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EVALUATION OF AIRBORNE VIDEOGRAPHY FOR ENUMERATING PACIFIC WALRUSES *(Odobenus rosmarus divergens)* ON SEA-ICE HAULOUTS

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ABSTRACT

Airborne videography using two fixed-mount Super-VHS cameras was unsatisfactory for recording imagery on transects that could be used to estimate the density of Pacific walrus *(Odobenus rosmarus divergens)* resting on sea ice. Counts from hand held Super-VHS by four observers of the number of walruses in groups were all significantly lower than visual real-time estimates. Counts from hand held High-Band 8-mm video by two observers were lower than counts from simultaneously exposed 35-mm photographic slides. Under conditions of direct sunlight, our comparison of 35-mm slides and High-Band 8-mm video indicated that the video resolution was inadequate for delineating partially visible walruses in dense aggregations and led to underestimating total numbers.

INTRODUCTION

Commercially available video cameras and recorders have been substantially improved recently. New Super-VHS (S-VHS) and Hi-Band 8-mm (HB-8) equipment have better resolution, high-speed shutters and increased performance under low-light conditions. Inexpensive, high-resolution video imagery is an attractive alternative to 35-mm photography, especially for projects that require frequent or extensive surveys. Additional advantages include immediate verification of image quality, simultaneous audio data recording, flexibility under variable lighting conditions, and the capability to superimpose ancillary information such as the digital output from LORAN-C navigation equipment.

Advances in video technology have been accompanied by a growing number of applications in natural resource monitoring and inventory (Everitt et al., 1988; Sidle and Ziewitz, 1990). Typically, airborne video has been used to assess habitat parameters rather than for counting animals. We evaluated video for developing or supplementing methods

to census the Pacific walrus population. The Pacific walrus population inhabits waters of the United States and Soviet Union (U.S.S.R), and the two nations have coordinated walrus surveys at 5-year intervals since 1975. Past efforts have identified several problems in obtaining accurate population estimates, including bias because the numbers of walruses in large groups were estimated and not counted. Video imagery was used to evaluate if, and under what conditions, resolution was sufficient for counting individual walruses in large groups.

We present results of two flights that recorded video images of walruses resting on sea ice. The first flight, over the Bering Sea west of Nome, Alaska, examined fixed-mount S-VHS as a technique for systematic data collection. Hand-held S-VHS also was compared with real-time observer estimates of walrus numbers. The second flight, over the southwestern Chukchi Sea, U.S.S.R., contrasted HB-8 video images with 35-mm photographic slides.

METHODS

The U.S. Fish and Wildlife Service and the U.S. Forest Service cooperated to evaluate airborne videography of walruses during 26-31 May 1989. The mission was based at Nome, Alaska. We used a Forest Service Queen Air aircraft that had been previously modified for aerial photography. Two Panasonic 300CLE, color S-VHS cameras were mounted in a 0.5-m-diameter belly port, one camera in a vertical position and the other angled 17° degrees from vertical. The 17° angle was the maximum attainable given constraints of camera size and port diameter. Rotating the mount to position the inclined camera perpendicular to the flight line maximized the image swath-width. This configuration was used to evaluate the potential for a complete video survey using line transect sampling (Burnham et al., 1980). Each camera was equipped with a Canon 10-120-mm zoom lens set at 10 mm and operated with a 0.001-second shutter speed and auto aperture. Panasonic AG-7400 S-VHS recorders were used with Scotch S-VHS magnetic tape. One camera was interfaced with a video animator and an IBM-compatible laptop computer that superimposed latitude, longitude, time, altitude, and flight direction from LORAN-C digital output directly onto the recorded image (Dewhurst and Meisner, 1988). Intercabin audio communications were input to both recorders by small microphones placed inside headset ear cups. Aircraft ground speed averaged 140 knots at 150 m altitude.

One S-VHS camera was hand held to record walrus groups concurrent with visual estimates of group size. From the co-pilot position, an experienced observer estimated the number of walruses in a group while a second person recorded video images through a plexiglass window just behind the aircraft wing. The zoom lens was set at 120 mm.

In the laboratory, walrus groups were "freeze-framed" on a Panasonic CT-2010Y monitor, and individual walruses were counted independently by four observers. The original visual estimates were not disclosed. Walrus groups showing

signs of entering the water during overflight were not included in the analysis.

