A Simulation Method for Estimating Negative Bias in Caribou Photocensuses

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Introduction

- Post-calving photocensus estimates based on non-random sampling of radio-collars are biased low (e.g. Davis et al 1979, Valkenburg et al 1985, Rivest et al1998).
- We estimate the magnitude of this bias by simulating the "true" population that generated the observed survey results.
- We explored the properties this simulation-based estimator using randomly generated populations of known size.
- An application of the method using the Western Arctic and Teshekpuk Herds is presented.

Methods

- Our approach is to simulate the size and state of aggregation of a herd, that when sampled with radio-collars, yields the count and group size distribution observed during the survey.
- To reconstitute the "true" herd from a survey, we repeatedly assign radio-collars to the observed groups using a multinomial random number generator. And use the proportion of the time each group was selected. To determine the number of groups of similar size that are in the "true" population.
- A group selected only 5% of the time would be taken to be one of 20 groups of similar size. A large group sampled nearly 100% of the time in the simulation would translate to one such group in the "true" population.
- We then fine-tuned the "true" herd size to ensure that the simulated population produced, on average, the same number of observed caribou in collared groups as were observed in the initial survey.

- To explore the properties of this method for a wide range in the state of aggregation and number of collars deployed, we fit a lognormal distribution to a series of real survey results to establish a realistic set of parameters (scale-location- number of groups) with which to generate populations of known size (100,000) and distribution (scale = 0.5, 1, 3).

- An additional expansion is necessary to account for missed collars.

Simulation Results

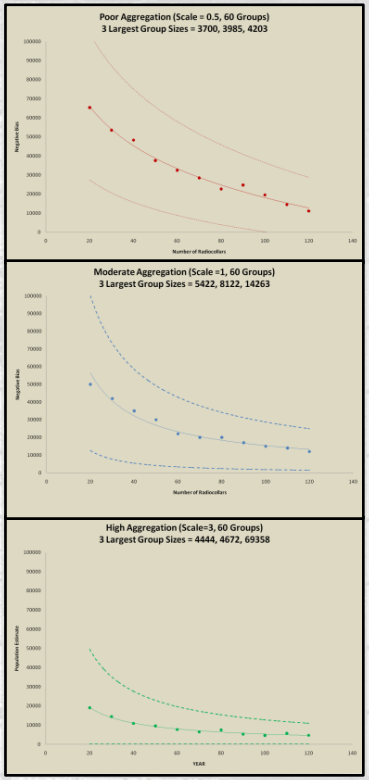


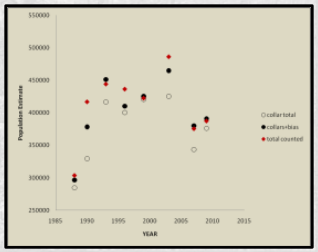
Fig 1a-c. Magnitude and standard error of negative bias of minimum count in a simulated caribou photocensus. Both parameters decrease with increasing number of collars and level of aggregation.

Western Arctic Herd Case Study

Year	Scale (σ)	Location (μ)	3 Largest Groups		
1988	1.8	8.3	92,251	82,822	25,582
1990	1.7	6.8	159,368	55,221	39,525
1993	2.5	7.2	109,591	61,984	40,889
1996	2.5	7.2	119,314	73,243	50,402
1999	3.2	5.7	237,722	64,947	62,771
2003	2.5	7.3	119,440	104,829	70,911
2007	1.5	8.4	42,390	40,433	37,341
2009	2.5	7.2	242,620	61,022	32,143
Average	2.3	7.3	140,337	68,063	44,946

← Table 1. Parameters for the lognormal distribution fitted to real survey data from the WAH. The largest group photographed averages >140K caribou. Aggregation quality tends to be quite high.

Figure 2. Survey results and estimates of bias from the WAH. The collar-only count tends to underestimate the "true population" by 7%, on average. In some years, the total number of caribou found using both collars and extensive searching matches or exceeds the "true" population estimated using only collared groups.

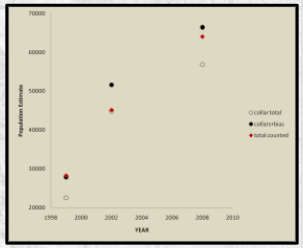


Teshekpuk Herd Case Study

Year	Scale (σ)	Location (μ)	3 Largest Groups		
1999	0.96	6.6	2958	2199	1944
2002	0.99	7.8	9325	7981	5067
2008	1.39	7.3	8278	7706	6191
Average	1.1	7.2	6854	5962	4401

← Table 2. Parameters for the lognormal distribution fitted to real survey data from the TCH. The largest group photographed averaged <7K caribou in these surveys. Aggregation quality tends to be poorer than that observed in the WAH.

Figure 3. Survey results and estimates of bias from the TCH. The moderate level of aggregation leads to a poorer minimum count. For these three surveys, the minimum count obtained using only collared groups was biased 16% low, on average. The low number of collars (<35) in the 1999 and previous surveys suggest that these estimates may have a large negative bias. Further research on earlier estimates and their potential bias is needed.



Conclusions

- An adequate number of radiocollars is essential to limit negative bias.
- Aggregation quality, although impossible to measure in real-time, plays an even greater role in limiting bias.
- This method provides a means for post-hoc evaluation of photocensus quality.
- Minimum count estimates which use a combination of radio-tracking and searching can produce abundance estimates with very low bias.

Ongoing Investigations

- How does our method of estimating bias compare to the methods of Rivest et al 1998, which estimates abundance and its variance?
- Teshekpuk Herd – what effect did an exponential increase in the number of radiocollars (<10 to >70) have on the apparent growth rate?
- Porcupine Herd – in 2007 a photocensus was conducted, but 20% of the photos were unusable. Can we salvage this estimate?
- Is there a critical number of collars needed per caribou to achieve a minimum count adequate for management? Is there a critical number of collars needed to produce an unbiased "true" population estimate.