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Variability of waterfowl aerial surveys: observer and air - ground comparisons — A preliminary report

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Abstract

The study examined nine pairs of unstandardized aerial-ground waterfowl surveys and compared observers' performances in 14 aerial surveys. Consistently more birds were seen and more species were identified in ground surveys than in aerial surveys. Cryptic species such as loons and grebes were overlooked in aerial surveys. Estimates of observer pairs differed significantly in 13 surveys. Discrepancies in estimates were larger for flocked birds than scattered ones. The percentage of birds classified similarly by each pair of observers averaged only 53% and ranged from 5 to 92%. The data summarized here indicate that density figures and species compositions derived from unstandardized aerial surveys should be considered critically, especially when no replicates have been flown.

Introduction

In the last decade, CWS and the British Columbia Fish and Wildlife Branch have carried out several aerial surveys to determine the coastal distribution of aquatic birds wintering in that province. Most surveys were designed to locate bird concentrations and were not aimed at estimating densities. The ruggedness of the coast and unstable weather conditions impaired standardization of the surveys, and several types of aircraft and observers were used. For most of the British Columbia coastline, those aerial surveys constituted the only source of information on wintering birds, and often the information was based on a single set of observations.

While the aerial surveys gave an overview of the coastal distribution of birds in winter, the prospect of increased oil tanker traffic and offshore drilling along the coast of British Columbia has emphasized the need for more information on the distribution, abundance, and behaviour of coastal aquatic birds. Because aerial surveys are the only practical way of surveying many coastal bird populations, and because of their extensive use in the past, it is important to identify the strengths and weaknesses of the technique to improve the interpretation of observations.

This report summarizes trends observed in air-ground and observer comparisons during unstandardized aerial surveys. Although the comparisons were

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Methods

Air-ground comparisons

I have compared the aerial and ground surveys from survey programs in the Fraser River estuary near Vancouver and in the Queen Charlotte Islands, BC.

Two sections of the Fraser River estuary were surveyed. The first, White Rock, consisted of 16 km of predominantly rocky shoreline used mostly by diving ducks. The second, Boundary Bay, extended over 20 km of mud and sand flats and harboured large concentrations of dabbling ducks. Three sections of shoreline were surveyed in the Queen Charlotte Islands. The first, on the east coast of Graham Island, extended over 40 km of sandy beaches; the second included 20 km of sandy beaches in McIntyre Bay on the north coast of Graham Island; and the third covered 8 km of rocky shoreline in Skidegate Inlet. All three sections had high densities of diving ducks but no large concentrations.

Cruising speeds ranged from 145 to 160 km/h and flying heights varied from 50 to 60 m during aerial surveys. Two observers, one on each side of the aircraft, recorded all observations on cassette tapes, which were transcribed at the end of each trip. Observations were not restricted to a fixed transect width and all birds seen were noted. We made ground counts with 7X35 mm binoculars and 15-60X zoom telescopes and counted all birds visible from the shore.

Aerial and ground surveys were done within 4 days of each other and covered the same shoreline section. They were all done in winter when bird populations are relatively stable.

Comparisons between observers

I took data for between-observer comparisons from aerial surveys on the Fraser River estuary, where bird densities were high and birds formed large flocks; from surveys in the Columbia Valley, where birds occurred in lower densities but still formed large concentrations; and from surveys over the offshore waters of Dixon Entrance off the Queen Charlotte Islands, where bird densities were very low. On each survey, two observers on the same side of the airplane counted the same population of birds. Observers were not restricted to a fixed transect width, but usually concentrated their search within a 200-m-wide strip.

Results

Air-ground comparisons

The observers saw approximately twice as many birds from the ground as from the air in all the paired surveys (Table I). Loons, grebes, and cormorants were seen more often in ground surveys. The large number

Table 1
Comparisons between aerial (A) and ground (G) surveys conducted in British Columbia