During July 1989, a Canon-A1 HB-8 video camcorder was used aboard a Soviet AN-26 aircraft for recording walruses resting on sea ice in the southwestern Chukchi Sea. The camera was hand held, and pictures were taken through an open door panel. The camera had an 8-80-mm zoom lens (set at maximum focal length), a 0.0005-second shutter speed, auto-aperture, and Canon Hi8 Metal-E recording tape. Walrus groups were simultaneously photographed through the open door with a motor-drive Canon A1 with 35-mm Ektachrome, 200 ASA film and an 80-210-mm zoom lens set at maximum magnification. Aircraft ground speed averaged 180 knots, and altitudes were 300, 400, and 500 m.

In the laboratory, the HB-8 video imagery was displayed on a Panasonic CT-2010Y monitor and two observers independently counted individual walruses within groups. Each observer also made independent counts of walruses in these groups from 35-mm color slides viewed under a 4X dissecting microscope, and by projecting the slides onto 35 x 45 cm-paper and tracing individual walruses for subsequent counting.

Walrus counts from the May survey and from each altitude in the July survey were analyzed separately. Analysis of variance with walrus groups treated as blocks was used to test for differences in counts by different observer and method combinations. Specific hypotheses about differences among observers and methods were tested with contrasts when the overall effect of observer and method combinations was significant ($P \leq 0.05$). Contrasts were also used to test hypotheses about the effect of observers within methods and methods within observers when the observer x method interaction was significant ($P \leq 0.05$) for the July survey.

RESULTS

During the May survey, walruses were seen hauled out on the unconsolidated southern edge of the sea ice from 100 km south to 100 km northeast of Bering Strait. Weather was predominantly low clouds with variable light penetration, typical of conditions encountered at the sea-ice edge.

At 150 m flight altitude, the vertical and perpendicular fixed-mount S-VHS cameras, together, recorded a total swath-width of about 200 m when the lens focal lengths were set at 10 mm. The highly-reflective sea ice and dark water produced high-contrast imagery. Individual walruses could not be delineated, and groups of walruses could not be distinguished from open water without audio verification. Manual aperture adjustments to improve shadow detail within the walrus aggregations did not effectively improve image quality. Three-power magnification (30-mm focal length) was sufficient to detect individuals from the vertical perspective; however, precise delineation was often confounded by a background of "dirty" ice caused by walrus defecation.

Hand-held S-VHS imagery of walruses, recorded from an oblique angle with maximum magnification, had sufficient resolution to identify individuals within about 0.5 km of the aircraft. The oblique angle reduced contrast, improved shadow detail within aggregations, and provided a more recognizable perspective of walrus forms. However, oblique angles reduced sightability of lower-lying individuals in tight aggregations.

The variance of walruses per group estimated visually during the survey and counted by each of the four observers of the hand-held S-VHS playback tended to increase with group size. Analyses were based on the log transform of the counts in order to stabilize this variance. None of the pairwise differences among the four S-VHS observer counts was significant. However, all S-VHS counts were significantly lower than the direct real-time estimate (Table 1).

Table 1. Mean proportional differences between the number of walruses counted directly and from Super-VHS images in each of 36 walrus groups.

Observer	Difference[A]
DD	.23*
JG	.21*
SH	.22*
CR	.19*

[A]Mean proportional difference is calculated as

$$\frac{1}{n}\sum_{i=1}^{n}\frac{(x_i-y_i)}{(x_i+y_i)/2}$$

where x_i is the direct count and y_i is the Super-VHS count for group i, $i=1,\cdots,n$.

*Difference between counts was significant at $\alpha=0.05$ based on ANOVA (see Methods).

During the July survey, walrus aggregations were recorded on remnant southern ice floes about 90 km northeast of the Chukotka Peninsula, U.S.S.R. Weather conditions were sunny and clear throughout the survey period.

In general, projected slides produced higher counts than magnified slides, and magnified slides produced higher counts than HB-8 imagery of the same walrus groups. Count variances increased with group size, and all analyses were based on the log transform of the counts.

The only significant difference between observers was for counts made from projected slides that were photographed at 300 m altitude (Table 2). For both observers, counts from projected slides were significantly higher than the corresponding magnified slides, except at the 400 m altitude (Table 3), and counts from projected slides were significantly higher than HB-8 video for all flight altitudes (Table 4).

Table 2. Mean proportional differences[A] between the number of walruses counted by 2 observers in each of n walrus groups using Hi-band 8 videography and 35-mm slides obtained at 3 altitudes.

