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Aerial Photography Techniques to Estimate Populations of Laughing Gull Nests in Jamaica Bay, New York, 1992-1995

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Abstract. We evaluated aerial photography (full coverage, using fixed-wing aircraft) and aerial video (transects, using helicopter) surveys to estimate the population of Laughing Gull (*Larus atricilla*) nests in Jamaica Bay, New York, during June 1992-1995. We counted 4,920 nests in the colony using aerial photography and estimated 5,367 nests using aerial video in 1992. In 1993-1995, we respectively counted 5,691, 5,095, and 6,126 nests in the colony using aerial photography, and estimated from ground plots that our counts differed from the actual number of nests by means of -9% to 1%. Overall (1993-1995) correction factors (by which to multiply the aerial photography nest counts) to estimate the mean and 95% lower and upper CI range of the nest population were 1.04, 0.96 and 1.13, respectively. Ninety-seven percent of nests identified using aerial photography or video had ≥1 adult Laughing Gull present or within 1 m of the nest. The aerial video survey was less expensive ($2,100 United States currency) than the aerial photography survey ($4,000). The estimated cost of a total count of nests from the ground is $6,700-$9,600. The aerial video survey provided an accurate estimate of the number of nests. Full-coverage aerial photography also provided an accurate estimate of nests in addition to habitat, nest distribution and nest density data. *Received 13 June 1996, accepted 3 October 1996.*

Key words.—Aerial photography, aerial survey, Jamaica Bay, Laughing Gull, *Larus atricilla*, nesting population.

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Gulls (*Larus* spp.) have frequently been reported as a hazard to aircraft (Dahl 1984, Kull 1984, Seubert 1990, Sherigalin 1990). There was an increase in Laughing Gull (*L. atricilla*) collisions with aircraft at John F. Kennedy International Airport (JFKIA) during the 1980s related to an expanding nesting colony adjacent to the airport in Jamaica Bay (Dolbeer *et al.* 1989). This strike increase prompted various management actions including egg oiling, shooting gulls, and vegetation management (Griffin and Hoopes 1991, Dolbeer *et al.* 1993, Dolbeer and Bucknall 1994, Buckley and McCarthy 1994). Belant and Dolbeer (1993) predicted that these management programs would have a minimal effect on national Laughing Gull populations; however, an accurate estimate of the size of the nesting colony in Jamaica Bay was needed annually to assess effects on the local population. A ground-based count of this colony in 1990 totaled 7,579 nests (Griffin and Hoopes 1991).

Although the mark-relocate method of counting nests from the ground is considered the most reliable technique for estimating or censusing many colonial nesting species (Wilkinson 1991), the technique can be labor intensive and difficult to implement in tidal marshes interspersed with creeks. In addition, ground-based nest counts cause considerable disturbance in nesting colonies (Wilkinson 1991). A review of Laughing Gull nesting population surveys for the United States revealed that many estimates of colony size are based on partial ground counts or visual counts from the air that often are subjective, incomplete, and of questionable accuracy (Belant and Dolbeer 1993). Therefore, we evaluated aerial photography techniques to estimate the population of Laughing Gull nests in Jamaica Bay. Aerial surveys have been used frequently to estimate populations of nesting birds (Harris 1991, Hutchinson 1979, Sidle and Ferguson 1982, Wilkinson 1991). Our objective was to evaluate aerial surveys using photography and video in estimating the population of Laughing Gull nests in a colony in Jamaica Bay.

METHODS

Aerial surveys were conducted in June 1992-1995 over Joco (124 ha), Silver Hole (37 ha), East High Meadow (46 ha), and East Joco Island (36 ha) Marshes within Jamaica Bay, Gateway National Recreation Area, New York (40°36'N, 73°47'W). These marshes are inter-

spersed with tidal creeks and mosquito-control ditches. Dominant vegetation includes *Spartina alterniflora*, *S. patens*, and *Distichlis spicata* (Buckley and Buckley 1984, Burger 1983). The dates of our aerial surveys coincided with peak incubation and initial hatching of eggs for Laughing Gulls on these marshes (Buckley and Gurien 1986, Griffin and Hoopes 1991).