Location	Dist., date	No. birds seen: Loon, grebe & cormorant	Dabbling ducks	Diving ducks	Unident. ducks	Total	No. spec. ident.	% birds ident. to spec.
White Rock 1977	(16 km)							
	A 29 Nov.	1	115	1562	89	1767	6	18
	G 30 Nov.	73	210	3518	843	4644	16	21
	A 15 Dec.	5	0	887	205	1097	4	16
	A 15 Dec.	3	2	1152	127	1284	4	10
	G 19 Dec.	42	264	1921	357	2584	16	33
Boundary Bay 1977	(20 km)							
	A 1 Nov.	20	13 795	503	127	1445	5	13
	G 4 Nov.	60	22 332	125	203	22 720	9	25
	A 29 Nov.	0	1365	0	6439	7804	2	14
	G 30 Nov.	6	17 583	206	34	17 829	12	14
	A 15 Dec.	1	0	61	3320	3382	0	0
	A 15 Dec.	4	100	49	1743	1896	2	6
	G 19 Dec.	13	17 367	166	0	17 546	10	12
Graham Island QCI* 1978	(40 km)							
	A 11 Jan.	38	0	1399	41	1478	5	51
	G 5 Jan.	134	13	2911	41	3099	16	58
McIntyre Bay QCI 1978	(20 km)							
	A 9 Jan.	7	0	385	17	409	5	73
	G 6 Jan.	206	0	1614	2	1821	15	94
Skidegate Inlet QCI 1978	(8 km)							
	A 11 Jan.	126	0	44	74	244	3	12
	G 8 Jan.	158	0	195	0	353	15	63
	G 5 Jan.	129	4	315	0	448	16	62

*QCI = Queen Charlotte Islands.

in this category recorded in the Skidegate Inlet aerial survey (Table I) may be attributed to the presence of Arctic Loon flocks that were easier to locate from the air. No Artic Loons were recorded in the other surveys.

Dabbling and diving ducks were consistently fewer in aerial than in ground surveys. The number of unidentified birds varied between the survey types, showing no clear pattern.

We identified consistently more species from the ground than from the air (Table I). The average number of species identified in 10 aerial surveys was 3.6 ± 0.58 (± standard error) compared with an average of 13.9 ± 0.93 for 9 ground surveys.

The percentage of birds identified to species averaged 21.3 ± 7.2 in aerial surveys and 42.4 ± 9.3 in ground surveys. Scaup were not identified to species in either type of survey, and dabbling ducks were not always speciated because of time constraints during the Boundary Bay ground surveys. That explains partially the low percentage of birds identified in some ground surveys.

Between – observer comparisons

In theory, two observers located on the same side of the aircraft should record similar numbers of birds, but they achieved this in only 1 of 14 surveys (Table 2). In all the remaining surveys, one observer saw significantly more birds than the other.

The reasons for those differences varied, some resulting from non-standardized techniques, others

from differences in the estimation and observation skills of observers. Among sources of errors occasionally noticed during a survey was the recording of birds that had flushed from one side of the aircraft to the other. One observer did not realize the origin of the birds and counted them, whereas the other did not. Flocks distant from the flight line were sometimes missed by one of the observers. Six surveys were divided into sub-sections to determine if observers' differences were random or if one of the two observers was constantly underestimating or overestimating (Table 3). In one survey, differences were associated with only one observer, but in the other five, it varied between observers. The degree of difference between observers was not constant but varied among sub-sections, indicating that observers' skills were influenced by external factors.

I found that bird density influenced the accuracy of observers' estimates. Differences between observers were larger in sections where flocks of birds were encountered than in sections where birds were widely spaced (Table 4). Observers differed not only in the numbers of birds they recorded, but also in the identification of the birds. The percentage of observations that were identically categorized by both observers ranged between 5.1% and 92% (Table 2). Even when both observers estimated the same number of birds as they did in survey 14, they did not identify the birds similarly. Only 24% of the birds seen were similarly classified in that survey. Differences in classification were probably due to differences in skill between observers. Also some observers are less scrupulous in their identification, whereas others will only identify to species level if certain of their identification.

Another major difference between observers occurred with the classification of mixed flocks. In one survey, one observer classified mixed flocks of dabbling ducks under "dabbling ducks" because he did not feel confident about the relative abundance of each species identified in the flock. The other observer, however, made a rough approximation of the relative abundance of each species.