	Altitude		
Method	300m (n=19)	400m (n=8)	500m (n=8)
Hi-Band 8 video	-.05	.04	.03
Magnified slides	.07	.00	.30
Projected slides	-.12*	-.21	-.25

[A]Mean proportional difference calculated as

$$\frac{1}{n}\sum_{i=1}^{n}\frac{(x_i-y_i)}{(x_i+y_i)/2}$$

where x_i is the count by observer DD and y_i is the count by observer JG using a given method for group i, i=1,⋯,n.

*Difference between counts is significant at α=0.05 based on ANOVA (see Methods).

Table 3. Mean proportional differences[A] between the number of walruses counted using magnification and projection of 35-mm slides in each of n walrus groups.

	Altitude		
Observer	300m (n=19)	400m (n=8)	500m (n=8)
DD	-.11*	-.01	.00*
JG	-.30*	-.21	-.56*

[A]Mean proportional difference calculated as

$$\frac{1}{n}\sum_{i=1}^{n}\frac{(x_i-y_i)}{(x_i+y_i)/2}$$

where x_i and y_i are the walrus counts obtained by a given observer for group i, i=1,⋯,n, using magnification and projection, respectively.

*Difference between counts is significant at α=0.05 based on ANOVA (see Methods).

DISCUSSION

S-VHS cameras in a fixed-mount were ineffective for obtaining unbiased density estimates of walruses hauled out on sea ice. When magnification was sufficient to delineate individuals, the corresponding reduction of image swath-width resulted in an insufficient sampling of the walrus population, which occurs in a highly clumped distribution across an extensive geographic area. Although fixed-mount videography proved unsuccessful for walrus surveys, the technique may be applicable to other populations with relatively even distributions or higher densities, and adequate contrast from their backgrounds. For such populations, videography can be expected to reduce errors associated with observer counts and distance measurements.

Table 4. Mean proportional differences[A] between the number of walruses counted with Hi-Band 8 videography and projected 35-mm slides in each of n walrus groups.

	Altitude		
Observer	300m (n=19)	400m (n=8)	500m (n=8)
DD	-.25*	-.06*	-.46*
JG	-.32*	-.31*	-.71

[A]Mean proportional difference calculated as

$$\frac{1}{n}\sum_{i=1}^{n}\frac{(x_i-y_i)}{(x_i+y_i)/2}$$

where x_i is the Hi-Band 8 count and y_i is the projected slide count obtained by a given observer for group i, i=1,⋯,n,.

*Difference between counts is significant at α=0.05 based on ANOVA (see Methods).

Systematic survey coverage was not possible when the video camera was removed from the fixed mount. Hand-held video, however, is an alternative to conventional photography. The video cameras captured 30 images per second with 0.001-second shutter speed and performed under cloudy, reduced-light conditions. We were able to review multiple video frames from a number of angles to select a frame with superior clarity and perspective of each walrus group.

The high precision obtainable from S-VHS imagery was indicated by the consistency of the counts of the four independent observers (Table 1). The S-VHS counts were significantly lower than the corresponding real-time estimates. True group sizes were unknown, however, so the accuracy of these counts cannot be inferred.

The HB-8 counts were also relatively precise, as indicated by the consistency between observers (Table 2). However, mean HB-8 video counts were consistently lower than mean counts of the same walrus groups made from 35-mm slides (Table 4). Photographic film has higher resolution than video imagery (Table 5); therefore, these results imply that walrus counts from HB-8 images underestimated density. The photographs had sufficient resolution and shadow detail to delineate partially obscured walruses that were not detectable with the lower-resolution HB-8 video. Given optimal light conditions, minimum aircraft turbulence, and access to an open window or door, photography appears to be more reliable than HB-8 video for recording walrus aggregations for enumeration.

Counting walruses from projected 35-mm slides appeared to be more accurate than counting from the same slides magnified with a dissecting scope. Although the only significant difference between observers was for projected slides, the discrepancy was later reduced by reviewing the traced walrus individuals and standardizing the procedures for identifying and delineating partially obscured animals.

Table 5. Calculated ground resolution for video and photographic cameras, flight altitudes (alt), and lens focal lengths (fl) used for this study.