Aerial Photography Survey

Using a Cessna 310 aircraft, personnel from Aerographics Corporation (Bohemia, New York) flew 7 transects at approximately 300-m intervals and at 370-m elevation over the marshes on 4 June 1992, 8 June 1993, 9 June 1994, and 16 June 1995. Flights were from 1000-1200 h with clear sky. Aerographics personnel took 60 overlapping black and white exposures during the 7 transects each year using a large format camera (Wild RC10 Precision Mapping Camera, 153 mm objective lens, 23 × 23 cm negatives, Kodak 2405 XX aerial film). Each exposure (scale 1:2424) covered approximately 554 × 554 m (30.7 ha). We selected 22-30 of the exposures each year to obtain complete coverage of the 4 marshes.

We had 4× enlargement prints (92 × 92 cm) made of the 22-30 exposures and covered each print with clear plastic, gridded in 1.9-ha blocks. Photographs were gridded to determine nest distribution and to avoid duplicate counts. An observer using a magnifying lens inspected each photograph and circled all nests detected with a permanent marker on the plastic overlay. A second observer reviewed each photograph.

In 1992, we did not conduct ground surveys of nests in the colony to assess the accuracy of our counts from photographs. In 1993, we established 7 30- × 30-m plots (5 on Joco and 2 on Silver Hole marshes) on 3 June. Plots were delineated with numbered 1- × 1.5-m cardboard markers staked flat to the ground at each corner and white cord stretched along the boundaries. Three to 6 observers searched each plot and marked nests with wire survey flags (5 × 8 cm). The number of eggs and approximate location within the plot was recorded for each nest. The number of nests counted in these plots on the aerial photographs was then compared with the number counted on the ground. Ground counts were not referenced until after nests on aerial photographs were counted. In 1994-1995, this same procedure was repeated using 10 plots (7 on Joco and 3 on Silver Hole) established on 6 or 7 June.

For each year, 1993-1995, and for the 3 years combined, we determined correction factors by which nest counts from photographs should be multiplied to estimate mean and 95% confidence intervals (CI) for the nest population. These correction factors were based on the standard error of difference in ground and photograph counts for plots and Student $t_{0.05}$ values (Steel and Torrie 1960:44-46).

Aerial Video Survey

We flew 16 parallel transects 90 m over the marshes at approximately 130-m intervals using a Bell Jet Ranger helicopter with a ground speed of about 30 kph on 16 June 1992. The flight was from 1100-1300 h with clear sky. Each transect was taped using a SVHS video recorder (Panasonic model AG-450) at 5× magnification and pointed straight down through the open door. The estimate of nests was obtained by viewing the imagery and counting the number of nests visible on the monitor screen with the tape on "still". The tape was then advanced to the area immediately adjacent to the previous screen, paused, and nests were again counted. This procedure was used for each transect. The area of marsh visible on the 50-cm monitor screen (10.74 m × 13.77m) at each pause was the unit of replication. Mean number of nests per ha (± SE) was determined for each marsh and this value was extrapolated to estimate the number of nests for each entire marsh. The area (ha) of each marsh was determined using a compensating polar planimeter and a 1:15,800 scale aerial phoograph. Because of disparity in sampling intensity (we did not survey the southern portion of Joco Marsh as intensively as anticipated) during the aerial video survey, we divided Joco Marsh into "north" and "south" units. Therefore, we did not obtain an overall standard error (SE) for this marsh.

We examined 500 nests on the photographs and 100 nests on the video in 1992 to estimate the proportion with Laughing Gulls either on, within 1 m of, or absent from nests. This sample was used to obtain minimum estimates of the number of nests with attending adults.

