

Standard Operating Procedure (SOP) 9: Data Analysis, Version 1.0

Protocol for Monitoring Brown Bears

Arctic (ARCN) Inventory and Monitoring Network

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The main Narrative for the Protocol for Monitoring Brown Bears, Arctic (ARCN) Inventory and Monitoring Network is available from the NPS Inventory and Monitoring Arctic Network website (<http://science.nature.nps.gov/im/units/arcn/>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/nrpm/>).

SOP 9 – Data Analysis

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SOP 9.0 – Introduction

This SOP describes the assumptions required under the double sampling photo mark-resight framework to insure proper inference. The general processes for analysis are also described.

SOP 9.1 – Methodological Assumptions

Historical brown bear surveys in ARCN were largely based on minimum count methods or mark-resight methods using physical marks (i.e., radio collars; Miller et al. 1997). When using a minimum count approach, one must assume that detection probability is constant across time and space for estimates to be comparable. This is unlikely to be true in a majority of cases. Also, because detection is assumed to be a fixed rate, there is no way to assign uncertainty to the resulting counts. Because of this, population change and variation in detection probability are confounded, decreasing statistical power to detect trends. Conventional mark-resight approaches for bears typically require a subset of the population of interest to be marked with radio collars (e.g., Miller et al. 1997). Aside from the high cost of capture and marking efforts, such approaches require the assumption that marked bears are representative of the population of interest. In addition, such studies are only possible over relatively small study areas. If inference to a larger area is desired, one must then assume that the study area population is representative of the larger landscape. These assumptions may be difficult to meet and are almost impossible to assess. The photo mark-resight approach of Schmidt et al. (2017) eliminates the need for physically marking individuals, allowing surveys to be completed at the landscape scale. Doing so eliminates the assumption of a representative marked sub-sample and provides direct inference at the landscape scale.

The success of the photo mark-resight approach is heavily dependent on the assumption that individual bear sightings within sampling units (i.e., subunits) can be identified conclusively. Although we cannot assess this assumption directly, we are confident that it can be met in ARCN. One of the key factors is that bears are rare on the landscape. On average only a few groups are seen by each survey team each day, leading to relatively few potential resightings. When group composition (e.g., sow with cubs vs. lone bear), coloration, and spatial location information are considered, groups that might have been seen by both teams can usually be reconciled quickly. Short revisit intervals also helps meet the assumption that the same bear groups are available to both teams. While not absolutely true, in most cases subunits are resurveyed within a few hours, reducing the chances of a bear moving in or out of the subunit. As with most bear survey approaches, we also assume that all bears are out of their dens and available to be sampled. This assumption is met by conducting surveys during late May and early June when bears should be out of their dens, but prior to green-up of the vegetation. As long as surveys are conducted during this timeframe, most bears should be out of their dens and available. Single-visit protocols are also subject to the problem that some individuals may be instantaneously unavailable for sampling (e.g., behind a rock, under a bush) during a particular pass by the airplane. Under the double sampling approach such problems are reduced because the short time between the first and second visits allows localized movements to occur (e.g., move out from behind a rock or bush). Also, because flight paths differ between teams, they tend to differ in perspective, lighting, direction, etc., increasing the chances that an individual that may have been unavailable from a particular path flown by the first team will be available to

the second team (Wilson et al. 2014). Further details on the methodological assumptions and their likelihood of being met are covered by Schmidt et al. (2017).

SOP 9.2 – Analysis of Double Observer Photo Mark-resight Bear Data

Each day all sightings are reconciled by the teams to identify any groups that were seen by both teams. The sightings for each bear group are then turned into a capture history with a 1 indicating the group was seen and a 0 for not seen by each of the two teams. For example, a group seen by the second team but not the first would be coded as 0,1. These sighting histories are created for each detected group. In addition, several additional 0,0 histories representing potential but undetected groups are added. This is called data augmentation (Royle 2009). The double observer mark-resight approach (Schmidt et al. 2017) then uses the variation in the capture histories to estimate how many of the 0,0 histories were real but undetected bear groups. The total number of bears is simply the average group size multiplied by the estimated number of groups in the sampled subunits. The total population size is the estimated number of bears in the sampled area divided by the proportion of the total survey area sampled. Random effects terms are added at the unit and subunit levels on occurrence probability and detection probability, respectively. This helps address variation in bear density among units and variation in the detectability of individuals. Because the same field protocol is used for each survey, detection information may be borrowed across surveys to improve inference. This is done through the use of informed priors on the parameters of the detection model. These priors are updated each year based on the posteriors of the prior years' analyses and can be considered to be analogous to analyzing all datasets together with a common detection parameter. Models are fit using OpenBUGS 3.2.3 (Thomas et al. 2006). Full details regarding model development, structure, and fitting are comprehensively covered by Schmidt et al. (2017).

SOP 9.3 – Literature Cited

- Miller, S.D., G.C. White, R.A. Sellers, H.V. Reynolds, J.W. Schoen, K. Titus, V.C. Barnes Jr., R.B. Smith, R.R. Nelson, W.B. Ballard, and C.C. Schwartz. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildlife Monograph No. 133.
- Royle, J. A. and R. M. Dorazio. 2008. Hierarchical modeling and inference in ecology. Academic Press, Bullington, Massachusetts.
- Royle, J.A. 2009. Analysis of capture-recapture models with individual covariates using data augmentation. *Biometrics* 65:267-274.
- Schmidt, J. H., K. L. Rattenbury, H. L. Robison, T. S. Gorn, and B. S. Shults. 2017. Using non-invasive mark-resight and sign occupancy surveys to monitor low-density brown bear populations across large landscapes. *Biological Conservation* 207:47-54.
- Thomas, A., O'Hara, B.O., Ligges, U. & Sturtz, S. (2006) Making BUGS open. *R News* 6, 12-17.
- Wilson, T.L., J.H. Schmidt, W.L. Thompson, and L.M. Phillips. 2014. Using double-observer aerial surveys to monitor nesting bald eagles in Alaska: are all nests available for detection? *Journal of Wildlife Management* 78:1096-1103.