How many birds are burrowing in this borough?

Using *N*-mixture models to estimate an Ancient Murrelet breeding population from chick counts

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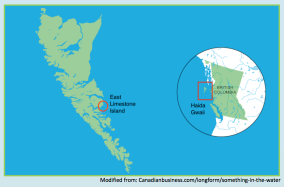
Our Question

Can we successfully use *N*-mixture models to estimate an Ancient Murrelet breeding population based on annual chick count data?

Background

- Producing estimates of seabird population sizes and trends requires expensive and labour-intensive fieldwork. Ideally, this could be reduced with the development of accurate modelling tools.[1]
- *N*-mixture models use data from counts over time at multiple locations to produce maximum likelihood estimates of population parameters, including a site abundance that takes into account imperfect detection.[2]
- The Ancient Murrelet (*Synthliboramphus antiquus*) is a burrow-nesting seabird species with an unusual chick rearing strategy.[3] The chicks are highly precocial and leave the burrow at several days old.
- At the East Limestone Island breeding colony the Laskeek Bay Conservation Society annually records Ancient Murrelet chick counts by intercepting chicks as they run to the shoreline. This monitoring has produced a record from 1990 to 2006 for two consistent sampling locations.



Modified from: Canadianbusiness.com/longform/something-in-the-water

Figure 1. Location of study site: East Limestone Island, Haida Gwaii, British Columbia, off the west coast of Canada.

Abundance Estimates

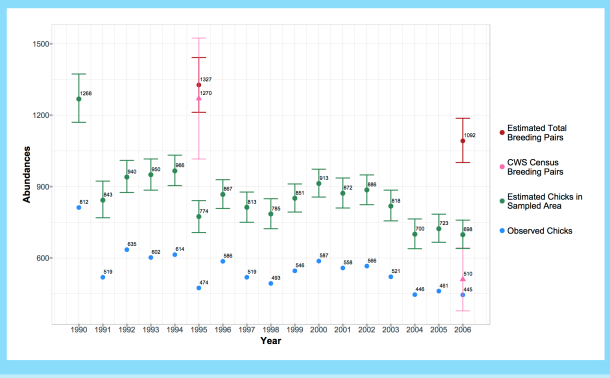


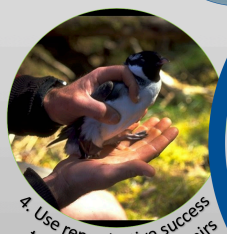
Figure 2. Annual estimates of total Ancient Murrelet chicks hatching in the sampled area (5.2 hectares) of the East Limestone Island colony, and actual chick counts from the sampled area. Estimates of total breeding pairs of adults in the whole colony area (~13 ha) using average reproductive success[6] to convert from chick numbers to breeding pairs, and compared to population estimates from the Canadian Wildlife Service (CWS).[7] Error bars are 95% confidence intervals for all estimates except CWS population estimates, which are 1 standard error.

Table 1. Comparison of results from two methods of estimating breeding population of Ancient Murrelets in the entire East Limestone Island colony. Canadian Wildlife Service estimates are based on burrow inspection in quadrats along transects.[7] We calculated the number of breeding pairs from total chick numbers estimated by an *N*-mixture model, using average reproductive success of 1.54 chicks per breeding pair.[6]

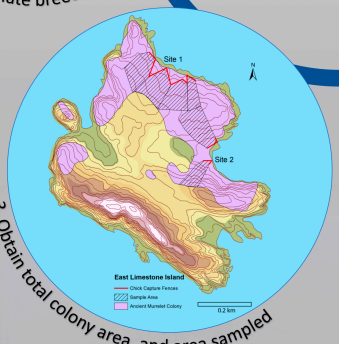
	Canadian Wildlife Service Census		Our Model	
Year	Number of Breeding Pairs (± 1 SE)	Colony Area (Hectares)	Chicks from sample area (95 % CI)	Total breeding pairs in entire colony area (95 % CI)
1995	1273 ± 254	13.76	774 (707, 841)	1327 (1212, 1442)
2006	509 ± 132	12.55	698 (640, 759)	1092 (1001, 1187)

Methods

1. Catch and count chicks annually



4. Use reproductive success to estimate breeding pairs



3. Obtain total colony area, and area sampled

5. Total breeding population

2. *N*-mixture Models[4]

Bin(*N*, *p*) — Models observed counts

Poisson(λ) — Models *N* (site abundance)

P(γ,ω) — Models recruitment and survival

Maximum Likelihood Estimates of:
- Initial Abundance (λ_1)
- Detection Probability (*p*)
- Recruitment (γ)
- Survival (ω_t)

Our *N*-Mixture Models:[5]
λ, *p*, γ, ω **Constant,** or vary by: **Year, Location**

Discussion

- Using *N*-mixture models to estimate chick numbers incorporates detection error. Our estimates of total chick numbers follow closely to the actual chick counts, and indicate that in the field approximately 64 % of the chicks that hatch in the sampled area are counted. Chicks could be escaping the trapping fences, getting diverted around trapping fences due to topography, and chicks can leave the colony before or after the nightly monitoring period.
- In 1995, our estimate of breeding population for the whole colony (1372 breeding pairs) is very similar to the estimate made from field surveys of burrow occupancy (1273 breeding pairs).[7]
- In 2006 the two population estimates are very different. Our estimates of adult numbers depend on having accurate data on reproductive success and total colony area. We are using an average reproductive success (1.54 chicks per breeding pair) that could be inappropriate for this time period or location.[3]
- The Canadian Wildlife Service (CWS) population estimate in 2006 implies there are far fewer breeding pairs than the previous census year, although the number of chicks actually observed does not change as dramatically over that time period. Could the CWS census be underestimating the breeding population?

Future work

- Incorporate covariates into more complex models. For example, breeding success and hence chick numbers could be influenced by the ENSO state the previous winter, and varies with sea surface temperature around the colony.[3]
- Can we apply these models to other seabird species? Because of the unique life-history strategy of this species, estimating adult numbers from chick counts could only be appropriate for others in the *Synthliboramphus* genus. However, *N*-mixture models can be applied to data from other survey methods that produce repeat counts at multiples sites over time; for seabirds, these could include on-the-water spotlight surveys and telescope counts.

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Acknowledgements

Thanks to the many Laskeek Bay Conservation Society volunteers and staff who have kept this long-term monitoring project going for almost 30 years! Thanks to Kelly Runyon for mapping files and advice. V.P. thanks her geography supervisors, Patrick O'Hara and Chris Bone. Analyses were run on Westgrid/Compute Canada with assistance from Dr. Belaid Moa.

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