RESULTS

Aerial Photography Survey

We could not confidently delineate Laughing Gull nests on the unenlarged aerial photographs (23 × 23 cm). However, nests were usually clearly visible on the 4× (92 × 92 cm) enlargements as light gray- to white-colored circles about 1 mm in diameter, contrasting with the darker vegetation. In 1992-1995, we counted 4,920, 5,691, 5,095 and 6,126 nests, respectively, on the photographs of the marshes (Table 1). Nest densities on the 1.9-ha blocks ranged from 0-271, 0-341, 0-494, and 0-434 in the respective years. In 1992, the highest concentrations of nests were found in the center of Joco Marsh in line with and about 0.8 km from the end of JFKIA's runway 4L (Fig. 1). The distribution of nests in 1993-1995 was similar to nest distribution in 1992 although relative numbers of nests among the 4 marshes varied (Table 2).

In 1993-1995, our counts of nests in the ground plots from aerial photographs differed from the actual number of nests counted in the plots by means of -9% to +1% (Table 3). If we adjust the photographic counts by these discrepancies, the estimated mean nest population was 6,032 in 1993, 5,554 in 1994 and 6,065 in 1995. The overall (1993-1995) correction factors to estimate the mean and 95% lower and upper CI

Table 1. Estimated number of Laughing Gull nests on marshes in Jamaica Bay, New York, from aerial photography and aerial video surveys, June, 1992-1995.

		Aerial photography			
			Corrected with 95% CI[1]		
Year	Aerial video	Counted	$\bar{X}$	Lower	Upper
1992	5,367	4,920	5,117	4,723	5,560
1993		5,691	6,032	5,008	7,512
1994		5,095	5,554	5,095	6,063
1995		6,126	6,065	5,085	7,596

[1]Estimated values based on correction values in Table 3. Because no ground plots were sampled in 1992, the mean correction value for 1993-1995 was used to adjust 1992 data. Correction values for the respective individual years were used in 1993-1995.

range of the nest population were 1.04, 0.96 and 1.13, respectively.

Aerial Video Survey

Nests were clearly visible from the video imagery, averaging about 18 mm in diameter on the 50-cm monitor screen. We counted nests in 934 screens (replicates), which comprised 5.5% overall coverage of the four marshes. Our estimates (±SE) for "north" and "south" JoCo Marsh were 3742 ± 482 and 383 ± 275 nests, respectively. Estimated number of nests from the aerial video survey in 1992 were similar to the number of nests counted in 1992 using photographs (Table 1).

For each survey in 1992, we estimated 97% of nests had adult Laughing Gulls present or within 1 m of the nest, suggesting most nests observed were occupied. Over 99% (590) of the 594 nests counted from the ground in plots in 1993-1995 had ≥ 1 egg, indicating nest counts were made at the peak of incubation.

Costs of Surveys

The cost of an aerial photography survey, including the flight, initial 60 photographs, and enlargements was $3,200 (United States currency). To obtain total counts of nests from photographs of each marsh required 40 person-h. Ground counts required an additional 30 person-h. Assuming a labor cost of $12.00/h, the entire survey cost about $4,000. Cost of the aerial video survey (assuming video equipment is available), including flight time and 30 person-h ($12.00/h) for viewing the imagery and summarizing data, was about $2,100. To conduct a single total count of nests from the ground on these marshes would require eight experienced people for 7 to 10 10-h days, representing 560-800 person-h (E. Hoopes, Univ. Mass.-Amherst, pers. comm.). At $12.00/h, this survey would cost between $6,700 and $9,600; excluding travel, per diem, and equipment costs.

DISCUSSION

Because of low herbaceous cover, lack of overhead cover, and high contrast between nests and adjacent vegetation, we believe aerial photography or video surveys are suitable for estimating the number of Laughing Gull nests in habitats such as found in Jamaica Bay. We undoubtedly overlooked some nests and miscounted other objects as nests on the aerial photographs; however, counts from ground plots indicated errors were <10%. Overall (1993-1995), counts from photographs needed to be adjusted by -4% to 13% to encompass the 95% CI of the nest population.