Variability within aerial surveys

We know little about the variability within aerial surveys because few workers have flown replicates. Two aerial surveys were flown back-to-back in Boundary Bay on 15 December 1977. In the first survey, 25 347 birds were counted compared with 31 271 in the second survey, a difference of 5924 birds or 19%. The same observers did both surveys, but one surveyed the shoreline portion of the flight line during one survey and the offshore portion during the other. Part of the difference in the numbers of birds seen results from different estimation in both surveys. For example, counts for Snow Geese and swans differed by more than 30% between surveys, and can be attributed to observers' differences and flight-line location. Those differences contribute to an increase in the variability of aerial surveys and therefore decrease their reliability for density estimation.

Surveys in 1977 and 1978 in the Queen Charlotte Islands illustrate the danger of drawing conclusions from single aerial surveys. Two sections of shoreline were surveyed on 15 January 1977 and 11 January 1978 during two independent surveys (Hatler *et al.* 1977, Savard 1979). More than seven times as many birds were seen in 1978 as in 1977 in the first section, and twice as many in the second one (Table 5). Anyone looking at each survey independently would arrive at a different conclusion about the value of those sections of shoreline for wintering birds. Both surveys were flown under similar clear weather conditions. However, the unusually calm sea in 1978 facilitated bird detection. Other factors such as bird distribution, aircraft type, flight-line location, flying height, and observers undoubtedly contributed to the discrepancy between the surveys. The instantaneous nature of aerial surveys should always be kept in mind when interpreting the results.

Discussion

Air-ground comparisons

Observers did not carry out aerial and ground surveys simultaneously but a few days apart. Large movements of birds are unusual in winter, but local movements in and out of the study area may have biased individual comparisons. However, some differences between the survey types were present in all the comparisons and probably represent real differences.

We recorded fewer species in aerial surveys than in ground surveys. During aerial surveys, observers only have a few seconds to identify species and estimate numbers, and therefore identifications depend more on the observers' skills, weather conditions, and bird density and behaviour.

Less common species amid large numbers of other birds were often overlooked from the air, as happened with cryptic and dispersed species such as loons, grebes, and cormorants in most aerial surveys. Therefore, absolute or relative density estimates of those species based solely on aerial surveys may be misleading. Each species has a particular degree of conspicuousness, according to its size, plumage, and behaviour when seen from the air. Also, the conspicuousness of a species is affected by weather conditons, habitat type (exposed vs protected waters), spatial distribution of birds (scattered or in groups) and their activity (feeding vs sleeping) (Graham and Bell, 1969). Stott and Olson (1972) found that dark-bodied birds such as scoters were difficult to see with a clear or partly cloudy sky, and the ocean coloured dark or blue, but were easily seen on overcast days. The reverse was true for goldeneyes and mergansers. The problem of identification in aerial surveys is also compounded by the logistics of surveying several species at once. Watson *et al.* (1969) showed that multiple species counts were less accurate than single species counts.

Table 2
Comparison of observer counts with both observers on same side of aircraft

Location and date (1977)	Obs. pair	No. birds seen by Obs. A	No. birds seen by Obs. B	Chi-sq., value	% birds similarly classified by both†
Columbia Valley					
(1) 14 Sept.	1	5721	6453	44.0*	55.0
(2) 5 Oct.	1	10 804	12 993	201.4*	66.8
Dixon Entrance					
(3) 23 Sept.	2	1585	1868	23.9*	92.0
Boundary Bay, open waters					
(4) 29 Nov.	3	3007	6661	1381.0*	55.4
(5) 29 Nov.	4	2551	4738	656.2*	51.1
(6) 15 Dec.	5	1216	1838	126.7*	45.1
White Rock					
(7) 29 Nov.	3	1947	3070	251.4*	65.1
(8) 29 Nov.	4	579	952	90.9*	5.1
(9) 15 Dec.	5	556	813	48.3*	50.3
(10) 15 Dec.	5	1171	1358	13.8**	81.4
Boundary Bay, shoreline					
(11) 29 Nov.	3	5508	1091	2956.5*	60.3
(12) 29 Nov.	4	4265	14 860	5869.5*	10.5
(13) 15 Dec.	5	6858	9080	312.4*	85.5
(14) 15 Dec.	5	753	777	0.4	24.3

* Significant at 99.9%.
** Significant at 95.0%.
† Equivalent to Bray-Curtis indices of similarity (Huhta 1979). Classification units included species, genus, group of species, i.e. surf scoter, scoter, surf or black scoter, and unidentified duck were four different categories under which a bird could be classified by an observer.