Media	S-VHS			HB-8			35-mm Ektachrome		
TV-lines	700.			450.			-		
Chip size (mm)	8.80			6.54			-		
line pairs/mm	27.6[A]			23.9[A]			36.0[B]		
fl (mm)	10	30	120	80	80	80	210	210	210
alt (m)	150	150	150	300	400	500	300	400	500
ground resolution (m)	.27[C]	.09	.02	.08	.11	.13	.02	.03	.03

[A]lp/mm = (TV-lines/2.88) / Chip size
[B]Factory specification
[C]Ground resolution = 0.5 x ((lp x fl) / alt)$^{-1}$

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Table 1. Visual estimates of walrus group sizes on sea-ice haulouts and mean counts by 4 observers that reviewed Super-VHS video imagery of the same groups; Bering Strait, Alaska, May 30-31, 1989.

Visual estimate	Super-VHS Count		Percent difference
	Mean	SD	
1	1.0	0.0	0
1	1.0	0.0	0
2	2.8	1.0	38
2	2.0	0.0	0
2	2.0	0.0	0
3	4.0	1.2	33
4	5.0	1.2	25
4	9.0	0.8	125
4	2.3	0.5	-44
6	4.0	1.4	-33
8	6.8	1.0	-16
8	9.5	1.3	19
8	3.0	0.0	-63
8	6.0	0.0	-25
9	9.8	1.0	8
10	10.0	1.4	0
10	19.5	0.6	95
12	10.8	0.5	-10
15	10.0	1.4	-33
18	12.3	1.0	-32
20	16.3	1.0	-19
27	20.0	2.2	-26
45	56.8	7.4	26
45	31.3	1.0	-31
50	26.8	2.5	-47
60	27.0	6.5	-55
65	43.5	7.1	-33
70	38.8	3.5	-45
75	45.3	6.8	-40
75	47.3	6.4	-37
78	60.5	9.3	-22
80	47.0	0.8	-41
100	45.0	9.8	-55
120	90.8	13.3	-24
150	74.3	17.1	-51
170	128.3	16.8	-25

Table 2. Mean counts of corresponding walrus groups by 2 observers using Hi-Band 8 videography and 35mm slides that were both magnified and projected. Airborne imagery was collected at 3 altitudes; southwest Chukchi Sea, USSR, July ??-??, 1989.

Hi-Band 8 Video		Magnified 35mm		Projected 35mm	
Mean	SD	Mean	SD	Mean	SD
300 m Altitude					
4.5	0.7	5.5	0.7	6.0	0.0
5.5	2.1	9.0	2.8	8.5	0.7
13.0	0.0	16.5	6.4	17.5	0.7
15.5	2.1	11.5	0.7	12.0	2.8
17.5	0.7	18.0	2.8	24.5	2.1
27.0	0.0	15.5	2.1	27.0	0.0
28.5	0.7	32.0	2.8	34.0	9.9
29.0	2.8	19.0	1.4	29.0	2.8
31.5	6.4	36.5	2.1	51.0	0.0
40.5	0.7	43.5	0.7	56.5	4.9
50.5	9.2	70.0	4.2	80.5	7.8
56.5	0.7	56.0	17.0	85.5	0.7
59.5	6.4	78.0	7.1	87.5	7.8
63.0	1.4	82.0	2.8	97.5	3.5
70.5	6.4	76.0	4.2	89.0	8.5
73.5	17.7	93.0	1.4	111.5	9.2
83.5	0.7	90.0	4.2	125.0	12.7
102.0	1.4	130.5	26.2	152.5	23.3
137.5	13.4	145.0	28.3	174.0	12.7
400 m Altitude					
9.5	0.7	10.5	0.7	9.5	0.7
11.5	2.1	15.5	0.7	15.5	4.9
21.5	4.9	16.0	1.4	21.5	4.9
24.5	10.6	25.0	4.2	26.0	8.5
31.0	9.9	43.5	6.4	51.0	2.8
46.0	0.0	69.0	0.0	78.5	0.7
144.5	36.0	110.5	37.5	137.5	41.7
281.5	51.6	276.0	29.7	334.5	2.1
500 m Altitude					
6.0	0.0	16.5	10.7	22.5	2.1
7.0	4.2	14.5	2.1	18.5	9.2
7.5	0.7	17.5	2.1	23.5	6.4
10.0	2.8	20.0	7.1	28.5	6.4
11.5	3.5	10.5	4.9	11.5	3.5
20.0	1.4	17.0	2.8	23.5	9.2
33.0	7.0	31.5	3.5	41.5	6.4
144.0	26.8	144.0	4.2	211.5	29.0