The counts of nests from each marsh determined from the aerial photography survey in 1992 were within the respective standard error values calculated from the aerial video survey. After correcting for bias via counting nests from the ground, the two techniques should provide similar estimates for a given nesting colony. Wilkinson (1991) found that counts of Royal (*Sterna maxima*)

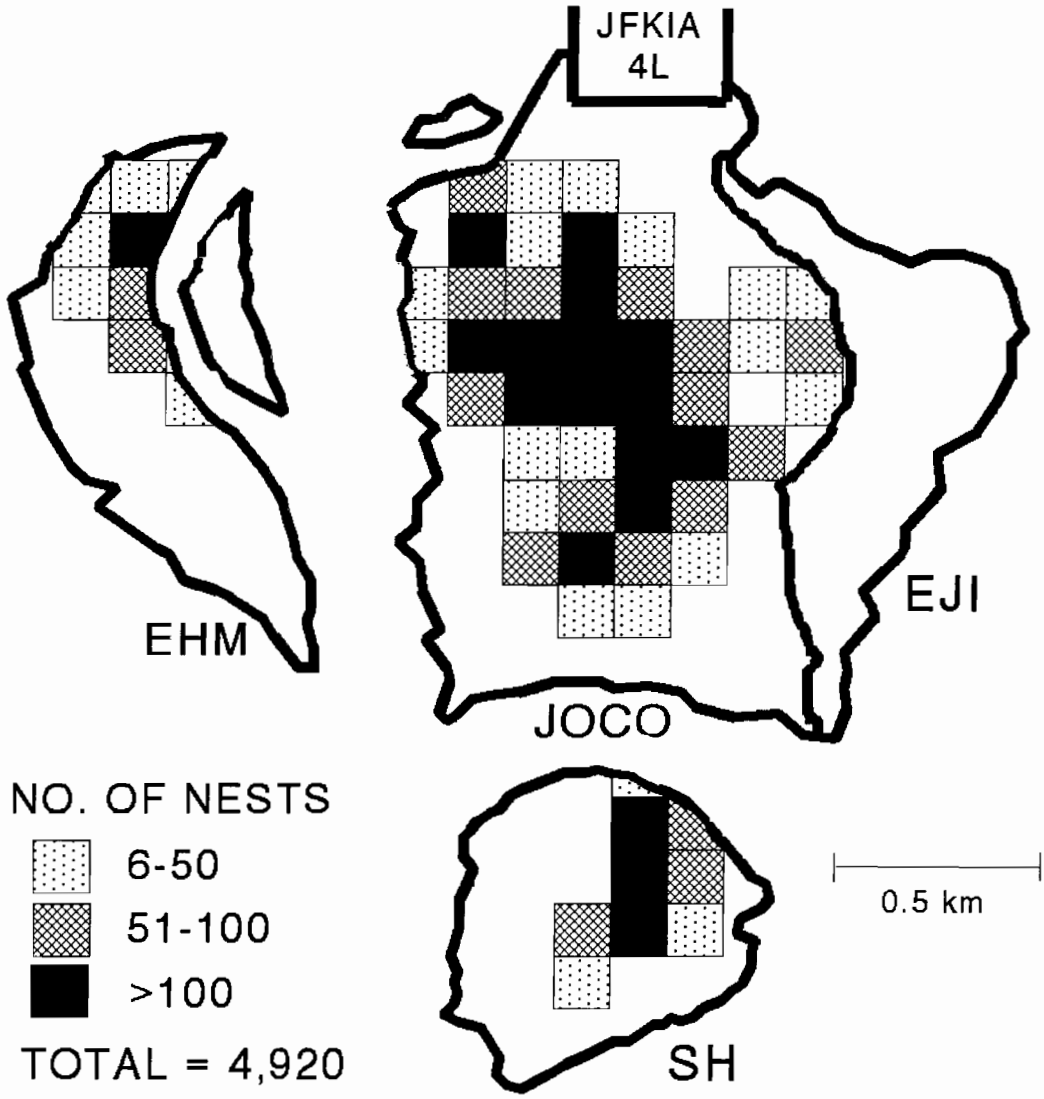

Figure 1. Distribution and relative abundance of Laughing Gull nests by 1.9-ha blocks on 4 marshes (EHM = East High Meadow, JOCO = Joco Island, EJI = East Joco Island, SH = Silver Hole) in Jamaica Bay, New York adjacent to runway 4L, John F. Kennedy International Airport (JFKIA), as determined from aerial photography, 4 June 1992.

and Sandwich Tern (*S. sandvicensis*) nests using aerial photographs were in agreement (±10%) with single ground and transect counts.

The high level of nest occupancy (97% for each survey) observed demonstrated that these techniques caused minimal disturbance, even when using a helicopter at 90-m elevation. In contrast, nest counts from the ground, particularly multiple counts of the same colony, can cause considerable disturbance (Wilkinson 1991).

The aerial video survey was the most time- and cost-efficient method to obtain an estimate of the nesting population of Laughing Gulls. However, data were more limited than were data collected using aerial photography, providing only an estimate rather than a total count of nests. Other advantages of aerial photography include the ability to better evaluate habitat, nest spacing and distribution, and nest density. Both techniques require substantially less time than would nest counts from the ground of the same ar-

Table 2. Estimated number of Laughing Gull nests on four marshes from aerial video and aerial photography surveys, Jamaica Bay, New York, June 1992-1995.

		Aerial video (SE)	Aerial photography (Corrected)[1]			