The influence of those factors is reduced in ground surveys, in which the observers saw consistently more birds than in aerial surveys. That should be expected in areas with good access from the ground, which allows a larger area to be surveyed and more time to detect birds. Also, several simultaneous overland aerial and ground surveys on delineated areas have shown that only a fraction of the animals present can be detected from the air (Gilbert and Grieb 1957, Diem and Lu 1960, Lotter and Cornwell 1969, Dzubin 1969, Caughley *et al.* 1976).

Ground surveys may sometimes overestimate or underestimate bird densities along straight shorelines when landscape features are rare and birds are distant from the shoreline. In such situations, birds can easily be missed or counts duplicated. We met such difficulties in the first two sections of the Queen Charlotte Island surveys and might have over-emphasized the differences in bird densities between aerial and ground counts.

Between - observer comparisons

Observers differed in their identification and estimation skills. Le Resche and Rausch (1974) and Wartzok and Ray (1975) showed that experienced observers who did aerial surveys regularly were more accurate than either inexperienced observers or experienced observers who did not fly regularly.

For aerial observers of equal ability, differences in the categorization of birds are likely to increase as bird density increases. At low density, observers have more time to make the identification and their classifications should be similar. Differences between observers impair the interpretation of aerial surveys; even when the population of birds remains stable, large fluctuations in numbers can be reported occasionally by different observers.

It is likely that the use of fixed transect-width, rigorous identification criteria and highly trained observers will increase the precision of aerial surveys. However, such standardization is not always possible and often not warranted. Several attempts have been made to improve the accuracy of aerial surveys of mammal populations (Caughley 1974, Caughley *et al.* 1976, Caughley 1977, Norton-Griffiths 1978). Comparatively little effort has been made to improve the efficiency of waterfowl aerial surveys, especially in coastal waters (Diem and Lu 1960, Martinson and Kaczynski 1967, Stott and Olson 1972). More research is needed to determine if the accuracy of coastal aerial surveys can be sufficiently improved to adequately monitor short- and/or long-term trends in some populations of sea ducks.

The data summarized in this report indicate the need for caution in interpreting the results of aerial surveys. Density figures derived from aerial surveys should be considered critically, especially when no replicates have been flown or when different observers have been used.

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Table 3
Differences in observer estimates*

	Aerial survey location					
	Columbia Valley	Boundary Bay (open waters)		Dixon Entrance		
Obs. pair	1	1	3	4	5	2
Survey section						
A	−38	+50	−52	−23	−11	−19
B	−42	−13	−68	−49	+ 5	+ 7
C	−20	+17	+17	−52	+47	−16
D	− 9	+22	− 6	−36	+ 5	−41
E	+ 7	−11	—	—	—	—
Av. dev. /section	23	23	36	40	17	21

*Coefficients of variation were used as a measure of difference (n=2). A coefficient of 0% would indicate that the estimates of both observers were similar. The signs + and − indicate only if the bias was associated with the same observer.

Table 4
Effect of flock size on differences* in observers' estimates

Transect no.	Obs. pair no.	Flocked† birds	Other birds
1	3	62*	34
2	3	76	33
3	4	29	12
4	4	55	34
5	4	62	26
6	5	51	6
Av. diff.		67	29

*Coefficient of variation was used as a measure of difference.
†Scaups and/or scoters only.

Table 5
Comparison of results of two aerials surveys done in January along eastern shoreline of Graham Island, BC

	Section A (40 km)		Section B (35 km)	
Classification	15 Jan. 1977	11 Jan. 1978	15 Jan. 1977	11 Jan. 1978
Loon	7	18	—	16
Grebe	2	8	—	75
Cormorant	6	12	17	69
Brant	—	—	75	147
Dabbling duck	—	—	430	47
Scaup	—	45	—	118
Goldeneye	29	656	25	319
Bufflehead	—	—	—	90
Oldsquaw	18	86	—	—
Harlequin duck	—	23	2	14
Scoter	108	589	—	269
Merganser	1	—	—	31
Unident. duck	12	41	102	54
Gull	102	606	97	275
Alcid	4	—	—	1
Total	289	2084	750	1725