U. S. Fish Wildl. Serv. Rep., Juneau. 8pp.

McLaren, M. A., and P. L. McLaren. 1984. Tundra swans in northeastern Keewatin District, N. W. T. Wilson Bull. 96:6-11.