Marsh	Area (Ha)	1992	1992	1993	1994	1995
Joco	124	4,125	3,998	4,002	3,755	4,595
Silver Hole	37	772 (131)	670	1,460	1,240	757
E. H. Meadow	46	443 (144)	449	516	414	479
E. Joco Is.	36	27 (27)	0	54	145	234
Total	243	5,367	5,117	6,032	5,554	6,065

[1]Estimated mean values based on correction values in Table 3. Because no ground plots were sampled in 1992, the mean correction value for 1993-1995 was used to adjust 1992 data. Correction values for the respective individual years were used in 1993-1995.

Table 3. Mean difference in number of Laughing Gull nests counted from ground and from aerial photographs in 30- × 30-m plots and estimated correction factors for adjusting aerial photograph counts to estimate mean number of nests (and 95% CI), Jamaica Bay, New York, June, 1993-1995.

		No. of nests counted from ground		Nest count difference: photographs minus ground		Correction factor for photograph count ($\overline{X}$ and 95% CI)[1]		
Year	No. of plots	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	Lower	Upper
1993	7	15.71	7.29	-0.86	3.18	1.06	0.88	1.32
1994	10	25.00	12.32	-2.00	2.79	1.09	1.00	1.19
1995	10	23.40	12.97	0.20	6.60	0.99	0.83	1.24
Total	27	22.00	10.22	-0.89	4.59	1.04	0.96	1.13

[1]Amount by which nest counts from photographs should be multiplied to estimate mean and 95% CI for nest population, based on standard error of difference in ground and photograph counts for plots and Student $t_{0.05}$ values with 6, 9, 9 and 26 df for 1993, 1994, 1995 and 1993-1995, respectively.

ea. These aerial survey techniques likely are suitable for assessing nesting populations of other species of colonial waterbirds, provided nests are not obscured by vegetation and colonies are at least moderately dense. Although frequently not done at present (Belant and Dolbeer 1993), photography or video should be implemented in aerial surveys of colonial nesting waterbirds to provide a permanent record.

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